

Basaveshwar Engineering College, Bagalkote

Department of Biotechnology

Scheme and Syllabus

2024-25

Vision of the Institute

To be an institution of excellence in education, research and innovation for a sustainable future

Mission of the Institute

1. Develop globally competent professionals for future talent requirements.
2. Nurture a culture of research, innovation and entrepreneurship.
3. Promote collaborations, extension and outreach programs for addressing industrial and societal needs.
4. Imbibe moral and ethical values.
5. Foster ecological and environmental consciousness.

Vision of the Department of Biotechnology

To be a centre for academic excellence in Biotechnology and innovative research for sustainable future.

Mission of the Department of Biotechnology

1. Develop technically competent and ethically oriented professionals
2. Promote collaborations with academia, industries and research institutes for societal needs.
3. Strengthen the culture of research, innovation, entrepreneurship and environmental consciousness.

PROGRAM EDUCATIONAL OBJECTIVES (PEOS)
OF
DEPARTMENT OF BIOTECHNOLOGY

- PEO1:** Graduates will apply fundamental knowledge of biological sciences and engineering principles to solve problems in Biotechnology and allied fields.
- PEO2:** Graduates will excel and succeed in industry/research/technical profession through global and rigorous education.
- PEO3:** Graduates will exhibit good scientific and engineering principles to comprehend, analyze, design and create novel products as well as solutions for the real time problems.
- PEO4:** Graduates will exhibit professionalism, ethical attitude, oral and written communication skills, team work, lifelong learning and ethical values for a successful professional career.

PROGRAM SPECIFIC OUTCOMES (PSOs):

- PSO1:** Graduates will be able to develop competency in applying engineering principles to environment, agriculture and healthcare systems.
- PSO2:** Graduates will be able to design, optimize, and manage bioprocesses for the development of bio-based products, ensuring quality, safety, and regulatory compliance in the industries.
- PSO3:** Graduates will be able to integrate bioethics, entrepreneurship, and environmental awareness to enhance technical skills in biotechnology applications.

Program Outcomes (POs):

- PO1: Engineering Knowledge:** Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization as specified in WK1 to WK4 respectively to develop to the solution of complex engineering problems.
- PO2: Problem Analysis:** Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development. (WK1 to WK4)
- PO3: Design/Development of Solutions:** Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required. (WK5)
- PO4: Conduct Investigations of Complex Problems:** Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling,

analysis & interpretation of data to provide valid conclusions. (WK8).

- PO5: Engineering Tool Usage:** Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems. (WK2 and WK6)
- PO6: The Engineer and The World:** Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment. (WK1, WK5, and WK7).
- PO7: Ethics:** Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (WK9)
- PO8: Individual and Collaborative Team work:** Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams.
- PO9: Communication:** Communicate effectively and inclusively within the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations considering cultural, language, and learning differences
- PO10: Project Management and Finance:** Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, and to manage projects and in multidisciplinary environments.
- PO11: Life-Long Learning:** Recognize the need for, and have the preparation and ability for i) independent and life-long learning ii) adaptability to new and emerging technologies and iii) critical thinking in the broadest context of technological change. (WK8)

Knowledge and Attitude Profile (WK)

- WK1:** A systematic, theory-based understanding of the natural sciences applicable to the discipline and awareness of relevant social sciences.
- WK2:** Conceptually-based mathematics, numerical analysis, data analysis, statistics and formal aspects of computer and information science to support detailed analysis and modelling applicable to the discipline.
- WK3:** A systematic, theory-based formulation of engineering fundamentals required in the engineering discipline.
- WK4:** Engineering specialist knowledge that provides theoretical frameworks and bodies of knowledge for the accepted practice areas in the engineering discipline; much is at the forefront of the discipline.
- WK5:** Knowledge, including efficient resource use, environmental impacts, whole-life cost, re-use of resources, net zero carbon, and similar concepts, that supports engineering design and operations in a practice area.
- WK6:** Knowledge of engineering practice (technology) in the practice areas in the engineering discipline.
- WK7:** Knowledge of the role of engineering in society and identified issues in engineering practice in the discipline, such as the professional responsibility of an engineer to public safety and sustainable development.
- WK8:** Engagement with selected knowledge in the current research literature of the discipline, awareness of the power of critical thinking and creative approaches to evaluate emerging issues.
- WK9:** Ethics, inclusive behavior and conduct Knowledge of professional ethics, responsibilities and norms of engineering practice. Awareness of the need for diversity by reason of ethnicity, gender, age, physical ability etc. with mutual understanding and respect, and of inclusive attitudes.

Sem.	BSC	ESC/ETC	HSSM/UHV	AEC	PCC	PEC	OEC	Proj.	Int.	Total
1.	08	09	02	1(SFH)						20
2.	08	09	02	1 (IDT)						20
3.	03				17					20
4.	03		01		16					20
5.			01 EVS	2(SS)	9	03	03	02		20
6.				1 (IKS)	13	03	03			20
7.			03		06	06		09		24
8.				03(MOOCs)			03 (MOOCs)		10	16
Tot.	22	18	09	08	61	12	09	10	10	160

B.E I - Semester Scheme of Teaching and Examinations

(Academic year 2024-25)

I - Semester (Computer Science Engineering Stream)

Branches: CSE/ISE/AIML/ (Chemistry Group)

Sl. No	Course Category	Course Code	Course Title	Teaching-Learning Scheme				Examination Duration (Hrs/Sem.)		Total Hours	Examination Scheme and Evaluation			Credits (C) = Total Hours /30
				L Hrs/Week (Hrs/Sem.)	T Hrs/Week (Hrs/Sem.)	P Hrs/Week (Hrs/Sem.)	Term Work (TW) and Self Learning (SL) (TW+SL) Hrs/Sem.	CIE	SEE		CIE	SEE	TOTAL	
1.	ASC(IC)	BMAS101C	Mathematics-I for CSE Stream	2(28)	2(28)	2(26)	30	5	3	120	50	50	100	4
2.	ASC(IC)	BCHS102C	Applied Chemistry for CSE Stream	2(28)	2(28)	2(26)	30	5	3	120	50	50	100	4
3.	ESC	BMEB103C	Computer-Aided Engineering Drawing	2(28)	0	2(26)	28	5	3	90	50	50	100	3
4.	ESC-I	BEEA104N	Engineering Science Course-I *	3(42)	0	0	42	3	3	90	50	50	100	3
5.	PLC-I	BCSB105D	Programming Language Course-I #	2(28)	0	2(26)	28	5	3	90	50	50	100	3
6.	AEC	BHSB106C	Professional Writing Skills in English	1(14)	0	-	13	2	1	30	50	50	100	1
7.	HSMS	BHSB10	Sanskriti	1(14)	0	-	13	2	1	30	50	50	100	1

