Syllabus (Sem V & VI)
Third Year
B. Tech. in Biotechnology Engineering
(To be implemented w.e.f. Academic Year 2023-24)

Department of Biotechnology Engineering
Kolhapur Institute of Technology's College of Engineering (Autonomous), Kolhapur, Maharashtra, INDIA

Title of the Course: Mass Transfer	L	T	P	Credit
Course Code: UBTC0501	4	-	-	4

Course Pre-Requisite:
Basic Concepts of Fluid Mechanics, Heat Transfer

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

Course Learning Objectives:

1. To explain molecular diffusion, Fick's law and role of convective and diffusive mass transfer in bioprocessing
2. To solve the problems based on process design and scale up of bioreactors
3. To analyze separation method like distillation, extraction and drying.
4. To solve case studies on separation 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 Cognitive	
		Level	Descriptor
CO1	Explain convective and diffusive mass transfer in bioprocessing	2	Understanding
CO2	Solve the problems based on process design and scale up of bioreactors	3	Applying
CO3	Illustrate the role of mass transfer in the unit operations such as distillation, extraction and drying	2	Understanding
CO4	Analyze the case studies on mass transfer based unit operations such as distillation, extraction and drying	4	Analyzing

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		
CO3	3	2											2		
CO4	3	2											2		

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, Fick's law of diffusion, Diffusivity, Molecular diffusion in gases, liquids and diffusion in solids, Mass transfer coefficient, Mechanism of mass transfer. Film theory, Convective mass transfer	**8 Hrs.**
Unit 2: Mass transfer in bioreactors Oxygen Transfer in Fermenters, Determination of KLa, Factors affecting KLa values, The balance between oxygen supply and demand, Classification of reactors based on agitation and aeration regime.	**8 Hrs.**
Unit 3: Process 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, Wave bioreactor, Single use/Disposable bioreactor, Reactor peripherals and accessories, Scale up aspects of Bioreactor (Constant power per Unit volume, Constant KLa, Constant impeller tip speed)	**8 Hrs.**
Unit 4: Distillation Vapour –liquid equilibrium, Raoult's law, Dalton's law, Relative volatility, Simple distillation, Flash distillation, Continuous rectification-binary systems, Analysis of	**8 Hrs.**

fractionating column by McCabe- Thiele method, Reflux ratio, azeotropic andextractive distillation	
Unit 5: Extraction Partition coefficient basis of extraction, Type of extraction processes, Type of equipment's, Scale up, Special extraction types (Aqueous twophase extraction, Supercritical fluid Extraction, Reverse Miceller Extraction)	**8 Hrs.**
Unit 6: Drying Principles of drying, Phase equilibria, Cross circulation drying, Through circulation drying, Drying of suspended particles, Freeze drying, Drying equipment's - dryers for solids and pastes, dryers for solution and slurries, Selection of drying equipment	**8 Hrs.**
Textbooks: 1. Robert E. Treybal,"Mass TransferOperations",Third Edition, McGrawHill, 1980. 2. McCabe&Smith,"UnitOperationofChemicalEngineering",5thEditionMcGrawHill, KogakushaLtd. 1998. 3. Bioprocess Engineering Principles by Pauline M.Doran – Academic Press. 4. Bioseparation - Shivshanker B. (Prentice Hall of India)	
References: 1. C. JGeankolis, Transport Processes and unit operations, 3rdEdition, PrenticeHall, India, 1993 2. Richardson &Coulson, "Chemical Engineering", Vol. 2, PergamonPress, 1970. 3. B.K Datta, Principles of mass transfer & separation process. 4. Product recovery in bioprocess technology – Biotol Series (Butterworth-Heinemann Ltd.)	

Title of the Course: Bioreaction Engineering	L	T	P	Credit
CourseCode:UBTC0502	4	-	-	4

Course Pre-Requisite:
Basics Of 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 behaviour.

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: 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'sCognitive	
		Level	Descriptor
CO1	Explain the reaction yields and reaction rates	2	Understand
CO2	Develop enzyme and cell culture kinetics.	3	Apply
CO3	Evaluate the performance of ideal batch, fed-batch and continuous modes of bioreactors.	5	Evaluate
CO4	Analyze enzymes and cell culture reactions in different modes of bioreactors.	4	Analyze
CO5	Illustrate the concept of non-ideality and multiple reactor systems	II	Understand

CO-POMapping:

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:

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: 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.	**8Hrs.**
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, 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.	**8Hrs.**
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 and total time for batch reaction cycle. Problems based on it	**8Hrs.**
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	**8Hrs.**
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.	**8 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, Maximizing 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	**8 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.)
1. 5. Biochemical Engineering- Blanch H.W. and Clark, D. S. (CRC Press)

Title of the Course: Fermentation Technology	L	T	P	Credit
Course Code: UBTC0503	4	-	-	4

Course Pre-Requisite: Microbiology, Biochemistry, Fluid Mechanics, Heat Transfer

Course Description:
First half 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 and details of fermentation run. Second half explains the control systems in fermentation processes with case studies and initial part of broth handling.

Course Learning Objectives:

1. To understand the microbial fermentations in terms of microbiological aspects of improvements of strains, nutritional requirements , media design and formulations
2. To correlate the sterilization basics and aseptic operations in fermentation process
3. To know the basics of controls in the fermentation process

Course Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive	
		Level	Descriptor
CO1	Recall microbiological basics of isolation, genetic improvements of producer strains and their culturing	1	Remembering
CO2	Relate the nutritional requirements of microorganisms for media preparations, optimizations and sterilization from small to large scale	3	Applying
CO3	Categorize the bioreactors based on applications	4	Analyzing
CO4	Explain the basic controls in the fermentation process	2	Understanding

CO-PO-PSO Mapping :

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

Assessments:
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

ISE1 and ISE2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.

MSE Assessment is based on 50% of course content

ESE Assessment is based on100% course content with 60-70% weightage for course content(normally last three modules) covered after MSE

Course Contents:

Unit 1: Microbiological Basics in Fermentation The range of fermentation processes, The chronological development of fermentation industry, Range of hosts used for the fermentation processes and their genotypes, Basics of isolation, improvement and preservation of industrially important microorganisms, Microbial repositories and procurement protocols, Nutritional requirements for industrial microorganisms, Basics of Culturing	**9Hrs.**
Unit 2: Media optimization and sterilization Media components and criteria of their choices (Energy sources, Carbon sources, Nitrogen sources, Buffers, Oxygen requirements, Antifoams), 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) Large scale sterilization	**9Hrs.**
Unit 3: Inocula development and fermentation process The development of inocula for bacterial, streptomycete, yeast, fungal processes, The aseptic inoculation of plant fermenters, Fermentation process (Quantifying cell concentration, Quantifying substrates and products), The role of in process quality control	**6Hrs.**
Unit 4:Bioreactors Advancements in culturing scales (Shake flasks, Small scale, pilot scale and large scale stirred tank reactors), Selection of reactors based on different criteria such as broth characteristics, producer entity type etc. Design and working aspects of stirred tank reactors and their current versions (wave bioreactors, single use/disposable bioreactors, perfusion cultures), Concept of Quality by	**9 Hrs.**

Design (Terminologies in QbD - Process characterization, Critical quality attributes, critical process parameters, Failure mode effect analysis)	
Unit 5:Measurements and control in fermentation process Fundamentals of process control, Components of basic control loop Sensors (Temperature, Pressure, Weight, Microbial biomass, Flow rate, Dissolved oxygen, Inlet and Exit gas, pH, Rate of stirring) , Controllers(Manual and automatic controllers), Type of control actions (ON-OFF, Proportional and PID) and Actuators Basic fermentation control loops (Temperature, pH, D.O., air flow rate, agitation, pressure and antifoam) Loop versus Sequence control	**8Hrs.**
Unit 6: Control case studies and broth handling strategies Case studies (Manual control of fermentation process, Automated controls involving event tracking control, logic gates), Operating systems of Bioreactors (SCADA, DCS, PLC etc.) Broth handling for product recovery - Characterization of fermentation broth, Requirements and types of pretreatments (Coagulation, flocculation, cell disruption for intracellular products)	**6Hrs.**
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 (Springer Pub., Ann Books India)	

Title of the Course: Cell Culture Technology Course Code: UBTE0521	L	T	P	Credit
	3	1	-	4

Course Pre-Requisite: Students admitted for this course will be expected to have sufficient background knowledge of Cell biology and general biology.

