	Course Code	:	**22UBT702C**	**Downstream Processing Technology**	**Semester**	:	**7**
	L:T:P	:	**3:0:0**		**Course Type**	:	**PCC**
Hours/Sem.	**Teaching**	:	**42 Hrs.**		**CIE Marks**	:	**50**
	Learning (TW+SL)	:	**42 Hrs.**		**SEE Marks**	:	**50**
	Exam	:	**6 Hrs.**		**Total Marks**	:	**100**
	Total Hrs.	:	**90 Hrs.**		**Credits**	:	**3**

Professional Competency:

Ability to systematically isolate, purify, and formulate biological products from complex harvesting media by integrating physical, chemical, and analytical unit operations, while simultaneously optimizing process economics, structural stability, yield, and regulatory product safety.

Course Objectives:

After completion of the course, student will be able to:

CO1: Analyze solid-liquid separation profiles and select mechanical clarification unit operations like filtration, sedimentation, or centrifugation.

CO2: Apply membrane separation mechanics, precipitation protocols, and advanced extraction principles to achieve partial purification of target fractions.

CO3 Design high-resolution purification strategies utilizing specific chromatography matrices, electrophoresis parameters, and analytical instrumentation footprints.

CO4 Formulate end-stage product finishing and preservation lines combining evaporation, crystallization, and freeze-drying setups.

UNIT-I **UNIT-I**

Scope and Importance of Bioseparations technology in biotechnology, Characteristics of bioproducts, Criteria for selection of bio-separation techniques. Economics of bio separations in biotechnology, cost-cutting strategies.

Recovery of Intracellular Products: Cell disruption methods: physical methods (osmotic shock, grinding with abrasives, solid shear, liquid shear) – chemical methods (alkali, detergents) – enzymatic methods.

Isolation of insolubles: Filtration, Sedimentation, Coagulation, Flocculation, and Centrifugation.Types of centrifuges and rotors, Differential, Density gradient (zonal and isopycnic).

UNIT-II **UNIT-II**

Product Recovery or Partial Purification:

Precipitation of Proteins, Nucleic acids, and Bioproducts by Ammonium Sulfate, Polyethylene Glycol, and Solvents;

Membrane separation processes: **Dialysis, Reverse osmosis, Electrodialysis, Pervaporation, Ultrafiltration;**

Extraction methods: **Solid-liquid and liquid-liquid extraction methods, Advanced Extraction Methods like Ultrasound, Microwave-assisted, Supercritical fluid Extractions, Solid-phase Extraction (Adsorption).**

UNIT-III **UNIT-III**

Product Purification or Product Enrichment:

Selective Separation Techniques: Aqueous Two-phase Extraction, Micellar and Reverse Micellar Extraction;

Chromatographic separation and Electrophoresis methods: Principles of Chromatographic separation methods, Different types of chromatographic methods, Ion–exchange chromatography, Gel chromatography, Affinity chromatography. Principles of Electrophoresis and Electrophoresis mobility, applications.

Application of analytical techniques: High-Performance Liquid Chromatography; Gas Chromatography; LC-MS; GC-MS; FTIR etc. used in bioprocess Industries.

UNIT-IV **UNIT-IV**

Product Finishing:

Product polishing and finishing: Crystallization, Drying (Tray, Freeze Drying, Spray Drying), Evaporation(Rotary Evaporator), Lyophilization, and Product stabilization.

Reference Books:

1. Bioseparations: Downstream Processing for Biotechnology: Authors: Paul A. Belter, E. L. Cussler, and Wei-Shou Hu (John Wiley & Sons).
2. Bioseparations Science and Engineering: Authors: Roger G. Harrison, Paul W. Todd, Scott R. Rudge, and Demetri P. Petrides (Oxford University Press).
3. Bioseparations: Principles and Techniques: Author: B. Sivasankar (PHI Learning).

Web links and Video Lectures (e-Resources)

1. **NPTEL:** Comprehensive Video Lecture Series (NPTEL / SWAYAM) Principles of Downstream Techniques in Bioprocess (IIT Madras) Instructor: Prof. Mukesh Doble
2. **NPTEL: Membrane Technology (IIT Guwahati)** Instructor: Prof. Kaustubha Mohanty
3. **NCBI Bookshelf -** Bioprocess and Separation Footprints

Course Outcomes:

Course Outcomes	Programme Outcomes											Program Specific Outcomes (PSOs)		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**
CO1	3 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	2 (WK5)	2 (WK8)	2 (WK2, WK6)	1 (WK1, WK5, WK7)	-	-	-	-	1 (WK8)	2	3	-
CO2	3 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	2 (WK5)	2 (WK8)	1 (WK2, WK6)	1 (WK1, WK5, WK7)	-	-	-	-	1 (WK8)	2	3	-
CO3	3 (WK1, WK2, WK3, and WK4)	2 (WK1, WK2, WK3, and WK4)	3 (WK5)	3 (WK8)	3 (WK2, WK6)	-	-	-	-	-	2 (WK8)	2	3	1
CO4	3 (WK1, WK2, WK3, and WK4)	2 (WK1, WK2, WK3, and WK4)	3 (WK5)	2 (WK8)	1 (WK2, WK6)	2 (WK1, WK5, WK7)	1 (WK9)	-	-	2	1 (WK8)	2	3	2

	Code	:	22UBT703H	**Bioentrepreneurship Development**	Semester	:	7
	LTP	:	3:0 :0		Course Type	:	HSMC
Hours/Sem.	Teaching	:	42 Hrs.		CIE Marks	:	50
	Learning (TW+SL)	:	42 Hrs.		SEE Marks	:	50
	Exam	:	6 Hrs.		Total Marks	:	100
	Total Hrs.	:	90 Hrs.		Credits	:	3

Professional Competency:

Demonstrate the ability to understand entrepreneurial skills, market analysis, management functions, product and personnel management, material management, and preparation of project feasibility reports for successful venture creation and management.

Course Objectives:

After completion of the course, student will be able to:

CO1: Understand entrepreneur skill and to do market survey.

CO2:Understand entrepreneurship management functions.

CO3:Understand product and personal management in the entrepreneurial journey.

CO4.Understand the material management and to prepare project feasibility report

UNIT-I **10 Hrs.**

ENTREPRENEUR & ENTREPRENEURSHIP: Definition, History, Concept, Characteristics, Need& Importance, types of entrepreneurship, Entrepreneurial process.

Soft Skills for entrepreneurs: Soft skills - Communicative skills, Creativity & Problem solving skills, & other managerial & leadership skills.

Business opportunity identification: Market survey tools, preparation of schedule and techniques of data collection. Production programme, plant capacity, manpower requirements and layout. Business plan format for micro and small enterprises. The financials of a project report.

UNIT-II **10 Hrs.**

ENTREPRENEURSHIP MANAGEMENT AND ITS FUNCTIONS:

Principle functions of management: planning, organizing, staffing, coordinating & controlling. Concept of Authority & Responsibility. Social responsibilities of the management: to the owners, employees, customers, community & government.

Administration: Definition, Nature, Principles & Elements of management. Management VS administration.

UNIT-III **10 Hrs.**

PRODUCTION MANAGEMENT:

Concept of productivity, measuring productivity, Productivity improvement techniques.

Concept of budget, classifications of the budget, components of budget, effective budgetary control. Break even analysis. Manufacturing /material planning, factory planning. Systems of wage payments, bonus, automation. Organization of production planning.

PERSONNEL MANAGEMENT:

Elements of personnel management, role of personnel manager, functions of personnel management –man power planning, recruitment, employee selection & training of personnel.

Employer - Employee relationship. Settlement of disputes.

