SEMESTER V

S. No.	Category	Course Code	Course Title	L	T	P	C
Theory							
1.	HS	BA23151	Entrepreneurship Development	3	0	0	3
2.	PC	BT23501	Bioprocess Principles	3	0	0	3
3.	PC	BT23502	Genetic Engineering	3	0	0	3
4.	PC	BT23503	Biochemical Thermodynamics	3	0	0	3
5.	PC	BT23504	Immunology	3	0	0	3
6.	PE	BT23*5*	Professional Elective I	3	0	0	3
Practical							
7.	PC	BT23505	Genetic Engineering Laboratory	0	0	4	2
8.	PC	BT23506	Immunology Laboratory	0	0	2	1
9.	EE	BT23507	Industrial Training I	0	0	2	1
10.	GE	GE23501	Professional Development III	0	0	2	1
Total				**18**	**0**	**10**	**23**

PAVAI ENGINEERING COLLEGE, NAMAKKAL
Approved
BOARD OF STUDIES
BIOTECHNOLOGY
20/6/24
AUTONOMOUS

PROFESSIONAL ELECTIVE COURSES – VERTICALS							
VERTICAL I – BIOPROCESS TECHNOLOGY							
S. No.	**Category**	**Course Code**	**Course Title**	**L**	**T**	**P**	**C**
1.	PE	BT23151	Fermentation Engineering	3	0	0	3
2.	PE	BT23152	Bioreactor Design and scaleup process	3	0	0	3
3.	PE	BT23153	Bioprocess Control and Instrumentation	3	0	0	3
4.	PE	BT23154	Transport Phenomena in Biological Systems	3	0	0	3
5.	PE	BT23155	Bioprocess Modelling and Simulation	3	0	0	3
6.	PE	BT23156	Bioprocess equipments and Plant Design	3	0	0	3
7.	PE	BT23157	Chemical Reaction Engineering	3	0	0	3
VERTICAL II – MEDICAL BIOTECHNOLOGY							
1.	PE	BT23251	Biosensors	3	0	0	3
2.	PE	BT23252	Forensic Science and Technology	3	0	0	3
3.	PE	BT23253	Vaccine technology	3	0	0	3
4.	PE	BT23254	Cancer Biology and Therapeutics	3	0	0	3
5.	PE	BT23255	Biomedical Engineering	3	0	0	3
6.	PE	BT23256	Bionanotechnology	3	0	0	3
7.	PE	BT23257	Tissue Engineering	3	0	0	3
VERTICAL III – AGRO BIOTECHNOLOGY							
1.	PE	BT23351	Plant Physiology and Abiotic Stress	3	0	0	3
2.	PE	BT23352	Therapeutic applications of Phytochemicals	3	0	0	3
3.	PE	BT23353	Mushroom Cultivation and Biofertilizer production	3	0	0	3
4.	PE	BT23354	Biotechnological Approach in Crop Improvement	3	0	0	3
5.	PE	BT23355	Advance Techniques in Agro Forestry	3	0	0	3
6.	PE	BT23356	Plant Tissue Culture and Transformation Techniques	3	0	0	3
7.	PE	BT23357	Fungal and Algal Technology	3	0	0	3

PROFESSIONAL ELECTIVE COURSES – VERTICALS							
VERTICAL IV – COMPUTATIONAL BIOTECHNOLOGY							
S. No.	**Category**	**Course Code**	**Course Title**	**L**	**T**	**P**	**C**
1.	PE	BT23451	Programming for Bioinformatics Applications	3	0	0	3
2.	PE	BT23452	Molecular Modelling	3	0	0	3
3.	PE	BT23453	Systems and Synthetic Biology	3	0	0	3
4.	PE	BT23454	Fundamentals of Algorithms for Bioinformatics	3	0	0	3
5.	PE	BT23455	Artificial Intelligence for Biotechnology	3	0	0	3
6.	PE	BT23456	Internet of Things in Biotechnology	3	0	0	3
7.	PE	BT23457	Data Mining and Machine Learning Techniques for Bioinformatics	3	0	0	3
VERTICAL V– ANIMAL BIOTECHNOLOGY							
1.	PE	BT23551	Animal Biotechnology	3	0	0	3
2.	PE	BT23552	Animal Health and Nutrition	3	0	0	3
3.	PE	BT23553	Developmental Biology	3	0	0	3
4.	PE	BT23554	Animal Cell Culture Technology	3	0	0	3
5.	PE	BT23555	Advances in Animal Biotechnology	3	0	0	3
6.	PE	BT23556	Biotechniques in Animal Breeding	3	0	0	3
7.	PE	BT23557	Stem Cell Technology	3	0	0	3
VERTICAL VI- BIO REGULATORY AFFAIRS							
1.	PE	BT23651	Clinical Trials and Health care policies in Biotechnology	3	0	0	3
2.	PE	BT23652	Biotechnological products and its validation	3	0	0	3
3.	PE	BT23653	Quality assurance and quality control in Biotechnology	3	0	0	3
4.	PE	BT23654	Bioentrepreneurship and patent design	3	0	0	3
5.	PE	BT23655	Intellectual property rights in Biotechnology	3	0	0	3
6.	PE	BT23656	Clinical Database Management	3	0	0	3
7.	PE	BT23657	Biosafety and Hazard Management	3	0	0	3

BA23151	ENTREPRENEURSHIP DEVELOPMENT	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	empower to adopt the management principles.
2	build entrepreneurial competencies and analyze support from government and agencies in entrepreneurship development.
3	appraise factors for launching a small business.
4	adopt business opportunities and prepare feasibility reports.
5	develop entrepreneurial mindset, creativity, and understand startup ecosystems.

UNIT I	BASICS OF MANAGEMENT AND ENTREPRENEURSHIP	9

Management: Meaning, Definition, Nature and Importance, Roles - Levels of Management - Functional areas of Management: Marketing, Finance, Production, HRM, IT, Research and Development. Introduction to Entrepreneurship and Intrapreneurship – similarities, differences, types of entrepreneurs - Functions of an entrepreneur

UNIT II	ENTREPRENEURIAL COMPETENCE AND ENVIRONMENT	9

Entrepreneurial Competence: Definitions, Roles, Styles, Characteristics, Competencies

Entrepreneurial Environment: Socio-cultural, Economic, Political factors; Institutional Support for small entrepreneurs. Central and State Government Industrial Policies and Regulations - Entrepreneurial Skillset: motivation, stress, ethical challenges

UNIT III	ENTREPRENEURIAL DEVELOPMENT AND STRUCTURES	9

Ownership Structures: Proprietorship, Partnership, Company, Cooperative, Franchise. Business Opportunity Identification, Feasibility Report, Financial and Technical Evaluation. Entrepreneurial Development Programs, Role of SSI, Failure Causes and Turnaround Strategies. Creativity techniques: Six Thinking Hats, Idea validation, Lean Canvas model.

UNIT IV	BUSINESS PLAN AND FUNDING STRATEGIES	9

Business Plan: Business opportunities-SWOT, Business plan process, Feasibility Study - AI in business plan preparation.

Financing ventures: sources of raising capital, seed funding, venture capital funding, funding opportunities for start-ups in India, - AI driven startup evaluation and scoring -Pitching, funding mix (debt vs equity), incubators, accelerators, crowd funding, angel investors.

UNIT V	WOMEN ENTREPRENEURSHIP AND SECTORAL OPPORTUNITIES	9

Women Entrepreneurship: Growth, Challenges, development, Strategic planning and growth for startups – Women Entrepreneurship Platform in India – Entrepreneurial schemes for women – SSI and MSME.

Entrepreneurship in Formal Sector: AI in Rural, Agriculture, Tourism, Manufacturing, Healthcare, Transport and allied services. Digital economy tools: social media marketing, affiliated marketing, influential marketing, mobile marketing.

	TOTAL PERIODS	45

COURSE OUTCOMES		
At the end of this course, students will be able to		**BT Mapped (Highest Level)**
CO1	implement the necessary managerial skills to become an entrepreneur	Applying (K3)
CO2	develop self-employment having been exposed to entrepreneurial environment.	Synthesis (K5)
CO3	select a best business idea by using appropriate methods to assess its viability	Knowledge(K1)
CO4	formulate a business plan and deploy the resources for sustainable growth	Synthesis (K5)
CO5	analyze government support systems and startup ecosystem resources like incubators and funding options..	Analyzing (K4)

TEXT BOOKS

1. Entrepreneurship: Theory, Process, and Practice By Donald F. Kuratko 11th Edition, 2021, Cengage Learning.
2. Entrepreneurship Development: New Venture CreationBy S.S. Khanka 6th Edition, 2021, S. Chand Publishing.

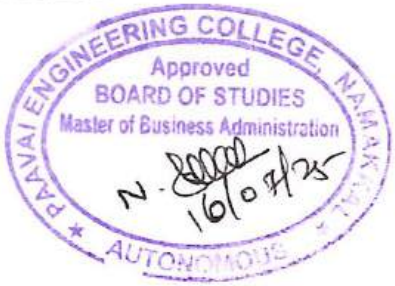
REFERENCE BOOKS

1. Entrepreneurship Development, by Sharma Sangeeta Second Edition, 2020, PHI Learning.
2. Entrepreneurship by Rajeev Roy Second Edition, 2011, Oxford University Press.
3. The Startup Owner's Manual: The Step-By-Step Guide for Building a Great Company, By Steve Blank and Bob Dorf, 2020 Edition.
4. Entrepreneurship: Starting and Operating A Small Business, By Steve Mariotti and Caroline Glackin, 7th Edition, 2021, Pearson

CO-PO MAPPING :

Mapping of Course Outcome (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes PSO's (1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak

CO's	Programme Outcomes(POs)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	-	1	-	1	-	-
CO2	-	-	-	-	1	2
CO3	-	-	-	1	-	1
CO4	-	-	2	-	2	-
CO5	1	-	1	-	2	-



BT23501	BIOPROCESS PRINCIPLES	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	explain the historical and modern developments in fermentation processes.
2	discuss the significance of medium formulations and analyze strategies for their optimization.
3	impart the knowledge on design and operation of fermentation processes with all its prerequisites.
4	illustrate the fundamental principles of microbial kinetics, metabolic stoichiometry, and energetics.
5	interpret the kinetics of microbial growth using appropriate models.

UNIT I OVERVIEW OF FERMENTATION PROCESSES 9

Outline of bioprocess, various (upstream and downstream) unit operations involved in bioprocesses; Components and functions of a bioreactor, main parameters to be monitored and controlled in fermentation processes; Different types of bioreactors used in fermentation processes; AI-based Monitoring and Control Systems.

UNIT II RAW MATERIALS AND MEDIA DESIGN FOR FERMENTATION 9

Criteria for good medium, medium requirements for fermentation processes, carbon, nitrogen, minerals, vitamins and other complex nutrients, oxygen requirements; Medium formulation of optimal growth and product formation; Examples of simple and complex media; Design of various commercial media for industrial fermentations, medium optimization methods; AI-driven Media Optimization, Big Data and AI in Substrate Selection.

UNIT III STERILIZATION KINETICS 9

Thermal death kinetics of microorganisms; The design of batch sterilization process; Sterilization of the fermenter, feeds, liquid wastes; Batch and continuous heat sterilization of liquid media, filter sterilization of liquid media, Filter sterilization of air; Design of batch and continuous sterilization equipment.

UNIT IV METABOLIC STOICHIOMETRY AND ENERGETICS 9

Stoichiometry of cell growth and product formation, elemental balances, degrees of reduction of substrate and biomass, available electron balances, yield coefficients of biomass and product formation, maintenance coefficients; Energetic analysis of microbial growth and product formation, oxygen consumption and heat evolution in aerobic cultures; Thermodynamic efficiency of growth.

UNIT V KINETICS OF MICROBIAL GROWTH AND PRODUCT FORMATION 9

Batch cultivation and continuous cultivation; Simple unstructured models for microbial growth, Monod model, growth of filamentous organisms, product formation kinetics – Leudeking-Piret models; Substrate and product inhibition on cell growth and product formation; Biomass estimation – Direct and Indirect methods; Artificial Intelligence for fermentation optimization.

TOTAL PERIODS 45

COURSE OUTCOMES		
At the end of this course, the students will be able to		**BT MAPPED (Highest Level)**
CO1	explain the steps involved in a fermentation process and describe the parts and types of bioreactors.	Understanding (K2)
CO2	describe how sterilization works and compare sterilization processes for liquids and air in fermentation.	Understanding (K2)
CO3	identify the important nutrients in a fermentation medium and prepare media that supports good microbial growth and product formation.	Applying (K3)
CO4	use basic formulas to calculate cell growth, energy use, and product formation in microbial processes.	Applying (K3)
CO5	apply models like the Monod and Leudeking-Piret equations to understand microbial growth and product formation.	Applying (K3)

TEXT BOOKS

1. Shuler ML, Kargi F, DeLisa MP, "Bioprocess Engineering: Basic Concepts", 3rd Edition, Prentice Hall, 2017.
2. Doran PM, "Bioprocess Engineering Principles", 2nd Edition, Elsevier Science, 2013.

REFERENCES

1. Stanbury PF, Whitaker A, Hall SJ, "Principles of Fermentation Technology", Second Edition, Elsevier, 2016.
2. Bailey JE, Ollis DF, "Biochemical Engineering Fundamentals", 2nd Edition, McGraw-Hill, 2017.
3. Crueger, Wulf, Anneliese Crueger, K R Aneja, "Biotechnology: A Textbook of Industrial Microbiology", 3rd Edition, MedTech, 2017.
4. Pirt SJ, "Principles of Microbe and Cell Cultivation", 1st Edition, Blackwell Scientific Publications, 1975.

CO/PO-MAPPING:

Mapping of Course Outcome (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes PSO's
(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak

CO's	PO's												PSO's	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	2	1	-	-	-	-	-	-	1	-	-	3	2
CO2	3	2	2	-	-	-	-	-	-	1	-	-	3	2
CO3	3	3	2	-	-	-	-	-	-	1	-	-	3	3
CO4	3	3	3	-	-	-	-	-	-	1	-	-	3	3
CO5	3	3	3	2	-	-	-	-	-	1	-	-	3	3

BT23502	GENETIC ENGINEERING	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	understand the basics of various enzymes used in genetic engineering.
2	explain the biology of cloning and expression vectors for gene transfer.
3	determine the strategies involved in the construction of genomic, cDNA and other libraries.
4	apply the fundamentals of tools and techniques involved in genetic engineering.
5	employ the application of genetic engineering in various fields.

UNIT I **ENZYMES USED IN GENETIC ENGINEERING** **9**

Nuclease- exonucleases and endonucleases; Restriction enzymes- nomenclature, types, applications; Restriction endonucleases- blunt and sticky ends; RNases, DNA Ligase, Polymerases; DNA Modifying enzymes- alkaline phosphatase, polynucleotide kinase and terminal deoxynucleotidyl transferase.

UNIT II **BIOLOGY OF CLONING AND EXPRESSION VECTORS** **9**

Characteristics of cloning vectors, pBR322 plasmid, PUC; λ Vectors, M13 Vectors, Shuttle vectors; Cosmids; Phagemids; Artificial Chromosomes - YAC, PAC, BAC, HAC; Expression Vectors, Insect, Yeast and Mammalian Vectors, Viral vectors - SV 40, Adenovirus and Retrovirus.

UNIT III **CONSTRUCTION OF LIBRARIES** **9**

Linkers, adaptors and homopolymer tailing; Construction of genomic library; cDNA construction- hairpin loop strategies; Directional and non-directional cDNA synthesis; Construction of full-length cDNA library- Oligo capping; Okayama and Berg method of cDNA cloning; Screening of libraries.

UNIT IV **TECHNIQUES FOR GENETIC ENGINEERING** **9**

Polymerase Chain Reaction (PCR), Types of PCR – RTPCR, Colony PCR, Inverse PCR, Nested PCR; RAPD; RFLP; Molecular beacons and Taqman assay; Nucleic acid sequencing; Southern and Northern blotting; Gene transfer technologies.

UNIT V **APPLICATIONS OF GENETIC ENGINEERING** **9**

Gene therapy- Ex-vivo and In-vivo; Genetic engineering in medicine- recombinant therapeutics and biopharmaceuticals, antibiotics, vaccines; Genetic engineering in agriculture- bio pesticides, herbicides; Applications of genetic engineering in environment- bioremediation or environmental clean-up; The role of AI in Genetic Engineering.

TOTAL PERIODS **45**

COURSE OUTCOMES

At the end of this course, the students will be able to		**BT MAPPED (Highest Level)**
CO1	comprehend the restriction and modification system and their role in genetic engineering.	Understanding (K2)
CO2	recognize the cloning vectors used in manipulation of genes.	Applying (K3)

CO3	examine the strategies involved in gene cloning and methods involved in screening of cloned genes to identify the target gene.	Applying (K3)
CO4	illustrate the PCR and sequencing based techniques involved in genetic manipulation.	Understanding (K2)
CO5	apply the genetic engineering in medicine, agriculture and environment.	Applying (K3)

TEXT BOOKS

1. Old RW, Primrose SB, Twyman RM, "Principles of Gene Manipulation - An Introduction to Genetic Engineering", 6th Edition, Wiley-Blackwell, 2006.
2. Primrose SB, Twyman RB, "Principles ofGene Manipulation and Genomics", 7th Edition, Wiley-Blackwell, 2014.

REFERENCES

1. Ausubel, F. M., R. Brent, R. E. Kingston, D. D. Moore, J. G. Seidman, J. A. Smith, and K. Struhl. "Current protocols in molecular biology", John Wiley & Sons New York, 1998.
2. Brown, Hugh Alex, John Abelson, and Melvin I. Simon, "Methods in enzymology", Academic Press, 2007.
3. Green MR, Sambrook J, "Molecular Cloning: A Laboratory Manual", 4th Edition, CSHL Press,2012.
4. Brown TA, "Gene Cloning and DNA analysis: An introduction", 8th Edition, Wiley Blackwell, 2020.

CO/PO MAPPING :

Mapping of Course Outcome (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes PSO's

(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak

	PO's												PSO's	
CO's	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	2	1	2	2	-	-	-	-	-	-	3	2	2
CO2	3	3	2	2	2	-	-	-	-	-	-	2	2	2
CO3	3	3	3	3	2	-	-	-	1	-	-	3	2	2
CO4	3	2	2	2	3	-	-	-	-	1	-	3	2	2
CO5	3	3	3	3	3	2	2	-	2	-	-	3	2	3

BT23503	BIOCHEMICAL THERMODYNAMICS	3	0	0	3

COURSE OBJECTIVES	
To enable the students to	
1	understand the basic thermodynamic relations and properties of fluids.
2	analyze and interpret the partial molar properties and property change of mixing.
3	develop the ability to apply the concept of phase equilibria.
4	study the chemical reaction equilibrium and its applications.
5	compute the thermodynamic principles in bioengineering.

UNIT I	THERMODYNAMIC PROPERTIES OF FLUIDS	9

Basic concepts and Laws of thermodynamics: Basics of Entropy: Volumetric Properties of Fluids: Estimation of thermodynamic properties using equations of state: Calculations involving actual property changes: Maxwell's relations and applications.

UNIT II	SOLUTION THERMODYNAMICS	9

Partial molar properties: concepts of chemical potential and fugacity: ideal and non-ideal solutions: concepts and applications of excess properties of mixtures: activity coefficient: composition models: Gibbs-Duhem equation.

UNIT III	PHASE EQUILIBRIUM SYSTEMS	9

Criteria for phase equilibria: VLE calculations for binary and multi component systems: liquid-liquid equilibria and solid-solid equilibria.

UNIT IV	CHEMICAL REACTION EQUILIBRIA	9

Chemical Reaction Equilibrium - evaluation of equilibrium constant: effect of temperature and pressure on equilibrium constant: Equilibrium conversion and yields for single and multiple reactions.

UNIT V	BIOCHEMICAL THERMODYNAMICS	9

Thermodynamics of microbial growth stoichiometry, thermodynamics of maintenance. Calculation of the operational stoichiometry of a growth process at different growth rates. Herbert-Pirt relation for electron donor, thermodynamics and stoichiometry of product formation: Integrating AI into thermodynamics.

TOTAL PERIODS	45

COURSE OUTCOMES		
At the end of this course, the students will be able to		**BT MAPPED (Highest Level)**
CO1	demonstrate an understanding of the first and second laws of thermodynamics and their applications in biochemical systems	Understanding (K2)
CO2	understand and apply the concepts of phase equilibria, and solution thermodynamics to analyse real-world biological systems.	Understanding (K2)
CO3	interpret the criteria of phase equilibria for single and multi component systems.	Applying (K3)

CO4	apply the concept of chemical reaction equilibria and equilibrium conversion.	Applying (K3)
CO5	use thermodynamic principles to optimize and design microbial processes in biotechnology, including energy balances and maintenance calculations.	Applying (K3)

TEXT BOOKS

1. Smith JM, Van Ness HC, and Abbot MM "Introduction to Chemical Engineering Thermodynamics", 8th Edition, Tata McGraw-Hill, 2019.
2. Gavhane KA, "Chemical Engineering Thermodynamics – I (SI Units)", 6thEdition, Nirali Prakashan, 2020.

REFERENCES

1. Christiana D. Smolke, "The Metabolic Pathway Engineering Handbook Fundamentals", CRC Press Taylor & Francis Group, 2010.
2. Sandler, Stanley I, "Chemical, biochemical, and engineering thermodynamics", John Wiley & Sons, 2017.
3. Elias I. Franses, "Thermodynamics with Chemical Engineering Applications",Cambridge University Press, 1stedition, 2014.
4. Kevin D Dahm, Donald P Visco, "Fundamentals of Chemical Engineering Thermodynamics", Routledge, Taylor & Francis Group, 2015.

CO/PO MAPPING :

CO/PO Mapping

(3/2/1 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak

	PO's												PSO's	
CO's	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	2	2	3	2	1	-	-	-	-	-	-	2	3	3
CO2	3	3	3	2	3	-	-	-	-	-	-	2	3	3
CO3	2	2	2	1	1	-	-	-	-	-	-	1	1	2
CO4	2	2	2	2	2	-	-	-	-	-	-	1	1	3
CO5	-	2	1	2	3	-	-	-	-	-	-	2	2	3

BT23504	IMMUNOLOGY	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	understand the structure, classification, and integration of the immune system.
2	gain the knowledge about development, activation, and regulation of immune responses.
3	learn the mechanisms of immunity against pathogens and tumors.
4	comprehend immune tolerance, hypersensitivity, autoimmunity, and transplantation immunology.
5	explore the immunological techniques for their applications in clinical and therapeutic fields.

UNIT I ORGANISATION OF IMMUNE SYSTEM **9**

Organisation and classification of immune system – immune cells and organs; innate and acquired immunity; Toll receptors and responses, classification of antigens – chemical and molecular nature; haptens, adjuvants; cytokines; complement pathway, antigen presenting cells; Major Histocompatibility Complex (MHC).

UNIT II HUMORAL AND CELLULAR IMMUNITY **9**

Development, maturation, activation, regulation, differentiation and classification of T-cells and B-cells, antigen processing and presentation, theory of clonal selection, TCR; Antibodies - structure and functions; Antibodies - genes and generation of diversity; Antigen- Antibody reactions.

UNIT III IMMUNITY AGAINST PATHOGENS AND TUMORS **9**

Inflammation; Protective immune responses to virus, bacteria, fungi and parasites; Tumor antigens, Tumor immune response, Tumor diagnosis, Tumor immunotherapy.

UNIT IV IMMUNE TOLERANCE AND HYPERSENSITIVITY **9**

Immune tolerance, Immuno deficiencies; Transplantation – Genetics of transplantation; Laws of transplantation; Allergy and hypersensitivity – Types of hypersensitivity, Autoimmunity, Autoimmune disorders and diagnosis.

UNIT V APPLIED IMMUNOLOGY **9**

Monoclonal Antibodies, Engineering of antibodies; T-Cell cloning - Classification of Vaccines, methods of vaccine development, immunodiagnostic methods (Immuno diffusion, ELISA, FACS), Immune modulatory drugs; Recent trends of AI in immunology.

TOTAL PERIODS **45**

COURSE OUTCOMES

At the end of this course, the students will be able to		**BT MAPPED (Highest Level)**
CO1	characterize the structure, functions and integration of immune system.	Understanding (K2)
CO2	elaborate the antigen-antibody interactions that offers defence mechanism.	Understanding (K2)

CO3	ascertain the immunoregulation in immunity development against pathogens.	Applying (K3)
CO4	identify, diagnose and evaluate theimmune tolerance and hypersensitivity.	Applying (K3)
CO5	employ the simple techniques to analyze cell and their morphology.	Applying (K3)

TEXT BOOKS

1. Peter J Delves, Seamus J Martin, Dennis R Burtn, Ivan M Roitt., "Roitts Essential Immunology", 13th Edition, Wiley –Blackwell, 2016.
2. Juditha Owen, Jenni Punt, Sharon A. Stranford, Kuby, "Immunology", Macmillan International, 7th Edition, 2012.

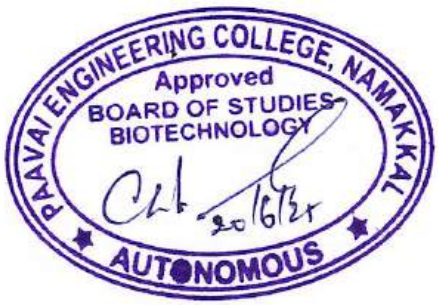
REFERENCES

1. Ashim K, Chakravarthy, "Immunology", Tata McGraw-Hill, 2006.
2. Coico, Richard, "Immunology: A Short Course", 6th Edition, John Wiley, 2008.
3. Khan, Fahim Halim, "Elements of Immunology", Pearson Education, 2009.
4. Robert R Rich, Thomas A Fleisher, William T Shearer, Harry Schroeder, Anthony J Frew, Cornelia Weyand M, "Clinical Immunology – Principles and Practice", Elsevier, 4th Edition, 2013

CO/PO MAPPING:

Mapping of Course Outcome (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes PSO's
(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak

	PO's												PSO's	
CO's	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	2	1	1	-	-	-	-	-	-	-	2	1	2
CO2	3	2	2	2	-	-	-	-	-	-	-	2	1	2
CO3	3	1	2	2	-	-	-	-	-	-	-	1	1	2
CO4	3	2	2	1	2	-	-	-	-	-	-	1	2	3
CO5	3	2	2	1	1	-	-	-	-	-	-	1	3	3



BT23505	GENETIC ENGINEERING LABORATORY	0	0	4	2

COURSE OBJECTIVES

To enable the students to

1	isolate and analyze proteins and nucleic acids using standard laboratory techniques.
2	perform DNA manipulation methods such as restriction digestion, ligation, and transformation.
3	apply gel electrophoresis, PCR, and Western blotting for separation, amplification, and detection.
4	use online bioinformatics tools for primer design and restriction mapping.