Course Description:

The course covers 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 illustrate the animal cell physiology and complexity and cell cycle concept
2. To prepare(setup) laboratory for cell culture, media preparation and sterilization
3. To identify, dissociate and study physiology and testing of cell lines.
4. To illustrate the genetic engineering in cell lines for tissue engineering.

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Descriptor
CO1	Illustrate the animal cell physiology and cell cycle concept	2	Understanding
CO2	Explain the preparation (setup) laboratory for cell culture, media preparation and sterilization	2	Understanding
CO3	Apply different techniques for testing of cell lines.	3	Apply
CO4	Analyze genetic engineering in cell lines for tissue engineering.	4	Analyze

CO-PO Mapping:

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

ISE1 and ISE2 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 & biology of cultured cells Introduction of Cell Culture Technology, Philosophy and complexity in cell culture, To grow the cell outside the body, Cell cycle concept, dividing cells	**5 Hrs.**
Unit 2:Equipment, aseptic techniques, safety protocols Biology of cell culture, Layout(s) & design(s) of cell culture facility, Precautions during designing the lab layout	**5Hrs.**
Unit 3:Culture media development& sterilization State of the art facility in cell culture lab, specialized facility in cell culture lab, Interaction of cell and glass/polycarbonate surface, Poly D lysine deposition, Surface chemical analysis, Cell growth process, Cell surface interface, Cell culture substrate patterning	**8 Hrs.**
Unit 4:Cell dissociation and testing of cell line Introduction of define system, Mechanical dissociation of hippocampal tissue, Rules for mechanical dissociation of tissue, Cell separation & In vitro myelination cell culture, Contamination, cryo-preservation & cyto-toxicity, Fluorescent assisted cell sorting	**5 Hrs.**
Unit 5:Genetic material into the cell and Cell morphology analysis (DNA, RNA RNP complex into the cell)Lentiviral based transduction, Retroviral based transduction, Lipofection and Electroporation. MTT assay for measuring metabolic activity, Basics of Flow cytometry and its	**8 Hrs.**

applications for analysis of physical and chemical characteristics of the cell.	
Unit 6:Protein Over-Expression and Gene Knock-out Different strategies for protein expression and its analysis using Flow cytometry and Western blot, CRISPR based Knock-out of specific genes and ways to assess the knock-outs.	**5 Hrs.**

Textbooks:

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

References:

1) Cell culture technology: Recent advances and future prospects (Euroscicon Meeting Reports Book 1) by Bruserud, Øystein and Astrid Englezou
2) Vertebrate Cell Culture II and Enzyme Technology: Volume 39 (Advances in Biochemical Engineering/ Biotechnology) by A.F. Bückmann and G. Carrea
3) Animal Cell Culture and Technology (The Basics) (Garland Science)) by Michael Butler
4) The Immortal Life of Henrietta Lacks by Rebecca Skloot

Title of the Course: Vaccine Technology Course Code:UBTE0522	L	T	P	Credit
	3	1	-	4

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

Course Description: Course emphasizes on different vaccines

Course Objectives:

1. Understand the scientific basis of immunity and different types of vaccines
2. Acquire the knowledge of modern recombinant vaccine and its preparation.
3. Understand Biopharmaceutical considerations of vaccine production.
4. Discuss various rules, regulations and legal issues in vaccine industry.

Course Learning Outcomes:

CO	After the completion of the course the student will be able to	Bloom's Cognitive level	Descriptor
CO1	Understand the scientific basis of immunity and different types of vaccines	2	Understanding
CO2	Explain modern recombinant vaccine and its manufacturing processes.	2	Understanding
CO3	Outline biopharmaceutical considerations of vaccine production.	2	Understanding
CO4	Explain various rules and regulations in vaccine industry.	2	Understanding

CO-PO Mapping:

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

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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	**6 Hrs.**
Unit: 2 Conventional vaccines: Classification, live attenuated vaccines, non- living vaccines; whole organism, subunitvaccines, 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.	**6 Hrs.**
Unit 5: Common vaccines used in modern times Epidemiology and etiology of microbial infections, Pneumonia and respiratory tract infections Diarrhea, Neurological diseases Viral hepatitis and liver cancer Cervical cancer, Systemic infections, Domestic animal and wildlife vaccines.	**6 Hrs.**
Unit 4 Biopharmaceutical considerations:	**6 Hrs.**

Production, formulation; additives, adjuvant and delivery systems, combination vaccines, characterization, storage.	
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.	**6 Hrs.**

Textbook:

1. Vaccines, 6th Edition - By Stanley A. Plotkin et al. Saunders, ISBN: 978-1-4557-0090-5 (http://www.sciencedirect.com/science/book/9781455700905) 3,
2. Pharmaceutical Biotechnology, 2nd Ed. By Crommelin D.J.A. &Sindelar R.D (Taylor & Francis)

References:

1. Health Topics – Vaccines. World Health Organization. Web access: http://www.who.int/topics/vaccines/en/ Vaccines and immunization.
2. US Center for Disease Control and Prevention (CDC) Web access: http://www.cdc.gov/vaccines/ Immunization against infectious disease (the Green Book).
3. 3) Public Health England. Web access: https://www.gov.uk/government/collections/immunisation-againstinfectious-disease-the-green-book

Title of the Course: Introduction to Bioinformatics	L	T	P	Credit
Course Code: UBTO0501	3	-	-	3

Course Pre-Requisite:
Computer Literacy, Basics of Biology, Basics of Python Language

Course Description:
Bioinformatics is integration of biology, chemistry, mathematics and computer science. This subject provides information on various biological databases and tools available for the life science field.

Course Objectives:

1. To understand the basics of biology and source of biological data.
2. To explain the importance of biological databases.
3. To differentiate and analyze the tools used for the analysis and interpretation of biological data.
4. To apply the tools for a specific biological problem.

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	Understand the basics of biology and sources of biological data.	2	Understanding
CO2	Explain the importance of bioinformatics and biological databases.	2	Understanding
CO3	Make use of the tools learnt for the analysis and interpretation of biological data for relevant applications in biology.	3	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	1														
CO2	2	1										1			
CO3		3		3	3							1	2		

Assessment:

Teachers 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

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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: Basics of Biology General biology, Introduction to Bio-molecules: Types,structure and function, Cell: Basic structure and function Flow of genetic information, Biological data and source of the biological data.	**8 Hrs.**
Unit 2: Introduction to Bioinformatics History, importance, opportunities, challenges and applications of Bioinformatics	**4 Hrs.**
Unit 3: Introduction and applications of Biological Databases Biological Database and its Types Introduction to data types and Source. General Introduction of Biological Databases; Nucleic acid databases (NCBI, DDBJ, and EMBL). Protein databases (Primary, Composite, and Secondary). Specialized Genome databases: (SGD, TIGR, and ACeDB). Structure databases (CATH, SCOP, and PDBsum), File formats in Biological databases	**8 Hrs.**

Unit 4: Analysis of Biological Data Sequence alignment tools (pairwise and multiple alignments), Tools for the primary, secondary structural data of the protein sequences, Ramachandran Plot, Expasy tools for sequence analysis, Tools for retrieving the drug data	**5 Hrs.**
Unit 5: Python Tools for Biological data analysis Bio python library : Introduction and sequence objects: Sequence as strings, slicing a sequence, turning sequence objects into strings, etc.	**5 Hrs.**
Unit 6: Case studies on the applications of Bioinformatics Case study on Homology modeling and docking studies, Case study on NGS data analysis with a pipeline and hands on session on the same, Studies on Chemo informatics, Health Informatics	**6 Hrs.**
Textbooks : 1.Bioinformatics theary and Practice, Chikhale N.J. GomasV.S, Himalaya Pub. House 2.Cell & Molecular Biology-Concepts & experiments, Gerald Karp, John Wiley and sons. New York,2002 3.Biopython Tutorial and Cookbook, Jeff Chang, Brad Chapman, Iddo Friedberg, Thomas Hamelryck,Michiel de Hoon, Peter Cock, Tiago Antao, Eric Talevich, Bartek Wilczy´nski, Biopython, February 12, 2023.	
References : 1.Bioinformatics: sequence and genome analysis, David Mount, Cold springer harbor press, 2004 2.Bioinformatics: Methods and Applications: Genomics, Proteomics and Drug Discovery, S. C. Rastogi, PHI Learning House, 2013	