UNIT-IV **10 Hrs.**

MATERIAL AND MARKETING MANAGEMENT :

Material Functions of purchasing & materials management, quality, quality standard & inspection, sources of supply, pricing, principles & practices, Inventory management (ABC analysis), product promotional strategy

Entrepreneurship in Biobusiness: BioMedical field, Clinical research, Agriculture. Government schemes for commercialization of technology. Legal requirements

Entrepreneurship in India: Scope & opportunities in Biotechnology. Government schemes.
A case study on developing the financial scheme of a project report or business plan. Costing and pricing of products with one case study

Text Books:

1. O.P. Khanna - "Industrial Engineering & Management", DhanpatRai& Sons publications, 2006.
2. T. R. Banga& S. C. Sharma - "Industrial Engineering & Management Science", 6th. Edn, Khanna Publications, 2003

Reference Books:

1. PoornimaCharanthimath – Entrepreneurship Development –small business entreprises, Pearson Education-2006
2. NSTEDB material for entrepreneurship development programme, EDI, Ahmadabad

Course Outcomes	Programme Outcomes											
	1	2	3	4	5	6	7	8	9	10	11	12
CO1	1(WK1, WK2, WK3 andWK4)	1(WK1, WK2, WK3 andWK4)			1(WK2, andWK6)			2		3	3(wk8)	
CO2	1(WK1, WK2, WK3 andWK4)				2(WK2, andWK6)			1		3	3(wk8)	
CO3	1(WK1, WK2, WK3 andWK4)				2(WK2, andWK6)			2		3	3(wk8)	
CO4	1(WK1, WK2, WK3 andWK4)	1(WK1, WK2, WK3 andWK4)			2(WK2, andWK6)			1		3	3(wk8)	
CO1	1(WK1, WK2, WK3 andWK4)	1(WK1, WK2, WK3 andWK4)			1(WK2, andWK6)			2		3	3(wk8)	

	Code : 22UHS711C	**Research Methodology & Intellectual Property Rights**		Semester :	7
	LTP : 3:0:0			Course Type :	AEC
Hours/Sem.	Teaching : 42 Hrs			CIE Marks :	50
	Learning (TW+SL) : 42 Hrs			SEE Marks :	50
	Exam : 06 Hrs			Total Marks :	100
	Total Hrs. : 90			Credits :	03

Professional Competency:

Graduates will be able to prepare research projects and formulate the problems and do ethical and structured research and protect or convert that research into real-world value.

Course Objectives:

After completion of the course, student will be able to:

CO1: Integrate research methodology in engineering sciences in relevant trades.

CO2: Exhibit reflective thinking in problem solving exercises.

CO3: Identify criteria to fit one's own intellectual work in particular form of IPRs and able to apply statutory provisions and procedure to protect different forms of IPRs at national and international level.

CO4: Develop skill of making search using modern tools and techniques and also student is able to become patent agent by cracking patent agent exam.

UNIT-I **12 Hrs.**

Introduction to Engineering Research

Fundamentals of Research: Meaning, objectives, and motivation in engineering research.

Types of Engineering Research: Basic, applied, and translational research; identifying and solving worthwhile problems.

Research Ethics: Ethics in engineering research and practice, types of research misconduct, and ethical issues in authorship.

UNIT-II **10 Hrs.**

Literature Review and Citations

Technical Reading & Analysis: Methods for reviewing literature, analysing prior art, and synthesizing new and existing knowledge.

Bibliographic Databases: Web of Science, Google, Google Scholar, effective search strategies.

Conceptualizing Research: Critical and creative reading, taking notes, reading mathematical models, algorithms, and datasheets.

Citations & Acknowledgments: Attribution, citation styles, impact of keywords, citing datasets, and knowledge dissemination.

UNIT-III **10 Hrs.**

Intellectual Property Rights (IPR) & Patents:

Introduction to Intellectual Property: Concepts of property and rights, forms of IPR, role in research and economic development, IP governance, and global innovation indicators.

Patents: Definition, objectives, criteria for patentability, software/business method patents, infringement, compulsory licensing, and government use of inventions.

Patent Process: Prior art search strategies, patent databases (free and paid), drafting specifications and claims, filing requirements, jurisdiction, opposition procedures, and renewal.

Filing Requirement of patent: Patent Application Forms. Work flow chart in obtaining Patents, Jurisdiction of Filing Patent Application. Pre-grant & Post-grant Opposition. Forms to be submitted, filing mechanism through Individual patent office and PCT route. Need for a Patent Attorney/Agent Revocation. Term of Patent, Patent renewal and Fee Structure National Bodies Dealing with Patent Affairs. Utility Models

UNIT-IV **10 Hrs.**

Copyrights and Related Rights: Classes of Copyrights. Criteria for Copyright. Ownership of Copyright.

Copyrights of the Author. Copyright Infringements. Copyright Infringement and remedies in case of infringement. Fair Use Doctrine. Copyrights and Internet. Non-Copyright Work. Copyright Registration. Judicial Powers of the Registrar of Copyrights. Fee Structure. Validity of Copyright. Copyright Profile of India. Copyright and the word 'Publish'. Transfer of Copyrights to a Publisher. Copyrights and the Word 'Adaptation'. Copyrights and the Word 'Indian Work'. Joint Authorship. Copyright Society. Copyright Board. Copyright Enforcement Advisory Council (CEAC). International Copyright Agreements, Conventions and Treaties. Interesting Copyrights Cases.

Trademarks: Eligibility Criteria. Who Can Apply for a Trademark. Acts and Laws. Classification of Trademarks. Registration of a Trademark. Process for Trademarks Registration. Prior Art Search. Validity of Trademark. Trademark Registry. Famous Case Law: Coca-Cola Company vs. Bisleri International Pvt. Ltd.

Industrial Designs: Eligibility Criteria. Acts and Laws to Govern Industrial Designs. Design Rights. Enforcement of Design Rights. Non-Protectable Industrial Designs India. Protection Term. Procedure for Registration of Industrial Designs. Prior Art Search. Application for Registration. Duration of the Registration of a Design. Importance of Design Registration. Cancellation of the Registered Design. Application Forms. Classification of Industrial Designs. Designs Registration Trend in India. International Treaties. Famous Case Law: Apple Inc. vs. Samsung Electronics Co.

Geographical Indications: Acts, Laws and Rules Pertaining to GI. Ownership of GI. Rights Granted to the Holders. Registered GI in India. Identification of Registered GI. Classes of GI. Non-Registerable GI. Protection of GI. Collective or Certification Marks. Enforcement of GI Rights. Procedure for GI Registration Documents Required for GI Registration. GI Ecosystem in India.

Case Studies on Patents. Case study of Curcuma (Turmeric) Patent, Case study of Neem Patent, Case study of Basmati patent. **IP Organizations In India. Schemes and Programmes**.

Text Books:

1. N.R. Subbaram. S. Viswanathan, (2008). "Hand book Indian Patent Law and, Practice" Printers and publishers Pvt, Ltd,
2. Dr. Nejakar Santosh M, Dr. Bendigeri Harish (2023-24) "Research Methodology and Intellectual Property Rights", ISBN 978-93-5987-928-4,
3. Thiel David V. "Research Methods for Engineers" Cambridge University Press,
4. Acharya N.K Intellectual Property Rights . 6th Edition, Asia Law House.

Reference Books:

1. P. Naryan, (2007). "Intellectual Property Law", 3rd Ed, Eastern Law House,
2. Dr. Myneni S.R.,(2019) "Law of Intellectual Property", 9th edition, Asia law House,.
3. Dr. Reddy G.B, (2020) "Intellectual Property Rights and Law", Reprint edition, Gogia Law Agency. Hyderabad,.
4. Cornish, "Intellectual Property Rights", Universal publications.
5. Dr.B.L.Wadehra,"Law Relating to Intellectual Property" 5thedition,Universal Law publishing Co, Delhi.
6. SWAYAM / NPTL/ MOOCS/ We blinks/ Internet sources/ YouTube videos and other materials / notes

Course Outcomes	Programme Outcomes									PSOs		
	1	2	3	4	5	6	7	8	9	1	2	3
CO1	-	2 +(WK1, WK2, WK3, and WK4)	2 WK5	3 WK8	2 WK2 & WK6	1 WK1, WK5 & WK7	2 WK9	3	-	1	2 WK8	3
CO2	-	3 (WK1, WK2, WK3, and	2 WK5	3 WK8	-	2 WK1,	2 WK9	2	-	-	2	2

		WK4)				WK5 & WK7					WK8	
CO3	-	-	-	-	2 WK2 & WK6	3 WK1, WK5 & WK7	2 WK9	3	-	1	3 WK8	1
CO4	-	-	-	2 WK8	3 WK2 & WK6	2 WK1, WK5 & WK7	-	1	-	1	-	1
CO1	-	2 (WK1, WK2, WK3, and WK4)	2 WK5	3 WK8	2 WK2 & WK6	1 WK1, WK5 & WK7	2 WK9	3	-	1	2 WK8	3

	Course Code	:	22UBT731E	Industrial BT	Semester	:	7
	L:T:P	:	3: 0:0		Course Type	:	PEC
Hours/Sem.	Teaching	:	42 Hrs.		CIE Marks	:	50
	Learning (TW+SL)	:	42 Hrs.		SEE Marks	:	50
	Exam	:	6 Hrs.		Total Marks	:	100
	Total Hrs.	:	90 Hrs.		Credits	:	3

Professional Competency:

Demonstrate the ability to understand, analyze, and apply industrial bioprocess principles for the production of primary metabolites, secondary metabolites, industrial enzymes, microbial products, and recombinant biopharmaceuticals for applications in healthcare, agriculture, food, and industrial biotechnology sectors.