LIST OF EXPERIMENTS

1. Isolation of Plasmid DNA and analysis.
2. Agarose Gel Electrophoresis.
3. Restriction enzyme digestion of DNA.
4. DNA Ligation.
5. Preparation of competent cells.
6. Transformation of DNA into competent cells.
7. Polymerase Chain Reaction.
8. Isolation and separation of protein using SDS-PAGE.
9. Western Blot.
10. Blue-White screening.
11. Induction and analysis of Gene Expression using IPTG protocol.

TOTAL PERIODS 60

COURSE OUTCOMES

At the end of this course, the students will be able to		BT MAPPED (Highest Level)
CO1	isolate and check proteins and DNA in the lab.	Applying (K3)
CO2	cut, join, and transfer DNA into bacterial cells.	Analyzing (K4)
CO3	separate and detect DNA and proteins using different techniques.	Analyzing (K4)
CO4	design primers and plan restriction sites using online tools.	Analyzing (K4)

CO/PO MAPPING :

Mapping of Course Outcome (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes PSO's
(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak

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

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BT23506	IMMUNOLOGY LABORATORY	0	0	2	1

COURSE OBJECTIVES

To enable students to

1	give practical training in the functioning of immune system.
2	handle biological samples, such as blood, for the isolation of serum, plasma, and immune cells.
3	gain laboratory training in different immunological and immunotechnological techniques.
4	explore advanced immunological assays.

LIST OF EXPERIMENTS

1. Animal Handling – Immunization – Breeding techniques by virtual methods.
2. Identification of immune cells in a blood smear.
3. Isolation of peripheral blood mononuclear cells.
4. Isolation of monocytes from blood.
5. Identification of blood group.
6. Isolation of serum and plasma.
7. Testing for typhoid antigens by Widal test.
8. Immunodiffusion by Ouchterlony Double Diffusion.
9. Immunoelectrophoresis – Rocket Immunoelectrophoresis.
10. Immunoelectrophoresis – Current Immunoelectrophoresis.
11. Enzyme-Linked ImmunoSorbent Assay (ELISA) – Types.

TOTAL PERIODS 30

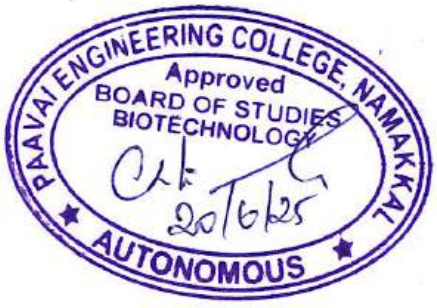
COURSE OUTCOMES

At the end of this course, the students will be able to		BT MAPPED (Highest Level)
CO1	perform blood sample analysis, including immune cell identification, blood group determination, and antigen testing using the Widal test.	Applying (K3)
CO2	acquire proficiency in separating serum and plasma and isolating immune cells.	Applying (K3)
CO3	perform and interpret results from immunological assays.	Applying (K3)
CO4	apply and correlate techniques in research or diagnostic contexts.	Analyzing (K4)

CO/PO MAPPING :

Mapping of Course Outcome (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes PSO's
(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak

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



BT23507	INDUSTRIAL TRAINING I	0	0	2	1

COURSE OBJECTIVES

To enable the students to

1	expose students to real-world industrial and research environments in biotechnology.
2	provide hands-on experience in standard industrial practices, operations, instrumentation, and regulatory compliance.
3	develop skills in technical problem-solving, troubleshooting, and process optimization.
4	enhance understanding of industrial safety protocols, GMP/GLP standards, bioethics, and sustainability practices.

GUIDELINES

The Industrial Training course is designed to provide students with practical exposure to real-world industrial operations, processes, and practices within the biotechnology sector. Students will undergo supervised training in reputed biotech, biopharmaceutical, or related industries, gaining valuable hands-on experience in areas such as production, quality control, research and development, or process engineering. The training emphasizes industry orientation, operation of equipment, adherence to GMP/GLP standards, safety procedures, and professional documentation. Students are expected to maintain a daily logbook, compile a comprehensive training report, and present their learnings through a viva-voce examination. Upon completion, students must submit their report detailing the work performed, which will be evaluated along with the viva-voce by an internal faculty panel.

TOTAL PERIODS	**30**

COURSE OUTCOMES

At the end of this course, the students will be able to		**BT MAPPED (Highest Level)**
CO1	apply theoretical concepts of biotechnology to practical industrial operations and processes.	Applying (K3)
CO2	apply standard operating procedures (SOPs) and regulatory practices such as GMP/GLP in a real-time industrial setting.	Applying (K3)
CO3	demonstrate technical and professional skills required for teamwork, communication, and reporting in an industrial environment.	Applying (K3)
CO4	prepare and present a comprehensive industrial training report with critical observations and recommendations.	Applying (K3)

CO/PO-MAPPING:

Mapping of Course Outcome (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes PSO's

(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak

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

GE23501	PROFESSIONAL DEVELOPMENT III	0	0	2	1

COURSE OBJECTIVES

To enable students to

1.	enhance their Resume writing skills and improving corporate vocabularies to survive in the corporate world.
2.	evaluate their interview skills and improve their interview presentation.
3.	solve the quantitative aptitude problems and improve their mental ability.
4.	improve critical thinking and reasoning skills.

UNIT I	RESUME WRITING SKILLS	6

Updated Resume Building III – Self Introduction III – Dressing Etiquette – JAM V – Corporate Vocabulary.

UNIT II	INTERVIEW SKILLS	6

Interview skills – General guidelines - Work Ethics – Group Discussion III – JAM VI – Presentation Competence – Mock Interview.

UNIT III	QUANTITATIVE APTITUDE	9

Cube Root and Square Root - Time and Work - Ages - Permutation and Combination - Probability – Calendar.

UNIT IV	LOGICAL REASONING	9

Series Completion - Blood Relations - Coding and Decoding - Data Sufficiency - Statements and Assumptions.

TOTAL PERIODS: 30

COURSE OUTCOMES Upon completion of the course, the students will be able to		BT MAPPED (Highest Level)
CO1	excel in drafting Resumes and speaking.	Applying (K3)
CO2	demonstrate the participative skills in group discussions and Interviews.	Applying (K3)
CO3	solve problems based on quantitative aptitude.	Applying (K3)
CO4	enhance their logical and verbal reasoning.	Analyzing (K4)

TEXTBOOKS

1. Aggarwal, R. S. A Modern Approach to Verbal & Non-Verbal Reasoning. Revised ed., 2024–25, S. Chand & Company Ltd., 2024.
2. Aggarwal, R. S. Objective General English: Fully Revised Video Edition. S. Chand & Company Ltd., 2022.

REFERENCES

1. Abhijit Guha, "Quantitative Aptitude ", Tata-Mcgraw Hil1.2015.
2. Word Power Made Easy By Norman Lewis, Wr.Goyal Publications.2016.
3. Johnson, D.W. Reaching out — Interpersonal Effectiveness and self- actualisation. Boston: Allyn and Bacon.2019.
4. Infosys Campus Connect Program — students' guide for soft skills.2015.

CO/PO MAPPING:

Mapping of Course Outcome (CO's) with Programme Outcomes (PO's)
(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak

CO's	Programme Outcomes (PO's)													
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PS01	PS02
CO1	3	2	2	3	3	1	-	-	-	-	-	-	3	2
CO2	-	2	3	-	2	-	2	-	-	-	-	-	3	2
CO3	3	2	2	2	-	-	1	-	-	-	-	-	2	3
CO4	3	2	2	-	-	1	-	-	-	-	2	-	2	3

BT23151	FERMENTATION ENGINEERING	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	recognize the overall industrial fermentation process and the process flow sheet.
2	understand the knowledge on algal biotechnology.
3	interpret the knowledge on production of commercially important primary metabolites and secondary metabolites.
4	understand the biological effluent treatment processes for fermentation industries.
5	apply the knowledge for the production of modern biological products.

UNIT I INTRODUCTION TO FERMENTATION 9

History and development of fermentation industry; General requirements of fermentation processes; types of fermentation – homo fermentation, hetero fermentation; category of fermentation based on end product formed – lactic acid fermentation, alcohol fermentation, acetic acid fermentation, butyric acid fermentation.

UNIT II ALGAL FERMENTATION 9

Isolation, preservation and improvement of industrially important micro- organisms. Microorganisms and raw materials used for microbial Oil production. Current technologies of biofuel production – . Cyanobacterial and algal fuels; Fine chemicals and nutraceuticals from algae; UV absorbing pigments Industrial products from macro algae - seaweed biotechnology; Bioweapons and Bioshields.

UNIT III FUTURE ASPECTS OF FERMENTATION ENGINEEIRNG 9

Microbial fungicides and Pesticides. Chemicals and Pharmaceuticals made by fermentation. Fermented food products – Beer, Wine. Genetically Modified Organisms. Biopolymers. Microbial leaching. Effluent treatment using microbes. Future of fermentation technology and its products.

UNIT IV BIOLOGICAL EFFLUENT TREATMENT 9

Microbes involved in aerobic and anaerobic processes in nature; Water treatment- BOD, COD, dissolved gases, removal of heavy metals, total organic carbon removal; secondary waste water treatments; use of membrane bioreactor; aquaculture effluent treatment; Aerobic sludge and land fill leachate process; aerobic digestion.

UNIT V FERMENTATION PROCESS ECONOMICS 9

Process economics: General fermentation process economics; materials usage and cost; capital investment estimate; production cost estimate. Case studies –Traditional product and recombinant product; Bioprocess validation: Introduction, why validation, when does validation occur, validation structure, resources for validation, validation of systems and processes including SIP and CIP; AI for Fermentation Process Optimization and Economic Forecasting.

TOTAL PERIODS 45

COURSE OUTCOMES		
At the end of this course, the students will be able to		**BT MAPPED (Highest Level)**
CO1	explain how fermentation works for different fermentation.	Understanding (K2)
CO2	describe how algae and microbes are used to make fuels, oils, pigments, and health products.	Understanding (K2)
CO3	identify modern and future fermentation uses.	Understanding (K2)
CO4	explain how microbes help clean wastewater.	Understanding (K2)
CO5	apply the cost and steps in fermentation processes.	Applying (K3)

TEXT BOOKS

1. Peter F Stanbury, Allan Whitaker, Stephen J Hall, "Principles of Fermentation Technology", Butterworth-Heinemann Press, UK, 2016.
2. Doran, Pauline M., "Bioprocess Engineering Principles", 2nd Edition, Academic Press, 2012.

REFERENCES

1. T El-Mansi, C Bryce, Arnold L Demain, AR Allman, "Fermentation Microbiology and Biotechnology", 2nd Edition, CRC Press, USA, 2006.
2. Richmond, Amos, and Qiang Hu (Eds.), "Handbook of Microalgal Culture: Applied Phycology and Biotechnology", 2nd Edition, Wiley-Blackwell, 2013.
3. Crueger, Wilhelm and Crueger, Anneliese, "Biotechnology: A Textbook of Industrial Microbiology" 2nd Edition, Panima Publishing, 2005.
4. Metcalf & Eddy, "Wastewater Engineering: Treatment and Resource Recovery", 5th Edition, McGraw-Hill, 2014.

CO/PO MAPPING :

Mapping of Course Outcome (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes PSO's

(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak

	PO's												PSO's	
CO's	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	2	-	-	2	-	-	3	2	-	-	2	-	3	-
CO2	2	-	3	-	3	-	2	3	-	-	3	-	2	2
CO3	2	-	3	-	3	-	2	2	-	-	2	-	3	3
CO4	2	-	3	-	2	-	2	-	-	-	2	1	2	3
CO5	2	-	3	2	3	-	3	3	-	-	2	2	3	2

BT23152	BIOREACTOR DESIGN AND SCALEUP PROCESS	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	introduce fundamental concepts of bioreactor operations and their applications in various biological systems.
2	explore aeration and agitation principles to optimize mixing and mass transfer in bioprocess systems.
3	provide insights into selecting and designing bioprocess equipment for efficient and sterile operations.
4	develop an understanding of scale-up and scale-down techniques for bioreactor optimization.
5	analyze case studies to understand the requirements and operations of bioreactors for microbial, plant, and animal cells.

UNIT I	BASIC BIOREACTOR CONCEPTS	9

Bioreactor Operation – Batch operation, semi-continuous and fed-batch operation, Continuous Operation – Chemostat, turbidostat; Microbiological reactors, enzyme reactors – Tank-type, Column-type biological reactors; Case studies – Continuous Fermentation with Biomass Recycle, Tanks-in-series, Tubular plug flow bioreactors.

UNIT II	AERATION AND AGITATION IN BIOPROCESS SYSTEMS	9

Mass transfer in agitated tanks; Power requirement for mixing; Agitation rate studies – Mixing time and residence time distribution; Bioreactor Geometry – Reactor, impeller, sparger and baffle design; shear damage, bubble damage, methods of minimizing cell damage; Case Studies for Aeration and Agitation.

UNIT III	SELECTION AND DESIGN OF BIOPROCESS EQUIPMENT	9

Materials of construction for bioprocess plants; Design considerations for maintaining sterility of process streams processing equipments, selection, specification; Design of heat and mass transfer equipment used in bioprocess industries; AI for Equipment Failure Prediction.

UNIT IV	BIOREACTOR SCALE-UP AND SCALE-DOWN	9

Scale-up Techniques – Scale up by geometric similitude, constant power consumption per volume, constant mixing time, constant impeller tip speed, constant volumetric mass transfer co-efficient; Scale-down Related Aspects; Case Studies in Bioreactor scale-up and scale-down aspects; AI in Scale-up/Scale-down Modeling.

UNIT V	CASE STUDIES	9

Case studies - Design of a stirred tank reactor (STR) for antibiotic production, Airlift and bubble column reactors for single-cell protein production, Packed bed/Trickle bed bioreactors for immobilized enzyme or cell systems, Scale-up of bioreactors for monoclonal antibody production in animal cell cultures, Continuous bioprocessing: case of perfusion bioreactors for vaccine production, Use of Process Analytical Technology (PAT) and digital twins for bioprocess monitoring and scale-up.

	TOTAL PERIODS	45

COURSE OUTCOMES		
At the end of this course, the students will be able to		**BT MAPPED (Highest Level)**
CO1	explain the principles and operational modes of different types of bioreactors.	Understanding (K2)
CO2	assess and apply strategies to improve aeration, agitation, and cell damage prevention in bioprocess systems.	Applying (K3)
CO3	select appropriate materials and design considerations for bioprocess equipment with sterility and efficiency in mind.	Applying (K3)
CO4	apply scale-up and scale-down strategies of bioreactors to solve problems in industrial fermentation processes.	Applying (K3)
CO5	analyze the factors influencing bioreactor design and operation for microbial, plant, and animal cell culture applications.	Analyzing (K4)

TEXT BOOKS

1. Michael L. Shuler, Fikret Kargi, Matthew De Lisa, "Bioprocess Engineering", 3rd Edition, Prentice Hall, 2017.
2. Pauline Doran, "Bioprocess Engineering Calculation", 2nd Edition, Blackwell Scientific Publications, 2012.

REFERENCES

1. James M Lee, "Biochemical Engineering", Prentice Hall, 1992.
2. James E Bailey, David F Ollis, "Biochemical Engineering Fundamentals", McGraw Hill, 1986.
3. S Liu, "Bioprocess Engineering: Kinetics, Biosystems, Sustainability, and Reactor Design", Elsevier, 2016.
4. Octave Levenspiel, "Chemical Reaction Engineering", Wiley, 2016.

CO/PO MAPPING :

Mapping of Course Outcome (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes PSO's

(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak

	PO's												PSO's	
CO's	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	2	-	-	2	-	-	3	2	-	-	2	-	3	-
CO2	2	-	3	-	3	-	2	3	-	-	3	-	2	2
CO3	2	-	3	-	3	-	2	2	-	-	2	-	3	3
CO4	2	-	3	-	2	-	2	-	-	-	2	1	2	3
CO5	2	-	3	2	3	-	3	3	-	-	2	2	3	2

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BT23153	BIOPROCESS CONTROL AND INSTRUMENTATION	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	understand how to measure and control key process variables in bioprocesses.
2	learn the basics of open-loop systems and mathematical tools to analyze system behavior.
3	study how closed-loop systems work in bioprocess control
4	explore how frequency response in designing stable and effective control systems.
5	get introduced to advanced control systems and biosensors.

UNIT I **BIOCHEMICAL PROCESS VARIABLES AND THEIR MEASUREMENTS** 9

Temperature, flow measurement and control, Pressure measurement and control, shaft power, rate of stirring, detection and prevention of foam, measurement of cells, measurement and control of dissolved oxygen, inlet and outlet gas analysis, pH measurement and control.

UNIT II **OPEN LOOP SYSTEMS** 9

Laplace transformation, application to solve ODEs. Open-loop systems, first order systems and their transient response for standard input functions, first order systems in series, linearization and its application in process control, second order systems and their dynamics; transportation lag.

UNIT III **CLOSED LOOP SYSTEMS** 9

Closed loop control systems, development of block diagram for feed-back control systems servo and regulatory problems, transfer function for controllers and final control element; Dynamics of sensors and measurement lags; Effect of controller parameters (P, PI, PID) on system response; Feed-forward control: concept, block diagram and applications in bioprocess.

UNIT IV **FREQUENCY RESPONSE** 9

Introduction to frequency response of closed-loop systems, control system design by frequency response techniques, Bode diagram, stability criterion, tuning of controller settings; Case Study: Closed-loop pH control in a bioreactor — block diagram and transfer function derivation; Case Study: Dissolved oxygen control loop — interaction of air flow valve and agitator speed.

UNIT V **ADVANCED PROCESS CONTROL AND BIOSENSORS** 9

Introduction to advanced control systems, cascade control, feed forward control On-line analysis of process parameters; Introduction to biosensors; Transduction principles used in biosensors; Characteristics of biosensors; Biosensors based on amperometric, potentiometric, thermistor FET, fiber optics and bioluminescence; Microbial biosensors; Fundamentals of digital process control; Use of computer in control and optimization of microbiological processes; Artificial neural networking and use in prediction of bioprocess and control.

TOTAL PERIODS 45

COURSE OUTCOMES		
At the end of this course, the students will be able to		**BT MAPPED (Highest Level)**
CO1	measure and control key process variables in bioreactors.	Understanding (K2)
CO2	use Bode plots and frequency response techniques to design and evaluate bioprocess control system stability.	Understanding (K2)
CO3	explain advanced control strategies and biosensors, and understand neural networks are used in bioprocess control.	Understanding (K2)
CO4	apply Laplace transforms to analyze the behavior of first and second-order open-loop systems.	Applying (K3)
CO5	develop and analyze feedback control systems.	Applying (K3)

TEXT BOOKS

1. Stephanopoulos G, "Chemical Process Control", Prentice Hall of India, 2003.
2. Coughnowr D, "Process Systems Analysis and Control", 3rd Edition, McGraw Hill, 2008.

REFERENCES

1. Curtis Johnson, "Process Control Instrumentation Technology", 8th Edition, 2008.
2. Marlin TE, "Process Control", 2nd Edition, McGraw Hill, New York, 2000.
3. Smith CA, Corripio AB, "Principles and Practice of Automatic Process Control", 3rd Edition, John Wiley, New York, 2005.
4. Doran, Pauline M., "Bioprocess Engineering Principles", Academic Press, 2nd Edition, 2012.

CO/PO MAPPING:

Mapping of Course Outcome (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes PSO's

(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak

	PO's												PSO's	
CO's	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	-	2	-	2	-	2	1	-	-	2	1	3	2
CO2	3	2	2	3	-	-	-	1	-	-	1	2	2	2
CO3	3	2	3	2	-	-	-	1	-	-	2	2	3	2
CO4	2	2	3	3	-	-	-	1	-	-	2	2	3	2
CO5	2	3	2	3	3	-	2	2	-	-	3	3	3	3

BT23154	TRANSPORT PHENOMENA IN BIOLOGICAL SYSTEMS	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	introduce basic transport laws at the molecular level.
2	develop velocity profiles and calculate average velocity.
3	apply shell energy balances and boundary conditions for heat transport.
4	determine concentration profiles and calculate average concentration for diffusion processes.
5	analyze the thickness of boundary layers and flow over flat surfaces.

UNIT I **TRANSPORT PHENOMENA BY MOLECULAR MOTION** **9**

Vectors/Tensors, Newton's law of viscosity, Newtonian and Non-Newtonian fluids, rheological models, Temperature, pressure and composition dependence of viscosity, Kinetic theory of viscosity, Fourier's law of heat conduction, Temperature, pressure and composition dependence of thermal conductivity, Kinetic theory of thermal conductivity, Fick's law of diffusion, Temperature, pressure and composition dependence of diffusivity, Kinetic theory of diffusivity.

UNIT II **ONE DIMENSIONAL MOMENTUM TRANSPORT** **9**

Shell Momentum balances, boundary conditions, velocity profiles, average velocity, momentum flux at the surfaces, of Newtonian and non-Newtonian for flow of a falling film, flow through circular tube, slits, flow through an Annulus, Adjacent flow of two Immiscible fluids. Equations of Change (Isothermal), equation of continuity, equation of motion, equation of energy (isothermal) their applications in fluid flow problems; AI for Flow Regime Classification.

UNIT III **ONE DIMENSIONAL HEAT TRANSPORT** **9**

Shell energy balances, boundary conditions, temperature profiles, average temperature, energy fluxes at surfaces for different types of heat sources such as electrical, nuclear viscous and chemical, Equations of change (non-isothermal), equation of motion for forced and free convection, equation of energy (non-isothermal); AI-enhanced Heat Transfer Prediction.

UNIT IV **ONE DIMENSIONAL MASS TRANSPORT** **9**

Shell mass balances, boundary conditions, concentration profiles, average concentration, mass flux at surfaces for Diffusion through stagnant gas film, Diffusion with homogeneous and heterogeneous chemical reaction, Diffusion in to a falling liquid film, Diffusion and chemical reaction in porous catalyst and the effectiveness factor, equation of continuity for binary mixtures, equation of change to set up diffusion problems for simultaneous heat and mass transfer.

UNIT V **TRANSPORT IN TURBULENT AND BOUNDARY LAYER FLOW** **9**

Turbulence phenomena; phenomenological relations for transfer fluxes; time smoothed equations of change and their applications for turbulent flow in pipes; boundary layer theory; laminar and turbulent hydrodynamics thermal and concentration boundary layer and their thicknesses; analysis of flow over flat surface. Introduction to macroscopic balances for isothermal flow systems, non- isothermal systems and multicomponent systems.

TOTAL PERIODS **45**

COURSE OUTCOMES		
At the end of this course, the students will be able to		**BT MAPPED (Highest Level)**
CO1	explain how momentum, heat, and mass transfer occur based on molecular motion.	Understanding (K2)
CO2	use shell balance methods to analyze flow, temperature, and concentration in one-dimensional systems.	Understanding (K2)
CO3	apply equations of change to solve isothermal and non-isothermal transport problems.	Applying (K3)
CO4	analyze diffusion and reaction processes in films, porous catalysts, and multicomponent systems.	Applying (K3)
CO5	interpret and apply concepts of turbulent flow, boundary layer theory, and macroscopic balances to real transport problems.	Analyzing(K4)

TEXT BOOKS

1. Bird RB, Stewart WE, Lightfoot EW, "Transport Phenomena," 2nd Revised Edition, John Wiley, 2007.
2. Brodkey RS, Hershey HC, "Transport Phenomena: A Unified Approach," Brodkey Publishing, 2003.

REFERENCES

1. Geankoplis CJ, "Transport Processes and Separation Process Principles," 4th Edition, Prentice-Hall Inc., 2003.
2. Deen, William M., "Analysis of Transport Phenomena", Oxford University Press, 2nd Edition, 2011.
3. Welty R, Wilson RW, Wicks CW, Rorer GE, "Fundamentals of Momentum, Heat and Mass Transfer," 5th Edition, John Wiley, 2007.
4. Incropera FP, DeWitt, DP, "Fundamentals of Heat and Mass Transfer", 6th Edition, 2007, Wiley.

CO/PO MAPPING:

Mapping of Course Outcome (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes PSO's

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	PO's												PSO's	
CO's	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	2	3	2	2	-	1	1	-	-	2	2	3	2
CO2	3	2	3	3	2	-	2	1	-	-	2	2	3	2
CO3	3	2	3	3	2	-	2	1	-	-	2	2	3	3
CO4	3	2	3	3	2	-	2	1	-	-	2	2	3	3
CO5	3	2	3	3	2	-	2	1	-	-	2	2	3	3

BT23155	BIOPROCESS MODELING AND SIMULATION	3	0	0	3

COURSE OBJECTIVES	
To enable the students to	
1	introduce fundamental concepts and principles of Modeling and simulation in bioprocesses.
2	develop mathematical models for different types of bioreactor systems.
3	explore advanced Modeling approaches for biological systems with varying complexity.
4	apply Modeling techniques to analyze biological processes such as wastewater treatment and fermentation.
5	familiarize students with simulation tools and techniques for bioprocess Modeling and parameter estimation.

UNIT I	BASIC MODELING PRINCIPLES	9

Introduction, definition of Modeling and simulation, different types of models, application of mathematical Modeling. Fundamental laws: continuity equation, energy equation, equation of motion, transport equation, equation of state, Phase and chemical equilibrium, chemical kinetics with examples.

UNIT II	MATHEMATICAL MODELS FOR BIOREACTOR SYSTEMS	9

Batch reactor, CSTR isothermal with cooling/heating jacket or coil, Fed Batch reactor; Ideal vs. non-ideal mixing: RTD (Residence Time Distribution) models; Scale-up criteria: geometric similarity, power input, mixing time.

UNIT III	MODELING APPROACHES FOR BIOLOGICAL SYSTEMS	9

Growth kinetic Models – structured and unstructured systems; Compartment models; Cybernetic models; Genetically structured models, Single cell models, Morphologically structured models. Thermal death kinetics models, Stochastic Model for thermal sterilization of medium; AI for Parameter Estimation.

UNIT IV	MODELING APPROACHES FOR BIOLOGICAL PROCESSESS	9

Immobilized cell bioreactor models (diffusion-reaction models); Biofilm reactor models (thickness, diffusion limitations); Packed bed or trickle bed bioreactor models; Modeling for activated sludge process, Model for anaerobic digestion, Model for lactic acid fermentation, antibiotic production, Ethanol fermentation.