Title of the Course: **Bioterrorism & National Security**	L	T	P	Credit
Course Code: UBTO0502	**3**	**-**	**-**	**3**

Course Prerequisite: Applied Sciences

Course Description: This course explains the basics Bioterrorism, application in various fields, identification, production and Bio security

Course Objectives:

1.Explain and classify Bioterrorism
2.Examine various Bioagents
3.Design bio-weapons and Biosecurity measures

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
1	Explain and classify Bioterrorism	2	Understanding
2	Examine various Bioagents	4	Analyzing
3	Design bio-weapons and Biosecurity measures	6	Creating

CO-PO Mapping:

CO\ PO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO 2	PSO 3
1	3	3	3	3		3	3		3	3	3	2	3	3	3
2	3	3	2	3	3	2		2	2	1	3	2	2	3	
3	3	3	3	3	3	1			2	1	3	2	2	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

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

UNIT-1 Definitions and History, Theory behind Categories of Bioagents, Biological Weapons Convention, Biological Warfare, Bioterrorism, and Bio crime Bio surveillance and Bio diagnostics	**6 Hrs.**
UNIT-2 Agro terrorism, Animal Diseases and Bio weapons (both intentional and unintentional)Biological Toxins and Biological Terrorism Advanced Vaccine Development, the Modern Approaches to Produce Vaccines as Quickly as Possible, Neglected Tropical Diseases, Stress, Immunity, and Infectious Disease	**6 Hrs.**
UNIT-3 Sociological Perspective on Biodefense and Bioterrorism, Public Health Preparedness, surveillance and Bioterrorism, The Use of Raman Spectroscopy for the Rapid Detection of Bioagents, Dual Use Research and Custom-Built Pathogens for Bioterrorism	**6 Hrs.**
UNIT-4 Novel Detections Methods for Bioagents , Bioagent Dissemination in the Atmosphere, Bioagent Dissemination by Zoonotic Transmission Biosecurity in the Food Industry	**6 Hrs.**

UNIT-5 Bioagent Dissemination in Water and Food , Genetically Engineered Microbes, Infectious Disease and Vaccines, Infectious Diseases: An International Approach	**6 Hrs.**
UNIT-6 Indian Defense Perspective on 21st Century Bioterrorism, biodefense, Biosecurity and Bioterrorism: Career Opportunities Globally, Environment, Health and Global Security, Where do we go from here?	**6 Hrs.**

References:

1. Biosecurity and Bioterrorism: Containing and Preventing Biological Threats. by Jeffrey Ryan 2nd Edition
2. Intelligence, Biosecurity and Bioterrorism by PF Walsh
3. War of Nerves: Chemical Warfare from World War I to Al-Qaeda. by Jonathan Tucker

Plague Wars: The Terrifying Reality of Biological Warfare. by Tom Mangold

Title of the Course: Biological Thermodynamics	L	T	P	Audit
Course Code: UBTA0561	3	-	-	-

Course Prerequisite:

Basics of unit and conversions , Basics of Thermodynamics at 10+2 Level

Course Description:

The objective of this course is to provide biotechnology engineering students the basic principles of thermodynamics to apply in Bioenergetics, metabolic activities, cellular respiration, growth and development processes, membrane transport systems, enzymatic reactions and much more.

Course 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 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 the basic concepts of thermodynamics like heat, enthalpy, internal energy, work	1	Understanding
CO2	Apply the basic concepts for deriving different laws	3	Applying
CO3	Examine different relationships between fundamental properties.	5	Analyzing
CO4	Evaluate energy requirements for different biochemical processes.	5	Evaluating

CO-PO Mapping:

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

Assessments:

ESE: Assessment is based on 100% course content.

Assessment Component	Marks
ESE	100

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: 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, 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:

1. Biological Thermodynamics – D.T. Haynie (Cambridge University Press)
2. A textbook of Chemical Engineering Thermodynamics – K. V. Narayanan (Prentice Hall of India)

References:

1. Introduction to Chemical Engineering Thermodynamics – Smith, Van Ness, Abbott (TMH)
2. Chemical, Biochemical and Engineering Thermodynamics – Stanley I. and Sandler (Wiley India Edition)
3. Chemical engineering thermodynamics – Y.V.C. Rao (New Age international)

Title of the Course: Bioreaction Engineering Laboratory	L	T	P	Credit
Course Code: UBTC0531	-	-	2	1

Course Pre-Requisite:
Biochemistry, Microbiology, Fermentation Technology

Course Description:
This course includes practical based on studies on bioreactions

Course Learning Objectives:

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

Course Outcomes:

CO's	After the completion of the course the student should able to	Bloom's Cognitive	
		Level	Descriptor
CO1	Interpret the order of reactions by experimental and graphical methods	2	Understand
CO2	Analyze enzyme catalyzed bioreactions	4	Analyze

CO-PO Mapping:

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

Assessment Scheme:
One component of In Semester Evaluation (ISE) and one component of ESE having each 50% weightage respectively.

Assessment Component	Marks
ISE	50
ESE (OE)	50

ISE are based on practical performed/ Quiz/ Presentation/ Internal oral etc.
ESE –Assessment 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	**2 Hrs**
Experiment No. 2: Determination of Pseudo First Order Reaction Aim and Objectives: To determine pseudo first 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	**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	**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	**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	**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.	**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)	**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	**2 Hrs**
Experiment No. 10:Deactivation Kinetics of Enzyme Aim and Objectives: To perform deactivation kinetics	**2 Hrs**

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: Fermentation Technology Laboratory	L	T	P	Credit
Course Code: UBTC0532	-	-	2	1

Course Pre-Requisite: Microbiology, Biochemistry, Fluid Mechanics, Heat Transfer

Course Description:
This course provides hands on experience on the aspects of isolation of producers, lab scale fermentations with the in-process analyses aspects taking case studies.

Course Learning Objectives:

1. To understand isolation methods for producer microbial strains
2. To run a complete fermentation process from media making, sterilization to inoculation
3. To know in-process analyses in the fermentation process

Course Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive	
		Level	Descriptor
CO1	Apply the knowledge of producer isolation, media preparation, sterilization and inoculation for lab scale fermentation with in-process parameter analyses	3	Applying

CO-PO-PSO Mapping :

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

Assessments:
One component of In Semester Evaluation (ISE) and one component End Semester Examination (ESE) having 50% weights each.

Assessment Components	Marks
ISE	50
ESE (POE)	50

ISE are based on Practical performance and Quiz/ 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	**2-3 Days**

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	**4 Hrs.**
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.	**2-3 Days**
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	**2-3 Days**
Experiment No. 5:Calculation of yield coefficients in fermentation **Aim and Objectives:** To calculate yield and yield coefficient in batch culture	**2 Hrs.**
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.	**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	**2 Hrs.**
Experiment No. 8:Study of Oxygen transfer efficiency in fermenter **Aim and Objectives:** To be able to calculate volumetric mass transfer coefficient in fermenter	**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 (Springer Pub., Ann Books India)

Title of the Course: Mini Project II	L	T	P	Credit
Course Code: UBTC0541	-	-	2	1

Course Pre-Requisite: All theoretical concepts and practical skills learnt in second year courses

Course Description:
Mini Project II includes a group of students working on a problem statement provided with preparation of work plan, execution and submission of a synoptic summary in the form of report.

Course Learning Objectives:
1. To explain the approach to address the problem statement provided using the fundamental understanding of concepts.
2. To develop a plan of work based on aim and objectives finalized.
3. To elaborate the synoptic plan and executed project work effectively using oral and written means.

Course Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive	
		Level	Descriptor
CO1	Explain the approach to address the problem statement provided using the fundamental understanding of concepts	2	Understanding
CO2	Interpret a plan of work based on aim and objectives finalized	2	Understanding
CO3	Develop the synoptic plan and executed project work effectively using oral and written means	3	Applying

CO-PO-PSO Mapping:

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

Assessments:
One In Semester Examination (ISE) having 100% weights.

Assessment Component	Marks
ISE	50

ISE is based on rubrics based progressive report submission and presentation to supervisors.