Course Outcomes:

After completion of the course, student will be able to:

CO1: Explain the principles of industrial biotechnology, fermentation processes, microorganisms used in industry, and modes of bioprocess operation.

CO2: Analyze the production processes and industrial applications of primary metabolites including organic acids, amino acids, and alcohols.

CO3: Evaluate the production and applications of secondary metabolites, industrial enzymes, and microbial bioproducts such as biofertilizers, biopesticides, biopolymers, and SCP.

CO4: Analyze the production and applications of modern biotechnology products including recombinant proteins, vaccines, and monoclonal antibodies**.**

UNIT-I	10 Hrs.

Introduction to Industrial Bioprocess: Biotechnology: Scope and importance, Commercial potential of Biotechnology in India. Historical overview of industrial fermentation process -traditional and modern Biotechnology. Industrial Fermentation- microorganisms, mode of operation, fermentation processes-pictorial representation.

UNIT-II	10 Hrs.

Production of Primary Metabolites: A brief outline of processes for the production of some commercially important organic acids (citric acid, lactic acid & acetic acid); amino acids (glutamic acid & tryptophan) and alcohols (ethanol & butanol)

UNIT-III	12 Hrs.

Production of Secondary Metabolites: Production processes for various classes of secondary metabolites: antibiotics: (penicillin streptomycin & erythromycin), vitamins (Vit B12 and Vit B2) and steroid biotransformation.

Production of Enzymes and Other Bioproducts: Production of industrial enzymes (proteases & amylases), Production of biopesticide, Biofertilizers, bio-preservative (Nisin), biopolymers (xanthan gum & PHB), cheese, SCP.

UNIT-IV	10 Hrs.

Production of Modern Biotechnology Products: Production of recombinant proteins having therapeutic and diagnostic applications (insulin, human growth hormone), Production of recombinant vaccines (Hepatitis B vaccine, cholera vaccine), production of monoclonal antibodies

Text Books:

1. Lee, S.Y., Nielsen, J. and Stephanopoulos, G., Industrial Biotechnology: Products and Processes, John Wiley & Sons, 2016
2. Waites, M.J., Morgan,N.L., Rockey,J.S., Higton, G., Industrial Microbiology: An Introduction Blackwell, 2001
3. Cruger, W., Cruger, A., A Textbook of Industrial Microbiology, Panima Publishing Corporation, 2nd Edition, 2005
4. Stanbury, P.F., A. Whitaker and S.J. Hall, Principles of Fermentation Technology, Butterworth – Heinemann (an imprint of Elsevier), 1995, 2nd Edition
5. James D. Watson, Richard M. Myers, Amy A. Caudy, and Jan A. Witkowski, Recombinant DNA: Genes and Genomes: A Short Course - W. H. Freeman, 2007

Reference Books:

1. Prescott, S.C. and Cecil G. Dunn, Industrial Microbiology, Agrobios (India), 2005
2. Moo-Young, Murrey, Comprehensive Biotechnology, 4 Vols. Pergamon Press, (An Imprint of Elsevier), 2004
3. C. F. A Bryce and EL. Mansi, Fermentation microbiology & Biotechnology, 1999
4. K. G. Ramawat and Shaily Goyal, Comprehensive Biotechnology, 2009

Course Outcomes	Programme Outcomes											Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
CO1	3(WK1, WK2, WK3 andWK 4)	2(WK1, WK2,WK3 andWK4)	1(WK5)	1(WK8)	“”	1(WK1, WK53 andWK 7)	“”	“”	“”	“”	2(WK8)	1	2	1
CO2	3((WK1, WK2,WK3 andWK 4)	3(WK1, WK2,WK3 andWK4)	2(WK5)	2(WK8)	1	1(WK1, WK53 andWK 7)	1(WK9)	“”	“”	“”	2(WK8)	1	2	2
CO3	3(WK1, WK2,WK3 andWK 4)	3(WK1, WK2,WK3 andWK4)	2(WK5)	3(WK8)	2	2 (WK1, WK53 andWK 7)	2(WK9)	1	1	“”	2(WK8)	1	2	1
CO4	3(WK1, WK2,WK3 andWK 4)	3(WK1, WK2,WK3 andWK4)	2(wk5)	2(WK8)	3	2(WK1, WK53 andWK 7)	1(WK9)	1	1	1	2(WK8)	1	2	2

	Course Code	:	22UBT732E	Food Processing Technology	Semester	:	7
	L:T:P	:	3: 0:0		Course Type	:	PEC
Hours/Sem.	Teaching	:	42 Hrs.		CIE Marks	:	50
	Learning (TW+SL)	:	42 Hrs.		SEE Marks	:	50
	Exam	:	6 Hrs.		Total Marks	:	100
	Total Hrs.	:	90 Hrs.		Credits	:	3

Professional Competency:

Ability to analyze food composition, quality, safety, spoilage, preservation, processing, packaging, and product development while applying food engineering principles and adhering to professional, ethical, regulatory, and sustainability requirements in the food industry.

Course Outcomes:

After completion of the course, student will be able to:

CO1: Analyze the basic constituents and importance various nutrients in food

CO2: Examine the techniques involved in detection of microbes in food industry, and analyse the steps in food production

CO3: Differentiate the microbes causing food spoilage and exhibit the preservation techniques and to know the Characteristics of food industry and scope

CO4: Apply the concepts of food Engineering and food waste management

UNIT-I **10 Hrs.**

Introduction

Constituents of food, soluble fibres, protein rich foods, popular fats and oils in foods, Food flavors, Browning reactions and its effects. Intrinsic and extrinsic parameters of foods, effect of inhibitors, pH and temperature. Minerals in foods. Aroma compounds in foods. Food additives, Vitamins, aminoacids, Sweeteners, Food colours. Toxic-trace elements in food.

UNIT-II **12 Hrs.**

Detection of Microorganisms

Culture, Microscopic and Sampling Methods, Conventional; SPC, Membrane Filters, Microscope colony Counts, Agar Droplets, Dry Films, Most probable Numbers (MPN), Dye reduction, Roll Tubes, Direct, Microscopic Count (DMC), Microbiological Examination of surfaces, Air Sampling, Metabolically Injured Organisms, Enumeration and Detection of Food-borne Organisms. Dairy products: Composition of milk, Sterilization of milk (Pasteurization and UHT), Cheese production, Acidophilus milk Yoghurt, Kumiss and Kefir. Marketingscopeofdairy&foodproductsFruitandvegetableprocessing:Jam,jelly,Juice, squash, wine, pickles and sauerkraut

UNIT-III **10 Hrs.**

Food Spoilage &Preservation

The Role and Significance of Microorganisms, Primary Sources of Microorganisms found in Foods Synopsis of common borne bacteria, Molds& Yeasts. Microbial Spoilage of Vegetables, Fruits, Fresh and Processed Meats, Poultry, and Seafood. Spoilage of Miscellaneous Foods, Food Preservation: Principles Underlying in spoilage and preservation, Application, Effect and Legal Status of Food Irradiation, Food Preservation with Low Temperatures, High Temperatures and Drying. Food Industry: Characteristics of Food Industry. Nutritional food supplements. Food packaging, New trends in packing, edible films. Factors influencing food product development, marketing and promotional strategies, Risks and benefits of food industry

UNIT-IV **10 Hrs.**

Food Engineering

Properties of fluid foods, Measurement of rheological parameters .Thermal properties of frozen foods. Food freezing equipment, storage of frozen foods. Food dehydration: Freeze Dehydration Calculation of drying times. Food waste

management

Text Books:

1. Food Science & Nutrition, by Sunetra Roady, Oxford University Press,2007.
2. Food microbiology byWilliam Frazier and Westhoff D.C,4thEdn,TATAMcGrawHill Pub(2005)
3. Modern Food Micro-Biology by James M.Jay,CBS Publishers.2005.