UNIT V	SIMULATION OF BIOPROCESSES	9

Software packages for simulation of bioprocesses – MATLAB-SIMULINK, Creating bioprocess models in MATLAB and Simulink environment. Linear and non-linear estimation of the kinetic parameters for types and models; Genome-scale metabolic models (GEMs) linked to bioreactor models; Hybrid Modeling - combining mechanistic and data-driven (AI/ML) models.

	TOTAL PERIODS	45

COURSE OUTCOMES		
At the end of this course, the students will be able to		BT MAPPED (Highest Level)
CO1	understand the foundational principles of mathematical modeling and simulation in biological systems.	Understanding (K2)

CO2	formulate mathematical models for batch, CSTR, and fed-batch reactor systems.	Applying (K3)
CO3	apply structured, unstructured, and stochastic approaches to model biological systems.	Applying (K3)
CO4	analyze and develop models for key biological processes like fermentation, digestion, and sludge treatment.	Analyzing (K4)
CO5	utilize simulation tools such as MATLAB-SIMULINK to create and optimize bioprocess models.	Analyzing (K4)

TEXT BOOKS

1. Luyben WL, "Process Modeling, Simulation and control for Chemical Engineers", McGraw Hill, 2nd Edition, 2013.
2. Bailey JA, Ollis DF, "Biochemical Engineering Fundamentals", McGraw Hill (New York), 2nd Edition, 2010.

REFERENCES

1. Shuler, Michael L., and Kargi, Fikret, "Bioprocess Engineering: Basic Concepts", Prentice Hall, 2nd Edition, 2001.
2. James E Bailey, David F Ollis, "Biochemical Engineering Fundamentals", McGraw Hill, 1986.
3. Nielsen, Jens, Villadsen, John, and Liden, Gunnar, "Bioreaction Engineering Principles", Springer, 3rd Edition, 2011.
4. Ingalls, Brian P., "Mathematical Modeling in Systems Biology: An Introduction", MIT Press, 2013.

CO/PO MAPPING:

Mapping of Course Outcome (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes PSO's

(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak

	PO's												PSO's	
CO's	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	2	-	-	-	-	-	-	-	-	-	-	3	-
CO2	3	3	2	-	-	-	-	-	-	-	-	-	2	2
CO3	3	3	2	-	-	-	-	-	-	-	-	-	2	3
CO4	2	3	3	2	-	-	-	-	-	-	-	-	3	3
CO5	-	2	3	3	2	-	-	-	-	-	-	2	3	3

BT23156	BIOPROCESS EQUIPMENTS AND PLANT DESIGN	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	understand the designing aspects of various equipment's used in biotech industry.
2	explore the design and construction of pressure vessel structures.
3	understand the construction details of extractors and absorption towers.
4	learn the types of pumps, seals, valves and switches.
5	design various types of piping and plant layout design.

UNIT I	HEAT EXCHANGERS, CONDENSERS, EVAPORATORS	9

Single and multi-process exchangers, double pipe, U tube heat exchangers, combustion details supporting structure. Single and vertical tube evaporation, Single and multi-effect evaporators, forced circulation evaporators; Design of shell-and-tube heat exchangers: baffle arrangements, tube pitch, fouling factors.

UNIT II	STORAGE VESSEL FOR VOLATILE AND NON-VOLATILE FLUIDS	9

Design of the following equipments as per ASME, ISI codes, drawing according to scale; monoblock and multiplayer vessels, combustion details and supporting structure; Pressure vessel design: internal pressure, external pressure, wind and seismic loads; Storage tanks: fixed roof vs. floating roof tanks — design and applications; AI in Risk Assessment.

UNIT III	EXTRACTOR, DISTILLATION AND ABSORPTION TOWER	9

Construction details and assembly drawing; Plate and Packed Extraction Towers; Plate and Packed absorption Towers; Plate and Packed Distillation Towers; Tray design: sieve, valve, bubble-cap trays — efficiency and hydraulic design; Packings: random vs. structured packings — pressure drop and mass transfer coefficients.

UNIT IV	PUMPS, MECHANICAL SEALS, VALVES AND SWITCHES	9

Various types of pumps, Principle of working, construction, usages, advantages and disadvantages; Various types of seals, effectiveness, usages; Pneumatic Seals; Gate, Globe and Butterfly Valves, their material of construction; Pneumatically Controlled Valves; Centrifugal vs. positive displacement pumps: selection criteria, pump curves; Priming and cavitation — causes and prevention.

UNIT V	PIPING, PLANT LAY OUT AND DESIGN	9

Various types of Piping, material of construction, their usage; Pipe lay out; Modern Plant Design and case Studies; Pipe sizing and pressure drop calculations; Piping codes and standards (ASME B31.3, IS codes); Expansion loops, supports, hangers — stress analysis in piping; Piping isometrics and orthographic drawings; AI in Smart Plant Layout.

	TOTAL PERIODS	45

COURSE OUTCOMES		
At the end of this course, the students will be able to		**BT MAPPED (Highest Level)**
CO1	comprehend the design of heat exchangers and evaporators	Understanding (K2)
CO2	demonstrate the skills in the design of pressure and storage vessels.	Understanding (K2)
CO3	design the distillation column, absorption column, and extractors	Applying (K3)
CO4	understand the usage of different pumps, mechanical seals, valves and switches	Applying (K3)
CO5	apply the knowledge in the design layout of industrial plants	Applying (K3)

TEXT BOOKS

1. Brownell LE, Young EH, "Process Equipment Design", Wiley Eastern India Limited 2009.
2. Mahajani, V. V., and Umarji, S. B., "Process Equipment Design", Macmillan India Ltd., 1st Edition, 2009.

REFERENCES

1. Coulson, J. M., and Richardson, J. F. "Chemical Engineering Volume 6: Chemical Engineering Design", Butterworth-Heinemann, 4th Edition, 2005.
2. Ray Sinnott & Gavin Towler "Chemical engineering design", V edition, Butterworth Heinemann, 2015.
3. Subhabrata Ray, Gargi Das, "Process Equipment and Plant Design: Principles and Practices", 1st Edition, Elsevier, 2020.
4. Ingalls, Brian P., "Mathematical Modeling in Systems Biology: An Introduction", MIT Press, 2013.

CO/PO MAPPING:

Mapping of Course Outcome (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes PSO's

(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak

	PO's												PSO's	
CO's	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	3	3	2	-	-	-	-	-	1	-	-	3	2
CO2	3	3	3	2	-	-	-	-	1	1	-	-	3	3
CO3	3	3	3	3	-	-	-	-	1	1	-	-	3	3
CO4	2	2	3	2	1	-	-	-	1	1	-	-	2	2
CO5	3	3	3	3	1	-	-	-	1	1	-	-	3	3

BT23157	CHEMICAL REACTION ENGINEERING	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	impart the basic concepts in reaction kinetics.
2	develop the knowledge for design of ideal reactors.
3	understand the practical aspects of non-ideal flow.
4	discuss the intermolecular and covalent catalysis in gas-liquid reactions.
5	apply the reaction engineering principles in biological systems.

UNIT I	KINETICS OF HOMOGENOUS REACTIONS	9

Concentration and temperature dependent term of rate equation; searching for mechanism; predictability of reaction rate from theory; Interpretation of batch reactor data; constant volume and variable volume batch reactor; temperature and reaction rate; development of rate equations for different homogeneous reactions (up to second order reactions both reversible and irreversible reactions).

UNIT II	REACTOR DESIGN	9

Ideal batch reactors; steady state MFR and PFR; holding time for flow systems; Design for single reactions; performance equations for single reactors; size comparison of single reactors – MFR vs PFR for first and second order reactions; multiple reactor systems with graphical comparison.

UNIT III	NON-IDEAL FLOW	9

Residence Time Distribution (RTD); Conversion in non-ideal flow reactors; Compartment Models; Dispersion Model; Tanks-in-series Models; Convection Models; earliness of mixing, segregation and RTD; AI for RTD Prediction.

UNIT IV	GAS – LIQUID REACTION	9

Reactivity – Coenzymes – Proton transfer – metal ions – Intra molecular reactions – Covalent catalysis – Catalysis by organized aggregates and phases. Inclusion complexation; AI in Catalyst Design.

UNIT V	BIOCHEMICAL REACTION SYSTEMS	9

Bioreactor Systems Definitions; Differences and similarities between chemical and bioreactors; Classification of bioreactors; Reactor configurations; Description of a conventional bioreactor with all aspects; Design equations for enzyme reactors; batch growth of microorganism; Design equation of a plug flow reactor; Estimation of kinetic parameters.

	TOTAL PERIODS	45

COURSE OUTCOMES

At the end of this course, the students will be able to		BT MAPPED (Highest Level)
CO1	understand the kinetics of homogeneous reactions.	Understanding (K2)
CO2	examine the design aspects for different ideal reactors.	Applying (K3)
CO3	demonstrate non-ideal flow in chemical reactors.	Applying (K3)

CO4	analysis the reactivity in gas liquid reaction.	Applying (K3)
CO5	outline the nature of biochemical reaction systems.	Applying (K3)

TEXT BOOKS

1. Levenspiel O. "Chemical Reaction Engineering", John Wiley, 3rd Edition, 2021.
2. Fogler HS, "Elements of Chemical Reaction Engineering", Prentice Hall of India, 6th Edition, 2020.

REFERENCES

1. Doran, Pauline M. "Bioprocess Engineering Principles", Academic Press, 2nd Edition, 2012.
2. Jencks, William P., "Catalysis in Chemistry and Enzymology", Dover Publications, Reprint Edition.
3. Himadri Roy Ghatak, Reaction Engineering Principles, CRC Press, 2018.
4. Mikkola JP, Salmi TO, Warna JP, "Chemical Reaction Engineering and Reactor Technology", 2nd Edition, Routledge Taylor & Francis Group, 2019.

CO/PO MAPPING:

Mapping of Course Outcome (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes PSO's

(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak

	PO's												PSO's	
CO's	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	2	3	-	-	-	-	-	-	-	-	-	3	2
CO2	3	3	3	2	-	-	-	-	1	1	-	-	3	3
CO3	3	2	3	2	-	-	-	-	1	1	-	-	3	3
CO4	2	1	2	3	2	-	-	-	-	-	-	-	2	3
CO5	3	2	3	3	2	-	-	-	1	1	-	-	3	3

BT23251	BIOSENSORS	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	understand the principle, operations and classification of biosensors.
2	utilize the working principles of metabolic sensors.
3	analyze the functions of affinity sensors and reagent less sensors.
4	learn the working principles of biological sensors.
5	expose the science and engineering by application of biosensors in various fields.

UNIT I	FUNDAMENTALS OF BIOSENSOR	9

Biosensors as functional analogs of chemoreceptors, structure and function of transducers, qualitative and quantitative sensors, sensor parameters; Transduction methods-optical, calorimetric, electrochemical and piezoelectric sensors; Supports and support modifications - synthetic polymers, carbon material supports, metal supports; bifunctional cross-linkers.

UNIT II	METABOLIC SENSORS	9

Methods of enzyme immobilization - adsorption, gel entrapment, covalent coupling, crosslinking; Immobilization effects in biosensors, characterization of immobilized enzymes in biosensors, effectiveness factor, enzyme loading test; Metabolic sensors-glucose, ascorbic acid, lactate sensors; Determination of alcohols, sensors for phenols and amines, coupled enzyme reactors, sequence electrodes for nucleic acid, enzyme sensor for inhibitors.

UNIT III	AFFINITY SENSORS AND REAGENTLESS SENSORS	9

Affinity sensors based on small ligands, immunosensors, immunoassay-RIA, ELISA and TELISA, piezoelectric immunosensors, optical immunosensors, electrochemical immunoassay; Biocompatibility of sensors; Biomimetic sensors, Bioconjugated silica nanoparticles for bioanalysis; AI for Biomimetic Sensor Design.

UNIT IV	NOVEL BIOSENSORS	9

Surface dielectric enhancement - gold nanoparticles enhanced surface plasmon resonance, magnetic biosensors and biochips, quantum dot based biosensors, DNA and protein conformational changes, optical and magnetic sensors, micro and nanocantilevers, electrochemical QCM, MEMS, PCR; Microchamber array chip system, Detection of target DNA on a single chip.

UNIT V	APPLICATIONS OF BIOSENSORS	9

Biosensors and diabetes management, Microfabricated biosensors and point-of-care diagnostics systems, Noninvasive biosensors in clinical analysis; Surface plasmon resonance and evanescent wave biosensors, Biosensors in cancer and HIV early diagnosis; AI for Point-of-Care Diagnostics.

	TOTAL PERIODS	45

COURSE OUTCOMES		
At the end of this course, the students will be able to		**BT MAPPED (Highest Level)**
CO1	summarize the principles of various biosensors sensors used in medical diagnosis.	Understanding (K2)
CO2	illustrate the working principles of metabolic sensors.	Understanding (K2)
CO3	sketch the physiological functions of immunosensors.	Applying (K3)
CO4	articulate and distinguish various modern biosensors used in medical diagnosis.	Applying (K3)
CO5	identify the advancements in the field of biosensors .	Applying (K3)

TEXT BOOKS

1. Ozkan, Sibel A., Bengi Uslu, and Mustafa Kemal Sezgintürk, eds., "Biosensors: Fundamentals, Emerging Technologies, and Applications", CRC Press, 2022.
2. Challa Kumar, "Nanomaterial's for Biosensors", Wiley-VCH Verlag GMBH, Germany 2007.

REFERENCES

1. Floriner-Gabriel Banica, "Chemical sensors and Biosensors-Fundamentals and Applications", John-Wiley & Sons Ltd, 2012.
2. PN Bartlett, "Bioelectrochemistry- Fundamentals-Experimental techniques and applications", John Wiley & Sons, England 2008.
3. Nalwa, "Encyclopedia of Nanoscience and Nanotechnology", Vol. 5, 2004.
4. Mahato, Kuldeep, and Pranjal Chandra, eds., "Biosensors for Personalized Healthcare", Springer, 2024.

CO/PO MAPPING :

Mapping of Course Outcome (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes PSO's

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CO's	PO's												PSO's	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	1	1	1	1	-	-	-	-	-	-	1	3	3
CO2	2	1	1	2	1	-	-	-	-	-	-	1	1	3
CO3	2	2	1	1	1	-	-	-	-	-	-	2	2	2
CO4	1	1	1	1	1	-	-	-	-	-	-	1	2	2
CO5	3	1	1	1	1	-	-	-	-	-	-	1	1	1

BT23252	FORENSIC SCIENCE AND TECHNOLOGY	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	explain the methods and principles of forensic investigations.
2	understand how forensic science can be applied in criminal investigations.
3	apply basic scientific principles of ballistics in forensic science.
4	examine the crime scenes using various patterns analysis.
5	utilize molecular analysis techniques for the identification of suspects.

UNIT I	INTRODUCTION TO FORENSIC SCIENCE	9

Introduction to Crime Laboratories, Responsibilities of the Forensic Scientist, Securing and Searching the Crime Scene, Recording and Collection of Crime Scene Evidence, Document Examination, Ethics and Integrity, Responsibilities of the Forensic Scientist, Role as an expert witness in court, Casework responsibilities - analyzing, interpreting, and reporting evidence. AI for Crime Data Analytics.

UNIT II	DISCOVERY AND RECOVERY OF HUMAN REMAINS	9

The Autopsy and Handling of a Dead Body, The Stages and Factors of Decomposition, determining the Age and Provenance of Remains, Asphyxia, Gunshot Wounds, Bite Marks; Use of cadaver dogs, Remote sensing - aerial, thermal, drones; Geophysical tools - GPR, magnetometry, Photography, sketching, 3D imaging, Chain of custody, field logs, Preparation for lab analysis.

UNIT III	PATTERN ANALYSIS	9

Biological Evidence – Overview; Body Fluids - Peripheral blood, Saliva, Semen, Urine, and Sweat, Blood; Markers for Evidence, Study of Hair, Study of Fibre; Detecting the Presence of Blood, Bloodstain Pattern Analysis;Tool Marks and Firearm Patterns; Types of tool marks - striated, impressed, Bullet and cartridge case comparisons, Ballistics matching techniques, Bloodstain Pattern Analysis (BPA).

UNIT IV	METHODS OF IDENTIFICATION	9

Forensic anthropology, Paleontology, Drug Identification and Toxicology, Types of identification - complete, partial, presumptive, Biological versus physical identification; Personal Identification Methods-Somatometry and somatoscopy, Anthropometry; Methods used in forensic for human identification - Autosomal STR Profiling, Analysis of Y chromosome, Analysis of Mitochondrial DNA.

UNIT V	SEQUENCING METHODS IN FORENSICS	9

Rules and Principles of Identification under Criminal Justice System, Autosomal single-nucleotide polymorphisms (SNP) typing, Biomarkers in forensic identification, Polymorphic Enzymes, DNA Finger Printing- RFLP; PCR directed Y chromosome sequences, PCR Amelogenein Gene, Next generation Sequencing; Mitochondrial DNA (mtDNA) Sequencing-Importance in degraded or ancient samples, Maternal lineage tracing, Y-Chromosome and X-Chromosome Sequencing-Male-specific identification, STR and SNP analysis on sex chromosomes, Applications in kinship, sexual assault cases.

	TOTAL PERIODS	45

COURSE OUTCOMES		
At the end of this course, the students will be able to		**BT MAPPED (Highest Level)**
CO1	explain the principles of forensic science to infer forensic investigation.	Understanding (K2)
CO2	figure evidence with proper methods of investigation through biological samples.	Understanding (K2)
CO3	interpret the results of molecular techniques for the identification of the criminals and the victims	Applying (K3)
CO4	appraise the knowledge in paleo biology and anthropology and its importance in forensics	Applying (K3)
CO5	design experiments in molecular techniques and implementation in forensic science	Applying (K3)

TEXT BOOKS

1. Lincoln PJ, Thomson J, "Forensic DNA Profiling Protocols", Humana Press, 2011.
2. Rudin N, Inman K, "An Introduction to Forensic DNA Analysis", 2nd Edition, CRC Press, 2002.

REFERENCES

1. Saferstein R, "Criminalistics: An Introduction to Forensic Science", 12th Edition, Pearson, 2017.
2. Butler JM, "Forensic DNA Typing, 2nd Edition, Biology, Technology, and Genetics of STR Markers", Imprint: Academic Press, 2005.
3. Siegel JA, "Forensic chemistry: fundamentals and applications", John Wiley and Sons, 2015.
4. Criminalistics: An Introduction to Forensic Science, by Richard Saferstein, 12th Edition, Pearson, UK, 2018.

CO/PO MAPPING :

Mapping of Course Outcome (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes PSO's

(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak

CO's	PO's												PSO's	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	1	1	1	1	-	-	-	-	-	-	1	3	3
CO2	2	1	1	2	1	-	-	-	-	-	-	1	1	3
CO3	2	2	1	1	1	-	-	-	-	-	-	2	2	2
CO4	1	1	1	1	1	-	-	-	-	-	-	1	2	2
CO5	3	1	1	1	1	-	-	-	-	-	-	1	1	1

BT23253	VACCINE TECHNOLOGY	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	categorize the different types of vaccines available for diseases.
2	understand the modern strategies and routes of immunization.
3	apply the concept of vaccine technology to the development of vaccines.
4	evaluate various delivery methods suitable for vaccines.
5	relate the quality control and regulatory guidelines involved in vaccine production.

UNIT I	INTRODUCTION TO VACCINATION	9

Vaccines - definition, History of vaccine development, Requirements for immunity; Basics of immunization-Epitopes, linear and conformational epitopes; Characterization and location of APC, MHC and immunogenicity; Immunization programs and role of WHO in immunization programs; AI for Vaccine Design History and Trends.

UNIT II	TYPES AND METHODS OF APPLICATION	9

Active and passive immunization; Viral, bacterial, parasite vaccine differences; Methods of vaccine preparation - Live, killed, attenuated, sub unit vaccines; Vaccine technology - Role and properties of adjuvants, Recombinant DNA and protein based vaccines, plant-based vaccines, edible vaccines, reverse vaccinology, combination vaccines, therapeutic vaccines; Peptide vaccines, conjugate vaccines; Cell based vaccines; Uses of nanoparticles in vaccine application; Reverse vaccinology.

UNIT III	TECHNIQUES IN VACCINE PRODUCTION	9

Cell culture and fermentation systems for vaccine production, Harvesting and Purification, Preservation and formulation techniques; Ill-finish operations and cold chain logistics; Quality control: sterility, potency, safety, and batch release testing Commercial production of DPT, TT, polio, rabies and hepatitis vaccines; AI for Bioprocess Monitoring.

UNIT IV	DELIVERY METHODS	9

Conventional Delivery Methods - Intramuscular (IM), Subcutaneous (SC), Intradermal (ID) injections, Oral vaccines (e.g., OPV, rotavirus); Advanced Delivery Technologies - Microneedle patches, Jet injectors (needle-free injection systems), Transdermal delivery systems, Mucosal delivery routes (oral, nasal, pulmonary); Genetic Vaccine Delivery - Electroporation for DNA vaccines, Lipid nanoparticle (LNP) systems for mRNA vaccines, Viral vector delivery systems (adenovirus, lentivirus), Gene gun (biolistic particle delivery); Adjuvant delivery systems.

UNIT V	REGULATORY AND BIOSAFETY MEASURES	9

Regulatory Frameworks - WHO prequalification process for vaccines, Regulatory pathways for new vaccine approvals, Good Manufacturing Practices (GMP) guidelines for vaccine production; Quality Assurance/ Quality Control (QA/QC) - QA/QC protocols during vaccine production, Sterility, potency, safety, and endotoxin testing, Validation of processes and equipment, Documentation and traceability in vaccine manufacturing; Ethical and Legal Considerations -Ethical review boards and guidelines (ICMR, Declaration of Helsinki); Case study: COVID-19 vaccine approval process.

	TOTAL PERIODS	45

COURSE OUTCOMES		
At the end of this course, the students will be able to		**BT MAPPED (Highest Level)**
CO1	understand the basics of immune system components, their functions.	Understanding (K2)
CO2	identify and classify vaccines and employ them in various applications.	Understanding (K2)
CO3	implement foundational immunological principles.	Applying (K3)
CO4	analyze the advanced methods of vaccine delivery.	Analyzing (K4)
CO5	evaluate the regulatory frameworks, quality control measures, and ethical considerations.	Analyzing(K4)

TEXT BOOKS

1. P Ramadass, "Animal Biotechnology - Recent concepts and Developments", MJP Publications, 2008.
2. TJ Kindt, RA Goldsby, BA Osborne and J Kuby, Kuby, "Immunology", W.H. Freeman & company, 2007.

REFERENCES

1. Cheryl Barton, "Advances in Vaccine Technology and Delivery", Espicom Business Intelligence, 2009.
2. Ronald W. Ellis, "New Vaccine Technologies", Landes Bioscience, 2001
3. Plotkin SA, Orenstein WA and Offit PA,"Vaccines", W B Saunders Company, 2012.
4. Thomas, Sunil, Ann Abraham, Jeremy Baldwin, Sakshi Piplani, and Nikolai Petrovsky, "Vaccine design", Springer New York, 2016.

CO/PO MAPPING :

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CO's	PO's												PSO's	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	3	3	2	2	2	-	-	-	1	-	1	3	2
CO2	2	2	1	3	2	-	-	-	-	1	-	1	3	1
CO3	2	3	3	2	1	-	-	-	-	1	-	1	1	3
CO4	3	3	3	2	1	2	-	-	-	1	-	1	3	2
CO5	2	2	2	2	3	1	-	-	-	1	-	1	3	2

BT23254	CANCER BIOLOGY AND THERAPEUTICS	3	0	0	3

COURSE OBJECTIVES	
To enable the students to	
1	understand the classification, causes, and characteristics of cancer.
2	illustrate the metabolism of carcinogens and the mechanisms of radiation-induced carcinogenesis.
3	identify key signal targets, kinases, oncogenes, and tumor suppressor genes involved in cancer.
4	analyze the clinical significance of metastasis and the heterogeneity of metastatic phenotypes.
5	demonstrate proficiency in cancer detection techniques, including imaging, tumor markers, and molecular tools.

UNIT I	FUNDAMENTALS OF CANCER BIOLOGY	9

Introduction to cancer, classification, causes, and characteristics; Regulation of the cell cycle, mutations in signal molecules, tumor suppressor genes, modulation of the cell cycle, apoptosis pathways, cancer metabolism, inflammation, immunology, and cancer death; Screening and early cancer detection using biochemical assays, tumor markers, and molecular tools.

UNIT II	PRINCIPLES OF CARCINOGENESIS	9

Theory of carcinogenesis - multi-stage theory, chemical, physical, biological carcinogenesis; Metabolism of carcinogens, mechanisms of radiation carcinogenesis, and epigenetics in cancer development; AI for Carcinogen Risk Assessment, AI in Epigenetics.

UNIT III	MOLECULAR BIOLOGY OF CANCER	9

Signal targets, activation of kinases, oncogenes (e.g., c-Myc, Ras, Bcl-2 family), tumor suppressor genes (e.g., Rb, p53, APC, BRCA); Role of retroviruses, telomerase, signal transduction pathways, and molecular mechanisms of apoptosis, AI in Oncogene and Tumor Suppressor Discovery.

UNIT IV	CANCER METASTASIS	9

Clinical significance of metastasis, heterogeneity of metastatic phenotype, metastatic cascade, three-step invasion theory, and role of cell adhesion molecules and proteinases; Angiogenesis and its regulation through VEGF signalling; AI for Metastasis Prediction.

UNIT V	CANCER DETECTION AND THERAPY	9

Cancer Detection Techniques -Physical Examination - Early signs, palpation methods; Bioassays - Detection via cellular or biochemical changes; Imaging - X-ray, MRI, CT, PET – role in tumor localization; Tumor Markers - PSA, CA-125, AFP – diagnostic and monitoring use; Molecular Tools - PCR, FISH, microarrays – detection at DNA/RNA level; Gene Therapies – Definition, Somatic vs germline therapy; Cancer Targets – Tumor suppressor gene replacement (e.g., p53), oncogene silencing.