**II - Semester (Computer Science Engineering Stream Branches: CSE/ISE/AIML/BT
(Physics Group)**

Sl. No	Course Category	Course Code	Course Title	Teaching-Learning Scheme				Examination Duration (Hrs/Sem.)		Total Hours	Examination Scheme and Evaluation			Credits (C) = Total Hours /30
				L Hrs/Week (Hrs/Sem.)	T Hrs/Week (Hrs/Sem.)	P Hrs/Week (Hrs/Sem.)	Term Work (TW) and Self Learning (SL) (TW+SL) Hrs/Sem.	CIE	SEE		CIE	SEE	TOTAL	
1.	*ASC (IC)	BMAT S201	Mathematics-II for CSE Stream	2(28)	2(28)	2(26)	30	5	3	120	50	50	100	4
2.	#ASC (IC)	BPHYS 202	Applied Physics for CSE Stream	2(28)	2(28)	2(26)	30	5	3	120	50	50	100	4
3.	ESC	BPOPS 203	Principles of Programming Using C	2(28)	0	2(26)	28	5	3	90	50	50	100	3
4.	ESC-II	BESCK 204x	Engineering Science Course-II *	3(42)	0	0	42	3	3	90	50	50	100	3
5.	PLC-II	BETCK 205x	Emerging Technology Course-II #	3(42)	0	0	42	3	3	90	50	50	100	3
6.	AEC	BENGK 206	Communicative English	1(14)	0	-	13	2	1	30	50	50	100	1
7.	AEC	BICOK 207	Indian Constitution	1(14)	0	-	13	2	1	30	50	50	100	1

B. E. III SEMESTER

Sl. No	Course Category	Course Code	Course Title	Teaching-Learning Scheme				Examination Duration (Hrs/Sem.)		Total Hours	Examination Scheme and Evaluation			Credits (C) =Total Hours/30
				L Hrs/Week (Hrs/Sem.)	T Hrs/Week (Hrs/Sem.)	P Hrs/Week (Hrs/Sem.)	Term Work (TW) and Self Learning (SL) (TW+SL) Hrs/Sem.	CIE	SEE		CIE	SEE	TOTAL	
1.	PCC	22UBT311C	Cell Biology and Genetics	3(42)	0	0	42	3	3	90	50	50	100	3
2.	IPCC	22UBT312C	Unit Operations	3(42)	0	2(26)	44	5	3	120	50	50	100	4
3.	IPCC	22UBT313C	Biochemistry	3(42)	0	2(26)	44	5	3	120	50	50	100	4
4.	PCC	22UBT314C	Microbiology	3(42)	0	0	42	3	3	90	50	50	100	3
5.	ESC	22UBT3XXC	Engineering Science Course	3(42)	0	0	42	3	3	90	50	50	100	3
6.	PCCL	22UBT316L	Microbiology Lab	0	0	2(26)	-	2	2	30	50	50	100	1
7.	UHV	22UHS317L	Social Connect and Responsibility	0	0	2(26)	-	2	-	30	100	-	100	1
8.	AEC	22UBT3XX	Ability Enhancement Course	0	0	2(26)	-	2	2	30	50	50	100	1
9.	MC	22UHS001M	Yoga-I	0	0	2(28)	-	2	-	30	25	-	-	PP
		22UHS002M	National Service Scheme (NSS)-I											
		22UHS003M	Physical Education-I											
		22UHS004M	Music-I											
Total				15	0	12					475	350	800	20

Engineering Science Course

22UBT315C **R programming for Biologists**

22UBT316C Python Programming

22UBT317C Human Anatomy and Physiology

22UBT318C Plant Physiology and Phyto-hormone

Ability Enhancement Course

22UBT319C	Bio-Lab Management and Risk Assessment
22UBT320L	Analysis of Dairy Products Lab
22UBT321C	Data presentation, Error Analysis and Inferences
22UBT322C	Biodiversity and Conservation Law

B. E. IV SEMESTER

Sl. No	Course Category	Course Code	Course Title	Teaching-Learning Scheme				Examination Duration (Hrs/Sem.)		Total Hours	Examination Scheme and Evaluation			Credits (C) =Total Hours/30
				L Hrs/Week (Hrs/Sem.)	T Hrs/Week (Hrs/Sem.)	P Hrs/Week (Hrs/Sem.)	Term Work (TW) and Self Learning (SL) (TW+SL) Hrs/Sem.	CIE	SEE		CIE	SEE	TOTAL	
1.	PCC	22UB T411C	Molecular Biology & Genetic Engineering	3(42)	0	0	42	3	3	90	50	50	100	03
2.	IPCC	22UB T412C	Biostatistics and Tools	3(42)	0	2(26)	44	5	3	120	50	50	100	04
3.	IPCC	22UB T413C	Immunotechnology	3(42)	0	2(26)	44	5	3	120	50	50	100	04
4.	BSC	22UB T441C	Biology For Engineers	3(42)	0	0	42	3	3	90	50	50	100	
5.	ESC	22UB T4XXC	Engineering Science Course	3(42)	0	0	42	3	3	90	50	50	100	03
6.	AEC	22UB T4XXX	Ability Enhancement Course	0	0	2(26)	-	2	2	30	50	50	100	03
7.	UHV	22UH S424C	Universal Human Value Course	1(14)	0	0	13	2	1	30	50	50	100	01
8.	PCCL	22UB T414L	Molecular Biology & Genetic Engineering Lab	0	0	2(26)	-	2	2	30	50	50	100	01
9.	MC	22UHS 001M	Yoga-II	0	0	2(28)	-	2	-	30	25	-	-	PP
		22UHS 002M	National Service Scheme(NSS) -II											
		22UHS 003M	Physical Education-II											
		22UHS 004M	Music-II											
Total				16	0	10					425	400	800	20

Engineering Science Course

- 22UBT415C Biochemical Thermodynamics
- 22UBT416C Marine Bioresources and applications
- 22UBT417C Bioprocess Principles and Stoichiometry**
- 22UBT418C Structural Biology and Biophysical Techniques

Ability Enhancement Course

- 22UBT419C Hydroponics, Aquaponics and Aeroponics
- 22UBT420L Water Analysis Lab
- 22UBT421L Extraction methods and herbal products lab**
- 22UBT422C Biopesticides and Biofertilizers

B. E. V SEMESTER

[illegible]

			II											
		22UHS00 4M	Music-II											
Total				17	0	06					475	450	900	21