Reference Books:

4. Food Microbiology by K.Vijay Ramesh M J P Publishers,2007.
5. Plant biotechnology In Agriculture by K.Lindsey and M.G.K.Jones ,Prentice

Course Outcomes:

Course Outcomes	Programme Outcomes											Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
CO1	2(WK1, WK2, and WK4)	" "	2(WK5)	" "" "	" "	3 (WK1, WK5 and WK7)	1 (WK9)	" "	" "	" "	3(WK8)	2	2	3
CO2	2(WK1, WK2, and WK4)	" "	2(WK5)	" "	3 (WK6)	1 (WK1, WK5 and WK7)	1 (WK9)	" "	1	" "	2(WK8)	2	3	3
CO3	2(WK1, WK2, and WK4)	1{ WK2, WK3, and WK4)	1(WK5)	" "	3 (WK6)	1 (WK1, WK5 and WK7)	2 (WK9)	" "	1	" "	1(WK8)	2	2	3
CO4	2(WK1, WK2, and WK4)	23(WK2, WK3, and WK4)	2 (WK5)	" "	2 (WK6)	1 (WK1, WK5 and WK7)	2 (WK9)	" "	1	" "	2(WK8)	2	1	3

	Course Code	:	**22UBT733E**	**Biosimulations**	**Semester**	:	**7**
	L:T:P	:	**3:0:0**		**Course Type**	:	**PEC**
Hours/Sem.	**Teaching**	:	**42 Hrs**		**CIE Marks**	:	**50**
	Learning (TW+SL)	:	**42 Hrs**		**SEE Marks**	:	**50**
	Exam	:	**06 Hrs**		**Total Marks**	:	**100**
	Total Hrs.	:	**90 Hrs**		**Credits**	:	**3**

Professional Competency:

Develop the knowledge and skills to apply biotechnological principles, molecular techniques, and bioprocess technologies for the development, production, quality evaluation, and regulatory compliance of biopharmaceutical products while adhering to ethical and biosafety standards.

Course Outcomes:

After completion of the course, student will be able to:

CO1: Explain the principles of mathematical modeling and apply fundamental conservation laws, transport equations, and reaction kinetics to biological and biochemical systems.

CO2: Develop and analyze mathematical models for biochemical engineering processes including batch, continuous, and continuous stirred tank reactor (CSTR) systems.

CO3: Apply bioprocess simulation software such as SuperPro Designer, COPASI, and COBRA to perform material, energy, and metabolic flux balance analyses.

CO4: Use MATLAB and SIMULINK to analyze experimental data, solve engineering problems numerically, and simulate dynamic biochemical systems.

UNIT-I	**10 Hrs.**

Modelling Principles: Basic modeling principles, uses of mathematical modeling classification of modeling techniques Fundamental laws, energy equations, continuity equation, equations of motion, transport equations, equations of state, equilibrium states and chemical kinetics-examples.

UNIT-II	**11 Hrs.**

Mathematical Models for Biochemical Engineering Systems: Mathematical models for Biochemical engineering systems, Mathematical models in batch and continuous process, continuous flow tanks, reversible reaction., storage and stability of biotech products. Short study of current biotech products. Adverse drug reactions.

UNIT-III	**11 Hrs.**

Simulation Softwares in Bioprocess: Introduction to SuperPro Designer for Material balance, Software for mass and energy balance; Energy Balance with and without reaction. Metabolic Flux Balance Analysis: Introduction, Principle of steady state metabolic flux balance analysis, COPASI, COBRA

UNIT-IV	**10 Hrs.**

Matlab and Simulink: MATLAB for data analysis Basics, Data analysis, curve fittings, Numerical integration, Euler and fourth order RungeKutta method, Simulation of gravity flow tank, SIMULINK for dynamic systems.

Text Books:

1. Luben W.L. “Process Modelling Simulation and Control for Chemical Engineers”, McGrawHill, International New York, 1990.
2. Franks RGE. “Mathematical Modeling in Chemical Engineering”, John Wiley and Sons, Inc., New York, 2004.

Reference Books:

1. Biquette W.B. “Process Dynamics- Modeling analysis with simulation”, Prentice Hall; 1 edition January 15, 1998.
2. William J. Palm. “Introduction to Matlab 7 for Engineers”, III, McGraw Hill 2005.
3. Kenneth J. Beers. “Numerical Methods for Chemical Engineering Applications in MATLAB”, Massachusetts Institute of Technology, Cambridge University press 2007 edition

Course Outcomes:

Course	**Programme Outcomes**	**Program Specific**

Outcomes												Outcomes (PSOs)		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**
CO1	3(WK1, WK2,WK3 WK4)	2(WK1, WK2,WK3 WK4)	-	1(WK8)	-	-	-	-	-	-	1(WK8)	1	2	2
CO2	3(WK1, WK2,WK3 WK4)	3(WK1, WK2,WK3 WK4)	2(WK5)	2(WK8)	1(WK6)	-	-	-	-	-	1(WK8)	1	2	2
CO3	2(WK1, WK2,WK3 WK4)	3(WK1, WK2,WK3 WK4)	22(WK5)	3(WK8)	3(WK6)	-	-	-	1	-	1(WK8)	2	2	2
CO4	2(WK1, WK2,WK3 WK4)	3(WK1, WK2,WK3 WK4)	22(WK5)	3(WK8)	3(WK6)	-	-	-	1	1	1(WK8)	2	2	2

	Course Code	:	22UBT734E	**Bioanalytical Techniques**	Semester	:	7
	L:T:P	:	3:0:0		Course Type	:	PEC
Hours/Sem.	Teaching	:	42 Hrs.		CIE Marks	:	50
	Learning (TW+SL)	:	42 Hrs.		SEE Marks	:	50
	Exam	:	6 Hrs.		Total Marks	:	100
	Total Hrs.	:	90 Hrs.		Credits	:	3

Professional Competency:

Ability to strategically select, operate, and interpret data from a comprehensive suite of advanced analytical instruments (spectroscopic, chromatographic, electrophoretic, and crystallographic) to isolate, quantify, and deduce the precise structural and functional conformations of complex biological macromolecules.

Course Outcomes:

After completion of the course, student will be able to:

CO1: Optical Spectroscopy & Centrifugation: Apply the principles of preparatory/analytical centrifugation to isolate cell fractions, and utilize UV-Visible and Fluorescence spectroscopy to quantify biomolecule concentrations and probe protein binding sites.

CO2: Advanced Structural Spectroscopy & Spectrometry: Interpret analytical data from advanced spectroscopic instruments (FTIR, ORD/CD, NMR) and mass spectrometers (LC-MS, GC-MS) to elucidate the molecular mass, functional groups, and 3D conformations of biological macromolecules.

CO3: Chromatographic Separations: Evaluate and select appropriate chromatographic techniques (Gel Filtration, Ion-Exchange, Affinity, GC, and HPLC) to design high-resolution purification strategies and estimate the molecular weight of target bioproducts.

CO4: High-Resolution Electrophoresis & Crystallography: Resolve complex proteomic and genomic mixtures using advanced electrophoretic systems (2D-PAGE, Capillary, PFGE), and determine the atomic-level structural coordinates of biological crystals using X-ray diffraction mechanics.