Course Description:	
The objective of the project is to make use of the knowledge gained by the student at various stages of the degree course. This helps to judge the basic understanding of concepts in various courses, capacity of planning and executing the application of the knowledge. Reporting the outcomes effectively. Projects Areas can be related to - 1. Microbiology 2. Biochemistry 3. Cell Biology 4. Molecular Biology 5. Enzyme Technology 6. Immunology 7. Genetic Engineering 8. Bioinformatics 9. Fluid Mechanics 10. Heat and Mass Transfer 11. Fermentation Technology 12. Cell Culture Technology	

Third Year B. Tech. Program in Biotechnology Engineering Semester- VI

Title of the Course: Bioprocess Calculations **Course Code: UBTC0601**	**L**	**T**	**P**	**Credit**
	4	**-**	**-**	**4**

Course Pre-Requisite:

Basics of mathematics units and conversions, heat and mass transfer

Course Description:

The course will cover concepts ranging from basics such as units and dimensions, stoichiometry to the simultaneous application of material and energy balances with and without occurrence of biochemical reaction

Course Learning Objectives:

1. To explain the general theory of material balance.
2. To discuss the basic principles of mass and energy balances for reactions with and without reaction.
3. To compute mass and energy balances on various process equipment's with and without reaction.
4. To explain the general theory of unsteady state material and energy balances

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 Cognitive**	
		Level	**Descriptor**
CO1	Recall different units and conversions in bioprocess calculations	2	Understanding
CO2	Apply material balance fundamentals for different unit processes	3	Applying
CO3	Solve energy balance problems for different unit processes	3	Applying
CO4	Evaluate unsteady state material and energy balance processes	5	Evaluating

CO-PO Mapping:

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

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
ISE1	10
MSE	30
ISE2	10
ESE	50

ISE1 and ISE2 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 Engineering Calculations Units and Conversions, Density, Specific Gravity; specific volume , Mole Concept, chemical composition, Pressure, Temperature , std. Conditions, physical and chemical data, stoichiometry, atomic mass, molar mass, Equivalent mass, Normality, Molarity, Molality.	**9Hrs.**
Unit 2: Material Balances without Biochemical Reaction Material balances, Thermodynamic Preliminaries, Law of Conservation of Mass, Procedure for Material-Balance Calculations, Material-Balance for industrially important operations continuous filtration, batch mixing, extraction, drying	**8Hrs.**
Unit 3: Material Balances with Biochemical Reaction Definition of terms involved, guidelines for solving problems, Material-Balance for industrially important operations: continuous acetic acid fermentation, Xanthan gum production, Material Balances with Recycle, By-Pass and Purge Streams, Stoichiometry of Growth and Product Formation	**8Hrs.**

Unit 4:Energy Balance without reaction Basic Energy Concepts, General Energy-Balance Equations, Enthalpy Calculation Procedures, Enthalpy Change in Non-Reactive Processes, Procedure for Energy-Balance Calculations without Reaction, Energy-Balance for industrially important operations: Continuous waterheater, cooling in downstream processing	**9 Hrs.**
Unit 5:Energy Balance with reaction Enthalpy Change Due to Reaction, Heat of Reaction For Processes With Biomass Production, Energy-Balance Equation For Cell Culture, Energy-Balance for industrially important operations: Continuous ethanol fermentation, Citric acid production Type of control actions (ON-OFF, Proportional and PID) and Actuators. Basic fermentation control loops (Temperature, pH, D.O., air flow rate, agitation, pressure and antifoam) Loop versus Sequence control	**8Hrs.**
Unit 6: Unsteady state material and energy Balance Unsteady-State Material-Balance Equations, Unsteady-State Energy-Balance Equations, Unsteady-State Mass Balance for industrially important operations: CSTR, Unsteady-State Energy Balance for industrially important operations: solvent heater	**9Hrs.**

Textbooks:

1. Bioprocess Engineering Principles-, Pauline Doran. (Academic Press).
2. Stoichiometry -Bhat B.I and S.M.Vora .(Tata McGraw Hill).
3. Basic Principles and Calculations in Chemical Engineering David M.Himmelblau. (Prentice Hall of India Pvt Ltd).
4. Bioprocess Engineering: Basic Concepts Michael Shuler and FikretKargi. (Prentice Hall).

References:

1. Chemical Process Principles -A.Hougen, K.M.Watson and R.A.Ragatz. (John Wiley and Asia Publishing Co.).
2. Elementary Principles of Chemical Processes. Richard Felder and Ronald W.Rausseau. (John Wiley & Sons).

Title of the Course: Bioprocess Equipment Design	L	T	P	Credit
Course Code: UBTC0602	4	-	-	4

Course Pre-Requisite: Unit operations, equipment used in bioprocess industries

Course Description:

Theobjectiveofthiscourseistoprovidebiotechnologyengineeringstudentsthebasicprinciplesofequipment design. Also, students will learn basics of flow sheet preparation and development.

Course Learning Objectives:

1. To explain the codes and standards for the mechanical design of equipment.
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 equipment.

Course Outcomes:

CO	After the completion of the course the student should able to	Bloom's Cognitive	
		Level	Descriptor
CO1	Explain the codes and standards for the mechanical design of equipment.	II	Understanding
CO2	Develop process flow diagrams (PFDs) and piping and instrument diagrams (P&IDs).	III	Applying
CO3	Analyze design procedures for commonly used process equipment.	IV	Analyzing
CO4	Estimate the design parameters for bioprocess equipment	V	Evaluating

CO-POMapping:

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

Assessments:

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE)andoneEndSemesterExamination(ESE)having20%,30%and50%weightsrespectively.

Assessment	Marks
ISE1	10
MSE	30
ISE2	10
ESE	50

ISE1andISE2arebasedonassignment/declaredtest/quiz/seminar/GroupDiscussionsetc.

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: 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.	**8Hrs.**
Unit 6: Dryer Introduction, types, mechanical design of dryer.	**8Hrs.**

Textbooks:

1. Robert E. Treybal, "Mass Transfer Operations", Third Edition, McGrawHill,1980.
2. McCabe and Smith, "UnitOperationofChemicalEngineering",5th Edition McGraw Hill, KogakushaLtd.1998.
3. Bioprocess Engineering Principles by Pauline M. Doran–Academic Press.
4. Bio separation -Shivshanker B. (Prentice Hall of India)

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)

Title of the Course: Bioseparation Processes	L	T	P	Credit
Course Code: UBTC0603	4	-	-	4

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

Course Description:

This course emphasizes on the downstream purification processes of products which is a continuation of the course of Fermentation Technology. First unit describes the biomass removal methods such as centrifugation and filtration followed by bulk impurity isolation operations such as precipitation, adsorption and fine purification operations such as chromatography and membrane technology. The last unit describes the finishing and formulation steps after purification.

Course Learning Objectives:

4. To understand the solid liquid separations for biomass isolations
5. To understand the bulk impurity isolation and fine purification operations for the product
6. To know about the finishing , filling and formulations of the products

Course Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive	
		Level	Descriptor
CO1	Explain basic principle of filtration and centrifugation with their mathematical models for process design	2	Understanding
CO2	Choose the bulk isolation unit operation based on chemical nature of product and impurities	3	Applying
CO3	Examine the type of fine purification method needed based on the impurity analysis	4	Analyzing
CO4	Summarize the finishing , formulations and filling processes	2	Understanding

CO-PO-PSO Mapping :

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

Assessments:

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
ISE1	10
MSE	30
ISE2	10
ESE	50

ISE1 and ISE2 are based on assignment/declared test/quiz/seminar/group discussions etc.
MSE Assessment is based on 50% of course content
ESE Assessment is based on100% course content with 60-70% weightage for course content(normally last three modules) covered after MSE

Course Contents:

Unit1: Filtration and Centrifugation Conventional filtration versus depth filtration, Basic theory of filtration, Types of filtration processes, Types of filtration equipment, Process time and filter area calculations, Scale up Theory of sedimentation, Equipment for sedimentation, Relative centrifugal field, Types of centrifugation, Types of centrifuges, Performance equation of centrifuges, Gyro and Sigma factor based scale up	**10Hrs.**
Unit2:Precipitation Chemistry of dissolution versus precipitation, Difference between crystallization and precipitation, Types of precipitation (using salts, using organic solvents, using acid/alkali, using electrolytes, using non ionic polymers), Precipitation Equipment, Precipitation yield calculations	**7Hrs.**
Unit3:Adsorption Chemistry of adsorption, Nature of adsorbents, Batch adsorption, Adsorption isotherms (Linear, Freundlich, Langmuir) and their use, Continuous adsorption (Adsorption in CSTR, Adsorption in fixed beds/ Frontal adsorption and its use)	**7Hrs.**
Unit4: Chromatography Planar chromatography (paper and thin layer) , Column chromatography Basic terms (Partition coefficient, Capacity factor, Retention time, relative retention, resolution, theoretical plates) , Principles and case studies on Normal phase chromatography, Ion-exchange chromatography, Adsorption chromatography, Reverse phase chromatography, Hydrophobic interaction chromatography, Affinity chromatography, Gel-filtration	**10Hrs.**

chromatography) Analytical chromatography versus preparative chromatography	
Unit5:Membrane separations Classification of membranes processes (micro-filtration, ultra-filtration, diafiltration, nano-filtration, reverse osmosis), Structure and preparation of membrane, Types of membrane modules, Membrane system and operation, Dead end (NFF) versus tangential flow (TFF) modes, Effects of parameters on flux, Important practical concepts (Concentration polarization, Fouling, Mass flux, Permeate Flux (LMH), retention/ rejection coefficient, sieving coefficient, Pressure drop , Transmembrane pressure, Concentration factor, NWP, NMWCO), Process flux, time and area calculations, Membrane system scale up	**8 Hrs.**
Unit6:Finishing, formulations and filling Finishing operations for API/DS (Buffer exchange, Concentration adjustments for liquid forms, Crystallization/Drying/Lyophilization for solid forms) , Different Formulations of API, Sterile filtration of final drug substance, Sterile filling /terminal sterilization of drug product (Dose design during filling) Stability studies drug substances (Accelerated, Long term, Stress , Photostability) Stability studies of drug product after packaging, Types of packaging based on Drug Delivery System (Pre-filled syringe (lyophilized powder with sterile WFI) , Vial, Cartridge, Medical devices (Pen assembly) etc.) (Container closure)	**6 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.)	

Title of the Course: Effluent Treatment (PE-II)	L	T	P	Credit
Course Code: UBTE0621	3	-	-	3

Course Pre-Requisite:
Biochemistry, Microbiology, Fermentation Technology

Course Description:
This includes theoretical understanding of waste management and waste treatment

Course Learning Objectives:
1. To acquaint students with methods of examination of water and waste
2. To understand methods of waste reduction, treatment, and management
3. To describe disinfection and sterilization techniques of waste

Course Outcomes:

CO's	After the completion of the course the student should be able to	Bloom's Cognitive	
		Level	Descriptor
CO1	Examine the water and waste qualitatively and quantitatively	4	Analyze
CO2	Demonstrate different methods for waste reduction	2	Understand
CO3	Make use of different methods for waste treatment	3	Apply
CO4	Choose various methods of disinfection and sterilization techniques	3	Apply

CO-PO Mapping:

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

Assessments:
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
ISE1	10
MSE	30
ISE2	10
ESE	50

ISE1 and ISE2 are based on assignment/declared test/quiz/seminar/group discussions etc.
MSE Assessment is based on 50% of course content
ESE Assessment is based on100% course content with 60-70% weightage for course content(normally last three modules) covered after MSE

Course Contents:	
UNIT: 1 Sources, characteristic, waste reduction and material recovery, hazardous waste management Role of microorganisms in waste treatment, Importance of Helminth eggs, Importance of *E.coli*, Bacterial examination of water preliminary, confirmatory, and completed test, Biological and Chemical Oxygen Demand (BOD andCOD) Water Quality Parameters and Treatment Standards	**6 Hrs**
UNIT: 2Bioremediation – Fundamentals and Applications Definition, Types of bioremediations, *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 andpaper.	**6 Hrs**
UNIT: 3 Physicochemical treatments (Screening, grit removal, oil and greaseremoval, primary sedimentation, precipitation)	**6 Hrs**
UNIT: 4 Biological treatments Aerobic effluent treatment**,** Fundamentals and design of Suspended growth processes – Activated sludge process and itsmodification, Aerated lagoons, Attached growth processes – Trickling filters,Rotating	**6 Hrs**
UNIT: 5 Anaerobic effluent treatment: Anaerobic digester, Up flow 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, Biogas production, sludge drying	**6 Hrs**

Reference books:

1. Metcalf and Eddy "Wastewater Engineering Treatment and Reuse", Tata McGraw Hill Publication, 6th Reprint. 2003.
2. E.W. Rice, R.B. Baird, A.D. Eaton, L.S. Clesceri, "Standard Methods for the Examination of Water and Wastewater", 22nd Edition
3. Microbiological Examination Methods of Food and Water: A Laboratory Manual neusely da Silva et. al. CRC Press; 1edition
4. Waste Water TreatmentM N Rao and A K Datta OXFORD & IBH PUBLISHING1 January 2020; 3 edition

5. WASTEWATER TREATMENT: Concepts and Design ApproachG. L. KARIA, R.A. CHRISTIAN PHI Learning Pvt. Ltd., 02-Apr-2013PHI publication; 2nd Edition
6. Manual of Water Supply and Treatment (3rd ed)- Ministry of Urban Development, New Delhi, 1991

Title of the Course: Green Technology	L	T	P	Credits
Course Code:UBTE0622	3	-	-	3

Course Pre-Requisite: Knowledge of enzymes, organic chemistry, sustainability and environment

Course Description: Principles of green chemistry & engineering, waste minimization, biofuels, biomass resources and conversion, LCA

Course Objectives:

1. To design products and processes to promote sustainable attributes of importance to the environment and the global community.
2. To amalgamate technical and scientific knowledge with consideration of environment, renewable energy management, waste utilization, and resource management for the progress of the globe.

Course Outcomes:

COs	After the completion of the course the student will be able to	Bloom's Cognitive level	Bloom's Cognitive Descriptor
CO1	Summarize principles of green chemistry and green engineering.	2	Understanding
CO2	Apply biocatalyst in different fields.	3	Applying
CO3	Analyze biofuels and power generation processes along with biomass resources and their conversion	4	Analyzing
CO4	Evaluate life cycle of different products in biotechnology	5	Evaluating

CO-PO-PSO Mapping :

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

Assessment Scheme:

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

Assessment	Marks
ISE1	10
MSE	30
ISE2	10
ESE	50

ISE 1 and **ISE 2** are based on Assignment / Declared test / Quiz / Seminar / Group discussions / presentation, etc.

MSE is based on 50% of course content (first three units).

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

Course Contents:

Unit 1: Introduction to Green Technology The twelve Principles of Green Chemistry and green engineering with examples, Green chemistry metrics- atom economy, E factor, reaction mass efficiency. Green reagents and catalysis, Safe product and process design – Design for degradation, Real-time Analysis for pollution prevention, inherently safer chemistry for accident prevention	**6 Hrs.**
Unit 2: Biocatalyst Introduction, Chemical Production by Biocatalysis- Bulk chemicals, Pharmaceuticals, Flavour and fragrance compounds, Carbohydrates. Green Biocatalytic Processes - Biocatalysis in supercritical CO2, Biocatalysis in waste treatment, Biodesulfurisation	**6 Hrs.**
Unit 3: Waste Minimisation in Pharmaceutical Process Development Introduction,Focus of Process Chemistry- Safety, increasing complexity, Means of purification, Choice of starting material, Yields, Number and order of steps, Robustness, Solvents, Reagents, Reaction temperature, Heavy metals, Examples.	**6 Hrs.**
Unit 4: Biofuels and power generation Physical and chemical characteristics of biofuels – Biomass, wood gas, bio methane; ethanol, biodiesel, Wood oil; Bio blends - Indian and International standard specifications. Adaptation of biofuel in various applications. Biofuel economy; Biofuel roadmap of India - policy issues, regulatory issues and economic impact; Entrepreneurship in biofuel - Prospects & Challenges, Case studies.	**6 Hrs.**
Unit 5: Biomass Resources and Biochemical conversion Microbial biomass. Large scale culture and harvest of photosynthetic organism - photo bioreactors; Microalgae for lipid and carbohydrate synthesis. Biodegradation and biodegradability of substrate; anaerobic digestion - Bioconversion of lignocellulosic feedstock to sugars - Bioconversion of sugars and starches to fuels - Difference of the technologies of starch ethanol and cellulosic ethanol.	**6 Hrs.**

Unit 6: Life Cycle Assessment in Biotechnology	**6 Hrs.**
The Methodology of LCA, LCA: Utility and Limitations, Applications of LCA in – Food Biotechnology, Pharmaceutical Biotechnology, Biopolymers, Biofuels, Biodegradable Waste Management	

Textbooks:

1. Green Chemistry: An Introductory Text, M. Lancaster, Royal Society of Chemistry, 2002
2. Renewable Energy, 3, Bent Sorensen, Academic Press, Aug 2004
3. Handbook of Green Chemistry and Technology, Clark, James H. and Macquarrie, Duncan J, Blackwell Science Ltd, 2002

Reference Books:

1. Biofuels - Securing the Planet's Future Energy Needs, -, A Demirbas, Springer, 2009
2.Biomass Assessment Handbook - Bioenergy for a sustainable environment, -, Frank Rosillo-Calle, Sarah Hemstock, Peter de Groot and Jeremy Woods, Earthscan, November 2006
3.Dictionary of Renewable Resources, 2nd, Zoebelein, Hans, Wiley-VCH, 2001
4. Comprehensive Biotechnology, 2nd, Murray Moo-Young, Elsevier, 2011

Title of the Course: Food Technology (OE-II)	L	T	P	Credits
Course Code:UBTO0601	3	-	-	3

Course Pre-Requisite: Knowledge of biochemistry and bioprocesses.