Elective-I

22UBT511E: Environmental BT

22UBT512E: Nutraceuticals

22UBT513E: Computational Biology

22UBT514E: Protein Engineering and Drug Design

Open Elective

22UBT532N: Biofuels Technology

B. E. VI SEMESTER

Sl. No	Course Category	Course Code	Course Title	Teaching-Learning Scheme				Examination Duration (Hrs/Sem.)		Total Hours	Examination Scheme and Evaluation			Credits (C) = Total Hours/30
				L Hrs/Week (Hrs/Sem.)	T Hrs/Week (Hrs/Sem.)	P Hrs/Week (Hrs/Sem.)	Term Work (TW) and Self Learning (SL) (TW+SL) Hrs/Sem.	CIE	SEE		CIE	SEE	TOTAL	
1.	PCC	22UB T601C	Bioprocess and Bioreaction Engineering	3(42)	0	0	42	3	3	90	50	50	100	03
2.	PCC	22UB T602C	Upstream Processing Technology	3(42)	0	0	42	3	3	90	50	50	100	03
3.	PCC	22UB T603C	Biotransformation and Enzyme technology	3(42)	0	0	42	3	3	90	50	50	100	03
4.	PCC	22UB T604C	Genomics & Proteomics	3(42)	0	0	42	3	3	90	50	50	100	03
5.	PEC	22UB T6XXE	Elective-II	3(42)	0	0	42	3	3	90	50	50	100	03
6.	OEC	22UX X6XXE	Open Elective –II	3(42)	0	0	42	3	3	90	50	50	100	03
7.	AEC	22UH S600C	Indian Knowledge System	1(14)	0	0	13	2	1	30	50	50	100	01
8.	PCC L	22UB T605L	Biokinetics & Enzyme Technology Lab	0	0	2(26)	-	2	2	30	50	50	100	01

9.	MC	22UHS 001M	Yoga-II	0	0	2(2 8)	-	2	-	30	25	-	-	PP
		22UHS 002M	National Service Scheme(NSS)-II											
		22UHS 003M	Physical Education-II											
		22UHS 004M	Music-II											
Total				19	0	04					425	400	800	20

Elective-II

22UBT621E: Biofuels Technology

22UBT622E: Food Biotechnology

22UBT623E: Biopython

22UBT624E: Bioreactor Design

Open Elective

22UBT632N : Environmental Technology

B. E. VII SEMESTER

Sl. No	Course Category	Course Code	Course Title	Teaching-Learning Scheme				Examination Duration (Hrs/Sem.)		Total Hours	Examination Scheme and Evaluation			Credits (C) =Total Hours/30
				L Hrs/Week (Hrs/Sem.)	T Hrs/Week (Hrs/Sem.)	P Hrs/Week (Hrs/Sem.)	Term Work (TW) and Self Learning (SL) (TW+SL) Hrs/Sem.	CIE	SEE		CIE	SEE	TOTAL	
1.	PCC	21UB T701 C	Bioethics, Biosafety and Regulatory affairs	3(42)	0	0	42	3	3	90	50	50	100	03
2.	PCC	21UB T702 C	Downstream Processing Technology	2(28)	0	0	26	3	3	60	50	50	100	02
3.	HS MC	21UB T703 H	Bioentrepreneurship Development	3(42)	0	0	42	3	3	90	50	50	100	03
4.	PEC	21UB T7XX E	Elective –III	3(42)	0	0	42	3	3	90	50	50	100	03
5.	PEC	21UB T7XX E	Electives-IV	3(42)	0	0	42	3	3	90	50	50	100	03
6.	PCC L	21UB T704L	Upstream Process & Bioseparation Techniques Lab	0	0	2(26)	-	2	2	30	50	50	100	01
7.	PP	21UB T705 P	Project	Two contact hours/week for interaction between the faculty and			-	1	3	180	50	50	100	06

				students										
8.	MC	21UH S001 M	Yoga	0	0	2(28)	-	2	-	30	10	50	-	PP
		21UH S002 M	National Service Scheme(NSS)											
		21UH S003 M	Physical Education											
		21UH S004 M	Music											
Total				14	0	04					360	400	700	21

Elective-III

21UBT731E: Industrial BT

21UBT732E: Food Processing Technology

21UBT733E: Biosimulations

21UBT734E: Bioanalytical techniques

Elective-IV

21UBT741E: Nanobiotechnology & Biomaterials

21UBT742E: Food Product Development

21UBT743E: Clinical Research & Data Management

21UBT744E: Pharmaceutical BT

B. E. VIII SEMESTER

Sl. No	Course Category	Course Code	Course Title	Teaching-Learning Scheme				Examination Duration (Hrs/Sem.)		Total Hours	Examination Marks			Credits (C) = Total Hours/30
				L Hrs/Week (Hrs/Sem.)	T Hrs/Week (Hrs/Sem.)	P Hrs/Week (Hrs/Sem.)	Term Work (TW) and Self Learning (SL) (TW+SL) Hrs/Sem.	CIE	SEE		CIE	SEE	TOTAL	
1.	AEC	21U BT0 XXO	MOOCs*	3	0	0	90	-	-	90	50	50	100	3
2.	HSM C	21U HS8 00C	Research Methodology & IPR	2(28)	0	0	26	3	3	60	50	50	100	02
3.	INT	21U BT8 02I	Industrial Internship	Two contact hours/week for interaction between the faculty and students				3	3	300	50	50	100	10
4.	TS	21U BT8 03S	Technical Seminar	Two contact hours/week for interaction between the faculty and students				3	3	30	50	50	100	01
Total				5	0	-					200	200	400	16

III SEMESTER

Course Code		:	22UBT311C	CELL BIOLOGY AND GENETICS	Semester	:	03
L:T:P		:	3:0:0		Course Type	:	PCC
Hours/Sem.	Teaching	:	42 Hrs.		CIE Marks	:	50
	Learning (TW+SL)	:	42 Hrs.		SEE Marks	:	50
	Exam	:	06 Hrs.		Total Marks	:	100
	Total Hrs.	:	90		Credits	:	03

Professional Competency:

Graduates will apply the principles of cell biology and genetics to understand cellular functions, genetic mechanisms, and their applications in disease diagnosis, prevention, and therapeutic interventions while adhering to ethical and professional standards

Course Outcomes:

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

1. Co-relate cellular structure-function relationship in the context of cell growth and death.
2. Apply the concepts of cell signalling to biofilm formation.
3. Apply the principles of membrane transport
4. Apply the principles of Mendelian Genetics to understand gene interactions, multiple alleles and sex linked inheritance.
5. Apply principles of Chromosome structure and gene frequencies in the context of inherited disorders and population genetics

MODULE-I

08 Hrs

CYTOLOGY AND CYTOSKELETON

Prokaryotic and eukaryotic cell. Cell Architecture- physio-chemical nature of plasma membrane Structure & functions of cell organelles: nucleus, mitochondria, chloroplast, ribosomes, peroxisomes, golgi bodies and endoplasmic reticulum.