	TOTAL PERIODS	45

COURSE OUTCOMES		
At the end of this course, the students will be able to		**BT MAPPED (Highest Level)**
CO1	understand the classification, causes, and characteristics of cancer and their relationship to cell cycle regulation and tumor suppression.	Understanding (K2)
CO2	demonstrate the metabolism of carcinogens and their impact on cancer development.	Applying (K3)
CO3	utilize the knowledge of apoptosis and retroviral mechanisms to interpret cancer progression.	Applying (K3)
CO4	explain the clinical significance and stages of the metastatic cascade.	Applying (K3)
CO5	evaluate advances in personalized treatment strategies and their implications for patient outcomes.	Applying (K3)

TEXT BOOKS

1. Weinberg RA. "The Biology of Cancer", 2nd Edition, Garland Science, 2013.
2. McDonald. "Molecular Biology of Cancer", 2nd Edition. Taylor & Francis, 2004.

REFERENCES

1. Pezzella, F., Tavassoli, M., & Kerr, D. J., "Oxford textbook of cancer biology", Oxford University Press, 2019.
2. Pelengaris, S., & Khan, M., "The molecular biology of cancer: A bridge from bench to bedside", 2013.
3. Hejmadi, M., "Introduction to cancer biology", Bookboon, 2014.
4. Pecorino, Lauren. "Molecular biology of cancer: mechanisms, targets, and therapeutics", Oxford university press, 2021.

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

BT23255	BIOMEDICAL ENGINEERING	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	interpret the knowledge on the human body subsystem, transducers.
2	explain the non-electrical parameters measurements and heart rate, sounds.
3	identify the electrical parameters and its measurements records, lead systems.
4	make use of imaging modalities and diagnostics.
5	illustrate various of life assisting and therapeutic devices and their applications.

UNIT I	HUMAN BODY SUBSYSTEM AND TRANSDUCERS	9

Brief description of muscular, cardiovascular and respiratory systems; their electrical, mechanical and chemical activities; Principles and classification of transducers for Bio-medical applications; Electrode theory, different types of electrodes; Selection criteria for transducers and electrodes; AI for Biomedical Signal Interpretation.

UNIT II	NON-ELECTRICAL PARAMETERS MEASUREMENT	9

Measurement of blood pressure - Cardiac output , Heart rate, Heart sound, Pulmonary function measurements – spirometer, Blood Gas analysers, blood pH, Measurement of blood pCO2, pO2; AI in Smart Blood Gas Analysis.

UNIT III	ELECTRICAL PARAMETERS MEASUREMENT AND ELECTRICAL SAFETY	9

ECG, EEG, EMG, ERG, Lead systems and recording methods; Typical waveforms, Electrical safety in medical environment, shock hazards, leakage current; Instruments for checking safety parameters of biomedical equipment; AI for ECG/EEG/EMG Analysis.

UNIT IV	IMAGING MODALITIES AND BIO-TELEMETRY	9

Diagnostic X-rays, Computer tomography, MRI, Ultrasonography, Endoscopy, Thermography, Different types of biotelemetry systems; AI in Medical Imaging, AI for Remote Patient Monitoring.

UNIT V	LIFE ASSISTING AND THERAPEUTIC DEVICES	9

Pacemakers, Defibrillators, Ventilators, Nerve and muscle stimulators, Heart Lung machine, Dialysers Diathermy, Lithotripsy; Application of Artificial Intelligence in Biomedical Engineering; AI for Smart Pacemakers and Defibrillators.

	TOTAL PERIODS	45

COURSE OUTCOMES

At the end of this course, the students will be able to		BT MAPPED (Highest Level)
CO1	develop and specify the mathematical model the inter relation among various physiological systems.	Understanding (K2)
CO2	discuss various non-electrical parameters and measurements.	Understanding (K2)
CO3	illustrate the knowledge on the electrical parameters and electrical safety.	Applying (K3)

CO4	apply the knowledge to identify the various types of analytical and diagnostic equipment's used in biomedical engineering	Applying (K3)
CO5	design a system component or process to meet desired needs within realistic constraints	Applying (K3)

TEXT BOOKS

1. Leslie Cromwell, "Biomedical Instrumentation and Measurement", Prentice Hall of India, New Delhi, 2007.
2. Joseph J.carr and John M. Brown, "Introduction to Biomedical Equipment Technology", John Wiley and sons, New York, Fourth Edition, 2012.

REFERENCES

1. Khandpur R.S, "Handbook of Biomedical Instrumentation", Tata McGraw-Hill, New Delhi, Second Edition, 2003.
2. Duane Knudson, "Fundamentals of Biomechanics", Springer, 2nd Edition, 2007.
3. Suh, Sang, Gurupur, Varadraj P., Tanik, Murat M., "Health Care Systems, Technology and Techniques", Springer, 1st Edition, 2011.
4. Ed. Joseph D. Bronzino, "The Biomedical Engineering Hand Book", 3rd Edition, Boca Raton, CRC Press LLC, 2006.

CO/PO MAPPING:

Mapping of Course Outcome (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes PSO's

(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak

	PO's												PSO's	
CO's	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	3	2	3	2	-	3	-	-	-	1	1	3	2
CO2	2	1	3	2	3	2	2	1	-	-	-	-	2	3
CO3	2	2	3	3	3	-	3	2	-	-	-	2	3	2
CO4	1	2	2	1	2	1	1	-	-	-	-	-	1	1
CO5	-	3	2	2	2	-	2	1	-	-	-	2	-	-

BT23256	BIONANOTECHNOLOGY	3	0	0	3

COURSE OBJECTIVES	
To enable the students to	
1	understand the principles and methods in Nano biotechnology.
2	explore the structure and stability of biomaterials for nanotechnology applications.
3	learn techniques of protein nanoparticle synthesis and functionalization.
4	learn techniques of DNA nanoparticle synthesis and functionalization.
5	evaluate the applications of nanobiotechnology in biomedical sectors.

UNIT I	NANOSCALE PROCESSES AND NANOMATERIALS	9

Overview of nanoscale processes and characterization of nanomaterials – Physicochemical properties of nanomaterials. Concepts in nanotechnology. Natural nanomaterials. Types of Nanomaterials (Quantum dots. Nanoparticles. Nanocrystals. Dendrimers. Polymeric nanoparticles. Bucky balls. Nanotubes). Synthesis and assembly of nanoparticles and nanostructures using bio-derived templates.

UNIT II	STRUCTURAL AND FUNCTIONAL PRINCIPLES OF NANOMATERIALS	9

Biomolecular structure and stability. Protein folding – Self-assembly. Self-organization. Information-Driven nano assembly. Biomaterials. Biomolecular motors. Traffic across membranes. Biomolecular sensing. Self-replication. Machine-phase bionanotechnology: AI in Biomolecular Sensing.

UNIT III	PROTEIN-BASED NANOTECHNOLOGY	9

Overview of protein nanotechnology. Nanotechnology with S-Layer protein. Engineered nanopores. Bacteriorhodopsin and its potential. Protein assisted synthesis of metal nanoparticles. Synthesis of protein-based nanoparticles. Protein nanopaticle-hybrids. Covalent and non-covalent protein nanoparticle conjugates. Protein-carbon nanotube conjugates.

UNIT IV	DNA-BASED NANOTECHNOLOGY	9

DNA-based nanostructures. Biomimetic fabrication of DNA based metallic nanowires and networks. Self-assembling DNA structures. DNA-nanoparticle conjugates. DNA-carbon nanotube conjugates. DNA templated electronics. DNA nanostructures for mechanics and computing. DNA nanomachine; AI for DNA-Nanoparticle Interaction Modeling.

UNIT V	APPLICATIONS OF NANOTECHNOLOGY	9

Promising nanobiotechnologies for applications in medicine. Liposomes in nanomedicine. Therapeutic applications of nanomedicine. Nano-Sized carriers for drug delivery and drug carrier systems. Protein and peptide nanoparticles. DNA based nano-particles. Lipid matrix nanoparticles for drug delivery. Nanobiosensors for imaging and diagnosis; Applications of AI in nanobiotechnology.

	TOTAL PERIODS	45

COURSE OUTCOMES		
At the end of this course, the students will be able to		**BT MAPPED (Highest Level)**
CO1	comprehend the fundamental processes and concepts of nano biotechnology.	Understanding (K2)
CO2	demonstrate the skills in nanoparticle synthesis and characterization.	Understanding (K2)
CO3	understand the synthesis of protein-based nanoparticles in biology.	Understanding (K2)
CO4	apply the various approaches for DNA based nanoparticles synthesis	Applying (K3)
CO5	correlate the potential applications in drug delivery, diagnostics, and environmental management.	Applying (K3)

TEXT BOOKS

1. David S. Goodsell, "Bionanotechnology", John Wiley & Sons, Inc., 2004.
2. Christof M. Niemeyer & Chad A. Mirkin, "Nanobiotechnology: Concepts, Applications, and Perspectives", Wiley-VCH Verlag GmbH & Co., 2004.

REFERENCES

1. Sitharaman B, "Handbook of Nanobiotechnology", CRC Press (Taylor & Francis Group), 2011.
2. Robert A. Freitas Jr., Toshio Tokura, "Nanomedicine: Principles and Perspectives", Springer (Nanostructure Science and Technology series), 2005.
3. Ajeet Kumar Kaushik and Chandra K. Dixit, "Nanobiotechnology for Sensing Applications: From Lab to Field",Apple Academic Press (Taylor & Francis Group),2017.
4. Anton Ficai, Alexandru Mihai Grumezescu, "Nanostructures for Antimicrobial Therapy", Elsevier (Nanostructures in Therapeutic Medicine series), 2017.

CO/PO MAPPING :

Mapping of Course Outcome (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes PSO's

(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak

	PO's												PSO's	
CO's	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	1	1	2	1	-	-	-	-	-	-	-	3	2	2
CO2	2	2	2	1	-	-	-	-	-	-	-	3	2	2
CO3	2	2	1	1	-	-	-	-	-	-	-	3	1	3
CO4	3	2	3	3	1	-	-	-	-	-	-	2	2	3
CO5	3	2	3	3	1	-	1	1	-	-	-	2	3	3

BT23257	TISSUE ENGINEERING	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	understand the fundamental concepts of tissue engineering and its role in healthcare.
2	explore the properties and applications of biomaterials in tissue engineering.
3	analyze the role of stem cells and growth factors in tissue regeneration.
4	study the design of scaffolds and bioreactors for tissue engineering applications.
5	gain insights into ethical issues and future prospects in the field.

UNIT I	INTRODUCTION	9

Introduction to tissue engineering - Basic definition; current scope of development; Use in therapeutics, cells as therapeutic agents, cell numbers and growth rates, measurement of cell characteristics morphology, number viability, motility and functions; Measurement of tissue characteristics, appearance, cellular component, ECM component, mechanical measurements and physical properties.

UNIT II	TISSUE ARCHITECTURE	9

Tissue types and Tissue components; Tissue repair, Engineering wound healing and sequence of events; Basic wound healing Applications of growth factors - VEGF/angiogenesis, Basic properties, Cell-Matrix and Cell-Cell Interactions, telomeres and Self-renewal, Control of cell migration in tissue engineering; AI for Wound Healing Modeling.

UNIT III	BIOMATERIALS	9

Biomaterials - Properties of biomaterials, Surface, bulk, mechanical and biological properties; Scaffolds and tissue engineering, Types of biomaterials, biological and synthetic materials, Biopolymers, Applications of biomaterials, Modifications of Biomaterials, Role of Nanotechnology; AI in Smart Scaffold Design.

UNIT IV	BASIC BIOLOGY OF STEM CELLS	9

Stem Cells - Introduction, hematopoietic differentiation pathway Potency and plasticity of stem cells, sources, embryonic stem cells, hematopoietic and mesenchymal stem cells, Stem Cell markers, FACS analysis, Differentiation; Stem cell systems- Liver, neuronal stem cells, Types and sources of stem cell with characteristics - embryonic, adult, hematopoietic, fetal, cord blood, placenta, bone marrow, primordial germ cells, cancer stem cells induced pluripotent stem cells.

UNIT V	CLINICAL APPLICATIONS	9

Stem cell therapy, Molecular therapy, In-vitro organogenesis, Neurodegenerative diseases, spinal cord injury, heart disease, diabetes, burns and skin ulcers, muscular dystrophy, orthopaedic applications, Stem cells and Gene therapy - Physiological models, issue engineered therapies, product characterization, components, safety, efficacy; Preservation freezing and drying; Patent protection and regulation of of tissue-engineered products, ethical issues; AI applications in tissue engineering; Applications of AI in medicine, drug testing, and biotechnology.

	TOTAL PERIODS	45

COURSE OUTCOMES		
At the end of this course, the students will be able to		**BT MAPPED (Highest Level)**
CO1	ability to understand the components of the tissue architecture	Understanding (K2)
CO2	design solutions for biomedical problems using tissue engineering techniques.	Understanding (K2)
CO3	develop different types of biomaterials and understand their role in nanotechnology	Applying (K3)
CO4	apply the basic concept of stem cells behind tissue engineering	Applying (K3)
CO5	apply the tissue engineering and stem cell therapy in various clinical applications	Applying (K3)

TEXT BOOKS

1. Bernhard O.Palsson, Sangeeta N. Bhatia, "Tissue Engineering" Pearson Publishers, 2009.
2. Meyer U, Meyer Th, Handschel J, Wiesmann HP, "Fundamentals of Tissue Engineering and Regenerative Medicine", 2009.

REFERENCES

1. Bernard N. Kennedy, "Stem cell transplantation, tissue engineering and cancer applications", Nova Science Publishers, 2008.
2. Raphael Gorodetsky, Richard Schäfer, "Stem cell-based tissue repair", RSC Publishing, 2011.
3. R Lanza, J Gearhart, "Essential of Stem Cell Biology", Elsevier Academic press, 2006.
4. Mao JJ, G Vunjak-Novakovic, "Translational Approaches In Tissue Engineering & Regenrative Medicine", Artech House, INC Publications, 2008.

CO/PO MAPPING:

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	PO's												PSO's	
CO's	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	1	1	1	1	-		-	-	-	-	-	2	1	1
CO2	1	1	2	2	-	2	-	-	-	-	-	2	1	1
CO3	2	2	3	2	-	1	-	-	-	-	-	1	1	1
CO4	2	2	3	3	-	2	-	1	-	-	-	1	2	2
CO5	3	3	2	2	2	2	-	1	-	-	-	1	3	2

BT23351	PLANT PHYSIOLOGY AND ABIOTIC STRESS	3	0	0	3

COURSE OBJECTIVES	
To enable the students to	
1	understand the photosynthetic apparatus and mechanism of photosystems.
2	gain knowledge on photorespiration process.
3	explore the role of plant hormones in growth regulation.
4	evaluate physiological basis of abiotic stress tolerance.
5	explain the molecular basis of abiotic stress tolerance in plants.

UNIT I	PHOTOSYNTHETIC APPARATUS AND PHOTO SYSTEMS	9

Photosynthetic apparatus, chloroplast structure, ultra-structure of thylakoids, pigment structure and function; Photo systems, Mechanism of light absorption, Chloroplast electron transport chain; Photochemical process, photochemical reaction; photophosphorylation – cyclic and non-cyclic, mechanisms of ATP synthesis, and concept of quantum yield.

UNIT II	PHOTOSYNTHESIS AND RESPIRATION	9

CO2 fixation and reduction in Calvin cycle, CO2 fixation in C4 plants; CO2 fixation in CAM plants and its significance; Difference among C3, C4 and CAM plants Photorespiration and its relevance; Effect of environmental factors on photosynthetic rates; Significance of photosynthesis in plant growth, development and bio productivity; Glycolysis, TCA cycle and electron transport chain.

UNIT III	PLANT GROWTH REGULATORS	9

Hormonal concept of growth and differentiation, Definition and classification of plant growth regulators-Hormones, endogenous growth substances and synthetic chemicals; Site of synthesis, biosynthetic pathways, metabolism and physiological roles of individual group of hormones- Auxins, Gibberlins, cytokinins, Abscisic acid and Ethylene, Brassinosteroids, Synthetic growth regulators- Classification, their effect on plant growth and development; Practical utility in agriculture and horticulture; Stress and hormones with special reference to ABA.

UNIT IV	PHYSIOLOGICAL BASIS OF ABIOTIC STRESS TOLERANCE	9

General features of drought and salinity stress, Plants' responses to drought and salinity stress, Escape and tolerance mechanism, Physiological and biochemical changes associated with tolerance-brief concept of osmolyte, ROS, antioxidative enzymes, Haber-Weiss reaction, lipid peroxidation; Growth and metabolic processes associated with tolerance to water logging.

UNIT V	MOLECULAR RESPONSES TO ABIOTIC STRESS	9

Signal perception and signal transduction in drought stress, Expression of regulatory and functional genes and significance of gene products. Aluminium and cadmium toxicity; Physiological processes affected by aluminium and cadmium; Alleviation of heavy metal stress by various technologies; Role of Phytochelatins; Application of AI Models to Predict Plant Photosynthesis Efficiency and Abiotic Stress Tolerance.

	TOTAL PERIODS	45

COURSE OUTCOMES		
At the end of this course, the students will be able to		**BT MAPPED (Highest Level)**
CO1	explain the function of photosynthetic apparatus and photo systems.	Understanding (K2)
CO2	identify the photosynthesis and respiration process.	Understanding (K2)
CO3	deduce the role of hormonal concept in growth and differentiation.	Applying (K3)
CO4	evaluate physiological basis of abiotic stress tolerance.	Applying (K3)
CO5	correlate the molecular responses to water deficit.	Applying (K3)

TEXT BOOKS

1. Devlin R.M. Witham F.G., "Plant Physiology", 4th Edition, New Delhi, India, 1983.
2. S.Chand & V.K Jain.," Fundamentals of Plant Physiology", 19th Edition, 2017.

REFERENCES

1. David O. Hall & Krishna K. Rao, "Photosynthesis", 6th Edition, Cambridge University Press, 1999.
2. Peter J. Davies, "Plant Hormones: Biosynthesis, Signal Transduction", 3rd Edition, Springer, 2010.
3. V.P. Sharma, "Plant Physiology", 3rd Edition, Rastogi Publications, 2018.
4. V.K. Jain, "Fundamentals of Plant Physiology", 15th Edition, S. Chand Publishing, 2020.

CO/PO MAPPING:

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	PO's												PSO's	
CO's	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	2	1	–	–	–	–	–	–	–	–	–	3	–
CO2	3	2	1	–	–	–	–	–	–	–	–	–	3	–
CO3	3	2	2	1	–	–	–	–	–	–	–	–	2	–
CO4	3	3	2	2	2	–	1	–	–	–	–	–	3	2
CO5	3	3	3	3	2	–	1	–	–	–	–	–	3	2

BT23352	THERAPEUTIC APPLICATIONS OF PHYTOCHEMICALS	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	describe the general detection, extraction and characterization procedures.
2	classify chemical properties and tests for identification and therapeutic applications.
3	summarize the pharmacological properties, photo-toxicity and therapeutic applications of anthocyanins and coumarins.
4	understand the use of biological properties of various bioactive compounds.
5	identify biosynthetic origin and pharmacological activities of carotenoids and alkaloids.

UNIT I	INTRODUCTION OF PLANT NATURAL PRODUCTS	9

History, General significance, Classification - Alkaloids, phenyl propanoids, polyketides, terpenoids; List of floral sources- general detection, extraction and characterization procedures.

UNIT II	GLYCOSIDES AND FLAVONOIDS GLYCOSIDES	9

Classification, therapeutic value, chemical properties and tests for identification; Baljet's test, Keller killian's test, Raymond's reaction, Kedde's reaction; Flavonoids - Sources, classification, biogenesis, extraction, isolation, identification and therapeutic applications.

UNIT III	ANTHOCYANINS AND COUMARINS ANTHOCYANINS	9

Sources, classification, extraction, isolation, identification and therapeutic applications; Coumarins - Sources, classification, biosynthesis; Furanocoumrarins and Pyranocoumarins - pharmacological properties and photo-toxicity.

UNIT IV	LIGNANS, TERPENES, VOLATILE OILS, SAPONINS LIGNANS AND NEOLIGNANS	9

Classification, natural sources and pharmacological applications; Terpenes: - Classification, biosynthesis, origin of 5-carbons isoprene unit, head to tail coupling and tail-totail coupling of isoprene units; Volatile Oils - Classifications, sources, medicinal and non-medicinal uses; Saponin -: Sources, classification, physical and biological properties.

UNIT V	CAROTENOIDS AND ALKALOIDS CAROTENOIDS	9

Sources, biogenesis, classification and therapeutic values; Alkaloids - Classification, distribution in nature, localization, nomenclature, physico-chemical properties, extraction, detection, isolation, purification, biosynthetic origin and pharmacological activities; Application of AI in Predicting and Discovering Plant Natural Products and Their Bioactivity.

	TOTAL PERIODS	45

COURSE OUTCOMES

At the end of this course, the students will be able to		BT MAPPED (Highest Level)
CO1	illustrate plant natural products and their general significance.	Understanding (K2)

CO2	comprehend the classification and biological properties of glycosides and flavonoids	Understanding (K2)
CO3	relate anthocyanins and coumarins anthocyanins for therapeutic applications	Understanding (K2)
CO4	examine lignans, terpenes, volatile oils, saponins lignans and neolignans for medical purpose	Applying (K3)
CO5	compute the biogenesis and physicochemical properties of carotenoids and alkaloids	Applying (K3)

TEXT BOOKS

1. Agarwal OP, "Organic chemistry–Chemistry of organic natural products", Vol. II, Goel Publishing House, 2002.
2. Farooqui, A. A. and Sreeraman, B. S., "Cultvation of medicinal and aromatic crops", Universities Press, 2001.

REFERENCES

1. R.M. Devlin, "Plant Physiology", 5th Edition, Wadsworth Publishing Company, California, 2010.
2. Kalsi, P. S. and Jagtap, S., "Pharmaceutical medicinal and natural product chemistry" N.K. Mehra, 2012.
3. Harborne, J. B., "Phytochemical methods –a guide to modern techniques of plant analysis", 3rd Edition edition, Chapman and Hall, 1998.
4. Yesodha, D., Geetha, S and Radhakrishnan, V., "Allied Biochemistry", Morgan publications, Chennai, 1997.

CO/PO MAPPING :

Mapping of Course Outcome (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes PSO's

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	PO's												PSO's	
CO's	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	2	1	–	–	–	–	–	–	–	–	–	3	–
CO2	3	2	2	–	–	–	–	–	–	–	–	–	3	2
CO3	3	2	2	–	–	–	–	–	–	–	–	–	2	2
CO4	3	3	2	2	–	–	–	–	–	–	–	–	3	2
CO5	3	3	3	3	2	–	–	–	–	–	–	–	3	3

BT23353	MUSHROOM CULTIVATION AND BIOFERTILIZER PRODUCTION	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	understand the basic concepts of mushroom cultivation and its importance.
2	interpret the mushroom Cultivation and harvesting techniques.
3	instill the ability and skills required to become entrepreneur in mushroom cultivation.
4	explain various methods of composting techniques and their steps.
5	illustrate various types of biofertilizer and their applications.

UNIT I MUSHROOM BIOLOGY MORPHOLOGY 9

Classification - edible and poisonous mushrooms; Life cycle of Basidiomycetes fungi; Breeding and Genetic improvement of mushroom strains; Medicinal and Nutritional value of mushrooms.

UNIT II MUSHROOM CULTIVATION TECHNIQUES 9

Cultivation conditions for tropical and temperate countries; Isolation, spawn production, growth media, spawn running and harvesting of mushrooms (Volvariella spp., Pleurotus spp., Agaricus spp., Calocybe spp., and Lentinus spp); Diseases or contamination; Post Harvest Technology - Freezing, drying, freeze drying and canning.

UNIT III ECONOMICS OF MUSHROOM CULTIVATION 9

Economics of the production of oyster mushroom, milky mushroom and paddy straw mushroom cultivation-Infrastructure facilities, expenditure on fixed assets, plant and machinery, cost of the project, recurring expenditure, interest and depreciation of the expenditure, cost of production and profit; Entrepreneurship in mushroom cultivation.

UNIT IV COMPOSTING TECHNIQUES 9

History of composting – compost, composting processes, microbiology of composting fate of pathogens, ingredients in composting; Various methods of composting - vermi-composting and home composting-steps in composting.

UNIT V BIO-FERTILIZERS AND THEIR PRODUCTION 9

Introduction – Types; Microbes as biofertilizer, Green manure, importance of macronutrients; Biofertilizers vs Chemical fertilizers; Nitrogen fixers – types and examples; Phosphate solubilizers – role of bacteria and Mycorrhizae -Mass cultivation and Application of Rhizobium, Azospirillum, Cyanobacteria, Mycorrhizae biofertilizers; Quality control; Challenges and opportunities; Biofertilizer Entrepreneurship; Application of AI in Optimizing Mushroom Cultivation and Biofertilizer Production.

TOTAL PERIODS 45

COURSE OUTCOMES		
At the end of this course, the students will be able to		BT MAPPED (Highest Level)
CO1	articulate various mushroom at different morphology and functional level.	Understanding (K2)
CO2	explain the mushroom cultivation, using different techniques.	Understanding (K2)
CO3	illustrate the marketing potential of the produced mushroom and composts.	Applying (K3)
CO4	classify various composting process and to identify its multifunctioning.	Applying (K3)
CO5	interpret the importance of biofertilizer and their mass production.	Applying (K3)

TEXT BOOKS

1. Sangeeta Hazarika, Hemphi Terangpi & Monmi Saikia, "Mushroom Cultivation Technology", Global Net Publishers, 2025.
2. Biswas, Subrata, M. Datta, and S. V. Ngachan, "Mushrooms: A Manual for cultivation", PHI Learning Pvt. Ltd., 2011.

REFERENCES

1. Pal, S.S. and Das, A., "Biofertilizers and Organic Farming", Agrotech Publishing Academy, 2012.
2. Tewari, Suresh Chander, and Pankaj Kapoor, "Mushroom Cultivation: An Economic Analysis", Mittal Publications, 2018.
3. Gogoi, Robin, Yella Rathaiah, and Tasvina Rahman Borah "Mushroom cultivation technology", Scientific Publishers, 2019.
4. Subba Rao NS, "Biofertilizers in agriculture and forestry", India Book House Ltd. New Delhi, 2024.

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(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak

	PO's												PSO's	
CO's	3	2	–	–	–	–	–	–	–	–	–	–	2	–
CO1	3	2	2	1	–	–	–	–	–	–	–	–	3	2
CO2	2	2	2	–	–	3	2	–	3	2	–	2	2	3
CO3	3	2	2	–	–	–	1	–	–	–	–	–	2	2
CO4	3	3	3	2	1	–	1	–	–	–	–	–	3	3
CO5	3	2	–	–	–	–	–	–	–	–	–	–	2	–

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BT23354	BIOTECHNOLOGICAL APPROACH IN CROP IMPROVEMENT	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	understand the features of plant chromosomes and its organization.
2	explain the various approaches of biotechnology for crop improvement.
3	interpret the molecular markers to analyze the genetic diversity for crop improvement.
4	conduct research to identify the application of molecular markers.
5	develop various transgenic plants for commercial applications.