UNIT-I **10 Hrs.**

Centrifugation

Introduction: Basic, Types of centrifuges: Desktop, High Speed and Ultracentrifuge (Preparatory and Analytical), Design and their working principle, Types of Rotors, Wall-effect

Spectroscopy :

(i) Absorption Spectroscopy

Simple theory of absorption of light by molecules, Chromophore and terminologies associated with absorption of molecules

The Beer-Lambert Law and its deviations

Single and double beam spectrophotometers for measuring Visible and Ultraviolet light: Instrumentation and Parameters measured in absorption Spectroscopy (UV-Vis spectrophotometer)

Empirical rule for the absorption spectra of biological macromolecules

Chemical Analysis by absorption spectroscopy using Visible and Ultraviolet light

(ii) Fluorescence Spectroscopy

Simple theory of Fluorescence

Instrumentation and Technology of Fluorescence Spectroscopy (Fluorescence spectrometer) Intrinsic Fluorescence measurements for information about the conformation and binding sites of proteins

Extrinsic fluorescence measurements for information about the conformation and binding sites of proteins

UNIT-II **10 Hrs.**

(iii) Infrared Spectroscopy

Infrared Spectroscopy: Basic Principle Instrumentation and Technology of Infrared Spectroscopy (Fourier-transform infrared spectroscopy (FTIR)) Information in Infrared Spectra and Applications of Infrared spectroscopy

(iv) Optical Rotatory Dispersion (ORD) & Circular Dichroism (CD)

Theory of Optical Rotatory Dispersion (ORD) & Circular Dichroism (CD) Relative values of ORD and CD measurements, Advantages of CD over ORD Instrumentation for measuring ORD and CD, Applications of ORD and CD

(v) Nuclear Magnetic Resonance (NMR) Spectroscopy Nuclear Magnetic Resonance (NMR) Spectroscopy : Principle Basic Instrumentation of NMR Spectrometer

Applications of NMR Spectroscopy

(vi) Mass spectrometry

Mass spectrometry: Basic Principle Instrumentation and main components of mass spectrometers Ionization source, Mass analyzers, and Detectors (LC-MS and GC-MS)

Applications of Mass Spectrometry

UNIT-III	**10 Hrs.**

Chromatography

Adsorption Chromatography: Simple Theory & Types

Operations of columns : Terminologies and concept

Elution : Types of elution methods

Supports : Concept of mesh size and mesh screen

Gas Chromatography: Principle, Basic set up of Gas chromatography system, Detectors and Uses of Gas chromatography Gel Chromatography (molecular-sieve chromatography): Simple Theory, Materials (dextran, agarose and polyacrylamide gels), Advantages of gel chromatography, Estimation of molecular weight and applications of gel chromatography Ion-Exchange Chromatography: Principle, Properties of Ion Exchangers, Choice of Ion Exchangers, Technique and application of Ion Exchange chromatography. High-Performance of Liquid Chromatography (HPLC): Principle, Application of pressure in HPLC, Advantages and uses of HPLC.

Affinity Chromatography: Principle, Methods of Ligand immobilization (Cyanogen-bromide-activated agarose, Aminoethyl- and hydrazide-activated polyacrylamide), uses of affinity chromatography

UNIT-IV	**10 Hrs.**

Iso-electric focusing (IEF): Principle, Technique and application, 2-D PAGE: Steps involved in 2-D PAGE, application in proteomics Pulse-field gel electrophoresis: Principle, Technique and Application Capillary electrophoresis: Principle, Technique and Application X-ray crystallography Interaction of X-ray with matter: Absorption, Scattering and diffraction (Bragg' s Law) Preparation of crystals : Hanging and sitting drop vapor diffusion methods

X-ray diffraction methods Application of X-ray Diffraction in Crystal structure

Reference Books:

1. Principles and Techniques of Biochemistry and Molecular Biology: Authors: Keith Wilson and John Walker (Cambridge University Press).
2. Biophysical Chemistry (Principles and Techniques): Authors: Avinash Upadhyay, Kakoli Upadhyay, and Nirmalendu Nath (Himalaya Publishing House).
3. Physical Biochemistry: Principles and Applications: Author: David Sheehan (John Wiley & Sons).

Web links and Video Lectures (e-Resources)

1. **NPTEL:** Bioanalytical Techniques and Bioinformatics (IIT Guwahati): Instructors: Dr. Nitin Chaudhary and Dr. Vishal Trivedi
2. **NPTEL: Biophysical Chemistry (IIT Delhi**): Instructor: Prof. Pramit Kumar Chowdhury
3. **Practical Industry Portals & Toolsets:** Agilent Technologies & Waters Corporation Analytical Repositories

Course Outcomes	Programme Outcomes											Program Specific Outcomes (PSOs)		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**
CO1	3 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	2 (WK5)	2 (WK8)	2 (WK2 ,WK6)	1 (WK1, WK5, WK7)	-	-	-	-	1 (WK8)	2	3	-
CO2	3 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	2 (WK5)	2 (WK8)	1 (WK2 ,WK6)	1 (WK1, WK5, WK7)	-	-	-	-	1 (WK8)	2	3	-
CO3	3 (WK1, WK2, WK3, and WK4)	2 (WK1, WK2, WK3, and WK4)	3 (WK5)	3 (WK8)	3 (WK2 ,WK6)	-	-	-	-	-	2 (WK8)	2	3	1
CO4	3 (WK1, WK2, WK3, and WK4)	2 (WK1, WK2, WK3, and WK4)	3 (WK5)	2 (WK8)	1 (WK2 ,WK6)	2 (WK1, WK5, WK7)	1 (W K 9)	-	-	2	1 (WK8)	2	3	2

	Course Code	:	22UBT741E	**Nanobiotechnology and Biomaterials**	Semester	:	7
	L:T:P	:	3:0:0		Course Type	:	PEC
Hours/Sem.	Teaching	:	42 Hrs.		CIE Marks	:	50
	Learning (TW+SL)	:	42 Hrs.		SEE Marks	:	50
	Exam	:	6 Hrs.		Total Marks	:	100
	Total Hrs.	:	90 Hrs.		Credits	:	3

Professional Competency:

To work professionally in nanobiotechnology & biomaterials sectors as there will be an intersection of biology, nanotechnology, materials science, and engineering techniques.

Course Outcomes:

After completion of the course, student will be able to:

CO1: Ability to explain the characterization techniques and to understand the importance of nano-particles in drug delivery system.
CO2: Ability to understand the importance of biopolymers.
CO3: Ability to differentiate biopolymer and synthetic polymer.
CO$: Ability to understand the importance of biocompatibility and apply the methods to test the implants and use in medical devices.

UNIT-I — **12 Hrs.**

Introduction to nanotechnology:

A Brief History of the Nano particles: Bottom-Up versus Top-Down; What Is Nanobiotechnology. Discussions on nanofabrication, nanolithography, nanotubes, buckyballs, structure-property relationships in materials, materials characterization techniques, scanning electron, scanning tunneling and atomic force microscopy (SEM, STM & AFM), biomolecule-surface interactions, quantum dots,

Applications of nanotechnology in the life sciences:

Buckyballs and Buckytubes, Diagnostics and Sensors, Drug Delivery Revenues Health Risks and Challenge.

UNIT-II — **10 Hrs.**

Biopolymers:

Polymers as biomaterials, microstructure, mechanical properties – effects of environment on elastic moduli, sterilization and disinfections of polymeric materials. Biocompatibility of polymers, chemically modified glycosaminoglycans, heparin like substances from non glycosaminoglycan polysaccharides and microbial glycosaminoglycan, surface immobilized heparins.

UNIT-III — **10 Hrs.**

Synthetic polymers:

Polymers in biomedical use, polyethylene and polypropylene, perfluorinated polymers, acrylic polymers, hydrogels, polyurethanes, polyamides, biodegradable synthetic polymers, silicone rubber, plasma polymerization, micro-organisms in polymeric implants, polymer sterilization.

UNIT-IV — **10 Hrs.**

Biocompatibility:

Definition, Wound healing process-bone healing, tendon healing. Material response: Function and Degradation of materials in vivo. Host response: Tissue response to biomaterials. Testing of implants: Methods of test for biological performance-In vitro and In vivo implant tests methods.

Medical devices:

Polyurethane elastomers, applications of polymers in medicine and surgery. Skin graft polymers, Properties of implant materials, metals and alloys.

Text Books:

1. B.Vishwanath (2011). “Nano Materials” Published by Narosa Publishing House Pvt. Ltd., New Delh.
2. Mark Ratner and Daniel Ratner (2003). “Nanotechnology:A Gentle Introduction to Next Gig Idea” Pearson Education Ltd.

Reference Books:

1. K Eric Drexler (1993). “Unbounding the future” Quill.
2. Stephen Lee and Lynn M Savage (2010). “Biological molecules in Nanotechnology”.