CYTOSKETAL ELEMENTS :

Cytoskeletal architecture & elements: Microtubules- structure & functions, shaping of the cells and mechanical support. Microfilaments- structure & functions. Structure of intermediate filaments. Cytoplasmic micro trabecular system (lattice).

MODULE-II

08 Hrs.

CELL CYCLE AND CELL SIGNALLING:

Cell cycle studies: mitosis and meiosis. Cell Birth, lineage and death, Cellular senescence and ageing, Senescence in ageing and age-related disease, Apoptosis and Necrosis. Cancer Cell Biology. Stem cell types.

Signalling molecules and cell surface, receptors; intracellular signal transduction; G protein coupled receptors; plant growth factors and hormones, Eukaryotic and Prokaryotic cell to cell signalling, endocrine signalling, quorum sensing and intercellular signalling, Signal peptides.

MODULE-III

08 Hrs.

MEMBRANE TRANSPORT:

Membrane transport, passive and active transport; transport into prokaryotic cells; Endomembrane System: Golgi, Lysosomes Vesicular Traffic, Secretion, and Endocytosis, exocytosis; entry of viruses and toxins into cells Membrane trafficking: Translocation of secretory proteins across the ER membrane;

protein modifications, folding and quality control in the ER; export and sorting of proteins to mitochondria, chloroplast and peroxisomes.	
MODULE-IV	10 Hrs.
GENETICS: Nature of genetic material, Mendelian Laws of inheritance, monohybrid and dihybrid inheritance, law of segregation & independent assortment, Gene interactions, supplementary genes - Comb patterns in fowls, Complementary genes - Flower color in sweet peas, Epistasis- Inhibitory and colored genes in fowls, simple problems. Identification of genetic material, classical experiments- Hershey & Chase, Avery, McLeod etc., Multiple alleles and groups antigens. Numericals based on concepts. Chromosome, Centrosome, telomere, Chemical composition of chromatin, structural organization of nucleosomes, heterochromatin. Polytene and lamp-brush chromosomes, human chromosomes.	
MODULE-V	08 Hrs.
CHROMOSOMAL DISORDERS Sex determination in plants, animals XX-XY, XX-XO, ZW-ZZ, ZO-ZZ types in animals. Chromosomal disorders. Sex linked inheritance molecular diseases, hemoglobinopathies. Disorders of coagulation, Colour blindness, hemophilia, Non-disjunction as a proof of chromosomal theory of inheritance, Linkage maps, crossing over. Chromosomal maps, interference coincidence.	
POPULATION GENETICS: Introduction, Gene frequency, and equilibrium estimation, changes in gene frequency, inbreeding and heterosis, genetic structure of population, speciation and evolution, prospects for the control of human evolution. Spontaneous and induced mutations, Eugenics. Pedigree analysis	
REFERENCE BOOKS 1. The Cell – A Molecular Approach, Cooper & Hausman, ASM Press, 2004. 2. Cell and molecular biology, EDPDe Robertis, EMF De Robertis, Lea & Febiger Intl. ed.1991. 3. Molecular Biology of the Cell, B. Alberts, et al., Garland Science, 4th ed. 2002. 4. Molecular Cell Biology Hardcover, James E. Darnell, Harvey Lodish, David Baltimore,1999 Web links and Video Lectures (e-Resources): • https://www.youtube.com/watch?v=LFyjJBiltFI • https://www.biologyonline.com/tutorials/biological-cell-introduction • https://study.com/academy/topic/cell-biology.html • https://www.edx.org/learn/cellular-biology • https://onlinecourses.swayam2.ac.in/cec19_bt12/preview	

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

CO3	3 (WK1, WK2, WK3, and WK4)	1 (WK1, WK2, WK3, and WK4)					1 (WK9)		-	-	1 (WK8)	3	2	
CO4	3 (WK1, WK2, WK3, and WK4)	2 (WK1, WK2, WK3, and WK4)					1 (WK9)		-	-	1 (WK8)	3	2	
CO5	3 (WK1, WK2, WK3, and WK4)	2 (WK1, WK2, WK3, and WK4)					1 (WK9)		-	-	1 (WK8)	3	2	

Course Code		:	22UBT312C	UNIT OPERATIONS	Semester	:	03
L:T:P*		:	3:0:2		Course Type	:	IPCC
Hours/Sem.	Teaching	:	42 + 26 Hrs.		CIE Marks	:	50
	Learning (TW+SL)	:	44 Hrs.		SEE Marks	:	50
	Exam	:	8 Hrs.		Total Marks	:	100
	Total Hrs.	:	120 Hrs.		Credits	:	04

Professional Competency:

Ability to analyse, design, and optimize momentum, heat, and mass transport systems alongside downstream mechanical separation processes in chemical, bioprocess, and pharmaceutical manufacturing plants.

Course Outcomes:

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

- CO1: Apply fundamental principles of fluid statics, kinematics, and dynamics to characterize fluid rheology, determine flow regimes, and measure flow rates using differential pressure devices.
- CO2: Solve steady-state conductive and convective heat transfer problems across composite geometries and design tubular heat exchangers using the Log Mean Temperature Difference (LMTD) method.
- CO3: Analyze mechanical separation and downstream solid-fluid operations—including terminal settling velocity in sedimentation, sieve screening efficiency, and pressure-drop resistances in rotary drum filtration.
- CO4: Determine molecular diffusivity and convective mass transfer coefficients across multiphase interfaces in chemical and bioprocess separation units.
- CO5: Evaluate binary distillation systems and drying characteristics for batch/continuous dryers.

MODULE-I

08 Hrs.

FUNDAMENTALS OF FLUID MECHANICS AND FLOW MEASUREMENTS:

Units and Dimensions- Basic and Derived units; Dimensional homogeneity; Dimensional Analysis; Fluid definition and Classification of fluids; Properties and Rheological behavior of fluids; Newton's Law of viscosity; Newtonian and Non-Newtonian types of Fluids; Fluid statics-Pascal's law; Barometric equation; and Pressure measurement using manometers (problems).

Basic fluid flow equations; Continuity equation; Bernoulli assumptions and theorem; Euler, and Bernoulli equations; Fluid flows, Types of flow: laminar and turbulent; Reynolds number and its Importance.

Flow measuring devices (Orifice meter, Venturimeter), and flow measurements.

MODULE-II

09 Hrs.

CONDUCTIVE & CONVECTIVE HEAT TRANSFER:

Modes of heat transfer; Conduction – Fourier's law of conduction, Thermal conductivity; Steady state heat conduction through uni-layer (slab/plane material) and multilayer (composite material/plane wall) and cylinder; Conceptual numericals on conduction; Convection- Forced and Natural convection, heat transfer co-efficient, conduction-convection-conduction examples, and combined equation; Concept of heat transfer coefficient- individual and overall.