UNIT	PLANT GENOME ORGANIZATION	9

Features of plant chromosomes - centromere, telomere, euchromatin, heterochromatin and nucleolus organizing region (NOR); karyotype (asymmetric and symmetric); C-value paradox, range of interspecific and intraspecific variation, origin of quantitative DNA variation; Estimation of various components of higher-plant genome - highly repetitive sequences, middle repetitive sequences, and unique DNA sequences; Rice and maize genome sequencing projects; cereal genome databases.

UNIT II	BIOTECHNOLOGICAL APPROACH FOR CROP IMPROVEMENT	9

Biotechnological approaches for disease resistance, protection against fungal pathogens and drought tolerance; Modification of crop-plant nutritional content (vitamins, amino acids and lipids); Modification of crop-plant taste and appearance (sweetness, starch and preventing discoloration); Polyploidy - induction of polyploidy by artificial methods; role of polyploidy in crop improvement.

UNIT III	MOLECULAR MARKERS AND CROP IMPROVEMENT	9

Types of molecular markers used in analyzing genetic diversity for crop improvement; molecular mapping and tagging of agronomically important traits; Molecular cytogenetic markers: FISH and GISH, their application in crop improvement; Transposable elements - mechanism of action and their role in crop improvement; Quantitative trait loci (QTL) mapping - introduction, types of mapping populations; Role in crop improvement.

UNIT IV	APPLICATION OF MOLECULAR MARKERS	9

Construction of molecular maps (using F2, DH, RILs); Gene tagging using bulked segregant analysis (BSA) and near isogenic lines (NILs); QTL analysis; map-based cloning of genes; Elementary idea of marker-assisted selection (MAS) in plant breeding; Application of AI in Genomic Data Analysis and Predictive Breeding for Crop Improvement.

UNIT V	PRODUCTION OF TRANSGENIC PLANTS IN VARIOUS FIELD CROPS	9

Transgenic Crops: Cotton, wheat, maize, rice, soybean, oilseeds, sugarcane, etc.; Commercial releases; Biotechnology applications in male sterility/hybrid breeding, molecular farming; MOs and related issues (risk and regulations); GMO; International regulations, biosafety issues of GMOs; Regulatory procedures in major countries including India, ethical, legal and social issues; Intellectual property rights; Nanotechnology and its applications in crop improvement programmes.

	TOTAL PERIODS	45

COURSE OUTCOMES		
At the end of this course, the students will be able to		**BT MAPPED (Highest Level)**
CO1	explain plant genome structure and analyze DNA sequence variation in plant genomes.	Understanding (K2)
CO2	apply biotechnological techniques for disease resistance and evaluate nutritional modification in crops.	Applying (K3))
CO3	investigate molecular markers and identify their role in enhancing crop improvement.	Applying (K3)
CO4	construct molecular maps and examine gene tagging in crop breeding.	Applying (K3)
CO5	assess the production of transgenic plants and explore biosafety and regulatory concerns in GMOs.	Applying (K3)

TEXT BOOKS

1. Singh, B.D., "Plant Breeding: Principles and Methods", Kalyani Publishers, 11th Edition, 2020.
2. Chopra, V.L., "Plant Biotechnology: Applications and Prospects", Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi, 2011.

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1. Kung S and Arntzen CJ, "Plant Biotechnology", Butterworth, Boston, 1989.
2. Grierson D, "Plant Genetic Engineering: Plant Biotechnology Series", Volume I. Blockie, Glasgow, London, 1991.
3. Purohit, S.S., "Biotechnology: Fundamentals and Applications", Agrobios (India), 4th Edition, 2013
4. Satyanarayana, U., "Biotechnology", Books and Allied (P) Ltd., 2013.

CO/PO MAPPING:

Mapping of Course Outcome (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes PSO's

(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak

	PO's												PSO's	
CO's	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	2	1	–	–	–	–	–	–	–	–	–	3	–
CO2	3	3	3	2	2	–	–	–	–	–	–	–	3	3
CO3	3	3	3	2	2	–	–	–	–	–	–	–	3	3
CO4	3	3	3	3	3	–	–	–	–	–	–	–	3	3
CO5	3	3	2	2	2	2	3	2	–	2	2	3	3	3

BT23355	ADVANCE TECHNIQUES IN AGRO FORESTRY	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	understand the fundamental concepts and principles of silviculture.
2	demonstrate forest mensuration, management and utilization.
3	infer the advances in tree improvement.
4	examine the advances in wood and non-wood forest products.
5	infer the climate change and implications for sustainable forest management.

UNIT I SILVICULTURE 9

General silvicultural principles; ecological and physiological factors influencing vegetation; natural and artificial regeneration of forests; nursery techniques; seed technology collection, storage, pre-treatment and germination; establishment and tendings; Silvicultural systems - clear felling, uniform, shafter-wood, selection, coppice and conversion systems; Social forestry - objectives, scope, necessity; agro-forestry; extension forestry; recreation forestry; people's participation.

UNIT II FOREST MENSURATION, MANAGEMENT AND UTILIZATION 9

Methods of measuring-diameter, girth, height and volume of trees; form factor; volume estimation of stand; sampling methods; yield calculation; current annual increment; mean annual increment; sample plots; yield and stand tables; aerial survey and remote-sensing techniques. Forest management-objectives and principles; techniques; sustained yield relation; normal forest; growing stock; regulation of yield-methods of application; Forest utilization: Logging and extraction techniques and principles; Minor and major forest product - definition and scope. Collection, processing and disposal of minor and major forest products.

UNIT III ADVANCES IN TREE IMPROVEMENT 9

Mendelian concepts as applied to forest trees; Cytological and chromosomal systems of forest trees; Cytoplasmic inheritance in trees; Colchiploid and mutation breeding for forest trees; Physiological basis of tree improvement; Pollution responses of trees; Pollen handling and hybridization techniques in forest trees; Tissue culture of trees; Indirect selection for improvement of desired traits, molecular markers; Juvenile traits and their role in genetic evaluation in tree improvement programmes.

UNIT IV ADVANCES IN WOOD AND NON-WOOD FOREST PRODUCTS 9

Mechanics of wood and wood composites, Application of orthotropic and non-linear constitutive relations, Laminate theory and failure criterion in the prediction of mechanical properties of solid woods; Wood-polymer, Hybrid composite processing; Methods of extraction, chemistry, processing, import and export potential of gums, resins, tannins, dyes, essential oils, fixed oils, cutch and katha, drugs, spices, poisons, insecticides, pesticides, wild edible fruits etc.

UNIT V CLIMATE CHANGE AND FORESTRY 9

Climate change and implications for sustainable forest management; Impact of climate change on Indian forest, Adaptation of forest trees to climate change, Potential for adaptation, Evolutionary mechanisms; The challenge of climate change for forest management, Different concepts of adaptation to climate change, Case studies on the management of certain tree species in India; Application of AI for Forest Resource Monitoring, Tree Improvement, and Climate Resilient Forestry.

TOTAL PERIODS 45

COURSE OUTCOMES		
At the end of this course, the students will be able to		**BT MAPPED (Highest Level)**
CO1	explain general silvicultural principles and social forestry.	Understanding (K2)
CO2	relate the concept of forest mensuration, management and utilization.	Understanding (K2)
CO3	investigate the tissue culture of trees, indirect selection for improvement of desired traits.	Applying (K3)
CO4	construct advances in wood and non-wood forest products.	Applying (K3)
CO5	assess the climate change and implications for sustainable forest management.	Applying (K3)

TEXT BOOKS

1. McManus B. Collins and Fred M White, "Elementary Forestry", Reston Publishing Company, Virginia, 1981.
2. MacDonald, Glen M., "Biogeography: introduction to space, time, and life", John Wiley & Sons, 2025.

REFERENCES

1. Dwivedi, A.P., "A Text Book of Silviculture, International Book Distributors", Dehra Dun, 1993.
2. Lal, J.B., "Tropical Silviculture: New Imperatives: New Systems, International Book Distributors", Dehra Dun, 2003.
3. Longman, K.A. and Jenik, J., "Tropical forest and its Environment: ELBS", Second Edition, London, 1987.
4. Shanmughavel, P., "Techniques in Forestry", Pointer, Jaipur, 2003.

CO/PO MAPPING :

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	PO's												PSO's	
CO's	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	2	–	–	–	2	2	–	–	–	–	–	3	–
CO2	3	3	2	2	2	–	2	–	–	–	–	–	3	2
CO3	3	3	3	2	3	–	–	–	–	–	–	–	3	3
CO4	3	3	3	2	2	–	1	–	–	–	–	–	3	3
CO5	3	2	2	–	–	3	3	2	–	2	–	2	2	3

BT23356	PLANT TISSUE CULTURE AND TRANSFORMATION TECHNIQUES	3	0	0	3

COURSE OBJECTIVES	
To enable the students to	
1	provide in-depth knowledge of plant tissue culture principles and methodologies.
2	explore the practical applications of tissue culture in agriculture, horticulture, and biotechnology.
3	impart the knowledge on genetic transformation techniques and their applications in plant improvement.
4	familiarize with current advances in plant tissue culture and transformation technologies.
5	get an insight into Recombinant DNA technology and methods of gene transfer.

UNIT	INTRODUCTION TO PLANT TISSUE CULTURE	9

History of plant tissue culture research, basic principles of plant tissue callus culture, meristem culture, organ culture, Totipotency of cells, differentiation and dedifferentiation; Methodology - sterilization (physical and chemical methods), culture media, Murashige and Skoog's (MS medium), phytohormones, medium for micro-propagation/clonal propagation of ornamental and horticulturally important plants Callus subculture maintenance, growth measurements, morphogenesis

UNIT II	CULTURE TYPES AND TECHNIQUES	9

Endosperm culture; Embryo culture -culture requirements, applications, embryo rescue technique; Production of secondary metabolites; Cryopreservation; Germ plasm conservation.

UNIT III	ORGAN CULTURE	9

Anther, Embryo and Meristem culture; Organogenesis, somatic embryogenesis and artificial seeds; Somatic Hybridization - Isolation, fusion and protoplast culture; Somoclonal Variation and cryopreservation.

UNIT IV	TISSUE CULTURE IN FOREST TREES	9

In-vitro propagation via enhanced release of auxiliary buds; Somatic organogenesis and somatic embryo genesis, leaf diseases, embryoid and synthetic seed production; Haploid culture and production of homodiploids, Protoplast isolation, culture and regeneration.

UNIT V	TRANSFORMATION TECHNIQUES	9

Genetic transformation techniques in plants - Gene transfer methods in plants, Direct DNA transfer methods, Agro bacterium mediated nuclear transformation; Ti and Ri plasmids, binary and co-integrated vector systems; genetic markers; reporter genes; genetic transformation techniques for overcoming biotic and abiotic stress; Green house and green home technology; Arid and semiarid technology; Integration of AI for Optimization and Automation in Plant Tissue Culture and Genetic Transformation.

	TOTAL PERIODS	45

COURSE OUTCOMES		
At the end of this course, the students will be able to		**BT MAPPED (Highest Level)**
CO1	understand the historical developments in plant cell culture and learn to handle the techniques in aseptic conditions.	Understanding (K2)
CO2	acquire knowledge on endosperm culture, embryo rescue technique and cryopreservation.	Understanding (K2)
CO3	analyze the recent methodologies of plant tissue and cell culture to develop a whole plant.	Understanding (K2)
CO4	examine the recent methodologies of plant tissue and cell culture to develop a whole plant.	Applying (K3)
CO5	apply the concepts of plant tissue culture in agricultural science for crop improvement.	Applying (K3)

TEXT BOOKS

1. Murthy BRC & VST Sai, "Botany-Plant tissue culture and its biotechnological applications", Venkateswara Publications, 2012.
2. Pullaiah, T. and M.V.Subba Rao, "Plant Tissue culture", Scientific Publishers, New Delhi, 2009.

REFERENCES

1. Bhojwani, S.S. and Razdan, M.K., "Plant Tissue Culture: Theory and Practice", Elsevier Science Amsterdam, 1996.
2. Glick, B.R., Pasternak, J.J., "Molecular Biotechnology- Principles and Applications of recombinant DNA", ASM Press, Washington, 2003.
3. Bhojwani, S.S. and Bhatnagar, S.P, "The Embryology of Angiosperms", Vikas Publication House Pvt. Ltd., New Delhi, 2011.
4. Snustad, D.P. and Simmons, M.J, "Principles of Genetics", John Wiley and Sons, U.K. 5th Edition, 2010.

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CO2	3	2	–	–	–	–	–	–	–	–	–	–	2	2
CO3	3	3	3	2	2	–	–	–	–	–	–	–	3	3
CO4	3	3	3	3	3	–	–	–	–	–	–	2	3	3
CO5	3	3	3	3	3	–	2	–	–	–	–	3	3	3

BT23357	FUNGAL AND ALGAL TECHNOLOGY	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	describe the key concepts in the research areas of mycology and algae.
2	discover the structure and reproduction of various fungal forms.
3	generalize the economic importance of lichens.
4	identify the general characteristics and classification of Algae.
5	analyze the application potentials of algae to produce commercial products.

UNIT	GENERAL CHARACTERS OF FUNGI	9

Introduction to the Fungi, Diversity of fungi and fungus-like organisms, History of mycology the fungal body and cells, and growth, fungal physiology, nutrition, and growth; Mushrooms, Mushroom poisoning, Rust and smut fungi, Range of structure and organization of vegetative and reproductive bodies; Ontogeny of conidia, Saccardo"s classification system, conidial fungi, sterile technique; Isolation and growing fungi.

UNIT II	FUNGAL FORMS AND ASSOCIATIONS	9

Structure and reproduction of fungal forms (no developmental stage) - Rhizopus, Aspergillus, Saccharomyces, Neurospora; Types, structure, reproduction; Mycorrhizae Clinical mycology - Structure, reproduction, Diagnoses and control measures of Dermatophytoses - (Trichophyton); Systemic mycoses (Candida), Fungal toxins; New Antifungal Agents and Vaccine Research in Clinical Mycology.

UNIT III	ECONOMIC IMPORTANCE OF FUNGI	9

Economic importance; Lichens - Habitat, Structure and organization of lichens; Method of reproduction; Physiological relationship of mycobiont and phycobiont; Economic importance of lichens, Mycorrhizae - Habitat, Structure and organization of Mycorrhizaes; Types of Mycorrhizae and its economic importance; Lichens as Bioindicators of Urban Pollution and Climate Change.

UNIT IV	ALGAE - INTRODUCTION	9

A general account and classification of Algae, distribution, range of thallus organization, pigmentation flagellation, reserve food, Reproduction (vegetative-asexual-sexual); Lifecycle patterns salient features of algal divisions, phylogeny, Fossil algae, Algae - Structure and reproduction with reference to the Anabaena, Chlorella, Volvox algal forms.

UNIT V	ALGAE - APPLICATIONS	9

Algal biotechnology; single cell proteins (SCP) - Spirulina as single cell protein; production and harvesting of algal biomass; Factors affecting biomass production; Cyanobacterial inoculants (BGA); Isolation, preparation of starter culture, mass cultivation, field applications and crop response; Economic importance of algae - Algae as food and fodder, use of algae in agriculture and space research, commercial products of algae - Agar Agar, Alginates, Carrageenan, diatomite, mucilage, minerals and elements; Algae in medicine and biofuels; Application of AI in Fungal and Algal Biodiversity Assessment and Industrial Biotechnology

	TOTAL PERIODS	45

COURSE OUTCOMES		
At the end of this course, the students will be able to		**BT MAPPED (Highest Level)**
CO1	explain the general characteristics, diversity, structure, and growth of fungi and algae.	Understanding (K2)
CO2	distinguish the structure and reproduction of important fungal and algal forms.	Understanding (K2)
CO3	generalize the role of fungi and algae in human health, agriculture, and industry.	Understanding (K2)
CO4	apply the basic techniques for isolating, growing, and studying fungi and algae.	Applying (K3)
CO5	examine the economic importance and modern applications of fungi and algae, including their use in biotechnology and biofuels.	Applying (K3)

TEXT BOOKS

1. Alexopoulos, C.J., Mims, C.W., and Blackwell, M. "Introductory Mycology", 4th Edition, Wiley India Pvt. Ltd., 2010.
2. Sharma, O.P. "Textbook of Algae", Tata McGraw Hill Education Pvt. Ltd., 2004.

REFERENCES

1. Webster, J. and Weber, R. "Introduction to Fungi", 3rd Edition, Cambridge University Press, 2007.
2. Dubey, R.C. and Maheshwari, D.K. "A Textbook of Microbiology", S. Chand Publishing, 2016.
3. Lee, R.E. "Phycology", 4th Edition, Cambridge University Press, 2008.
4. Kumar, H.D. "Introductory Phycology", Affiliated East-West Press Pvt. Ltd., 1999.

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CO2	3	3	2	2	2	–	–	–	–	–	–	–	3	2
CO3	3	3	2	–	2	–	–	–	–	–	–	–	3	3
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CO5	3	3	3	–	2	–	–	–	–	–	–	2	3	3

PAAVAI ENGINEERING COLLEGE, NAMAKKAL
Approved
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BIOTECHNOLOGY
20/6/21
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BT23451	PROGRAMMING FOR BIOINFORMATICS APPLICATIONS	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	acquire programming skills and database management.
2	introduce the fundamentals of PERL programming language.
3	gain knowledge about the different operators and their functions.
4	understand the regular expressions characters.
5	impart knowledge about the applications of PERL in bioinformatics.

UNIT I	INTRODUCTION	9

Introduction to Operating systems, Linux commands, File transfer protocol (FTP) and TELNET; Data life cycle; Database management system models; Structured Query Language (SQL) - Data Definition Language (DDL), Data Manipulation Language (DML) and Query and its examples; Procedural Language extensions to Structured Query Language (PL/SQL) - Stored procedure, Database triggers; Relational Data Base Management System (RDMS).

UNIT II	PERL PROGRAMMING	9

PERL - overview, variables and data types, control structure; Loops- while loop, for loop, until loop; File handles - opening and closing files, reading and writing file handles; Library Functions - String specific functions, User defined functions.

UNIT III	OPERATORS	9

Arithmetic Operators, Assignment Operators, Logical operators, Equality Operators, Increment and Decrement Operators, String Concatenation and Repetition, Operators precedence and associativity, Conditional Operators, Logical Operators, Operators for manipulating arrays, Operators for manipulating hashes.

UNIT IV	REGULAR EXPRESSIONS	9

Simple characters, PERL regular expressions, grouping with ()s, anchor characters; pattern matching, regular expression shortcuts, defining subroutines, returning values, using arguments, inheritance in PERL, polymorphism in PERL.

UNIT V	APPLICATIONS OF PERL IN BIOINFORMATICS	9

PERL programming for - Concatenating DNA Fragments; Transcription - DNA to RNA, Reading Protein Files, Finding Motifs, Simulating DNA, Generating Random DNA, Analysing DNA, Translating DNA to Proteins, Reading DNA from Files in FASTA format, Separating Sequence and Annotation, Parsing Annotation, Parsing PDB files, Parsing BLAST output, Bio-PERL: AI-Driven Automation of Bioinformatics Pipelines Using PERL Scripting and Machine Learning APIs, Integration of AI-Powered Natural Language Processing with PERL for Intelligent Parsing and Querying of Biological Databases.

	TOTAL PERIODS	45

COURSE OUTCOMES		
At the end of this course, the students will be able to		**BT MAPPED (Highest Level)**
CO1	understand the basics of Linux operating system and the SQL for database creation and management.	Understanding (K2)
CO2	infer the data types to construct programs in PERL.	Understanding (K2)
CO3	relate the various operators, regular expressions, conditional statements and loops in PERL programs.	Applying (K3)
CO4	apply simple characters and regular expression shortcuts in PERL.	Applying (K3)
CO5	appraise the applications of PERL programming in handling genomics and proteomics data.	Analysing (K4)

TEXTBOOKS

1. Tisdall, James, "Beginning Perl for Bioinformatics: an introduction to Perl for Biologists ", O'Reilly Media, Inc.", 2001.
2. Elmasri, Ramez, "Fundamentals of database systems", Pearson Education India, 2008.

REFERENCES

1. Moorhouse, Michael, and Paul Barry, "Bioinformatics biocomputing and Perl: an introduction to bioinformatics computing skills and practice", John Wiley & Sons, 2005.
2. Dwyer, Rex A, "Genomic perl: From bioinformatics basics to working code", Vol. 1. Cambridge University Press, 2003.
3. Guttag, John V. Introduction to computation and programming using Python. MIT Press, 2013.
4. Jones, Adam, "Advanced Perl Techniques for Bioinformatics: Optimizing Data Analysis and Computational Biology", Walzone Press, 2025.

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

BT23452	MOLECULAR MODELING	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	understand the basic concepts of computational / theoretical chemistry / biology for drug designing.
2	explain the principle involved in molecular mechanics and energy minimization.
3	apply molecular dynamics and Simulation for conformational analysis.
4	correlate drug interaction with macromolecules.
5	interpret the different strategies used in designing drugs and prodrugs.

UNIT I	QUANTUM MECHANICS	9

Introduction - coordinate systems; potential energy surfaces - introduction to quantum mechanics, postulates; Schrodinger wave equation - hydrogen molecule; Born-Oppenheimer approximation. Introduction to computer hardware and software.

UNIT II	MOLECULAR MECHANICS AND ENERGY MINIMIZATION	9

Empirical force field models, Bond stretching- angle bending, torsional term, nonbonding interactions; Thermodynamics properties using a force field- derived and non-derived energy minimization methods, simplex - sequential univariate method, steepest descent method, conjugate gradient method, Newton-Rapson method.

UNIT III	MOLECULAR DYNAMICS	9

Basic principles of molecular dynamics - Constrain dynamics, Conformational changes from molecular dynamics; Monte Carlo Simulation – chemical potential, Gibbs energy, bias Monte Carlo method; Conformational analysis, Ab initio – Density; Functional Theory and semi empirical methods.

UNIT IV	MACROMOLECULAR MODELING	9

Identification and mapping of active sites; Design of ligands for known macromolecular target sites; Drug-receptor interactions; Classical Structure-Activity Relationship and Quantitative Structure-Activity Relationship (SAR/QSAR) studies and their implications to the 3D modeler; 2D and 3D database searching; pharmacophore identification and novel drug design.

UNIT V	STRUCTURE PREDICTION AND DRUG DESIGN	9

Structure Prediction - Introduction to comparative modeling, sequence alignment, constructing and evaluating a comparative model; Predicting Protein Structures using Threading, Molecular Docking, AutoDock and Hex Protein docking; Structure based DeNovo Ligand design; Drug Discovery - Cheminformatics, QSAR; Drug Design - Analog and Structure based drug design; Integration of AI for Accelerated Quantum Chemistry Calculations and Potential Energy Surface Prediction.

	TOTAL PERIODS	45

COURSE OUTCOMES		
At the end of this course, the students will be able to		**BT MAPPED (Highest Level)**
CO1	summarize the software skills for biomolecules Modeling.	Understand (K2)
CO2	understand the different methods involved in molecular Modeling.	Understand (K2)
CO3	infer the dynamics of the molecules in conformational change.	Applying (K3)
CO4	appraise the development of biomolecules related to drug interaction.	Analyzing (K4)
CO5	interpret the structure of protein in drug designing.	Analyzing (K4)

TEXT BOOKS

1. Leach, Andrew R. "Molecular Modeling: principles and applications", Pearson education, 2001.
2. Mannhold, Raimund, Hugo Kubinyi, and Hendrik Timmerman. "Molecular Modeling: Basic Principles and Applications", John Wiley & Sons, 2008.

REFERENCES

1. Allinger, Norman L. "Molecular structure: understanding steric and electronic effects from molecular mechanics", John Wiley & Sons, 2010.
2. Silverman, Richard B., and Mark W Holladay. "Organic chemistry of drug design and drug action", Academic press, 2014.
3. Ramachandran, K. I., Gopakumar Deepa, and Krishnan Namboori. "Computational chemistry and molecular modeling: principles and applications", Springer Science & Business Media, 2008.
4. Hinchliffe, Alan. Molecular Modeling for beginners. John Wiley & Sons, 2003.

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CO1	3	3	2	2	2	-	2	-	-	-	-	1	1	1
CO2	2	3	2	2	2	-	2	1	-	-	-	1	1	2
CO3	2	3	-	1	2	-	2	-	-	-	-	-	1	1
CO4	2	3	1	1	2	-	2	1	-	-	-	1	2	2
CO5	2	3	1	3	3	-	2	2	-	-	-	2	3	3

BT23453	SYSTEMS AND SYNTHETIC BIOLOGY	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	acquire the basics of gene expression and cell metabolism.
2	understand the biological networks, designing and simulation techniques.
3	explore synthetic biology tools used for designing artificial genetic circuits and components.
4	apply numerical and computational methods in analyzing and optimizing biological systems.
5	study real-world examples of engineered biological systems and ethical issues related to synthetic biology.

UNIT I	INTRODUCTION TO BASIC CELLULAR AND MOLECULAR BIOLOGY	9

Central dogma of biology, mechanisms of gene expression; Kinetics of enzyme action - Rate Processes, Raw laws, Stoichiometric analysis, Enzyme reaction kinetics; Introduction to cell metabolism - Metabolic pathways, Protein signaling.

UNIT II	BIOLOGICAL NETWORKS	9

Introduction to systems and synthetic biology; Biological networks- metabolic, signaling, regulatory networks, Network alignment and comparisons, network organization; Designing, simulating and building gene circuits, Genome design and synthesis.

UNIT III	SYNTHETIC NETWORKS	9

Introduction to Synthetic Networks - Simple Synthetic Networks, Structure of Synthetic Networks, Applications of Synthetic Networks; Building Synthetic Networks - Design of Promoters, Design of RNAs, Design of Circuits; Characterization and Optimization of Devices; Gene Expression and Network Performance - Noise in Gene Expression, Monitoring Outputs; Examples of Synthetic Networks.

UNIT IV	TOOLS IN SYSTEMS AND SYNTHETIC BIOLOGY	9

Flux-based Analysis (FBA); Computer aided design tools for metabolic engineering (Integer Linear Program, retrosynthesis); Development of a flux theoretical model, correlation of the model with experimental data, Simulation of synthetic networks, Manipulating DNA and measuring network responses.