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

Course Objectives:

1. To summarize the students about chemical, biochemical and microbiological characteristics of foods.
2. To explain the principles and techniques of biotechnology in the production, processing and marketing of high-quality food and dairy products in a global context.
3. To learn and apply engineering principles and concepts in handling, storing, processing,packaging and distributing food and related products

Course Outcomes:

COs	After the completion of the course the student will be able to	Bloom's Cognitive level	Bloom's Cognitive Descriptor
CO1	Summarize the students about chemical, biochemical and microbiological characteristics of foods.	2	Understand
CO2	Explain the principles and techniques of biotechnology in the production, processing and marketing of high quality food and dairy products in a global context.	2	Understand
CO3	Learn and apply engineering principles and concepts in handling, storing, processing,packaging and distributing food and related products	3	Apply

CO-PO-PSO Mapping :

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

Assessment Scheme:

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

Assessment	Marks
ISE1	10
MSE	30
ISE2	10
ESE	50

ISE 1 and **ISE 2** are based on Assignment / Declared test / Quiz / Seminar / Group discussions /

presentation, etc. **MSE** is based on 50% of course content (first three units). **ESE** is based on 100% course content with 60-70% weightage for course content (last three units) covered after MSE.	
Course Contents:	
Unit: 1 Introduction World food demand and Indian scenario, constituents of food (Water, Carbohydrates, Fats and oils, Proteins), quality and nutritive aspects. Food additives. Introduction to FSSAI standards. Deteriorative factors and their control, preliminary processing methods and preservation operation. Introduction to Food Safety Management System (FSMS) and HACCP	**6Hrs.**
Unit 2: Production and utilization of food products Milk and Milk products: Fluid Milk and some of its derivatives, Ice cream and related frozen desserts, Cheese and their varieties, reduced fat dairy products, Essential micro-organisms and Fermented milk products. Meat, Poultry and Eggs: Meat and meat products, Poultry, Eggs Sea Foods: Fish procurement, Marine fish, Shellfish, Fish byproducts, Contaminants in FishSpoilage micro-organisms, treatment and disposal of food processing wastes	**6Hrs.**
Unit3: Food Microbiology i. Microbiology in food and factors affecting their growth. ii. Preservation of food iii. Food Spoilage iv. Food poisoning and food borne diseases v. Sanitation of food plants vi. Bacteriology of water-Sampling, inspection	**6 Hrs.**
Unit 4:Improved technology for food processing i. Enzymes in bakery and cereal products ii. Enzymes in fruit juice production iii. Enzymes in cheese making and beverage production.	6**Hrs.**
Unit 5:Analysis of major food ingredients i. Analysis of preservatives-natural and synthetic ii. Food colors. iii. Food flavor enhancing agents. iv. Chemical measurements Detection and measurement-heavy metals, fungal	**6 Hrs.**

Unit 6: Downstream processing in food industries and packaging	**6 Hrs.**
Electro dialysis Systems, Reverse Osmosis System, Types of Reverse- Osmosis and Ultra filtration, Drying Processes & Dehydration Systems, Dehydration System Design, Sedimentation and Centrifugation **Packaging**:Introduction, Food Protection, Product contaminants, Product communication and product convenience, Mass transfer in packaging material, packaging material and product shelf life, Food canning technology, Heat sterilization of canned food.	

References:

1) Food Science: 5th Edition-Potter, Norman N. (CBS Publishers & Distributors)
2) Fennema's Food Chemistry, Fourth Edition Srinivasan Damodaran, Kirk L. Parkin, Owen R. Fennema
3) Food Processing Technology: Principles and Practice by P J Fellows, Wood Head Publishing Limited.
4) Processing Fruits: science and Technology by Diane M. Barrette, Laszlo Somogyi, Hosahalli Ramaswamy
5) Fundamental s of Food Engineering by Stanley Charm.
6) Introduction to Food Engineering - R. Paul Singh, Dennis
7) Heid, J. L.andJoslyn,M. A. ,Fundamental s of Food
8) Processing Operation, The AVIPublishingCo;Westport
9) Heldman, D. R., Food Process Engineering,TheAVI Publishing Co; Westport ,1975.
10) Hal l, C. W; Farall, A. W.&Rippen, A. L;Encyclopedia of Food Engineering, Van Nostrand-Reinhold.
11) Food Process Engineering-Heldman D. R. (AVI Publishing Co)
12) Food Processing and preservation- B. Sivsankar PHI Learning Pvt. Ltd.

Title of the Course: Bioenergy (OE-II)	L	T	P	Credits
Course Code:UBTO0602	3	-	-	3

Course Pre-Requisite: Knowledge of energy, renewable entry, sustainable development and nanotechnology.

Course Description: Biomass, algal biomass, bioenergy, bioethanol, biohydrogen, biodiesel and bio-oil.

Course Objectives:

1. To summarize various energy and fuels sources
2. To analyze various properties of different bioenergy sources and fuels.
3. To apply economical production methods for these energy and fuels.

Course Outcomes:

COs	After the completion of the course the student will be able to	Bloom's Cognitive	
		Level	Descriptor
CO1	Summarize bioenergy and biomass feedstock processes	2	Understanding
CO2	Apply various production methods for bioethanol, biodiesel, bio-oil and bio-hydrogen	3	Applying
CO3	Analyze various properties of fuels	4	Analyzing
CO4	Explain future sources for production of bioenergy	2	Understanding

CO-PO-PSO Mapping :

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1		1				1	2				1	1			
2	1	2	3	1							2		2	2	1
3	2	2											3		
4		1	1			3	3	1			1	3		2	

Assessment Scheme:

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

Assessment	Marks
ISE1	10
MSE	30
ISE2	10
ESE	50

ISE 1 and **ISE 2** are based on Assignment / Declared test / Quiz / Seminar / Group discussions / presentation, etc. **MSE** is based on 50% of course content (first three units). **ESE** is based on 100% course content with 60-70% weightage for course content (last three units) covered after MSE.	
Course Contents:	
Unit 1: Introduction to Bioenergy Introduction, bioenergy development and drivers, biomass materials and sources, advanced fuels from algae,biomass supply and availability, overview of conversion technologies, overview of conversion technologies	**6 Hrs.**
Unit 2: Biomass Feedstocks Introduction, Biomass Components, Modern Biomass, Bioenergy, and Green Energy, feedstocks, Biomass Characterization, Biomass Fuel Analyses, Biomass Optimization and Valorization, Chemicals from Biomass	**6 Hrs.**
Unit 3: Bioethanol Introduction, Synthetic Ethanol Production Processes, Production of Ethanol from Biomass, Sugars from Biomass by Hydrolysis, Bioethanol Production by Fermentation of Carbohydrates, Bioethanol Feedstocks, Fuel Properties of Ethanol.	**6 Hrs.**
Unit 4: Biodiesel& Bio-oils Introduction to biodiesel, advantages and disadvantages of use of biodiesel, raw materials for biodiesel production, typical oil crops useful for biodiesel production, biodiesel production process, bio-oil introduction, bio-oil properties, application of bio-oil	**6 Hrs.**
Unit 5: Bio-hydrogen Introduction, Biohydrogen production, renewable biomass sources for biohydrogen production, biohydrogen production from food processing wastes, industrial by-products, algae, pretreatment methods employed for the preparation of biomass feedstock, bioreactor configurations used for fermentative biohydrogen production, economics of biohydrogen production and perspectives	**6 Hrs.**
Unit 6: Algal Biomass: A Promising Source for Future Bioenergy Production Introduction, classification of algal biomass, cultivation of algal biomass, biogas production from algal biomass, bioethanol production from algal biomass, biodiesel production from algal biomass.	**6 Hrs.**