Heat transfer equipment: Double pipe heat exchanger; Shell and Tube heat exchanger (with working principle and construction); Elementary design of Double pipe heat exchanger and Shell and Tube heat exchanger; Flow arrangements in Heat transfer equipment's - co-current and counter-current flow; Concept of Log Mean Temperature Difference (LMTD); Conceptual numericals on LMTD.	
MODULE-III	09 Hrs.
MECHANICAL OPERATIONS USED IN BIOTECHNOLOGY: Theory of Settling and Sedimentation; Types of Settling - Free and Hindered; Terminal settling velocity, Batch sedimentation process; Equipment like thickeners. Size Separation- Importance of screening operation; Average particle size; Sieve analysis, Types: Differential and Cumulative analysis; Screen Effectiveness. Theory of Filtration; Types of Filtration; Distribution of overall pressure drop (Resistances); Filter medium; Characteristics of filter medium; Filter aids; Factors Affecting Rate of Filtration; Filtration equipment's - Rotary Drum Filter.	
MODULE-IV	08 Hrs.
MASS TRANSFER CONCEPTS: Diffusion: Fick's law of diffusion; Measurement of diffusivity; Types of diffusion; Steady-state molecular diffusion in fluids at rest and laminar flow (stagnant/unidirectional and bidirectional); Two film theory of mass transfer; Mass transfer coefficients, and their correlations; Liquid-Liquid, Solid-Liquid, Liquid-Gas, Solid-Liquid-Gas mass transfer. Principles, mass transfer considerations in unit operations like Extraction, Absorption, Adsorption, Crystallization and Evaporation.	
MODULE-V	08 Hrs.
MASS TRANSFER OPERATIONS: Distillation: Methods of distillation, distillation of binary mixtures using McCabe Thiele method. Drying operations, batch, and continuous drying. Conceptual numericals. Concept Of Mixing, Homogeneous and Heterogeneous Mixtures, Importance of Mixing and Agitation, Mixing liquids with liquids, Construction and Flow Patterns of Impellers, Mixing Of Gases With Liquids	
List of Experiments in Unit Operations Laboratory (Any 10)	
1. Verification of Bernoulli's theorem and equation 2. Venturimeter and 3. Orifice meter 3. Conduction in multi-layer slab (Composite material) 4. Natural convection 5. LMTD calculation in the heat exchanger (Co-current) 6. Calculation of LMTD and Over all heat transfer coefficient (Counter-current) 7. Batch sedimentation 8. Settling of Particles (Terminal settling velocity) 9. Size Separation- Sieve analysis (Differential analysis) and Screen Effectiveness (Cumulative analysis) 10. Extraction 11. Distillation 12. Drying	
Reference Books	
1. McCabe, W. L., Smith, J. C., & Harriott, P. Unit Operations of Chemical Engineering. McGraw-Hill.	

2. Geankoplis, C. J. Transport Processes and Separation Process Principles. Prentice Hall.
3. Treybal, R. E. Mass-Transfer Operations. McGraw-Hill.
4. Doran, P. M. Bioprocess Engineering Principles. Academic Press.

Web links and Video Lectures (e-Resources)

1. **NPTEL:** Transport Processes I: Heat and Mass Transfer Instructor: Chemical Engineering Faculty (NPTEL / Swayam Ecosystem)
2. **NPTEL:** Mass Transfer Operations I & II Instructor: Prof. Bishnupada Mandal (IIT Guwahati)

Course Outcomes	Programme Outcomes											Programme Specific Outcomes		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
CO 1	3 (WK1, WK2, WK3, and WK4)	2 (WK1, WK2, WK3, and WK4)	2 (WK5)	1 (WK8)	1 (WK2, WK6)	-	-	-	-	-	1 (WK8)	3	2	1
CO 2	3 (WK1, WK2, WK3, and WK4)	2 (WK1, WK2, WK3, and WK4)	3 (WK5)	2 (WK8)	1 (WK2, WK6)	-	-	-	-	-	1 (WK8)	3	2	1
CO 3	2 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	2 (WK5)	2 (WK8)	1 (WK2, WK6)	-	-	-	-	-	1 (WK8)	2	3	1
CO 4	2 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	2 (WK5)	1 (WK8)	1 (WK2, WK6)	-	-	-	-	-	1 (WK8)	2	2	1
CO5	2 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	2 (WK5)	2 (WK8)	1 (WK2, WK6)	-	-	-	-	-	1 (WK8)	2	3	1

Course Code		:	22UBT313C	BIOCHEMISTRY	Semester	:	03
L:T:P		:	3:0:2		Course Type	:	IPCC
Hours/Sem.	Teaching	:	42+26 Hrs.		CIE Marks	:	50
	Learning (TW+SL)	:	44 Hrs.		SEE Marks	:	50
	Exam	:	08 Hrs.		Total Marks	:	100
	Total Hrs.	:	120		Credits	:	04

Professional Competency:

Analyse biomolecular structures, evaluate metabolic pathways, correlate pathway dysfunctions with clinical disorders, and execute quantitative bio-analytical laboratory techniques.

Course Outcomes:

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

1. Explain the fundamentals of biologically important molecules such as structures, functions and interactions with energetic of reactions, develop skills prepare standard solutions.
2. Interpret the metabolic pathways of the carbohydrates along with disorders and identify the given biomolecules.
3. Understand the importance of regulation of lipid metabolism and their inborn errors of metabolism and determine the concentration of test samples.
4. Recognize the biosynthetic precursors for the amino acid metabolism and comprehend the regulatory pathways involved in amino acid metabolism and its disorders
5. Understand the origin of atoms in the formation of purine and pyrimidine and interpret the salvage pathways along with disorders in the nucleic acid metabolism.

MODULE-I

09 Hrs.

BASIC CONCEPTS:

pH, Henderson Hesselbalch equation, buffers and their properties, concentration of solutions..
BIOMOLECULES: Classification, structure, properties and functions of Carbohydrates, Lipids, Proteins and Nucleic acids (in brief)

BIOENERGETICS:

Energy flow cycle, High energy compounds, structure and properties of ATP, biological oxidation - Electron transport chain, ATP synthesis. Oxidative phosphorylation

MODULE-II

09 Hrs.

METABOLISM OF CARBOHYDRATE:

Glycolysis –metabolism. Aerobic and anaerobic pathway and regulation, TCA cycle, NADPH Cycle, Calvin Cycle, Glyoxylate cycle, Pentose Phosphate Pathway. Gluconeogenesis – regulation of gluconeogenesis. Disorders of carbohydrate (lactose intolerance, galactosemia, diabetes).