UNIT V	ETHICS IN SYSTEMS AND SYNTHETIC BIOLOGY	9

Biosafety introduction; Reengineering living organisms, ethical questions of synthetic biology, Current science-society situation and the place of synthetic biology; Controversies around key concepts - novelty, perfection, intentionality, complexity, life; Scientist's responsibility - Dual-use research and its implications from ethics to biosecurity; AI-Driven Design and Simulation of Synthetic Gene Circuits, AI-Enabled Network Analysis and Metabolic Pathway Optimization in Systems Biology.

	TOTAL PERIODS	45

COURSE OUTCOMES		
At the end of this course, the students will be able to		**BT MAPPED (Highest Level)**
CO1	explain basics cellular and molecular biological in signaling pathways.	Understanding (K2)
CO2	understand the biological networks, its organization, designing and simulation.	Understanding (K2)
CO3	apply basic synthetic biology circuits in synthetic networks	Applying (K3)
CO4	use computational tools to analyze gene functions and optimize biological system performance.	Applying (K3)
CO5	apply real-life applications of engineered biological systems and related ethical and legal issues.	Applying (K3)

TEXT BOOKS

1. Klipp, Edda, Ralf Herwig, Axel Kowald, Christoph Wierling, and Hans Lehrach. Systems biology in practice: concepts, implementation and application. John Wiley & Sons, 2005.
2. Christina Smolke. The Synthetic Biology Handbook. CRC Press, 2009.

REFERENCES

1. Machin, David, Simon Day, and Sylvan Green, eds. Textbook of clinical trials. John Wiley & Sons, 2007.
2. Kitano, Hiroaki. Foundations of systems biology. The MIT Press Cambridge, Massachusetts London, England, 2001.
3. Covert, Markus W. Fundamentals of systems biology: from synthetic circuits to whole-cell models. CRC Press, 2017.
4. Palsson, Bernhard. Systems biology: properties of reconstructed networks. Cambridge university press, 2006.

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CO3	2	1	3	2	1	1	-	-	-	-	-	1	1	2
CO4	2	1	3	3	3	2	-	1	-	-	-	1	2	2
CO5	3	2	2	2	2	2	-	3	-	-	-	1	3	2

BT23454	FUNDAMENTALS OF ALGORITHMS FOR BIOINFORMATICS	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	learn different types of algorithms involved in biological problems solving.
2	understand dynamic programming in DNA/protein sequence alignments.
3	explore exact matching, hidden Markov models, and its role in gene prediction.
4	gain knowledge about artificial neural networks and their applications in pattern recognition in biology.
5	study specific algorithms used for analyzing DNA and RNA structures, motifs, and regulatory elements.

UNIT I	INTRODUCTION TO ALGORITHMS	9

Algorithms - complexity of algorithms and running time: Polynomial, Nondeterministic Polynomial time (NP) complete problems, Recursion, Linear, exhaustive search, Branch and Bound, divide and conquer algorithms, Travelling salesman problem, sorting.

UNIT II	DYNAMIC PROGRAMMING AND SEQUENCE BASED ALGORITHMS	9

Dynamic programming - Principles and its uses; Local and Global alignment – principles, finding longest common subsequences; Heuristics; Second generation alignment tools for database searching - BLAST, FASTA, ClustalW; Statistical and Similarity based methods for gene prediction, Models of evolution.

UNIT III	EXACT MATCH AND HIDDEN MARKOV MODELS	9

Knuth-Morris-Pratt and Boyer-Moore algorithm for exact match and graph, Maximum Likelihood algorithm; Hidden Markov Model (HMM) - Forward and Backward Algorithms; Most probable state path - Viterbi algorithm; Parameter Estimation for HMMs - Baum-Welch Algorithm, EM Algorithm, Applications of profile HMMs for multiple alignment of proteins and for finding genes in the DNA.

UNIT IV	ARTIFICIAL NEURAL NETWORKS	9

Introduction to Artificial Neural Networks (ANN) - a simple neuron, firing rule, network layers; Architecture of Artificial Neural Network, Feed-Forward networks, Feed-Back networks, Perceptrons, Pattern recognition problems, Back Propagation Algorithm, Applications of Neural Networks.

UNIT V	DNA AND RNA RELATED ALGORITHMS	9

Restriction enzyme mapping algorithms - algorithms for partial digest, double digest problem; Motif finding - finding regulatory motifs in DNA, DNA computing, Genome alignment, Suffix Trees; RNA secondary structure prediction - Base pair maximization and the Nussinov folding algorithm, Energy minimization and the Zuker folding algorithm, Design of covariance models, Application of RNA Fold; Deep Learning for Complex Sequence Alignment and Gene Prediction, AI-Augmented RNA and DNA Structure Prediction.

	TOTAL PERIODS	45

COURSE OUTCOMES		
At the end of this course, the students will be able to		**BT MAPPED (Highest Level)**
CO1	summarize suitable algorithms for biological data analysis problems.	Understanding (K2)
CO2	explain sequence alignments using dynamic programming and heuristic tools.	Understanding (K2)
CO3	implement Hidden Markov models for gene prediction and protein sequence analysis.	Applying (K3)
CO4	examine the basics of neural networks and their applications in bioinformatics.	Applying (K3)
CO5	analyze the algorithms involved in RNA folding, motif discovery, and DNA computing.	Analyzing (K4)

TEXT BOOKS

1. Guigó, Roderic, and Dan Gusfield, eds. Algorithms in Bioinformatics: Second International Workshop, WABI 2002, Rome, Italy, September 17-21, 2002, Proceedings. Vol. 2452. Springer Science & Business Media, 2002.
2. Neil C. Jones and Pavel A. Pevzner, "An Introduction to Bioinformatics Algorithms", MIT Press, 2004.

REFERENCES

1. Pavel Pevzner, "Computational Molecular Biology: An Algorithmic Approach", MIT Press, 2000.
2. Baldi, Pierre and Brunak, Søren, "Bioinformatics: The Machine Learning Approach", MIT Press, 2001.
3. Richard Durbin, Sean R. Eddy, Anders Krogh, and Graeme Mitchison, "Biological Sequence Analysis: Probabilistic Models of Proteins and Nucleic Acids", Cambridge University Press, 1998.
4. Tandy Warnow, "Computational Phylogenetics: An Introduction to Designing Methods for Phylogeny Estimation", Cambridge University Press, 2017.

CO/PO MAPPING:

Mapping of Course Outcome (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes PSO's

(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak

	PO's												PSO's	
CO's	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	1	1	1	2	3	1	-	-	-	-	-	2	1	1
CO2	1	1	2	2	3	1	-	-	-	-	-	2	1	1
CO3	2	2	1	2	3	1	-	-	-	-	-	1	1	1
CO4	2	2	1	3	3	1	-	1	-	-	-	1	2	2
CO5	2	3	2	2	3	1	-	1	-	-	-	1	3	3

BT23455	ARTIFICIAL INTELLIGENCE FOR BIOTECHNOLOGY	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	infer the concepts of artificial intelligence.
2	explore the knowledge representation.
3	relate the expert systems in artificial intelligence.
4	acquire the methods of solving problems using artificial intelligence.
5	identify the concepts of expert systems and machine learning on various applications.

UNIT I	INTRODUCTION TO ARTIFICIAL INTELLIGENCE	9

Artificial Intelligence - History Importance and Applications: Machine Learning Basics - Supervised Learning, Unsupervised Learning: Neural Networks, Basics of Neural Networks, Introduction to Deep Learning, Data Preprocessing, Data Cleaning, Data Transformation.

UNIT II	AI SOFTWARE FOR BIOTECHNOLOGY	9

Introduction to TensorFlow, Basics of Keras, Genomics and AI, AI in Genome Sequencing, Basic Genomic Data Analysis, Data Mining in Biotechnology, Basic Techniques, Introduction to Big Data, Big Data in Biotechnology, Basic Data Analysis.

UNIT III	DRUG DISCOVERY	9

AI in Drug Discovery, Basics of Target Identification, Introduction to Virtual Screening, AI in Personalized Medicine, Basics of Precision Medicine, AI Applications, Proteomics and AI, AI in Protein Structure Prediction, Protein Protein Interactions.

UNIT IV	OTHER BIOTECHONOLGY	9

Clinical Applications of AI, AI in Disease Diagnosis, Predictive Modeling, AI in Medical Imaging, Basics of Image Analysis, Case Studies, AI in Agricultural Biotechnology, AI in Crop Genomics, Pest Resistance, AI in Environmental Biotechnology, AI in Bioremediation, Case Studies.

UNIT V	AI INNOVATIONS	9

AI in Industrial Biotechnology, AI in Process Optimization, AI in Biofuel Production, AI in Food Biotechnology, AI in Food Safety, Case Studies, AI and Bioethics, Ethical Considerations in AI, Regulatory Framework, Future Prospects of AI in Biotechnology, Innovations, Challenges and Opportunities.

	TOTAL PERIODS	45

COURSE OUTCOMES

At the end of this course, the students will be able to		BT MAPPED (Highest Level)
CO1	infer problems that are amenable to solutions by AI methods.	Understanding (K2)
CO2	demonstrate knowledge representation and apply to solve a given problem	Understanding (K2)
CO3	report a given problem in the language/framework of different AI method	Applying (K3)

CO4	appraise knowledge inference and expert systems	Analyse (K4)
CO5	use AI based solutions for industrial and healthcare applications	Applying (K3)

TEXT BOOKS

1. Russell, Stuart J., and Peter Norvig, "Artificial intelligence: a modern approach", Pearson, 2016.
2. Preethi Kartan, "Artificial Intelligence in Biotechnology", Delve Publishing, 2020.

REFERENCES

1. Pham, Tuan D., Hong Yan, Muhammad W. Ashraf, and Folke Sjöberg, "Advances in Artificial Intelligence, Computation, and Data Science", Springer International Publishing, 2021.
2. Hamadani, Ambreen, Nazir A. Ganai, Hamadani Henna, and Janibul Bashir, eds. "A Biologist's Guide to Artificial Intelligence: Building the Foundations of Artificial Intelligence and Machine Learning for Achieving Advancements in Life Sciences", Elsevier, 2024.
3. Khemani D, "Artificial Intelligence", Tata Mc Graw Hill Education, 2013.
4. Carpentieri, Bruno, and Paola Lecca, eds. "Big data analysis and artificial intelligence for medical sciences", John Wiley & Sons, 2024.

CO/PO MAPPING:

Mapping of Course Outcome (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes PSO's

(1/23 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak

CO's	PO's												PSO's	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	1	1	1	1	-	1	1	-	-	1	1	3	3
CO2	2	1	1	2	2	-	2	1	-	-	1	1	1	3
CO3	2	2	1	1	2	-	1	1	-	-	1	2	2	2
CO4	1	1	1	1	2	-	2	2	-	-	1	1	2	2
CO5	3	1	1	1	3	-	2	3	-	-	1	1	1	1

BT23456	INTERNET OF THINGS IN BIOTECHNOLOGY	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	learn the history and basic concepts of Internet of Things.
2	identify the various components of Internet of Things.
3	use Internet of Things for different biotechnological applications.
4	categorize Internet of Things for various pharmaceutical applications.
5	apply the concepts of Internet of Things in case studies.

UNIT I	HISTORICAL BACKGROUND OF IoT	9

Internet of Things – Definition, Basic concept, major domains in biotechnology; Timeline - History, Present and Future of IOT; Biosensor integration and intelligence; Artificial intelligence and IOT; Biotech – IoT evolution – Agriculture, Healthcare, Pharma, Diagnostics and Treatment.

UNIT II	COMPONENTS OF IoT	9

Functional Blocks of an IoT Ecosystem – Sensors and Actuators, Transceivers; Communication platforms - Ethernet, cellular, and Wi-Fi; Processors and Boards; Power Supplies - conventional thin film batteries; Photovoltaic panels and energy harvesting modules, Gateways and Routers, Devices and Equipment Products used by end users - enabled equipment, wearables, hand-held scanners, and tracking devices.

UNIT III	IoT IN BIOTECHNOLOGY	9

Introduction to Biotechnology and IoT integration; Smart laboratories as IoT transformation; Healthcare Revolution – role in COVID, biomedical device and digital integration, data management system, drug delivery system; Agriculture – Precision agriculture, Environmental monitoring, Bioinformatics – Cloud analytics, genomics, proteomics and transcriptomics; AI-Driven Predictive Analytics in IoT-Enabled Smart Labs.

UNIT IV	IoT IN PHARMACEUTICAL BIOTECHNOLOGY	9

Discovery of novel drugs and biologics; Challenges - product instability and subsequent recalls, GMP regulations, supply chain management; Concept of "Organ in a Chip", Smart warehouses, 2D bar-coding,Radio frequency identification RFID tags, Automatic Information Data Collection (AIDC) in packaging; Complete digital footprint - cold chains for the temperature-sensitive drugs during the transport; Intelligent IoT Systems for Precision Medicine and Digital Therapeutics.

UNIT V	CASE STUDIES	9

Era of "omics" - high evolutionary pace of novel microbial strains, phages and other biological breakthroughs, Acquisition of reproducibility and consistency; IoT enabled instruments with intelligence - Cloud servers; Case Study - Healthcare leader Bayer; Case Study - Laboratory automation, Synbio (Europe British) enhancing productivity, accuracy and reproducibility, Automated smart labs (USA); Case Study - Ginkgo Bio-works.

	TOTAL PERIODS	45

COURSE OUTCOMES		
At the end of this course, the students will be able to		**BT MAPPED (Highest Level)**
CO1	understand the historical development of Internet of things	Understanding (K2)
CO2	infer sensors, communication models and various protocols for IoT.	Understanding (K2)
CO3	apply the IoT concepts in biotechnology and agriculture fields	Applying (K3)
CO4	compare the data and use 2D bar-coding to IoT in pharmaceutical biotechnology.	Applying (K3)
CO5	use the IoT concepts in analyzing the case studies.	Analyzing (K4)

TEXT BOOKS

1. Tripathy, B. K., and J. Anuradha, eds. "Internet of things (IoT): technologies, applications, challenges and solutions", CRC press, 2017.
2. Srivastav, Alok Kumar, Priyanka Das, and Ashish Kumar Srivastava. "Introduction to Biotechnology and IoT Integration." In Biotech and IoT: An Introduction Using Cloud-Driven Labs, Berkeley, CA: Apress, 2024.

REFERENCES

1. Srivastav, Alok Kumar, and Priyanka Das. "IoT, Biotechnology, and the Future of Agriculture." In Biotechnology and IoT in Agriculture and Food Production. Apress, Berkeley, CA, 2025.
2. Uckelmann, Dieter, Mark Harrison, and Florian Michahelles, eds. "Architecting the internet of things", Springer Science & Business Media, 2011.
3. Greengard, Samuel. "The internet of things", MIT press, 2021.
4. Karki, Parkash, and Perry Lea, "Internet of things for architects", Packt Publishing, 2018.

CO/PO MAPPING:

Mapping of Course Outcome (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes PSO's

(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak

	PO's												PSO's	
CO's	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	1	-	1	2	2	-	-	-	-	-	-	2	1	1
CO2	1	3	1	2	2	-	-	-	-	-	-	2	2	3
CO3	1	2	1	2	2	1	1	-	-	-	-	1	1	3
CO4	1	2	1	2	2	1	1	-	-	-	-	1	2	3
CO5	3	2	2	2	2	1	-	-	-	-	-	1	3	2

BT23457	DATA MINING AND MACHINE LEARNING TECHNIQUES FOR BIOINFORMATICS	3	0	0	3

COURSE OBJECTIVES	
To enable the students to	
1	understand the fundamental concepts and algorithms of data mining and machine learning.
2	apply machine learning techniques to biological data analysis.
3	explore clustering, classification, and visualization methods in bioinformatics.
4	develop skills for preprocessing biological datasets and handling large-scale data.
5	use bioinformatics tools for data mining applications in genomics and proteomics.

UNIT I	OVERVIEW OF MACHINE LEARNING TECHNIQUES	9

Introduction to Machine learning – Types (Supervised and unsupervised techniques); Empirical Risk Minimization, Structural Risk Minimization; Measuring the accuracy of learned hypotheses – Metrics, Receiver Operating Characteristic (ROC) and Area Under the Curve (AUC); Comparing learning algorithms - cross-validation, learning curves, and statistical hypothesis testing.

UNIT II	MACHINE LEARNING TECHNIQUES	9

Classification - Decision tree, Bayesian, Rule based classification, Artificial Neural network, Support Vector Machine, Hidden Markov Models; Case based reasoning and applications in Bioinformatics; Clustering - Partition Methods, Hierarchical methods, Density based methods, Grid based clustering, Model based clustering, clustering of high dimensional data, constraints based clustering; Analysis of molecular dynamics trajectories, Protein Array data Analysis.

UNIT III	DATA MINING TECHNIQUES AND ALGORITHMS	9

Frequent pattern mining - Apriori, Frequent pattern-growth algorithms, Association rule mining in biological datasets; Dimensionality reduction techniques – Principal Content Analysis, t-Stochastic Neighbor Embedding, Feature selection and extraction in bioinformatics data; Evaluation metrics and model validation in data mining.

UNIT IV	DATA PREPROCSSING AND VISUALIZATION	9

Overview of data preprocessing; Data cleaning, Data integration, Data reduction, Data transformation and discretization; Visualization- Visualizing a single attribute, Visualizing pair of attributes, Visualizing several attributes, Visualizing results of machine learning.

UNIT V	APPLICATIONS OF DATA MINING	9

Application of Data Mining in Biodata analysis - DNA/protein sequence Analysis, Genome analysis, Protein Structure Analysis, Pathway analysis, microarray data analysis, annotation, gene ontology, gene mapping; Biological data mining tools: Entrez, BLAST, Sequence Retrieval System (SRS); Deep Learning Approaches for Multi-Omics Integration and Analysis, Explainable AI (XAI) for Biological Data Mining and Decision Support.

	TOTAL PERIODS	45

COURSE OUTCOMES		
At the end of this course, the students will be able to		**BT MAPPED (Highest Level)**
CO1	paraphrase of machine learning and data mining principles.	Understanding (K2)
CO2	apply classification and clustering algorithms to biological data.	Applying (K3)
CO3	appraise data preprocessing and visualization techniques effectively.	Analyzing (K3)
CO4	use advanced data mining algorithms in bioinformatics.	Applying(K3)
CO5	analyze and interpret data mining results in biological contexts.	Analyzing(K4)

TEXT BOOKS

1. Witten, Ian H., and Eibe Frank. "Data mining: practical machine learning tools and techniques with Java implementations." Acm Sigmod Record 31, no. 1 (2002): 76-77.
2. Clarke, Bertrand, Ernest Fokoue, and Hao Helen Zhang. "Principles and theory for data mining and machine learning." 2009.

REFERENCES

1. Wang, Jason TL, Mohammed J. Zaki, Hannu TT Toivonen, and Dennis Shasha. "Introduction to data mining in bioinformatics - In Data mining in bioinformatics", pp. 3-8. London: Springer London, 2005.
2. Carugo. "Data mining techniques for the life sciences", Edited by Oliviero Carugo, and Frank Eisenhaber. Vol. 609. New York: Humana Press, 2010.
3. Yang, Xin-She, "Introduction to algorithms for data mining and machine learning", Academic press, 2019.
4. Pujari, Arun K, "Data mining techniques", Universities press, 2001.

CO/PO MAPPING:

Mapping of Course Outcome (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes PSO's

(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak

	PO's												PSO's	
CO's	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	1	1	1	1	2	2	-	-	-	-	-	2	1	1
CO2	1	3	1	1	2	2	-	-	-	-	-	2	2	3
CO3	1	1	1	2	2	1	-	-	-	-	-	1	1	3
CO4	1	1	1	-	2	2	-	-	-	-	-	1	2	2
CO5	3	1	2	2	2	2	-	-	-	-	-	1	3	2

BT23551	ANIMAL BIOTECHNOLOGY	3	0	0	3

COURSE OBJECTIVES	
To enable the students to	
1	describe the theories of the origin of life and evolution.
2	classify animal diversity and their levels with examples.
3	summarize the various cell culture techniques and their structural organization.
4	use the micromanipulation technology and embryos transfer.
5	examine the concepts transgenic animal technology and their importance in biotechnology.

UNIT I	ORIGIN AND EVOLUTION OF LIFE	9

Theories of the origin of life - early earth; modern self-assembly theories - Oparin Haldane theory of chemical evolution. The Miller Urey experiment. Organic evolution. Development of evolution theory. Darwin's theory; Origin and evolution of human being.

UNIT II	ANIMAL DIVERSITY	9

Basis of classification, levels of organization (Symmetry, diploblastic and triploblastic organization). Coelom, segmentation, Notochord; The nature of natural selection - Examples of natural selection, levels of selection, selection of organisms and groups, species selection.

UNIT III	STRUCTURAL ORGANIZATION AND CELL CULTURE TECHNIQUES	9

Animals Tissues, Epithelial Tissue, connective Tissue, Muscle Tissue, Neural Tissue; Culturing of cells, primary and secondary cell lines, Cell Culture-Scaling up of animal cell culture- monolayer culture, suspension culture.

UNIT IV	MICROMANIPULATION OF EMBRYOS	9

Equipment used in micromanipulation; Artificial insemination and germ cell manipulations; Enrichment of X and Y bearing sperms from semen samples of animals; In vitro fertilization and embryo transfer; Stem cell cultures - embryonic stem cells and their applications; Strategies to produce transgenic animals; AI-based Image Analysis for Embryo Micromanipulation and IVF Success Prediction.

UNIT V	TRANSGENIC ANIMALS	9

Concepts of transgenic animal technology; strategies for the production of transgenic animals and their importance in biotechnology; stem cell cultures in the production of transgenic animals - Three dimensional cultures and tissue engineering; Production of pharmaceuticals and donor organs; AI-driven Genomic and Phenotypic Data Integration for Transgenic Animal Design.

	TOTAL PERIODS	45

COURSE OUTCOMES		
At the end of this course, the students will be able to		BT MAPPED (Highest Level)
CO1	explain the evolution of life and origin.	Understanding (K2)
CO2	classify the animal diversity and levels of organization.	Understanding (K2)

CO3	describe the animal cell culture techniques and structural organizations.	Understanding (K2)
CO4	examine the micromanipulation technology and breeding of farm animals.	Applying (K3)
CO5	utilize the transgenic animal technology for the production of transgenic animals.	Applying (K3)

TEXT BOOKS

1. Freshney, R. Ian., "Culture of animal cells: a manual of basic technique and specialized applications", John Wiley & Sons, 2015.
2. Verma, Ashish S., and Anchal Singh, eds. "Animal biotechnology: models in discovery and translation", Academic Press, 2013.

REFERENCES

1. Sue Dallas, Emily Jewell, "Animal Biology and Care", Wiley-Blackwell, Third Edition, 2018.
2. Shull, Aaron Franklin, George Roger Larue, and Alexander Grant Ruthven, "Principles of animal biology", Second Edition, McGraw-Hill Book Company, Incorporated, 2009.
3. Ranga M.M, "Animal Biotechnology", Agrobios India Limited, 2002.
4. Ramadass P, Meera Rani S., "Text Book of Animal Biotechnology", Second Edition, Akshara Printers, 2002.

CO/PO MAPPING :

Mapping of Course Outcome (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes PSO's

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CO's	PO's												PSO's	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	1	1	1	1	-	1	-	-	-	-	-	2	1	2
CO2	1	1	1	1	-	-	-	-	-	-	-	2	1	2
CO3	2	2	1	1	-	1	-	1	1	-	-	2	3	3
CO4	3	3	3	2	-	2	1	1	-	-	-	3	3	3
CO5	2	3	3	2	-	2	1	1	-	-	-	2	3	2

BT23552	ANIMAL HEALTH AND NUTRITION	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	describe the fundamental nutritional requirements of animals and their role in maintaining health and productivity.
2	identify animal diseases and explain their symptoms, causes, and diagnostics.
3	explain the fundamental concepts of therapeutic methods used in the treatment and management of animal diseases.
4	implement animal behavior knowledge in experimental settings and its relevance to research and welfare practices.
5	use knowledge of animal behavior in experimental research.

UNIT I	BASIC NUTRITIONAL REQUIREMENTS AND FEEDING	9

Nutritional requirements for rat, mice, guinea pigs, rabbit; Types of diets - Natural, semi synthetic and synthetic; Feeding of water, nutrition to kids, youngster, adults, mature adults; Significance of carbohydrates, lipids, proteins, major minerals, trace minerals, fat soluble vitamins, water soluble vitamins.

UNIT II	ANIMAL HEALTH AND DISEASE MANAGEMENT	9

Food and Water borne infections, Bacterial, Viral and Parasitic infections - its causative agent, sources of infection, symptoms and prevention; Biosecurity - Disease transmission and management.

UNIT III	ANIMAL DISEASE DIAGNOSIS	9

Monoclonal antibodies and their use in diagnosis; Antigen-antibody based diagnostic assays including radioimmunoassay and enzyme immunoassays; Immunoblotting; Nucleic acid based diagnostic methods including nucleic acid probe hybridization; Restriction endonuclease analysis; PCR, Real time PCR; Nucleic acid sequencing; Probiotics; AI-enabled Disease Detection and Predictive Diagnostics in Laboratory Animals.

UNIT IV	ANIMAL VACCINES AND THERAPEUTICS	9

Introduction to the concept of vaccines; Conventional methods of vaccine production; Recombinant approaches to vaccine production; Recombinant cytokines and their use in the treatment of animal infections; monoclonal antibodies in therapy; gene therapy for animal diseases.

UNIT V	ANIMAL BEHAVIOR IN EXPERIMENTAL RESEARCH	9

Types of behavior, Behavioral observation of mice, guinea pigs, rabbit; Neuroscience research, chicken welfare, Spatial behavior, rat social behavior, Zebrafish studies; Livestock and wild life summary data sheet; AI-driven Behavior Tracking and Analysis in Experimental Animal Research.

	TOTAL PERIODS	45

COURSE OUTCOMES		
At the end of this course, the students will be able to		**BT MAPPED (Highest Level)**
CO1	explain the scope, regulatory issues, and commercially available products produced using animal biotechnology.	Understanding (K2)
CO2	describe the importance of cell culture studies for in vitro studies and for scaling up the products at the commercial level.	Understanding (K2)
CO3	summarize the principles behind in vitro fertilization and biopharming in order to create transgenic animal of commercial importance.	Understanding (K2)
CO4	utilize knowledge of available viral vectors to create recombinant DNA for gene therapy purposes	Applying (K3)
CO5	demonstrate the process of creating recombinant products for gene therapy and illustrate the importance of molecular probes	Applying (K3)

TEXT BOOKS

1. Ranga M.M., "Animal Biotechnology, Agrobios India Limited, 2002.
2. Ramadass P, Meera Rani S. "Text Book of Animal Biotechnology", 2nd Edition, Akshara Printers, 2002.