Web links and Video Lectures (e-Resources)

Course Outcomes	Programme Outcomes											Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
CO1	3 (WK1, WK2, WK3 and WK4)	2 (WK1 WK2 WK3 and WK4)	3 (WK5)	-	3 (WK2 and WK6)	-	3 (WK9)	-	-	-	3 (WK8)	3	3	3
CO2	3 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3 and WK4)	3 (WK5)	-	3 (WK2 and WK6)	-	3 (WK9)	-	-	-	3 (WK8)	3	3	3
CO3	2 (WK1 WK2, WK3a nd WK4)	3 (WK1, WK2, WK3 and WK4)	3 (WK5)	-	3 (WK2 and WK6)	-	3 (WK9)	-	-	-	3 (WK8)	3	3	3
CO4	3 (WK1, WK2, WK3 and WK4)	3 (WK1, WK2, WK3 and WK4)	3 (WK5)	-	3 (WK2 and WK6)	-	3 (WK9)	-	-	-	3 (WK8)	3	3	3

	Course Code	:	22UBT742E	**Food Product Development**	Semester	:	7
	L:T:P	:	3:0:0		Course Type	:	PEC
Hours/Sem.	Teaching	:	42 Hrs.		CIE Marks	:	50
	Learning (TW+SL)	:	42 Hrs.		SEE Marks	:	50
	Exam	:	6 Hrs.		Total Marks	:	100
	Total Hrs.	:	90 Hrs.		Credits	:	3

Professional Competency:

Develop innovative, safe, and market-oriented food products by applying principles of food formulation, processing, quality assurance, regulatory compliance, and commercialization while demonstrating professional and entrepreneurial skills.

Course Outcomes:

After completion of the course, student will be able to:

CO1: Demonstrate the principles, stages, regulations, and market aspects involved in food product development.

CO2: Apply formulation, processing, packaging, and quality assurance principles for developing safe and high-quality food products.

CO3: Evaluate food products using sensory, nutritional, physicochemical, and microbiological quality assessment techniques, and prepare technical documentation.

CO4: Apply the concepts of functional food development, product commercialization, entrepreneurship, and industrial scale-up to develop innovative food products.

UNIT-I — **12 Hrs.**

INTRODUCTION TO FOOD PRODUCT DEVELOPMENT

Food industry trends and market opportunities , Consumer needs and market research,

Product development processes : Idea generation, screening, concept development, prototype development, commercialization ,Product life cycle ,Competitor analysis and benchmarking, Intellectual Property Rights (IPR) in food products ,Food regulations and labeling requirements Food standards (FSSAI, Codex Alimentarius) The product development process, privacy policies and Knowledge of basic laboratory procedures, Standard Operating Procedure (SOPs), process flows in manufacturing, product life cycle and competitor studies.

UNIT-II — **10 Hrs.**

FOOD FORMULATION AND PROCESSING

Selection of raw materials and ingredients, Functional properties of food ingredients, Product formulation techniques, Standardization of recipes, Processing methods for food products, Product optimization, Food packaging materials and technologies, Shelf-life studies and storage conditions Quality assurance and Good Manufacturing Practices (GMP)

UNIT-III — **10 Hrs.**

FOOD FORMULATION AND PROCESSING SELECTION OF RAW MATERIALS AND INGREDIENTS

Functional properties of food ingredients, Product formulation techniques, Standardization of recipes Processing methods for food products, Product optimization, Food packaging materials and technologies ,Shelf-life studies and storage conditions, Quality assurance and Good Manufacturing Practices (GMP)

UNIT-IV — **10 Hrs.**

FUNCTIONAL FOODS AND PRODUCT COMMERCIALIZATION

Functional foods and nutraceuticals, Probiotics and prebiotics, Fortified foods, Sports nutrition products, Geriatric and pediatric foods, Plant-based and alternative protein products, Product branding and marketing, Entrepreneurship in food product development, Scale-up from laboratory to pilot plant, Case studies on successful food product innovations.

Text Books:

1. Food Science & Nutrition, by Sunetra Roady, Oxford University Press, 2007.
2. FoodmicrobiologybyWilliamFrazierandWesthoffD.C,4th Edn,TATAMcGrawHill Pub(2005)

Reference Books:

1. Modern Food Micro-Biology by James M.Jay, CBS Publishers. 2005.
2. Food Microbiology by K. Vijay Ramesh M J P Publishers, 2007.

Web links and Video Lectures (e-Resources)

1. https://www.coursera.org/?utm_sourcewEB
2. https://swayam.gov.in/?utm_source
3. https://nptel.ac.in/?utm_source

Course Outcomes	Programme Outcomes											Program Specific Outcomes (PSOs)		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**
CO1	**3** (WK1, WK2,WK3 WK4)	**2** (WK1, WK2,WK3 WK4)	1 (WK5)	-	-	1 (WK1WK5, and WK7)	1(WK9)	-	1	-	2 (WK8)	2	3	2
CO2	**3** (WK1, WK2,WK3 WK4)	**3** **(** WK1, WK2,WK3 WK4)	**3** (WK5)	2(WK8)	2 (WK2 and WK6)	3 (WK1, WK5, and WK7)	1(WK9)	1	1	1	2 (WK8)	2	3	2
CO3	2 (WK1, WK2,WK3 WK4)	**3** **(** WK1, WK2,WK3 WK4)	2 (WK5)	**3**(WK8)	**3** WK2 and WK6)	3 (WK1, WK5, and WK7)	1(WK9)	2	**3**	1	2 (WK8)	2	3	3
CO4	2 (WK1, WK2,WK3 WK4)	2 **(** WK1, WK2,WK3 WK4)	**3** (WK5)	2(WK8)	2 WK2 and WK6)	3 (WK1WK5, and WK7)	2(WK9)	**2**	**2**	**3**	**3** (WK8)	2	3	3

	Course Code	:	22UBT743E	Clinical Research	Semester	:	7
	L:T:P	:	3:0:0		Course Type	:	PEC
Hours/Sem.	Teaching	:	42 Hrs.		CIE Marks	:	50
	Learning (TW+SL)	:	42 Hrs.		SEE Marks	:	50
	Exam	:	6 Hrs.		Total Marks	:	100
	Total Hrs.	:	90 Hrs.		Credits	:	3

Professional Competency:

Demonstrate the ability to understand therapeutic products, Analyze pharmaceutical marketing strategies, Apply principles of pharmaceutical research, drug regulation and epidemiological principles and interpret study designs.

Course Outcomes:

After completion of the course, student will be able to:

1. Exploit the knowledge to know the clinical importance of different therapeutic products and identify formulations, manufacturing and supply of materials
2. Study the philosophy behind organization of research Ability to understand control measures used in drug and its control.
3. Elucidate the marketing strategies of pharma products and compare the social and ethical issues.
4. Inculcate the epidemiology study designs, case reports and case series

UNIT-I **12 Hrs.**

INTRODUCTION

The philosophy behind organization of research. Disease target identification and selection. Patenting new active substances. Receptor-based approaches, agonists, antagonists, enzyme inhibitors. Lead optimization and candidate selection of molecules for exploratory human investigation. In vitro and In vivo testing of new compounds Relationship between animal and human pharmacology.

CLINICAL PHARMACOLOGY

Pre-clinical development to support testing in humans. Safety testing, Pharmaceutical development -formulations, manufacture and supply of materials, labeling and presentation, stability and storage, purity, compatibility, disposal; Concepts of Pharmacovigilance

UNIT-II **10 Hrs.**

THERAPEUTICS

Clinical importance of Therapeutic Proteins, Antibodies, Enzymes; Hormones and Growth Factors, Interferon's, Interleukins and Additional Regulatory Factors.

MANAGEMENT OF DRUGS

Management of common acute and chronic diseases. Major drug classes including biologicals. Measurement of drug effects Adverse drug reactions (short term & long term). Benefit and risk, Drug interactions; Prescribing for particular populations . Controlled drugs and drug dependence, Over dosage and treatment of poisoning. Patient compliance and information, Therapeutic Drug Monitoring.

UNIT-III **10 Hrs.**

HEALTHCARE MARKETPLACE

National and local formularies. Product information (Generic v/s Rx), advertising and claims Product support and promotion Product life-cycle management Product liability Codes of practice including the MHRA Blue Principles of health economics Pharmacoepidemiology Competition, in-licensing, co-marketing.

SOCIAL, ETHICAL ISSUES

patents and copyrights. Social-genetic discrimination: insurance and employment, human cloning, foeticide, sex determination. Ethical: somatic and germ line gene therapy, clinical trials, the right to information, ethics committee function. Preservation and clinical use of blood and blood components.

UNIT-IV	10 Hrs.

CLINICAL RESEARCH Types of Epidemiology study designs, ecological (correlation) studies, Case reports and case series, prevalence surveys or cross-sectional studies, case control studies, Clinical Trials, Small Clinical Trials, Placebo Responses in Clinical Trials, Large Clinical Trials and Registries – Clinical Research Institutes, Data **Management in Clinical Research:** General Principles and Guide to Sources, Clinical Research from Pharmaceutical Industry Perspective.