MODULE-III

08 Hrs.

METABOLISM OF LIPID :

Biosynthesis of palmitic acid, Regulation of fatty acid biosynthesis and biodegradation of triglycerides and fatty acids (beta oxidation). Disorders of Lipid metabolism (atherosclerosis, ketone bodies (acidosis-kesosis), Gaucher disease and LDL-hypercholesterolemia)

MODULE-IV

08 Hrs.

METABOLISM OF AMINO ACIDS :

Biosynthesis of essential amino acids: Lysine, Methionine and Glutamine. Biodegradation of amino acids, deamination, transamination and urea cycle. Disorders of amino acid metabolism (phenylketonuria, alkaptonuria, tyrosinemia and maple syrup urine disease).

MODULE-V

08 Hrs.

METABOLISM OF NUCLEIC ACIDS :

Biosynthesis, biodegradation, and regulation of Purines, pyrimidines, Disorders of nucleic acid metabolism (Gout, Leshnyhn syndrome, hyper and hypo uricemia, adenosine deaminase deficiency).

LIST OF EXPERIMENTS

1. pH measurements, volume / weight measurements, concentration units, sensitivity Specificity, precision, accuracy, preparation of buffers of constant strength.
2. Qualitative tests for carbohydrate and lipids.
3. Qualitative tests for amino acids and proteins.
4. Estimation of blood sugar by Folin Wu method/ O-Toluidine method
5. Estimation of amino acid by ninhydrin method.
6. Estimation of DNA by DPA method
7. Determination of Saponification value and iodine value of lipids with error analysis.
8. Estimation of proteins by Lowry's method.
9. Estimation of urea by DAMO method.
10. Estimation of iron from haemoglobin with error analysis.

REFERENCE BOOKS

1. David L. Nelson and Michael Cox (2017). "Lehninger Principles of Biochemistry" 7th edition W.H Freeman Co., Pub.
2. Lubert Stryer (2010) "Biochemistry" -5th edition Freeman & Co., Pub.
3. Voet & Voet (2011) "Biochemistry" - 4th edition, John Wiley, New York Pub.
4. Thomas M. Davlins (2010) " Biochemistry with clinical correlations" 7th edition Wiley-Liss;.
5. Mathews, Vanholde & Arhen (2010). "Biochemistry" -3rd edition, Pearson Education Pub
6. Elliot & William H (2011). "Biochemistry & Molecular Biology" 3rd edition, John Wiley.
7. U. Sathyanarayana (2022). "Biochemistry" -5th edition, Books and Allied Pub.
8. Plummer D. T (2017) "Practical Biochemistry" – 3rd edition McGraw Hill Education pub.
9. T N. Pattabhiraman, (2015) "Laboratory Manual & Practical Biochemistry" 4th Edition, All India Publishers & Distributors.
10. Sadasivam, S. and Manickam (2008) A Biochemical Method. 3rd Edition, New Age International Publishers, New Delhi.
11. Beedu Sashidhar Rao and Vijay Deshpande (2005) "Experimental Biochemistry" I.K International Pvt. Ltd.

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

	WK3, and WK4)	WK3, and WK4)			WK6)	& WK7)								
CO4	3 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	3 (WK5)	-	2 (WK2 and WK6)	2 (WK1 ,WK5 & WK7)	2 (WK9)	-	-	-	2 (WK8)	3	2	2
CO5	2 (WK1, WK2, WK3, and WK4)	2 (WK1, WK2, WK3, and WK4)	2 (WK5)	-	2 (WK2 and WK6)	2 (WK1 ,WK5 & WK7)	2 (WK9)	-	-	-	3 (WK8)	3	2	3

Course Code		:	22UBT314C	MICROBIOLOGY	Semester	:	03
L:T:P*		:	3:0:0		Course Type	:	PCC
Hours/Sem.	Teaching	:	42 Hrs.		CIE Marks	:	50
	Learning (TW+SL)	:	42Hrs.		SEE Marks	:	50
	Exam	:	6 Hrs.		Total Marks	:	100
	Total Hrs.	:	90 Hrs.		Credits	:	3

Professional Competency:

Apply fundamental microbiological principles and techniques to identify, characterize, culture, isolate, enumerate, and control microorganisms, and evaluate their applications in healthcare, public health, environmental management, agriculture, fermentation, and industrial biotechnology.

Course Outcomes:

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

- CO1: Classify microorganism along with their structural and functional roles
- CO2: Apply learning of microscopy and microbial techniques in identification and enumeration
- CO3: Describe and relate the occurrence of microbes caused diseases.
- CO4: Apply principles of food and dairy microbiology in food fermentation, functional foods and food safety management.
- CO5: Explain the occurrence and role of general microflora of air, water and soil.

MODULE-I

08 Hrs.

Introduction:

OVERVIEW OF MICROBIOLOGY AND MICROORGANISMS:

Scope and History of Microbiology (Major mile stones) .Prokaryotes, Archaea and Eukaryotes. Microbial diversity and Taxonomy. Classification, characteristics and reproduction of Bacteria, Viruses, Fungi, Protozoa, Algae, Actinomycetes.

MODULE-II

10 Hrs.

METHODS AND TECHNIQUES IN MICROBIOLOGY:

Microscopy: Bright-Field, Dark-Field, Phase-contrast, Fluorescence, Electron Microscopy (SEM, TEM). Micrometry. Media: types and preparation. Pure culture Techniques (streak-plate, spread plate, pour plate). Staining techniques (Simple and differential). General features of true bacteria (Rickettsia, Mycoplasma and Chlamydia), Prions, Spirochetes

MODULE –III

08 Hrs.

MICROBIAL GROWTH AND CONTROL:

Microbial growth Phases, Factors affecting the growth, growth measurement and enumeration. Metabolism; Primary and Secondary metabolites with examples, Control of microorganisms by Physical methods and chemical methods, antibiotics, chemotherapeutic agents and Phage biotics

MODULE –IV

08 Hrs.

MICROBIOLOGY AND DISEASES:

Common diseases caused by microbes :viruses (Polio,H1N1,SARS,Covid-19,HIV,Hepatitis), bacteria(TB, Cholera, Typhoid, Pneumonia, Plague, Diphtheria, *E.coli* infections), Protozoans (Malaria, Leishmaniasis and Amoebiasis).Common types of fungal infections (ringworm, yeast infection).Microbiome and gut health. h

MODULE -V

08 Hrs.

Microbiology of Air, Water & Soil

Aerobiology, Air sampling techniques and commonly found atmospheric microbe profile. Water

sampling techniques, Microbiology of potable water and waste water treatment. Microbiology of soil: Soil fertility, Biofertilizers: VAM, Rhizobium and Azotobacter. **Industrial Microbiology:** Microbial processes using yeasts and bacteria (production of alcohol, vinegar, cheese), Microbes as source of protein (SCP), gelatin agents (alginate, xanthin, agar agar) Microbial insecticides, Enzymes from Microbes