REFERENCES

1. Zipser B, Schleking A, Kaiser S, Sachser, N., "Effects of domestication of biobehavioural profiles: a comparison of domestic guinea pigs and wild cavies from early to late adolescence", Frontiers in Zoology, 2014.
2. Boix J, von Hieber D, Connor B, "Gait Analysis for Early Detection of Motor Symptoms in the 6-OHDA Rat Model of Parkinson's Disease", Frontiers in Behavioral Neuroscience, 2018.
3. Khan, Firdos Alam., "Animal biotechnology in Biotechnology Fundamentals", CRC Press, 2018.
4. Verma, Ashish S, and Anchal Singh, eds., "Animal biotechnology: models in discovery and translation", Academic Press, 2013.

CO/PO MAPPING :

Mapping of Course Outcome (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes PSO's

(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak

	PO's												PSO's	
CO's	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	2	2	1	1	-	1	-	-	-	-	-	2	2	2
CO2	2	3	2	2	-	2	-	-	-	-	-	2	2	2
CO3	2	3	2	2	-	2	-	-	-	-	-	2	2	3
CO4	2	2	2	2	-	3	1	1	-	-	-	3	3	3
CO5	2	2	3	3	-	2	2	2	-	-	-	2	3	3

BT23553	DEVELOPMENTAL BIOLOGY	3	0	0	3

COURSE OBJECTIVES	
To enable the students to	
1	discuss the fundamental concepts of developmental biology.
2	interpret the molecular processes involved in plant development.
3	differentiate the cellular and molecular mechanisms of embryogenesis and tissue development and regeneration in mammals.
4	utilize the knowledge of late development, tissue development and regeneration in mammals.
5	implement understanding of the processes leading to senescence and evolutionary adaptation.

UNIT I	OVERVIEW	9

Development Biology: Developmental genetics: Cell fate determination in C. elegans; Gametogenesis, Fertilization, Cleavage, Gastrulation, Axis formation in amphibian, Anterior-posterior patterning in amphibians, Anterior-posterior patterning in drosophila.

UNIT II	PLANT DEVELOPMENTAL BIOLOGY	9

Plant embryogenesis: Patterning in early embryo; Root and Shoot Meristems, Transition to Floral Meristem; Floral Development: Plant homeotic in flowers, Gene Activity Model (ABC model); The floral identity genes encode homeotic proteins; Developmental map of Arabidopsis.

UNIT III	MAMMALIAN DEVELOPMENTAL BIOLOGY - I	9

Hox gene and dorsoventral patterning, Left-right patterning, Patterning in Central nervous system: Early mammalian development, Ectoderm-eye development, epidermis, hair development, neural crest, tooth development and axon guidance; Signaling pathways in ectodermal appendage development (e.g., Wnt, FGF); Molecular basis of craniofacial development (link to neural crest).

UNIT IV	MAMMALIAN DEVELOPMENTAL BIOLOGY - II	9

Mesoderm-somites, development of muscle, bone, kidney, heart and vessels, formation of limbs; Endoderm, Sex determination in Drosophila, mammals and other species, Regeneration in mammals and lower vertebrates: Mechanisms of organogenesis (focus on liver, pancreas — endoderm-derived organs).

UNIT V	ENVIRONMENT AND DEVELOPMENT	9

Environmental regulation and development, Aging and Senescence, Infertility; Cancer as a developmental disease; Modularity in Development and Evolution; Epigenetic modifications in response to environmental cues; Developmental origins of health and disease (DOHaD hypothesis); AI-based Modeling and Prediction of Gene Regulatory Networks in Developmental Biology, AI-driven Image Analysis for Developmental Biology and Morphogenesis.

	TOTAL PERIODS	45

COURSE OUTCOMES		
At the end of this course, the students will be able to		**BT MAPPED (Highest Level)**
CO1	comprehend the basic aspects behind the field of developmental biology	Understanding (K2)
CO2	expose the plant developmental process	Understanding (K2)
CO3	generalize the early developmental processes involved in mammalian development	Understanding (K2)
CO4	demonstrate knowledge of late developmental processes like tissue maturation and regeneration	Applying (K3)
CO5	interpret the role of developmental processes in aging, cancer, and species evolution	Applying (K3)

TEXT BOOKS

1. Cooper, G.M., Hausman, R.E., "The Cell: A Molecular Approach", Eighth Edition, ASM Press and Sinauer Associates, 2019.
2. Gilbert, S. and Barresi, M., "Developmental Biology", Eleventh Edition, Sinauer Associates, USA, 2016.

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1. Karp, G. "Cell and Molecular Biology: Concepts and Experiments", Eighth Edition, John Wiley & Sons Inc., 2015.
2. Wolpert, L & Tickle, "Principles of Developmental Biology" 4th Edition, Oxford University Press, 2011.
3. Becker, Kleinsmith, and Hardin, "The World of the Cell", 19th Edition, Benjamin Cummings Publishing, San Francisco, 2018.
4. Gilbert, SF, "Developmental Biology", Tenth edition, Sinauer Associates, Inc., Publishers, Sunderland, Massachusetts, USA, 2014.

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(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak

	PO's												PSO's	
CO's	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	1	2	1	1	-	1	-	-	-	-	-	2	1	2
CO2	2	2	1	1	-	-	-	-	-	-	-	2	1	2
CO3	2	2	1	1	-	-	-	-	-	-	-	2	3	3
CO4	3	3	3	2	-	2	1	1	-	-	-	3	3	3
CO5	3	3	3	2	-	2	1	-	-	-	-	2	3	2

BT23554	ANIMAL CELL CULTURE TECHNOLOGY	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	describe the basic requirements of an animal cell culture lab.
2	explain the preparation and applications of animal cell culture media.
3	demonstrate theoretical and practical knowledge on bioreactors and cell growth.
4	utilize real-time applications of culturing techniques in laboratory practice.
5	implement the basic concepts of animal cell culture to obtain useful products.

UNIT I BASIC REQUIREMENTS OF LAB FACILITY 9

Safety - biosafety levels, SDS, safety equipment's, personal protective equipment's, safe laboratory practices; Basic cell culture equipment - centrifuge, Inverted microscope, confocal microscope, flow cytometer, Hemocytometer, cell culture vessels, bioreactors; Cell culture laboratory, Aseptic work area, Cell culture hood, Incubator, cryostorage, cell counter, aseptic technique, Maintenance of nutrients, prevention of cross contamination.

UNIT II MEDIA PREPARATION AND TYPES 9

Media components - Serum, tissue extracts, growth factors, hormones, carrier proteins, lipids, vitamins, additive, detergents; Types of media - natural media, synthetic media, chemically defined and serum free media, advantages and disadvantages of different media; BSS, CMRL, Eagle's, RPMI, animal cell cultures, their maintenance and preservation.

UNIT III BIOREACTORS AND GROWTH OF CELLS 9

Bioreactor process control, stirred animal cell culture, Air-lift fermentor, Chemostat / Turbidostat; Culturing - various types of cultures suspension cultures, continuous flow cultures, immobilized cultures; somatic cell fusion; growth of cells.

UNIT IV GENETIC ENGINEERING OF ANIMAL CELL 9

Gene therapy-prospects and problems, Recent advancements in Gene therapy; Knockout mice and mice model for human genetic disorder; Baculo virus in biocontrol; Enzymes technology, Somatic manipulation of DNA, Nucleic acid hybridization and probes in diagnosis- preparation of probes, evaluation and applications; Recent advancements in diagnostic tool development and its diagnostic procedure

UNIT V PRODUCTS FROM ANIMAL CELL 9

Enzymes – asperagenase, collagenase, urokinase, pepsin, hyaluronidase; Hormones- leutinizing hormones, FSH, chronic; Vaccines - FMD, measles and mumps, rubella, rabies monoclonal antibodies, interferon, plasminogen activator; AI-assisted Cell Culture Monitoring and Bioreactor Process Optimization, AI-based Design of Diagnostic Tools and Gene Therapy Strategies.

TOTAL PERIODS 45

COURSE OUTCOMES		
At the end of this course, the students will be able to		**BT MAPPED (Highest Level)**
CO1	describe the basic requirements of a laboratory facility for cell culture.	Understanding (K2)
CO2	explain the various types of media, their preparation, and sterilization for cell culture.	Understanding (K2)
CO3	optimize the factors influencing cell growth in bioreactors.	Applying (K3)
CO4	manipulate embryos and animals for the production of transgenic animals.	Applying (K3)
CO5	use the animal cell culture techniques to produce valuable products like hormones and vaccines.	Applying (K3)

TEXT BOOKS

1. Watson JD, Gilman M, Witowski J, and Zoller M., "Recombinant DNA", 3rd Edition, Scientific American Books, 2007.
2. Glick BR, Cherryl LP, "Molecular Biotechnology: Principles and Applications of Recombinant DNA", 6th Edition, ASM Press, 2022.

REFERENCES

1. Lewin B., "Genes VIII" , Pearson Prentice Hall, 2004.
2. Primrose S.B., Twyman R.H., and Old R.W. "Principles of Gene Manipulation." 7th Edition. Oxford, 2006.
3. Davis J.M., "Basic Cell Culture: A Practical Approach", IRL Press, 2nd Edition, 2002
4. Freshney RI. "Culture of Animal Cells – a manual of basic techniques and specialized applications", Wiley- Blackwell, 8th Edition, 2021.

CO/PO MAPPING:

Mapping of Course Outcome (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes PSO's

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	PO's												PSO's	
CO's	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	1	2	1	1	-	1	-	-	-	-	-	2	1	2
CO2	2	2	1	1	-	1	-	-	-	-	-	2	1	2
CO3	2	2	2	2	-	2	1	1	-	-	-	2	2	3
CO4	3	3	2	3	-	2	1	1	-	-	-	3	3	3
CO5	3	3	3	3	-	2	2	2	-	-	-	3	3	3

BT23555	ADVANCES IN ANIMAL BIOTECHNOLOGY	3	0	0	3

COURSE OBJECTIVES	
To enable the students to	
1	explain the foundational principles of animal biotechnology.
2	summarize the biology and applications of viral vectors.
3	perform essential animal cell culture techniques.
4	utilize genetic engineering methods in animal sciences.
5	demonstrate the use of recent advancements in animal biotechnology applications.

UNIT I	BASICS OF ANIMAL BIOTECHNOLOGY	9

Historical developments in animal biotechnology; Scope of Animal Biotechnology, Animal Biotechnology for the production of regulatory proteins, blood products, vaccines, hormones and other therapeutic proteins; Emerging trends - precision breeding, gene editing for therapeutic protein production; Role of animal biotechnology in personalized medicine.

UNIT II	MOLECULAR BIOLOGY	9

Biology of animal viral vectors- SV40, adenovirus, retrovirus, vaccinia virus, herpes virus, adeno-associated virus and baculovirus; Applications of commercially available viral vectors and their pros and cons.

UNIT III	CELL CULTURE TECHNOLOGIES AND TISSUE ENGINEERING	9

Principles and methods of animal cell culture; Primary culture, secondary culture, and continuous cell lines; Scale-up of animal cell culture: bioreactors for animal cell culture; 3D cultures, organotypic cultures, and co-culture systems; Tissue engineering basics: scaffolds, biomaterials, bioprinting; Applications in regenerative medicine and therapeutic implants; Ethical, safety and regulatory aspects of cell and tissue engineering.

UNIT IV	GENOME EDITING AND EMERGING TOOLS	9

Principles of gene editing: restriction enzymes to programmable nucleases; CRISPR/Cas systems: types, design, delivery and applications in animals; TALENs, ZFNs and other genome editing platforms; Applications: generation of knockout and knock-in animals; Ethical considerations and biosafety of gene-edited animals; Case studies: Gene editing for disease resistance, productivity and welfare; Future perspectives: Synthetic biology and gene drives in animal biotechnology; AI-assisted Design and Optimization of Genome Editing Tools in Animals.

UNIT V	ADVANCEMENTS AND APPLICATIONS IN ANIMAL BIOTECHNOLOGY	9

Rumen manipulation- probiotics embryo transfer technology, invitro fertilization, transgenesis methods of transferring genes into animal oocytes, eggs, embryos and specific tissues by physical, chemical and biological methods; Biopharming Transgenic animals (case study : Mice, Cows, Pigs, Sheep, Goat, Birds and Insects); Artificial insemination and embryo transfer; AI-driven Bioprocess Monitoring and Automation in Animal Cell Culture and Biopharming.

	TOTAL PERIODS	45

COURSE OUTCOMES		
At the end of this course, the students will be able to		**BT MAPPED (Highest Level)**
CO1	discuss the applications of animal biotechnology in various domains	Understanding (K2)
CO2	summarize the principles and uses of viral vector technology	Understanding (K2)
CO3	analyze advanced animal biotechnology techniques including rumen manipulation, IVF, transgenesis, biopharming.	Applying (K3)
CO4	apply cell culture principles, scale-up strategies, and tissue engineering concepts for regenerative and therapeutic applications.	Applying (K3)
CO5	employ advanced biotechnological techniques for problem-solving in animal biotechnology	Applying (K3)

TEXT BOOKS

1. Brown, T.A., "Gene Cloning and DNA Analysis: An Introduction", 7th Edition, Wiley-Blackwell, 2016.
2. Singh, B.D. & Shekhawat, N.S., "Animal Biotechnology", CRC Press, 2021.

REFERENCES

1. Watson, J.D., Gilman, M., Witowski and Zoller, M., "Recombinant DNA", 3rd Edition, Scientific American Books, 2007.
2. Glick, B.R. and Pasternack, J.J., "Molecular Biotechnology", 3rd Edition, ASM Press, 2003.
3. Lewin, B., "Genes VIII", Pearson Prentice Hall, 2004.
4. Davis J.M., "Basic Cell Culture: A Practical Approach", 2nd Edition, IRL Press, 2002.

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CO1	3	2	1	-	-	-	-	-	-	-	2	-	2	-
CO2	3	3	2	1	-	-	-	-	-	-	2	-	2	-
CO3	2	2	3	2	2	-	-	-	-	-	-	-	2	2
CO4	1	1	2	3	2	2	1	-	-	-	-	-	3	3
CO5	1	2	2	2	3	2	1	1	-	-	-	-	3	3

BT23556	BIOTECHNIQUES IN ANIMAL BREEDING	3	0	0	3

COURSE OBJECTIVES	
To enable the students to	
1	identify the fundamental tools and equipment necessary for cell culture.
2	explain micromanipulation and its applications in animal biotechnology.
3	describe the concept of stem cells and embryonic stem cells in transgenic animals.
4	discuss the research significance of transgenic animals.
5	implement CPCSEA ethical guidelines during animal handling and experimentation.

UNIT I	BASIC TOOLS REQUIREMENTS FOR CELL CULTURE AND MICROMANIPULATION	9

Scope and applications of micromanipulation in biotechnology and research; Design and layout of a cell culture laboratory; Essential Equipment and Instruments – Incubators, Microscopes for cell observation, Refrigerators and freezers, Autoclaves and sterilization tools; Cell Handling Tools; Micromanipulation Instruments - Microinjection systems, Micropipette pullers and microneedles, Laser microdissection systems, Use of micromanipulators in cloning and IVF.

UNIT II	MICROMANIPULATION AND ITS APPLICATION	9

Enrichment of x and y bearing sperms from semen samples of animals; artificial insemination and germ cell manipulations; in vitro fertilization and embryo transfer; micromanipulation technology and breeding of farm animals; AI-based Sperm and Embryo Quality Assessment for Micromanipulation and IVF.

UNIT III	STEM CELLS AND TRANSGENIC ANIMALS	9

Stem cells – sources, types, uses, ES cells, pluripotent stem cells, adult stem cell, epithelial stem cell, bone marrow and hematopoietic, neural stem cell, transgenic techniques, Stem cell mediated transgenic animals; AI-enabled Monitoring and Prediction in Stem Cell Culture and Transgenic Animal Production.

UNIT IV	TRANSGENIC ANIMALS IN RESEARCH	9

Ethics of transgenic technology, Dolly (transgenic sheep), Transgenic mice, rat, sheep, goat, rabbit, pig, fish, cow- case studies.

UNIT V	ETHICAL GUIDELINES ON ANIMAL BREEDING	9

Justification on research, care and housing of laboratory animals, acquisition of laboratory animals, experimental procedure, CPCSEA guidelines; Animal integrity and ethical limits to breeding; Animal welfare issues; Record Maintenance as per guidelines.

	TOTAL PERIODS	45

COURSE OUTCOMES		
At the end of this course, the students will be able to		BT MAPPED (Highest Level)
CO1	describe how to work safely in a cell culture lab and use basic tools.	Understanding (K2)
CO2	explain how micromanipulation is applied in animal reproduction.	Understanding (K2)

CO3	summarize what stem cells are, their sources, applications, and role in creating genetically modified animals.	Understanding (K2)
CO4	discuss the use of transgenic animals in research.	Understanding (K2)
CO5	demonstrate ethical practices in animal care, experimentation, and record keeping.	Applying (K3)

TEXT BOOKS

1. Watson, J.D., Gilman, M., WitowskiJ. and Zoller, M., "Recombinant DNA", 3rd Edition, Scientific American Books, 2007
2. Glick, B.R. and Pasternack, J.J. "Molecular Biotechnology", 3rd Edition, ASM Press, 2003.

REFERENCES

1. Lewin, B. "Genes VIII", Pearson Prentice Hall, 2004.
2. Freshney, R.I., "Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications", 6th Edition, Wiley-Blackwell, 2010.
3. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., and Walter, P., "Molecular Biology of the Cell", 5th Edition, Garland Science, 2008.
4. Trounson, A and Gardner, DK, "Hand book of Invitro Ferilization", 2nd edition, CRC Press, 2000.

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CO1	2	2	2	1	-	1	1	-	-	-	-	2	1	2
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CO3	2	2	2	2	-	2	2	1	-	-	-	2	2	2
CO4	2	2	3	3	-	2	2	2	-	-	-	3	3	3
CO5	3	3	3	3	-	2	3	2	-	-	-	3	3	3

PAAVAI ENGINEERING COLLEGE, NAMAKKAL
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BIOTECHNOLOGY
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BT23557	STEM CELL TECHNOLOGY	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	describe the fundamental principles of stem cell biology, including differentiation, self-renewal, and pluripotency.
2	summarize applications of stem cells in regenerative medicine, disease modeling, and drug discovery.
3	explain advanced techniques in stem cell isolation, culture, and characterization.
4	distinguish between technical and ethical challenges in the clinical application of stem cell technologies.
5	examine challenges in clinical translation and ethical considerations in advanced stem cell technologies.

UNIT I	INTRODUCTION TO STEM CELLS	9

Stem Cells – Definition, classification, Sources and Properties. Types of stem cells – Embryonic stem cells, Adult stem cells. Induced pluripotent stem cells; Methods of isolation, study of stem cells and their viability; Markers and assays for characterization. Cryopreservation techniques for various stem cell types; Banking of embryonic and adult stem cells; Quality control and ethical considerations in stem cell preservation.

UNIT II	HUMAN EMBRYONIC AND ADULT STEM CELL	9

Stem cells and their developmental potential; In vitro fertilization-culturing of embryos - blastocyst-inner cell mass-isolation and growing ES cells in lab; Identification and characterization of human ES cells; Somatic stem cells-test for identification of adult stem cells- adult stem cell differentiation-trans differentiation-plasticity-different types of adult stem cells-liver stem cells-skeletal muscle stem cells-bone marrow derived stem cells.

UNIT III	DIFFERENTIATION OF STEM CELLS INTO CELL TYPES	9

Factors influencing cell specialization – internal factors – asymmetric segregation, cell signaling mechanisms – diffusion, direct contact and gap junctions; environmental factors – temperature, drugs and injuries; mechanism of stem cell differentiation – errors in cell differentiation – anaplasia, dysplasia and metaplasia; AI-based Prediction and Control of Stem Cell Differentiation Pathways.

UNIT IV	STEM CELLS IN TISSUE ENGINEERING	9

Haematopoietic Stem Cells-Growth factors and the regulation of haematopoietic stem cells, clinical applications of haematopoietic stem cells; HLA matching, patient selection, peripheral blood and bone marrow transplantation; Mesenchymal stem cells and their role in bone tissue engineering-bone repair; Stem cell based gene therapy and benefits to human; Techniques in stem cell technology – cryo preservation, fluorescence activated cell sorting (FACS), green fluorescent protein tagging.

UNIT V	APPLICATION AND ETHICAL ISSUES	9

Therapeutic applications-Parkinsons disease, Cancer stem cell – Neural stem cell for central nervous system repair – Spinal cord injury – use of ESC to treat heart disease – Burns and skin ulcers – Stem cell policy and ethics, stem cell research. Use of Genetically Modified Stem Cells in Experimental Gene Therapies; AI in Quality Control and Ethical Compliance of Stem Cell Banking and Therapies.

	TOTAL PERIODS	45

COURSE OUTCOMES		
At the end of this course, the students will be able to		BT MAPPED (Highest Level)
CO1	understand the differentiation of stem cells into specific cell types.	Understanding (K2)
CO2	determinethe factors affecting stem cell differentiation.	Understanding (K2)
CO3	describe the developmental potential of human embryonic and adult stem cells.	Understanding (K2)
CO4	differentiate between various types of stem cells and characterize their properties.	Analyzing (K4)
CO5	analyze current challenges, applications, and ethical issues in stem cell research.	Analyzing (K4)

TEXT BOOKS

1. Robert Paul Lanza, "Essentials of stem cell biology", Academic Press, 2006
2. Ariff Bongso, Eng Hin Lee, "Stem cells", World Scientific Publication Co. Pvt. Ltd., 2005.

REFERENCES

1. Alberts et al, "Molecular Biology of the Cell", 2014.
2. Stephen Sullivan, Chad Cowan, "Human Embryonic Stem Cells", 2007.
3. Scott F. Gilbert, "Developmental Biology", 2020.
4. Ali Gholamrezanezhad, "Stem cells in clinic and Research", Intech, 2013.

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CO's	PO's												PSO's	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	2	2	2	1	-	1	1	-	-	-	-	2	1	2
CO2	2	2	2	1	-	1	1	-	-	-	-	2	1	2
CO3	2	2	2	2	-	2	2	1	-	-	-	2	2	2
CO4	2	2	3	3	2	2	2	2	-	-	-	3	3	3
CO5	3	3	3	3	3	2	3	2	-	-	-	3	3	3

BT23651	CLINICAL TRIALS AND HEALTHCARE POLICIES IN BIOTECHNOLOGY	3	0	0	3

COURSE OBJECTIVES	
To enable the students to	
1	explain the epidemiologic methods, study design and protocol preparation.
2	infer the basic bio-statistical techniques involved in clinical research.
3	outline the principles involved in ethical, legal and regulatory issues in clinical trials.
4	articulate the governing regulations in clinical research and healthcare research.
5	identify the knowledge healthcare policies in its system.

UNIT I	CLINICAL RESEARCH PRACTICES	9

Good clinical practice - (ICH GCP E6), Clinical trial materials (Documentation, Investigational drugs, logistical materials); Clinical trials protocols - Clinical trial process, importance of Clinical Data Management; Clinical Research Practices- Introduction, Scope, Minimum Standards, Best Practices, Importance of data privacy, Legislation and Regulatory guidance; Clinical trials - Clinical trial design, Trial size and study population, Randomized control studies, Additional trial designs.

UNIT II	TYPES AND DESIGNS IN CLINICAL RESEARCH AND SAFETY MONITORING IN CLINICAL TRIALS	9

Types of research designs based on controlling method - Experimental, Quasi experimental, and Observational methods; Randomization techniques - Simple randomization, restricted randomization, blocking method and stratification; Time Sequences - Prospective and Retrospective; Sampling methods - Cohort study, case control study and cross-sectional study; Health outcome measures - clinical and physiological, humanistic and economic.

UNIT III	CLINICAL TRIAL STUDY AND GOVERNING REGULATIONS	9

Roles and responsibilities of Investigator - Study Coordinator, Sponsor, Monitor, Contract Research Organization, Site management Organizations; Document preparation guidelines - Protocols, Investigator's Brochure, Informed Consent Form, Case report forms, Contracts and agreements, Trial Master File preparation and maintenance, Investigator Site File, Pharmacy File, Dairy Cards; AI-Assisted Clinical Trial Design and Data Management.

UNIT IV	HEALTHCARE SYSTEM COMPONENTS	9

Health Care System Components - Elements of a Health Care System, The Role and Financing Methods of Third-Party Payers, The Production of Medical Services; U.S. Health Care System – an overview, Production of Health Services and Provider Choice in the United States.

UNIT V	HEALTH CARE POLICIES	9

Health care policy- overview, Private health care sectors, Health policy and planning; Policy Definition and Training-Potential Future Concerns for Data Privacy, Recommended Standard Operating Procedures; AI for Healthcare Policy and Data Privacy Compliance in Clinical Research.

	TOTAL PERIODS	45

COURSE OUTCOMES		
At the end of this course, the students will be able to		**BT MAPPED (Highest Level)**
CO1	relate the key concepts in the design of clinical trials.	Understanding (K2)
CO2	summarize the study designs used and identify the key issues in data management for clinical trials.	Understanding (K2)
CO3	explain the roles of regulatory affairs in clinical trials.	Understanding (K2)
CO4	discover the methods for financing aspects of healthcare system.	Applying (K3)
CO5	construct the validation procedures for healthcare policies in different sectors.	Applying (K3)

TEXT BOOKS

1. Walsh, Gary, "Biopharmaceuticals: biochemistry and biotechnology", John Wiley & Sons, 2013.
2. David Machin, Simon Day and Sylvan Green, "Textbook of Clinical Trials", John Wiley and Sons, 2005.

REFERENCES

1. Browner, Warren S., Thomas B. Newman, Steven R. Cummings, and Deborah G. Grady, "Designing clinical research", Lippincott Williams & Wilkins, 2022.
2. Friedman, Lawrence M., Curt D. Furberg, David L. DeMets, David M. Reboussin, and Christopher B. Granger. Fundamentals of clinical trials. Springer, 2015.
3. Hackshaw, Allan, "A concise guide to clinical trials", John Wiley & Sons, 2024.
4. Baggott, Rob, "Understanding health policy", Policy press, 2015.