Textbooks:

1. Biofuels- Securing the Planet's Future Energy Needs (Green Energy and Technology) Ayhan Demirbas Springer 2009
2. Bioenergy Engineering,Prof. Mahendra S. Seveda, Dr. Pradip D. Narale, Dr. Sudhir N. Kharpude, Narendra Publishing House 2022
3. Direct Thermochemical Liquefaction for Energy Applications-Fast pyrolysis Lasse Rosendahl A. Pattiya Woodhead Publishing 2018

Reference Books:

1. Biomass Feedstocks. In: Biofuels. Green Energy and Technology Ayhan Demirbas, Springer, London 2009
2. Introduction to Bioenergy. In: Bioenergy Carol Williams, Anju Dahiya, Pam Porter,Academic Press, Boston 2015
3.Biohydrogen A volume in Biomass, Biofuels, Biochemicals 2nd Ashok Pandey S. Venkata Mohan Jo-Shu Chang, Patrick C. Hallenbeck, Christian Larroche, Elsevier, 2019
4. Dielectric Spectroscopy in Biodiesel Production and Characterization, Green Energy and Technology, S. D. Romano and P. A. Sorichetti, Springer-Verlag London Limited, 2011

Title of the Course: Drug Development Process	L	T	P	Audit Course VI
Course Code: UBTA0661	**3**	**-**	**-**	

Course Pre-Requisite: Microbiology, Biochemistry, Human Biology, Bioinformatics

Course Description:
This course explains drug life cycle from discovery up to market through the phases of pre-clinical and clinical trials with their regulatory aspects in brief.

Course Learning Objectives:

7. To understand the new drug discovery process with its tools
8. To appreciate the life cycle of drug from discovery to market
9. To know the basics of regulatory affairs their agencies

Course Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive	
		Level	Descriptor
CO1	Explain the drug life cycle from the discovery to post market surveillance	2	Understanding
CO2	Summarize the pre-clinical and clinical research stages in the drug development	2	Understanding
CO3	Recall the regulatory agencies and their affairs	1	Remembering

CO-PO-PSO Mapping :

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	1			1	3	3							2		
2	1	1	2	1	2	3	2	3					1		3
3			1	1	1	3	2	3		1					1

Assessments:
One End Semester Examination (ESE) having 100% weights.

Assessment Component	Marks
ESE	100

ESE: Assessment is based on 100% course content

Course Contents:

Unit 1: Drug Discovery Diseases and disorders in human system, Approaches to address diseases and disorders (pre disease medication and post disease medication) , Mechanisms of diseases and disorders, Available medication versus First-in-class medication In silico target based drug discovery process (Target identification and validation, assay development and screening, lead identification, optimization and clinical candidate selection, ADME and toxicological properties of the drug candidates, Translational PK/PD modeling)	**6 Hrs.**
Unit 2 : Drug Development Drug Development Pathway: drug life cycle from identified lead molecule to drug in the market Classification of drugs, Types of compounds (small molecules, biologics, biosimilars etc.), Different phases in development (preclinical and clinical trials, approval process and life cycle management), Current and future drug development process	**6 Hrs.**
Unit 3 : Preclinical Research Animal models of disease, Systems used –In vivo (drug administration, organ bath and quantification techniques from body fluids and organs novel drug with unknown activity , 14C labeled drug tracing through preclinical imaging and molecular techniques (NOAEL, safety, LD50 , acute /chronic) Pharmacokinetics - ADME studies and Pharmacodynamics In vitro (systemic assays by 3D cell culture models , in vitro toxicity assays) Animal ethics and alternatives , 21 CFR Part 58.1: Good Laboratory Practice for Nonclinical Laboratory Studies	**6Hrs.**
Unit 4: Clinical Research- I Designing Clinical Trials (Introduction to clinical trials, Important abbreviations used in clinical trials), Clinical Research Phase studies (Phase 1 to 4 trials, Roles and responsibilities of people involved in clinical research, Essential documents required, Ethics committee, Protocol design, ICH-GCP guidelines, Clinical research glossary) Investigational New Drug Process	**6Hrs.**
Unit 5: Clinical Research- II Key goals in early clinical development: How to design and conduct EIH studies, Translating preclinical data to clinical. Study design questions: Study Design options- parallel group, crossover, adaptive, randomized, blinding, etc., Routes of administration – oral delivery, parenteral delivery , other dosage forms, Dose selection, dose progression (safety and PD/efficacy considerations) Supporting Studies (DDI, Special Populations, Abuse Liability, TQT), Prescribing information of a drug (Absorption, Bioavailability, Distribution, Metabolism, and Elimination, Dose-Exposure relationships, Quantitative	**6 Hrs.**

Pharmacology/Pharmacometrics , Clinical Pharmacodynamics , Principles of PK/PD modeling and simulation)	
Unit 6 : Clinical Data Management and FDA History of FDA Regulation, Regulatory requirements in different countries (focus on FDA and EMA), Regulatory interactions at different phases of development , CTA - IND – NDA, Tools for expedited review and approval , Safety database, Regulatory compliance and post approval commitments FDA Assistance , CMC activities, Target drug product profile, Scalability of API and drug product to meet clinic / market demand, Process and product quality attributes, Past, Present and Future, Future drug modalities – Challenges and Opportunities	**6 Hrs.**

Textbooks:

1. Understanding Biopharmaceuticals: Manufacturing and Regulatory Issues by Grindley, Jill E. Ogden (CRC Press)
2. Pharmaceutical Biotechnology, 2nd Ed. By Crommelin D.J.A. , Sindelar R. D ,Bernd Meibohm (Springer)
3. Pharmaceutical Biotechnology by Gary Walsh (Wiley)
4. Drug Discovery and Clinical Research by SK Gupta and Sushma Srivastava (ICRI Pub.)
5. Principles and Pactice of Clinical Research by John I. Gallin and Frederick P. Ognibene (Academic Press)

References:

1. Pharmaceutical Biotechnology by O. Kayser, R. H. Muller (Wiley - VCH)
2. Handbook of Pharmaceutical Biotechnology by Jay P Rho, Stan G Louie (Haworth Press.)
3. Basic Principles of Drug Discovery and Development by Benjamin E. Blass (Academic Press)
4. Biopharmaceutical Drug Design and Development by Susanna Wu-Pong (Humana Press)
5. Practical Guide to Clinical Data Management by Susanne Prokscha (CRC Press)

Title of the Course: Bioprocess Equipment Design Laboratory	L	T	P	Credit
Course Code: UBTC0631	-	-	2	1

Course Pre-Requisite:
Knowledge of equipment used in Bioprocess Industries

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

Course Learning 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 Outcomes:

CO's	After the completion of the course the student should able to	Bloom's Cognitive	
		Level	**Descriptor**
1	Show different equipment symbols, instruments symbols, stream designations	2	Understand
2	Analyze parts of reactors and heat exchangers	4	Analyze
3	Develop standard P&IDs based on process requirements	6	Create

CO-PO Mapping:

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

Assessment Scheme:
One component of In Semester Evaluation (ISE) and one component of ESE having 67% and 33% weightage respectively.

Assessment Component	Marks
ISE	50
ESE (OE)	25

ISE are based on practical performed/ Quiz/ Presentation/ Internal oral etc.
ESE –Assessment 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	**2 Hrs**

Experiment No. 2: Instrument Symbols and stream Designation Aim: To Draw Instrument Symbols and learn stream Designations used in flow sheet synthesis. Objectives: To understand various Instrument Symbols and learn stream Designations used in flow sheet synthesis	**2 Hrs**
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	**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.	**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	**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	**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	**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	**2 Hrs**

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 Mc-Graw 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)

Title of the Course: Bioseparation Processes Laboratory	L	T	P	Credit
Course Code: UBTC0632	-	-	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 Learning Objectives:
To understand the principle and methodology of purification and analysis of the product

Course Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive	
		Level	Descriptor
CO1	Analyze different unit operations involved in purification of bio-products	4	Analyzing

CO-PO-PSO Mapping :

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

Assessments:
One component of In Semester Evaluation (ISE) and one component End Semester Examination (ESE) having 50% weights each.