Text Books:

1. Pelczar, Chan and Noel Kreig, "Microbiology" - 5th Edition Tata Macgraw Hill ,2010
2. Tortora, Funke and Case, "Microbiology an Introduction" -8th Edition, Pearson Education, 2006.
3. S. Sundara Rajan" College Microbiology"- 2nd edition, Bangalore Vardhana ,2007

Reference Books:

1. Prescott, Harley & Klein, "Microbiology" -7th Edition, WCB/McGraw Hill, Int. Edition. 2008
2. Prescott and Dunn,2002, "Industrial Microbiology"-Agribios India.
3. E Alcamo I. "Fundamentals of Microbiology"6th Ed, Jones & Bartlet, Pub. 2001

Course Outcome	Programme Outcomes											Programme Specific Outcomes		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
CO1	3 (WK1, WK2, WK3, andWK4)	2(WK1, WK2, WK3, and WK4)	(WK5)	-	-	-	-	1	-	-	2	3	3	3
CO2	3 WK1, WK2, WK3, andWK4)	3(WK1, WK2, WK3, and WK4)	2 (WK5)	-	2 (WK6)	3(WK1, WK5 and WK7)	-	-	-	-	3 (Wk8)	2	2	3
CO3	3 (WK1, WK2, WK3, andWK4)	2(WK1, WK2, WK3, and WK4)	2 (WK5)	-	2 (WK6)	-	1 (wk9)	-	-	-	2	2	2	3
CO4	3 (WK1, WK2, WK3, andWK4)	2(WK1, WK2, WK3, and WK4)	2 (WK5)	-	2 (WK6)	2(WK1, WK5 and WK7)	2 (wk9)	-	-	-	3 (Wk8)	2	2	3
CO5	2(WK1, WK2, WK3, andWK4)	1 (WK1, WK2, WK3, andWK4)	1(WK5)	-	1(WK6)	1(WK5 and WK7)	-	-	-	-	3(WK8)	1	2	1

Course Code		:	22UBT315C	R PROGRAMMING FOR BIOLOGIST	Semester	:	03
L:T:P*		:	3:0:0		Course Type	:	ESC
Hours/Sem.	Teaching	:	42Hrs.		CIE Marks	:	50
	Learning (TW+SL)	:	42Hrs.		SEE Marks	:	50
	Exam	:	6Hrs.		Total Marks	:	100
	Total Hrs.	:	90Hrs.		Credits	:	03

Course Outcomes:

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

CO1: Download and install R and R Studio CRAN website and the internet and the help commands.

Command packages: standard command packages, running and manipulating the commands, Establishment of R programming

CO2: Apply R in data management and visualization.

CO3: Solve fundamental problems.

CO4: Use of operators and functions in R.

Module-I

8 Hrs.

INTRODUCTION:

Fundamentals, installation and use of software, data editing, Downloading and installation of R from CRAN on windows and Linux OS. Getting help from CRAN website and the internet and the help commands. Command packages: standard command packages, running and manipulating the commands, Establishment of R programming.

Module-II

8 Hrs.

DATA TYPES:

R & R Studio Installation, Scalar, Vectors, Matrix, List, Data frames, Factors, Handling date in R, Conversion of data types, Operators in R, importing data and manipulating data in R.

Module-III

8 Hrs.

CONDITIONAL STATEMENTS AND FUNCTIONS:

If ...else, For loop, While loop, Repeat loop, Apply(), sApply(), rApply(), tApply. conditional executions and loops, data management with sequences. Data management with repeats, sorting, ordering, and lists.

Module-IV

8 Hrs.

DATA MANAGEMENT:

Vector indexing, factors, Data management with strings, display and formatting. data management with display paste, split, find and replacement, manipulations with alphabets, evaluation of strings, Data frames import of external data in various file formats.

Module-V

8 Hrs.

STATISTICS:

Basics of statistics, statistical functions, compilation of data. Data Visualization in R using GG Plot: Box Plot, Histograms, Scatter Plotter, Line chart, Bar Chart, Heat maps Misc. functions and Data Visualization using Plotly:3Dview, Geo Maps, Null Handling, Merge, Grep, Scan.

Practical Module

- Installation and working with R
- Executing simple programs in R
- Using graphical data visualization
- Problem solving using R

Suggested Learning resources

Suggested Learning Resources:

Books

- R For Dummies 2nd Edition by Andrie de Vries and Joris Meys, 2015.
- R in a Nutshell 2e: A Desktop Quick Reference Paperback by Joseph Adler, 2012.
- Learning R: A Step-By-Step Function Guide to Data Analysis Paperback by Richard Cotton, 2013.
- R Programming for Beginners: Fast and Easy Learning R by Steven Keller, 2016

Web Links and E Sources:

- <https://nptel.ac.in/courses/111104100>
- <https://www.youtube.com/watch?v=fDRa82lxzaU>
- <https://www.udemy.com/topic/r-programming-language>
- <https://www.udemy.com/course/r-programming/>
- <https://www.mygreatlearning.com/great-lakes-pgpdbsa?>
- <https://www.coursera.org/learn/r-programming>
- <https://www.edx.org/learn/r-programming>
- <https://www.udemy.com/topic/r-programming-language/>

Course Outcomes	Programme Outcomes											PSOs		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
CO1	2 (WK1 , WK 2, WK 3, and WK4)	1 (WK1 to WK4)	-	-	3 (WK 2,W K6)	-	-	-	-	-		3	1	-
CO2	3 (WK1 , WK2, WK3, and WK4)	2 (WK1, WK2, WK3, and WK4)	2 (WK5)	2 (W K8)	3 (WK 2,W K6)	1 (WK 1 ,WK 5, WK7)	-	-	-	1(W eek 11 to Wee k 14)		3	3	-
CO3	3 (WK1 , WK2, WK3, and WK4)	3 (WK1 , WK2, WK3, and WK4)	2(WK5)	2 (W K8)	3 (WK 2,W K6)	-	-	-	-	-		3	3	-
CO4	3 (WK1 , WK2, WK3, and WK4)	2 (WK1 , WK2, WK3, and WK4)	1 (WK5)	1 (W K8)	3 (WK 2,W K6)	-	-	-	-	-		3	2	-

Course Code		:	22UBT316C	PYTHON PROGRAMMING	Semester	:	03
L:T:P*		:	3:0:0		Course Type	:	ESC
Hours/Sem.	Teaching	:	42 Hrs.		CIE Marks	:	50
	Learning (TW+SL)	:	42 Hrs.		SEE Marks	:	50
	Exam	:	06 Hrs.		Total Marks	:	100
	Total Hrs.	:	90 Hrs.		Credits	:	03