Text Books:

1. Gary Walsh., Biochemistry and Biotechnology, 2002, John Wiley & Sons Ltd.
2. Gallin and . J. I. Ognibene F. P, 2007 Principles and Practice of Clinical Research by, 2nd Edition, Elsevier Publication

Reference Books:

1. William J. Williams, Ernest Beutler, Allan JU. Erslev, Marshall A. Lichtman,2005, Hematology
2. John Wiley & Sons Ltd by Arunabha Ray & Kavitha Gulati, 2007,Current Trends in Pharmacology IK Intl.

Web links and Video Lectures (e-Resources)

Course Outcomes	Programme Outcomes											Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
CO1	1 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	3 (WK5)	-	2 (WK2 and WK6)	-	2 (WK9)	1	-	-	2 (WK8)	2	2	1
CO2	1 (WK1, WK2, WK3, and WK4)	2 (WK1, WK2, WK3, and WK4)	3 (WK5)		1 (WK2 and WK6)		2 (WK9)	1			3 (WK8)	3	1	1
CO3	1 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	3 (WK5)	-	1 (WK2 and WK6)	-	1 (WK9)	1	-	-	2 (WK8)	2	1	1
CO4	1 (WK1, WK2, WK3, and WK4	3 (WK1, WK2, WK3, and WK4)	3 (WK5)	-	1 (WK2 and WK6)	-	2 (WK9)				3 (WK8)	3	3	3

	Course Code	:	22UBT744E	Pharmaceutical BT	Semester	:	07
	L:T:P	:	3:0:0		Course Type	:	PEC
Hours/Sem.	Teaching	:	42 Hrs		CIE Marks	:	50
	Learning (TW+SL)	:	42 Hrs		SEE Marks	:	50
	Exam	:	06 Hrs		Total Marks	:	100
	Total Hrs.	:	90 Hrs		Credits	:	03

Professional Competency:

Develop the knowledge and skills to apply biotechnological principles, molecular techniques, and bioprocess technologies for the development, production, quality evaluation, and regulatory compliance of biopharmaceutical products while adhering to ethical and biosafety standards.

Course Outcomes:

After completion of the course, student will be able to:

CO1: Apply the basics of biology in drug discovery, drug formulation and analyze the Pharmacokinetics and Pharmacodynamics parameters of drugs along with drug metabolism in drug development.

CO2: Select and apply the knowledge of the techniques used in the manufacture of pharmaceutical products in the field of Biopharmaceuticals.

CO3: Select and apply appropriate techniques and advanced techniques in drug delivery system and understand the role of biotherapeutics and stem cells in Biopharmaceuticals.

CO4: Demonstrate an ability to apply principles of Pharmaceutical Biotechnology to protect the global community from various dreadful diseases.

UNIT-I **10 Hrs.**

Introduction:

Introduction to Pharmaceutical Biotechnology, History of Pharmaceutical Industry. Drug design and development process, Fundamental principles and processes involved in preclinical and clinical development of a chemical or biological entity. Orphan drugs, Provisions for and use of unlicensed medicines, Drug abuse and dependence, Prescriptional and Non-prescriptional drugs.

Drug metabolism:

Evolution of Drug Metabolism as a Science, Phase I Metabolism (microsomal oxidation, Reduction, Hydrolysis), Phase II Metabolism (Drug conjugation reactions). Pharmacodynamics and Pharmacokinetics of drugs.

UNIT-II **11 Hrs.**

Toxicology:

Branches of Toxicology-In vivo toxicity tests- Acute, Sub acute and chronic toxicity tests.

Manufacturing principles and formulations:

Tablets-Types of tablets, Role and composition of tablets, Preformulation of tablets-organoleptic, physical properties, compressibility and flowability, evaluation of tablets-hardness, disintegration, and friability. Preparation of tablets-Granulation and compression method, Tablet coating and its applications, Parental preparations, herbal extracts, Oral liquids, Ointments, Quality control, storage and stability of biotech products. Short study of current biotech products. Adverse drug reactions.

UNIT-III **11 Hrs.**

Biosimilars:

Biosimilars, Characteristic of high selling peptides and proteins. Therapeutics Based on Biotechnology- Hematopoietic growth factor and Tissue plasminogen activators, Interferons and Hepatitis B vaccine.

Stem cells and tissue engineering:

stem cells-types of stem cells, embryonic stem cells, adult stem cells ,Tissue engineering, Cells as Therapeutic Agents for tissue defects, artificial liver and pancreas.

Drug delivery system:

Delivery of biopharmaceuticals-Use of Artificial Intelligence in drug delivery, , Advanced drug Delivery Systems,

Liposomes and Nanoparticles Drug Delivery System, Hydrogel based Drug Delivery System.

UNIT-IV **10 Hrs.**

Analysis of biologicals & pharmaceuticals:

Vitamins Cold remedies Laxatives Analgesics, NSAID, antiseptics, Antacids, Antibiotics and Biologicals. Packaging techniques – Glass containers, plastic containers, film wrappers and bottle seals.

Advanced pharmacology:

Introduction to pharmaceutical chemistry, classification of drugs based on therapeutic actions using suitable examples. Antineoplastic agents, Immunomodulators, Heavy metals and heavy metal antagonists, Therapeutic gases. Free radical biology and antioxidants.

Text Books:

1. Gary Walsh, Biopharmaceuticals Biochemistry and Biotechnology (2nd Edition), Wiley Publishers, 2013,
2. Bartram Katzung, Basic & Clinical Pharmacology (9th Edition), McGrawHill, 2009
3. Leon Lachman, Herbert. Lieberman & Joseph Kanig, Vergese, The Theory & Practice of Industrial Pharmacy, (3 rd Edition), Publishing House Bombay. 1987

Reference Books:

1. Pharmaceutical Biotechnology by K Sambamurthy & Ashutosh Kar, New Age, 2006.
2. Pharmaceutical Biotechnology by S P Vyas and V K Dixit, CBS Publishers, 2007
3. Hematology, William J. Williams, Ernest Beutler, Allan JU. Erslev, Marshall A. Lichtman

Course Outcomes	Programme Outcomes											Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
CO1	2 (WK1, WK2,WK3 WK4)	3 (WK1, WK2,WK3 WK4)	2 (WK5)	2(WK8)	2 (WK2 and WK6)	3 (WK1, WK5, and WK7)	1(WK9)	-	-	1(WK8)	3	3	3	2
CO2	2 (WK1, WK2,WK3 WK4)	2(WK1, WK2,WK3 WK4)	2 (WK5)	2(WK8)	3 (WK2 and WK6)	3 (WK1, WK5, and WK7)	2(WK9)	-	-	2(WK8)	2	3	3	2
CO3	2 (WK1, WK2,WK3 WK4)	3(WK1, WK2,WK3 WK4)	3 (WK5)	2(WK8)	3(WK2 and WK6)	3 (WK1, WK5, and WK7)	2(WK9)	-	-	2(WK8)	3	3	3	3
CO4	2(WK1, WK2,WK3 WK4)	3(WK1, WK2,WK3 WK4)	3 (WK5)	1(WK8)	2(WK2 and WK6)	3 (WK1, WK5, and WK7)	3(WK9)	-	-	2	2	3	3	3

	Course Code	:	22UBT704L	Upstream Process and Bioseparation Techniques Lab	Semester	:	07
	L:T:P	:	0:0:2		Course Type	:	PCCL
Hours/Sem.	Teaching	:	26 Hrs.		CIE Marks	:	50
	Learning (TW+SL)	:	00 Hrs.		SEE Marks	:	50
	Exam	:	4 Hrs.		Total Marks	:	100
	Total Hrs.	:	30 Hrs.		Credits	:	01

Professional Competency:

Ability to systematically execute, analyze, and simulate an end-to-end industrial bioprocess—seamlessly linking raw upstream kinetic profiles and biological fermentations to rigid downstream extraction and analytical validation

Course Outcomes:

After completion of the course, student will be able to:

CO1: Fermentation Kinetics & Primary Processing: Execute batch cultivation runs (such as ethanol and citric acid production via Aspergillus niger) to quantify microbial growth, thermal death, and substrate-utilization kinetics, and estimate fundamental Monod parameters. (Bloom's Level: Evaluate)

CO2: Primary Recovery & Phase Extraction: Apply mechanical cell disruption, cross-flow filtration, and centrifugation to clarify crude broths, and implement fractional precipitation or liquid-liquid / aqueous two-phase extraction (ATPS) to capture raw target fractions. (Bloom's Level: Apply)

CO3: High-Resolution Analytics & Product Stabilization: Formulate customized sublimation cycles for the lyophilization of biological samples, and resolve product purity and yield parameters from fermented broth using analytical HPLC / GC configurations. (Bloom's Level: Create / Analyze)

CO4: Computer-Aided Process Simulation: Construct integrated, economically viable bioprocess flowsheets and model unit operation performance constraints inside industrial software environments like SuperPro Designer. (Bloom's Level: Create)

LIST OF EXPERIMENTS	26 per batch Hrs.