Assessment Components	Marks
ISE	50
ESE (POE)	50

ISE are based on Practical performance and Quiz / 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	**2 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	**2 Hrs.**
Experiment No. 3: Aqueous two-phase extraction **Aim and Objectives:** To select aqueous twophase extraction system and calculate partition coefficient	**2 Hrs.**
Experiment No. 4: Isoelectric point precipitation **Aim and Objectives:** To precipitate casein from milk using Isoelectric point precipitation	**2 Hrs.**
Experiment No. 5: Salt precipitation / Organic solvent precipitation **Aim and Objectives:** 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	**2 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	**2 Hrs.**
Experiment No. 8: Ion exchange chromatography **Aim and Objectives:** To purify the protein of interest by ion exchange chromatography	**2 Hrs.**
Experiment No. 9: Gel filtration chromatography **Aim and Objectives:** To purify the protein of interest by gel filtration chromatography	**2 Hrs.**
Experiment No. 10: Affinity chromatography / Reverse phase chromatography **Aim and Objectives:** To purify the protein of interest by affinity/reverse phase chromatography	**2 Hrs.**

Experiment No. 11: Demonstration of membrane modules **Aim and Objectives:** 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	**2 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.)	

Title of the Course: Effluent Treatment(PE-II) Laboratory Course Code: UBTE0633	L	T	P	Credit
	-	-	2	1

Course Pre-Requisite:
Biochemistry, Microbiology, Fermentation Technology

Course Description:
This includes theoretical understanding of waste management and waste treatment

Course Learning Objectives:
To perform various examinations of drinking water and effluent/wastes

Course Outcomes:

CO's	After the completion of the course the student should be able to	Bloom's Cognitive	
		Level	Descriptor
CO1	Examine physic-chemical characteristics of water and waste for different purposes	4	Analyze
CO2	Examine biological characteristics of water and waste for different purposes	4	Analyze

CO-PO Mapping:

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

Assessment Scheme:
Two components of In Semester Evaluation (ISE) and one End Semester oral Examination (ESE) having 50%, weights respectively.
Assessment Component Marks ISE 1 25 and ESE (OE) 25

Course Contents:

Experiment No. 1: BOD test **Aim and Objectives:** To perform BOD test	**5 Days**
Experiment No. 2: COD test **Aim and Objectives:** To perform COD test	**2 Hrs**
Experiment No. 3: MPN test **Aim and Objectives:** To perform MPN test	**2 Hrs**

Experiment No. 4: Confirmed test **Aim and Objectives:** To perform **Confirmed** test	**2 Hrs**
Experiment No. 5: Completed test (IMViC) **Aim and Objectives:** To perform **Completed** test	**2 Hrs**
Experiment No. 6: Alkalinity test **Aim and Objectives:** To perform Alkalinity test	**2 Hrs**
Experiment No. 7: Phosphorus test **Aim and Objectives:** To perform Phosphorus test	**2 Hrs**
Experiment No. 8: TKN test **Aim and Objectives:** To perform **TKN** test	**2 Hrs**
Experiment No. 9: Break Point Chlorination **Aim and Objectives:** To perform Break Point Chlorination treatment	**2 Hrs**
Experiment No. 10: Determine Solids in waste **Aim and Objectives:** Determine Solids in waste	**2 Hrs**

Reference books:

1. Metcalf and Eddy "Wastewater Engineering Treatment and Reuse", Tata McGraw Hill Publication, 6th Reprint. 2003.
3. E.W. Rice, R.B. Baird, A.D. Eaton, L.S. Clesceri, "Standard Methods for the Examination of Water and Wastewater", 22nd Edition
4. Microbiological Examination Methods of Food and Water: A Laboratory Manual neusely da Silva et. al. CRC Press; 1edition
5. Waste Water TreatmentM N Rao and A K Datta OXFORD & IBH PUBLISHING1 January 2020; 3 edition
6. WASTEWATER TREATMENT: Concepts and Design Approach
7. G. L. KARIA, R.A. CHRISTIAN PHI Learning Pvt. Ltd., 02-Apr-2013PHI publication; 2nd Edition
8. Manual of Water Supply and Treatment (3rd ed)- Ministry of Urban Development, New Delhi, 1991

Title of the Course: Green Technology Laboratory Course Code:UBTE0634	L	T	P	Credit
	-	-	2	1

Course Pre-Requisite: Knowledge of biocatalysis, kinetics, titration and LCA is required.

Course Description: Course describes performing techniques and skills of handling various experiments in green technology.

Course Objectives:

1. To perform immobilization and biocatalysis reaction and analyze its kinetics
2. To perform titration
3. To synthesis and analyze fuel content
4. To perform LCA of products in biotechnology domain

Course Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive	
		Level	Descriptor
CO1	Apply immobilization, biocatalysis, kinetics and LCA techniques for sustainable process development	3	Applying
CO2	Analyze various analytes for various purposes	4	Analyzing

CO-PO-PSO Mapping :

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

Assessments:

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

Assessment Components	Marks
ISE	50
ESE (POE)	50

ISE are based on Practical performance and Quiz / Internal Oral etc.

ESE Assessment is based on practical and oral examination.

Course Contents:

Experiment No. 1: ---**Immobilization/Encapsulation of enzyme**	-2- **Hrs.**
Experiment No. 2: ---**Biocatalysis (Calculation of yield, selectivity, conversion)**	2-- **Hrs.**

Experiment No. 3: ---**Enzyme kinetics/Determination of the rate of reaction and its order.**	2-- **Hrs.**
Experiment No. 4: --- **Demonstration of LCA (open LCA software)**	2-- **Hrs.**
Experiment No. 5: ---**Determination of amount of ascorbic acid in a vitamin C tablet by redox titration**	2-- **Hrs.**
Experiment No. 6: ---**Analysis of biodiesel synthesized from oil**	2-- **Hrs.**
Experiment No. 7:---**Separation of food dyes by paper chromatography**	2-- **Hrs.**
Experiment No. 8:---**Standardization of a sodium hydroxide solution**	2-- **Hrs.**
Experiment No. 9:---**Determining the percent of water in salt**	2-- **Hrs.**
Experiment No. 10:---**Determining the amount of acid in ketchup** and hot sauce	2-- **Hrs.**

Reference books

1. Fundamental immunology,5,William E Paul,Lippincott Williams & Wilkins, Philadelphia,2003.
2. Practical Immunology,4,Frank C. Hay, Olwyn M.R,Westwood
3. Short Protocols in Immunology -John E. Coligan

Title of the Course: Mini Project III	L	T	P	Credit
Course Code: UBTC0641	-	-	2	1

Course Pre-Requisite: All theoretical concepts and practical skills learnt in second- and third-year courses

Course Description:
Mini Project II includes a group of students working on a problem statement provided with preparation of work plan, execution and submission of a synoptic summary in the form of report.

Course Learning Objectives:
1. To explain the approach to address the problem statement provided using the fundamental understanding of concepts.
2. To develop a plan of work based on aim and objectives finalized.
3. To elaborate the synoptic plan and executed project work effectively using oral and written means.

Course Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive	
		Level	Descriptor
CO1	Explain the approach to address the problem statement provided using the fundamental understanding of concepts	2	Understanding
CO2	Interpret a plan of work based on aim and objectives finalized	2	Understanding
CO3	Develop the synoptic plan and executed project work effectively using oral and written means	3	Applying

CO-PO-PSO Mapping :

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

Assessments:
One In Semester Examination (ISE) having 100% weights.

Assessment Component	Marks
ISE	50

ISE is based on rubrics based progressive report submission and presentation to supervisors.

Course Description :

The objective of the project is to make use of the knowledge gained by the student at various stages of the degree course. This helps to judge the basic understanding of concepts in various courses, capacity of planning and executing the application of the knowledge. Reporting the outcomes effectively. Projects Areas can be related to - 1. Fermentation Technology 2. Cell Culture Technology 3. Bioprocess Equipment Design and Drawing 4. Bioseparation Processes 5. Effluent Treatment 6. Green Technology 7. Bioprocess Calculations 8. Drug Discovery and Development	