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	PO's												PSO's	
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CO1	2	1	1	1	3	-	-	-	-	-	1	1	1	2
CO2	2	1	3	1	3	-	-	-	-	-	1	3	1	2
CO3	2	2	2	2	3	-	-	-	-	-	2	2	1	3
CO4	1	2	3	2	2	-	-	-	-	-	2	3	1	3
CO5	1	2	2	3	2	-	-	-	-	-	2	2	1	3

BT23652	BIOTECHNOLOGICAL PRODUCTS AND ITS VALIDATION	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	explain the importance of validation in biotechnological processes and products.
2	illustrate gain insights into process validation and quality assurance techniques.
3	identify the validation and calibration of equipment in pharmaceutical, nutraceutical, and cosmetic industries.
4	discover the regulatory framework for validation across various biotechnological domains.
5	utilize the validation processes to medical devices and biotechnological equipment.

UNIT I GOOD MANUFACTURING AND LABORATORY PRACTICES 9

Process validation and quality assurance - Installation Qualification (IQ), Operational Qualification (OQ) and Performance Qualification (PQ) for laboratory instruments: Methods of validation and calibration of equipment: Documentation: importance and significance; Current Good Manufacturing Practices (cGMP) and Current Good Laboratory Practices (cGLP); United States Food and Drug Administration (USFDA)-guidelines, Regulatory guidelines from the 1990 onwards.

UNIT II PHARMACEUTICAL PRODUCT VALIDATION 9

Introduction to Pharmaceutical Validation - Scope and merits; Validation and calibration of Master plan, ICH and WHO guidelines for calibration and validation of equipments; Validation of specific dosage form – Types; Government regulation, Manufacturing Process Model, URS, DQ, IQ, OQ and PQ of facilities, Analytical methods validation.

UNIT III NEUTRACEUTICAL PRODUCTS VALIDATION 9

Introduction, Clinical data findings on nutraceuticals, Potential roles of nutraceuticals, Nutraceuticals in Various Diseases, Role of nutraceuticals in disease prevention and health promotion, List of nutraceuticals with health benefits, Formulations and Challenges Involved, Safety and Quality Control of Nutraceuticals, Formulation Challenges, Future Prospects of Nutraceuticals, Microbiological quality control for Nutraceuticals.

UNIT IV MEDICAL DEVICES VALIDATION 9

Validation and Verification of Medical devices – Physical, Mechanical and Biological testing of medical devices, Chemical Testing of Medical Device materials; Product specification files and medical Device validation in quality systems - regulatory requirements of validation for Medical devices, approaches for verification, qualification, process validation for medical devices, critical issues in each step of the process; risk assessment for validation.

UNIT V BIOTECHNOLOGY PROCESS AND EQUIPMENT VALIDATION 9

Biotechnology Process validation - General considerations for process equipments, Regulatory requirements for process validation, Documentation, Analytical methods; AI in Predictive Equipment Calibration and Process Validation, AI-Driven Quality Control and Risk Assessment for Medical Devices and Nutraceuticals.

TOTAL PERIODS 45

COURSE OUTCOMES		
At the end of this course, the students will be able to		**BT MAPPED (Highest Level)**
CO1	show the fundamental principles of validation and quality assurance.	Understanding (K2)
CO2	explain the validation and calibration processes for laboratory and industrial equipment.	Understanding (K2)
CO3	select the regulatory guidelines and validation processes to pharmaceutical, nutraceutical products.	Applying (K3)
CO4	construct methods for the validation of medical devices and associated testing techniques.	Applying (K3)
CO5	develop the validation procedures for biotechnological processes and equipments.	Applying (K3)

TEXT BOOKS

1. Fra. R. Berry and Robert A. Nash. "Pharmaceutical Process Validation", 2nd Edition, 2003.
2. Chan, Chung Chow, Herman Lam, Y. C. Lee, and Xue-Ming Zhang, eds. "Analytical method validation and instrument performance verification", Vol. 18. Hoboken: John Wiley & Sons, 2004.

REFERENCES

1. Ball, Douglas J., Daniel L. Norwood, Cheryl LM Stults, and Lee M. Nagao, eds., "Leachables and extractables handbook: safety evaluation, qualification, and best practices applied to inhalation drug products", John Wiley & Sons, 2012.
2. Ramakrishna, Seeram, Lingling Tian, Charlene Wang, Susan Liao, and Wee Eong Teo., "Medical devices: regulations, standards and practices", Woodhead Publishing, 2015.
3. Shayne Cox Gad, Samanta Gad-McDonald, "Biomaterials, Medical Devices and Combination Products: Biocompatibility Testing and Safety Assessment", CRC Press, 2015.
4. Ermer, Joachim, and Phil W. Nethercote, eds. "Method validation in pharmaceutical analysis: A guide to best practice", John Wiley & Sons, 2025.

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CO2	1	3	-	1	-	-	-	1	-	-	-	-	1	2
CO3	1	1	-	3	-	-	-	1	-	-	-	-	2	2
CO4	2	1	-	1	3	-	-	2	-	-	-	-	2	3
CO5	3	1	-	1	3	-	-	2	-	-	-	-	2	3

BT23653	QUALITY ASSURANCE AND QUALITY CONTROL IN BIOTECHNOLOGY	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	interpret the concepts of quality assurance and quality control in pharmaceutical and clinical settings.
2	explain the role and importance of international guidelines like ICH, GLP, GMP, and ISO in ensuring product and process quality.
3	summarize quality assurance and quality control practices in clinical trials, data management, and auditing processes.
4	generalize the quality systems and regulatory frameworks.
5	identify the documentation practices, standard operating procedures (SOPs).

UNIT I	QUALITY ASSURANCE AND QUALITY CONTROL	9

Quality Assurance (QA), Quality Control (QC), Role of QA and QC, QA testing, Test for QA and QC; Practice of cGMP- Overview of ICH Guidelines - QSEM, with special emphasis on Q-series guidelines; Quality assurance unit in GLP, protocol for conduct of non-clinical testing, control on animal house; Scope of quality certifications - responsibilities of QA and QC departments, Analysis of raw materials, finished products, packaging materials, in process quality control (IPQC), Developing specification (ICH Q6 and Q3); AI for Automated QA/QC Data Analytics and Compliance Monitoring.

UNIT II	QA AND QC IN CLINICAL TRIALS	9

Audit criteria - Audit process, Responsibilities of stakeholders in audit process, Audit follow-up and documentation, Audit resolution and Preparing for FDA inspections; Fraud and misconduct management Standard Operating Procedures (SOP), Data management plan, CRF and Data base design considerations; Quality Control and Quality Assurance in CDM, Data mining and warehousing; AI-Enabled Risk Management and Fraud Detection in Clinical and Regulatory QA Audits.

UNIT III	QA AND QC IN PHARMACEUTICAL INDUSTRIES	9

Quality Assurance and GMP; Quality Control test for containers, Rubber closures and secondary packing materials, Scope, organization and responsibility of QC, Product Assessment, Drug Packaging, Functions and classification of Pharmaceutical Packaging, Quality Control of Packaging Materials, Parameters Tested, Tests on Containers as Per Indian Pharmacopoeia; USFDA Documentation, Loan license auditing, Common technical documentation (CTD), Drug master file (DMF).

UNIT IV	QUALITY SYSTEM REGULATIONS AND QC OF MEDICAL DEVICES	9

Quality System Requirements 21 CFR Part 820 - Labeling requirements 21 CFR Part 801, Post marketing surveillance of MD and Unique Device Identification (UDI), Quality System requirements and clinical evaluation and investigation; IMDRF study groups and guidance documents, ISO 13485, Quality Risk Management of Medical Devices; ISO 1497.

UNIT V	QUALITY IN NUTRACEUTICALS, FOOD, BIOLOGICAL AND COSMETIC PRODUCTS	9

WHO guidelines on nutrition; NSF International - its role in Dietary Supplements and Nutraceutical industries, NSF Certification and standards for Food And Dietary Supplements; Good Manufacturing Practices for Nutraceuticals, Quality, safety and legislation for herbal products in India, USA and European Union; Analysis of Cosmetics, Toxicity screening and test methods - Quality control and toxicity studies as per Drug and Cosmetics Act; Analysis of Food additives- milk constituents and milk products - Pesticide analysis.

	TOTAL PERIODS	45

COURSE OUTCOMES		
At the end of this course, the students will be able to		**BT MAPPED (Highest Level)**
CO1	explain the difference and relationship between quality assurance and quality control.	Understanding (K2)
CO2	illustrate the key global guidelines (e.g., ICH, GLP, ISO) relevant to pharmaceutical, clinical, and food industries.	Understanding (K2)
CO3	demonstrate the data management practices and audits in clinical trials.	Understanding (K2)
CO4	identify the quality systems and regulatory practices related to pharmaceuticals, medical devices, and nutraceuticals.	Applying (K3)
CO5	develop the quality control techniques to food, cosmetics, and biological product testing as per regulatory norms.	Applying (K3)

TEXT BOOKS

1. Shayne Cox Gad, "Clinical Trials Handbook", Wiley-Interscience, 2009.
2. John J. Tobin and Gary Walsh, "Medical Product Regulatory Affairs: Pharmaceuticals, Diagnostics", 2nd Edition, Medical Devices, 2018.

REFERENCES

1. P.P.Sharma, "Cosmetics - Formulation, Manufacturing & Quality Control", 6th Edition, Vandana Publications, New Delhi, 2021.
2. Mindy J. Allport-Settle, "Current Good Manufacturing Practices: Pharmaceutical, Biologics, and Medical Device Regulations and Guidance Documents Concise Reference", Pharmalogika Inc., USA, 2009.
3. Willig, H., Tuckeman, M.M. and Hitchings, W.S., "Good Manufacturing Practices for Pharmaceuticals", Fifth Edition, Marcel Dekker Drugs and the Pharmaceutical Sciences, by CRC Press, New York, 2000.
4. Ajaz S. Hussain, "Quality by Design for Biopharmaceuticals: Principles and Case Studies", Wiley, 2012.

CO/PO MAPPING:

Mapping of Course Outcome (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes PSO's

(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak

	PO's												PSO's	
CO's	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	2	-	1	-	-	-	-	-	-	-	-	-	3	2
CO2	2	-	3	-	-	-	-	-	-	-	-	-	3	2
CO3	1	-	2	-	3	-	-	-	-	-	-	-	2	3
CO4	1	-	3	-	-	-	-	-	-	-	-	-	3	3
CO5	1	-	3	3	2	-	-	-	-	-	-	-	3	3

BT23654	BIOENTREPRENEURSHIP AND PATENT DESIGN	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	understand the basics of entrepreneurship.
2	learn how to identify customer needs and target markets.
3	develop the ability to create a business plan.
4	gain practical knowledge of managing a business.
5	describe legal, ethical, and intellectual property rights (IPR) in a business.

UNIT I	INTRODUCTION TO ENTREPRENEURSHIP	9

Need of Entrepreneurship - Entrepreneurship skills, Characteristics of a team member; Identify and meet a market need - Target market, Identifying target market, Market segments, customer profile, role of market research; Steps of market research - Types of competition, Entrepreneurs in a market economy, Types of Ownership; AI for Startup Market Research and Competitive Analysis.

UNIT II	BUSINESS PLAN DEVELOPMENT	9

Business plan- Introduction, Elements of a Business Plan, Components of financial plan, Development of a business plan; Writing a sample business plan -Formats of Business Plan, Components of Business Plan, Executive Summary, Business Venture, Product/Service, Market, Marketing Strategy, Competitor Analysis, Marketing Plan, Production Plan, Operational Plan, Manpower Planning, Organizational Plan, Financial Plan, Risk Assessment.

UNIT III	MARKETING, FINANCE AND ACCOUNTING, STAFF MANAGEMENT	9

Location and Set up for Business - Market your Business, Marketing, Marketing Mix, Marketing strategy, Types of goals, Marketing Plan, Product Mix, Pricing; Objectives - Finance, Protect and Insure Your Business, Record Keeping and Accounting, Financial Management, Hire and Management of staffs.

UNIT IV	LEGAL AND ETHICAL CONCERNS	9

Meet your legal ethical and social obligations - Ethics and Business, Social responsibilities, Respect the environment, Exports and Imports; International business - Growth in Today's market places, Case studies.

UNIT V	IPR AND PATENT DESIGN	9

Fundamentals of IPR - Patenting, Technology, Research, Innovation, Patent Rights, Licensing and Technology Transfer, IPR of biological systems, Industrial Design; Management of IPR -Types, Patents, Trademarks, Copyrights, Industrial Designs, Geographical Indications, Integrated Circuits, Plant Varieties and Farmers Rights, Trade Secrets; AI Applications in Intellectual Property Analytics and Patent Landscaping.

	TOTAL PERIODS	45

COURSE OUTCOMES		
At the end of this course, the students will be able to		**BT MAPPED (Highest Level)**
CO1	acquire relevant knowledge on Entrepreneurs need and Market need.	Understanding (K2)
CO2	summarize the key learning strategies for a business plan.	Understanding (K2)
CO3	illustrate how to set up a business, manage finance, marketing and managing the staff.	Understanding (K2)
CO4	demonstrate the ideas on Legal, Ethical, Social obligation.	Understanding (K2)
CO5	classify IPR and patent filing process.	Understanding (K2)

TEXT BOOKS

1. Shreya Sanghvi Malik , Shiv Kant Shukla, "Bioentrepreneurship Development", Biotech Consortium India Limited (BCIL), New Delhi, 2008.
2. Act, list of amending. "The Patents Act, 1970." 1970.

REFERENCES

1. Tulsian, P.C., and Vishal Pandey, "Business Organisation and Management", Pearson Education, 2011.
2. Deborah E. Bouchoux, "Intellectual Property: The Law of Trademarks, Copyrights, Patents, and Trade Secrets", Cengage Learning, 2019.
3. Kuratko, Donald F., "Entrepreneurship: Theory, Process, and Practice", Cengage Learning, 2016.
4. Pandey, Neeraj, and Khushdeep Dharni, "Intellectual Property Rights", PHI Learning Pvt. Ltd., 2014.

CO/PO MAPPING :

Mapping of Course Outcome (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes PSO's

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	PO's												PSO's	
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CO1	1	2	2	1	-	1	-	3	3	1	3	2	-	-
CO2	1	2	2	2	-	1	-	3	2	1	3	2	-	-
CO3	1	2	2	1	-	1	-	3	2	1	3	2	-	-
CO4	1	2	2	2	-	1	-	3	2	1	3	2	-	-
CO5	1	2	2	2	-	1	-	3	2	1	3	2	-	-

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BT23655	INTELLECTUAL PROPERTY RIGHTS IN BIOTECHNOLOGY	3	0	0	3

COURSE OBJECTIVES	
To enable the students to	
1	summarize the fundamental concepts of IPR and their significance in the biotechnology sector.
2	explain patent laws, processes, and their application to biotechnological inventions.
3	infer the ethical, legal, and socio-economic implications of IPR in biotechnology.
4	relate the students with international treaties and frameworks governing IPR in biotechnology.
5	demonstratethe skills to navigate IP management, including patent filing, licensing, biopiracy issues.

UNIT I	INTRODUCTION TO INTELLECTUAL PROPERTY RIGHTS	9

Definition and scope of Intellectual Property (IP) - Patents, trademarks, copyrights, trade secrets, and geographical indications; Importance of IPR in biotechnology - Role in innovation, commercialization, and industry growth; Overview of IP laws in India and globally - Historical context and evolution, Types of IP relevant to biotechnology, Patents, plant variety protection, and traditional knowledge, Case studies: IP in drug discovery and agricultural biotechnology.

UNIT II	PATENT LAWS AND BIOTECHNOLOGICAL INVENTIONS	9

Patentable subject matter in biotechnology - Genes, proteins, microorganisms, and processes; Criteria for patentability - Novelty, inventive step, and industrial applicability; Patent filing process - National and international procedures (PCT system); Challenges in patenting biotechnological inventions - Ethical and legal considerations; Case studies - Patenting of CRISPR technology and recombinant DNA products.

UNIT III	BIOETHICS, BIOSAFETY AND IPR	9

Principles of bioethics - Autonomy, justice, beneficence, and non-maleficence, Ethical issues in patenting living organisms and genetic material: Biosafety regulations - Cartagena Protocol, Indian Biosafety Rules, and their relation to IPR; Socio-economic impacts of biotech IP - Access to medicines, farmer rights, and public health; Case studies - Ethical controversies in gene editing and stem cell patents.

UNIT IV	INTERNATIONAL IPR FRAMEWORKS AND BIOTECHNOLOGY	9

International treaties - TRIPS Agreement, Convention on Biological Diversity (CBD), and UPOV, Role of the World Intellectual Property Organization (WIPO) in biotech IP, Access and benefit sharing under the Nagoya Protocol; Harmonization of IP laws across countries - Challenges and opportunities, Case studies - Basmati rice and neem patent controversies.

UNIT V	IP MANAGEMENT AND COMMERCIALIZATION IN BIOTECHNOLOGY	9

IP licensing and technology transfer in biotechnology - Strategies for protecting traditional knowledge and preventing biopiracy, Role of patents in product development and market entry, Enforcement of IPR; Patent infringement, litigation, and dispute resolution; Case studies - IP strategies of biotech companies (e.g., Biocon, Amgen); AI-Enabled Patent Analytics and Landscape Mapping, AI for Detecting Biopiracy and Monitoring Traditional Knowledge Misuse.

	TOTAL PERIODS	45

COURSE OUTCOMES		
At the end of this course, the students will be able to		**BT MAPPED (Highest Level)**
CO1	explain the principles and types of Intellectual Property Rights relevant to biotechnology.	Understanding (K2)
CO2	construct the patent laws and procedures to protect biotechnological inventions.	Understanding (K2)
CO3	summarize ethical and legal challenges associated with patenting living organisms and genetic resources.	Understanding (K2)
CO4	utilizethe impact of international IPR frameworks, such as TRIPS, on biotechnology innovation.	Understanding (K2)
CO5	explain the strategies for managing IP in biotechnology, including licensing and combating biopiracy.	Understanding (K2)

TEXT BOOKS

1. Ganguli, P, "Intellectual Property Rights: Unleashing the Knowledge Economy", Tata McGraw-Hill, 2001.
2. Singh, B. D., "Biotechnology", Kalyani Publishers, 2015.

REFERENCES

1. Erbisch, F. H., & Maredia, K. M., "Intellectual Property Rights in Agricultural Biotechnology", CABI Publishing, 2004.
2. Watal, J, "Intellectual Property Rights in the WTO and Developing Countries", Oxford University Press, 2001.
3. Rastogi, S., &Pathak, N. "Genetic Engineering" Oxford University Press, 2009.
4. World Intellectual Property Organization (WIPO), "WIPO Intellectual Property Handbook", 2020.

CO/PO MAPPING :

Mapping of Course Outcome (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes PSO's

(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak

	PO's												PSO's	
CO's	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	1	-	2	-	-	-	-	-	-	1	-	-	3	3
CO2	2	2	2	-	-	-	-	-	-	-	-	-	3	3
CO3	1	2	2	-	-	-	-	-	-	2	-	-	3	1
CO4	2	1	-	2	-	-	-	-	-	2	-	-	3	3
CO5	2	2	1	-	-	-	-	-	-	2	-	-	3	3

BT23656	CLINICAL DATABASE MANAGEMENT	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	impart the basic concepts in clinical trials.
2	develop the knowledge for various clinical data management.
3	compare the different aspects and activities involved clinical database and clinical research.
4	discuss the data validation and clinical trials database environment.
5	demonstrate the clinical quality audit and logistics and regulations.

UNIT I	INTRODUCTION TO CLINICAL TRIALS	9

Basic statistics for clinical trials, Roles and Responsibilities of key stakeholders; Preparations and planning for clinical trials, Essential documentation in clinical research and regulatory submissions, Clinical Trial's project planning and management, Study Start-up process, Clinical monitoring essentials, Compliance, Auditing and Quality Control in clinical research.

UNIT II	CLINICAL DATA MANAGEMENT	9

Introduction to Data Management - Data Definition and Types, Study Set Up, CRF Design Considerations, Data Entry, Remote Data Entry, Identifying and Managing Discrepancies, Medical Coding, Database Closure, Data Management Plan, Electronic Data Capture, Tracking CRF Data, Managing Lab Data, Collecting Adverse Event Data, Creating Reports and Transferring Data, Enterprise Clinical Data Management Tools.

UNIT III	CLINICAL DATA ANALYSIS AND MANAGEMENT	9

Study set-up, Introduction to Clinical Database - Documents, guidelines used in CDM, Data Entry, Data Review/Data Validation, Query Management, Data management plan, Project management for the clinical data manager, Vendor selection and management, Data management standards in clinical research, Design and development of data collection, Edit check design principles.

UNIT IV	CLINICAL CASE REPORT FORMS	9

CRF Completion Guidelines - CRF printing and vendor selection, Data validation, programming and standards, Laboratory data handling, External data transfer; Patient – reported outcomes, CDM presentation at investigator meetings, Metrics for clinical trials, Systems Software Validation Issues, Clinical Trials Database Environment.

UNIT V	CLINICAL QUALITY AUDIT AND LOGISTICS WITH REGULATIONS	9

Audit - Definition, types and procedures, Audit standards, Audit trail and its role in authenticity of data, Audit plan, Audit by regulatory authorities, GMP, GDP and logistics, Preparing and delivering audit reports, Good audit, New product development and GxP Regulations; AI Applications in Clinical Data Management and Query Resolution, AI for Patient Recruitment and Retention in Clinical Trials.

	TOTAL PERIODS	45

COURSE OUTCOMES		
At the end of this course, the students will be able to		**BT MAPPED** (Highest Level)
CO1	learn the basics of clinical trials, including the planning, documents, and quality checks needed to run them.	Understanding (K2)
CO2	understand how clinical data is collected, entered, checked for errors, and organized for analysis.	Applying (K3)
CO3	use basic tools to review and manage clinical data and make sure it meets project and industry standards.	Applying (K3)
CO4	learn how to design case report forms and handle data from labs and patients in clinical trials.	Applying (K3)
CO5	know how audits and rules like GxP and GMP help keep clinical trial data accurate and trustworthy.	Applying (K3)

TEXT BOOKS

1. Susanne Proksch, "Practical Guide to Clinical Data Management", 3rd Edition, CRC Press, 2011.
2. Richard K Rondel "Clinical Data Management", 2nd Edition, Wiley Publishing House, 2000.

REFERENCES

1. Rondel, R.K., Varley, S.A. and Webb, C.F. eds., "Clinical data management", New York: Wiley, 2000.
2. Smith, Jonathan A., ed. "Qualitative psychology: A practical guide to research methods", Sage, 2016.
3. Webb, "Clinical Data Management", 2nd Edition, Wiley 2021.
4. Machin, D., Day, S. and Green, S. eds., "Textbook of clinical trials", John Wiley & Sons, 2007.

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	PO's												PSO's	
CO's	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	2	-	-	-	-	-	-	-	-	-	-	2	1
CO2	-	3	2	-	-	-	-	-	1	-	-	-	2	2
CO3	-	2	3	-	-	-	1	-	2	-	-	-	3	2
CO4	-	2	2	3	-	-	-	-	-	-	-	-	2	1
CO5	2	-	-	-	2	3	-	-	1	-	-	-	2	2

BT23657	BIOSAFETY AND HAZARD MANAGEMENT	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	understand the importance of safety in industrial environments.
2	learn implementation and monitoring of safety procedures.
3	conduct risk analysis and emergency planning effectively.
4	perform safety audits and hazard identification.
5	manage hazardous operations through systematic hazard analysis.

UNIT I INTRODUCTION 9

Need for safety in industries- Safety Programs, components and realization; Potential hazards - extreme operating conditions, Toxic chemicals; Safe handling; Human Error and Accident Causation, Lessons from Historical Process Accidents, Design for Safety Principles.

UNIT II QUALITY CHECKS 9

Implementation of safety procedures - Periodic inspection and replacement; Accidents - identification and prevention; Promotion of industrial safety, Safe Storage and Handling of Hazardous Chemicals, Chemical Compatibility and Labelling, Protective Equipment Standards for Handling Chemicals.

UNIT III RISK ANALYSIS 9

Overall risk analysis - emergency planning on-site and off-site emergency planning, risk management ISO 14000, EMS models, Case studies; Quantitative risk assessment – rapid and comprehensive risk analysis; Risk due to Radiation, Explosion due to over pressure, Jet fire-fire ball, Layer of Protection Analysis (LOPA), Risk Matrices and Risk Ranking.

UNIT IV SAFETY AUDITS 9

Hazard identification safety audits - checklist, What If analysis, Vulnerability models, Event tree analysis, Fault tree analysis; Hazan past accident analysis, Fixborough - Mexico-Madras, Vizag, Bopal Tragedy analysis, Behavioral Safety and Organizational Factors, Barriers and Safeguards in Safety Audits.

UNIT V HAZARDOUS OPERATIONS 9

HAZOP-guide words - parameters, derivation, causes, consequences, recommendation, coarse HAZOP study; Case studies-pumping system, Reactor system, Mass transfer system;Hazardous Reaction Hazards and Runaway Reactions;Emergency Isolation and Shut Down Systems (ESD); AI-Enabled Predictive Safety Analytics, AI in Risk Assessment and Emergency Response.

	TOTAL PERIODS	**45**

COURSE OUTCOMES

At the end of this course, the students will be able to		BT MAPPED (Highest Level)
CO1	Understand the importance of industrial safety and the proper handling of hazardous materials.	Understanding (K2)
CO2	Learn how to implement safety checks and prevent workplace accidents.	Understanding (K2)
CO3	Apply methods to analyze and manage risks in emergency situations.	Applying (K3)
CO4	Use safety audit tools and analyze past industrial accidents.	Applying (K3)
CO5	Perform hazard analysis using HAZOP and understand its application in process systems.	Applying (K3)

TEXT BOOKS

1. Kletz T.A., "Critical aspects of safety and loss prevention", Butterworth-Heinemann, 2014.
2. Carson P.A., "Hazardous chemicals handbook", Elsevier, 2002.

REFERENCES

1. American Institute of Chemical Engineers. Center for Chemical Process Safety, "Guidelines for Engineering Design for Process Safety", Wiley-Blackwell, 1993.
2. Hyatt N, "Guidelines for process hazards analysis, hazards identification and risk analysis", Dyadem Press, 2004.
3. Wagenaar W.A., Patrick T.W. Hudson, "Industrial safety- In A Handbook of Work and Organizational Psychology", Psychology Press, 2013.
4. Hollnagel, "Barriers and accident prevention", Routledge, 2016.

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	PO's												PSO's	
CO's	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	2	-	-	-	-	-	-	-	-	-	-	3	2
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CO3	-	3	2	-	-	-	-	-	2	-	-	-	3	3
CO4	-	2	3	2	-	-	-	-	2	-	-	-	2	3
CO5	-	2	2	3	-	-	-	-	-	-	-	-	3	3