1. Microbial Growth kinetics and Estimation of Monod parameters in Batch Bioreactor/Batch culture.
2. Microbial Death Kinetics during the sterilization process.
3. Production and estimation of citric acid from Aspergillus niger.
4. Preparation and production of ethanol in a fermenter: Study of growth, product formation, and substrate utilization.
5. Bioprocess Modeling using SuperPro Designer: Flow sheeting of the Bioprocess using SuperPro Designer, Design of various Bioreactors using SuperPro Designer.
6. Solid-liquid separation method: Removal of Intracellular Proteins by cell disruption methods.
7. Solid-liquid separation method: Separation of biomass and extracellular components by Filtration (cross-flow) and Centrifugation.
8. Product enrichment operations: Precipitation of a bioproduct from crude solution or the extract.
9. Product enrichment operations: Liquid-liquid and Aqueous two – phase extraction of bio-products from biological sources.
10. Extraction and estimation of bioactive compounds from natural sources.
11. Lyophilization of any bioproduct
12. Separation and estimation of ethanol or citric acid from fermented broth.
13. Analysis of biomolecules/bioactive compounds by HPLC / GC

Open Ended Experiment(s) OR Open Ended Program(s)

Separation and Purification of bioactive compounds/proteins/Enzymes any other products different sources

Reference Books:

1. Bioseparations Science and Engineering: Authors: Roger G. Harrison, Paul W. Todd, Scott R. Rudge, and Demetri P. Petrides (Oxford University Press).
2. Laboratory Manual in Bioprocess Engineering: Author: N. Shanthi (MJP Publishers).

3. Protein Purification Protocols: Editor: Paul Cutler (Humana Press / Methods in Molecular Biology series)
4. Bioprocess Engineering: Basic Concepts Authors: Michael L. Shuler, Fikret Kargi, and Matthew DeLisa (Prentice Hall).

Bioprocess Engineering Principles Author: Pauline M. Doran (Academic Press).

Web links and Video Lectures (e-Resources)

1. Practical Industrial Handbooks & Methodologies Cytiva (GE Healthcare) Protein Purification Handbooks
2. Lyophilization Technology Application Notes (SP Scientific / Labconco)

Course Outcomes	Programme Outcomes											Program Specific Outcomes (PSOs)		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**
CO1	3 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	2 (WK5)	2 (WK 8)	2 (WK2, WK6)	1 (WK1, WK5, WK7)	-	-	-	-	1 (WK8)	2	3	-
CO2	3 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	2 (WK5)	2 (WK 8)	1 (WK2, WK6)	1 (WK1, WK5, WK7)	-	-	-	-	1 (WK8)	2	3	-
CO3	3 (WK1, WK2, WK3, and WK4)	2 (WK1, WK2, WK3, and WK4)	3 (WK5)	3 (WK 8)	3 (WK2, WK6)	-	-	-	-	-	2 (WK8)	2	3	1
CO4	3 (WK1, WK2, WK3, and WK4)	2 (WK1, WK2, WK3, and WK4)	3 (WK5)	2 (WK 8)	1 (WK2, WK6)	2 (WK1, WK5, WK7)	1 (WK 9)	-	-	2	1 (WK8)	2	3	2

	Course Code	:	22UBT705P	**Project**	Semester	:	07
	L:T:P	:	0-0-2		Course Type	:	PP
Hours/Sem.	Teaching	:	-		CIE Marks	:	50
	Learning (TW+SL)	:	-		SEE Marks	:	50
	Exam	:	4Hrs		Total Marks	:	100
	Total Hrs.	:	240Hrs		Credits	:	8

Professional Competency:

Apply biotechnological knowledge, research methodology, ethical practices, and scientific communication skills to independently design, execute, analyze, and present research or industry-oriented projects that address real-world biotechnology challenges.

Course Outcomes:

After completion of the course, student will be able to:

CO1 Able to improve industrial processes using biotechnological methods.

CO 2. Able to demonstrate an awareness of ethical issues associated with their chosen field of research.

CO 3. Able to apply the knowledge in field of design, record, analyze and economics of project.

CO 4. Able to develop and demonstrate the ability to effectively communicate written and oral presentations to a scientific audience.

Course Outcomes	Programme Outcomes											Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
CO1	3 (WK1, WK2, WK3, and WK4	3 (WK1, WK2, WK3, and WK4	3 (WK5)	3 (WK8)	3 (WK2 and WK6)	3 (WK1,WK 5 & WK7)	2 (WK9)	2	2	3	2 (WK8)	3	3	3
CO2	3 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	3 (WK5)	3 (WK8)	3 (WK2 and WK6)	2 (WK1,WK 5 & WK7)	3 (WK9)	2	2	3	3 (WK8)	3	3	3
CO3	3 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	3 (WK5)	3 (WK8)	3 (WK2 and WK6)	2 (WK1, WK5 & WK7)	3 (WK9)	3	2	2	2 (WK8)	3	3	3
CO4	3 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	3 (WK5)	3 (WK8)	3 (WK2 and WK6)	3 (WK1,WK 5 & WK7)	3 (WK9)	3	2	2	3 (WK8)	3	3	3

Course Code	:	**22UBT801I**	**Internship**	**Semester**	:	**08**
L:T:P	:	**0-0-2**		**Course Type**	:	**Int**
Hours/Sem. **Teaching**	:	**-**		**CIE Marks**	:	**50**
Learning (TW+SL)	:	**-**		**SEE Marks**	:	**50**
Exam	:	**6Hrs**		**Total Marks**	:	**100**
Total Hrs.	:	**300 Hrs**		**Credits**	:	**10**

Professional Competency:

Develop professional competence by applying biotechnology knowledge and engineering skills in an industrial or research environment while demonstrating ethical practices, teamwork, communication, and problem-solving abilities

Course Outcomes:

After completion of the course, student will be able to:

CO1: Apply biotechnology principles and engineering knowledge to understand industrial processes, equipment, and standard operating procedures in a professional workplace.

CO2: Demonstrate technical skills by participating in laboratory, production, quality control, quality assurance, research, or related industrial activities while following safety and regulatory guidelines.

CO3: Analyze industrial practices, identify operational challenges, and propose feasible technical solutions using scientific and engineering approaches.

CO4: Prepare a comprehensive internship report and effectively communicate internship experiences through presentations, demonstrating professional ethics, teamwork, and lifelong learning.

Course Outcomes	**Programme Outcomes**											**Program Specific Outcomes (PSOs)**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**
CO1	3 (WK1 ,WK2, WK3,WK4)	2 (WK1 ,WK2, WK3WK4)	–	2 (WK8)	2 (WK2 and WK6)	-	2 (WK9)	1	–	–	2 (WK8)	2	3	2
CO2	2 (WK1 ,WK2, WK3,WK4)	2 (WK1 ,WK2, WK3WK4)	2 (WK5)	2 (WK8)	3 (WK2 and WK6)	2 (WK1,WK 5, and WK7)	2 (WK9)	2	2	–	2 (WK8)	2	3	2
CO3	2 (WK1 ,WK2, WK3,WK4)	3 (WK1 ,WK2, WK3WK4)	2 (WK5)	3 (WK8)	2 (WK2 and WK6)	1 (WK1, WK5, and WK7)	3 (WK9)	1	2	2	2 (WK8)	2	3	2
CO4	1 (WK1 ,WK2, WK3,WK4)	1 (WK1 ,WK2, WK3WK4)	–	–	–	–	3 (WK9	3	3	3	3 (WK8)	2	3	2