Professional Competency	
To analyze simple computational problems and design structured algorithmic solutions.	
Course Outcomes:	
At the end of the course, the student will be able to: CO1: Develop algorithmic solutions to simple computational problems. CO2: Read, write, debug, and execute simple Python programs. CO3: Structure simple Python programs for solving problems. CO4: Decompose a Python program into functions	
MODULE-I	
08 Hrs.	
ALGORITHMIC PROBLEM SOLVING Algorithms, building blocks of algorithms (statements, state, control flow, functions), notation (pseudo code, flow chart, programming language), algorithmic problem solving, simple strategies for developing algorithms (iteration, recursion). Illustrative problems: find minimum in a list, insert a card in a list of sorted cards, and guess an integer number in a range, Towers of Hanoi.	
MODULE-II	
08 Hrs.	
DATA EXPRESSION Python interpreter and interactive mode; values and types: int, float, boolean, string, and list; variables, expressions, statements, tuple assignment, precedence of operators, comments; modules and functions, function definition and use, flow of execution, parameters and argument.	
MODULE-III	
08 Hrs.	
STATEMENTS, CONTROL FLOW Illustrative programs: exchange the values of two variables, circulate the values of n variables, distance between two points. Conditionals: Boolean values and operators, conditional (if), alternative (if-else), chained conditional (if- elif-else); Iteration: state, while, for, break, continue, pass; Strings: string slices, immutability, string functions and methods, string module.	
MODULE-IV	
08 Hrs.	
FUNCTIONS, LISTS Fruitful functions: return values, parameters, local and global scope, function composition, recursion; Lists as arrays. Illustrative programs: square root, gcd, exponentiation, sum an array of numbers, linear search, binary search. Lists: list operations, list slices, list methods, list loop, mutability, aliasing, cloning lists, list parameters.	
MODULE-V	
08 Hrs.	
TUPLES, DICTIONARIES: Tuples: tuple assignment, tuple as return value; Dictionaries: operations and methods; advanced list processing - list comprehension; Illustrative programs: selection sort, insertion sort, merge sort, histogram.	
REFERENCE BOOKS	
1. Think Python: How to Think Like a Computer Scientist Allen B. Downey. Shroff O'Reilly Publishers 2nd edition, 2016.	

2. An Introduction to Python –Revised and updated for Python 3.2 Guido van Rossum and Fred L. Drake Jr Network Theory Ltd., 2011.
3. Introduction to Computer Science using Python: A Computational Problem-Solving Focus Charles Dierbach Wiley India Edition, 2013.
4. Introduction to Programming in Python: An Inter-disciplinary Approach Robert Sedgewick, Kevin Wayne, Robert Dondero Pearson India Education Services Pvt. Ltd, 2016.
5. Fundamentals of Python: First Programs Kenneth A. Lambert CENGAGE Learning, 2012.

Course Outcomes	Programme Outcomes											Programme Specific Outcomes		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
CO 1	3 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	2 (WK5)	-	-	-	-	-	-	-	2 (WK 8)	2	-	-
CO 2	2 (WK1, WK2, WK3, and WK4)	2 (WK1, WK2, WK3, and WK4)	2 (WK5)	-	3 (WK 2 and WK6)	-	-	-	-	-	2 (WK 8)	2	-	-
CO 3	2 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	3 (WK5)	-	-	-	-	-	-	-	2 (WK 8)	2	-	-
CO 4	2 (WK1, WK2, WK3, and WK4)	2 (WK1, WK2, WK3, and WK4)	3 (WK5)	-	-	-	-	-	-	-	2 (WK 8)	2	-	-

Course Code		:	22UBT317C	HUMAN ANATOMY AND PHYSIOLOGY	Semester	:	03
L:T:P*		:	3:0:0		Course Type	:	ESC
Hours/Sem.	Teaching	:	42 Hrs.		CIE Marks	:	50
	Learning (TW+SL)	:	42 Hrs.		SEE Marks	:	50
	Exam	:	06 Hrs.		Total Marks	:	100
	Total Hrs.	:	90 Hrs.		Credits	:	03

Professional Competency:	
To apply underlying physiological and anatomical principles to analyze human bodily processes.	
Course Outcomes:	
At the end of the course, the student will be able to: 1) Apply the basic knowledge of physiology as a process of various human anatomical systems. 2) Co-relate functioning of different tissue and organ systems in the context of health and disease. 3) Analyze the interface between different organ systems essential for maintenance of health & well-being.	
MODULE-I	
10 Hrs.	
INTRODUCTION TO HUMAN BODY: Definition and scope of anatomy and physiology, levels of structural organization and body systems, basic life processes, homeostasis, basic anatomical terminology. Skeletal system: Divisions of skeletal system, types of bone, salient features and functions of bones of axial and appendicular skeletal system Organization of skeletal muscle. Lymphatic system: Lymphatic organs and tissues, lymphatic vessels, lymph circulation and functions of lymphatic system Peripheral nervous system: Classification of peripheral nervous system: Structure and functions of sympathetic and parasympathetic nervous system. Origin and functions of spinal and cranial nerves. Special senses: Structure and functions of eye, ear, nose and tongue and their disorders.	
MODULE-II	
08 Hrs.	
TISSUES, SKELETAL & MUSCULAR SYSTEM: Epithelial tissue, Connective tissues (Blood, Bones, cartilages), Muscular tissues, Nervous tissue, Cartilage and bone; Comparison between cartilage and bone; Functions of skeletal system; Joints; Muscles of limb movement. Principal types of muscles; General properties of muscles; Mechanism of muscle contraction and relaxation, Red and white muscle fibers.	
MODULE-III	
08 Hrs.	
DIGESTIVE SYSTEM: Overview of digestive system, functional anatomy of digestive system: mouth, pharynx, oesophagus, the stomach the small and large intestine. Digestive glands, Enzymes; Physiology of Digestion and Absorption.	
EXCRETORY SYSTEM: Methods of excretion; Physiological processes involved in excretion; Kidneys; Anatomy and physiology, Nephron and its structure. Functions of nephron; Nephron physiology and mechanism of urine formation; Regulation of urine formation; Osmoregulation by kidney.	
MODULE-IV	
08 Hrs.	
RESPIRATORY & CIRCULATORY SYSTEM: Structure of respiratory organs; Mechanism of breathing; pulmonary air volumes, Gas exchange in the lungs. Kinds of respiration; Transport of respiratory gases in the blood Structure, Composition and functions of blood. Blood Groups and Rh factor. Blood clotting mechanism, Basic anatomy of the heart, Physiology of heart, blood vessels and circulation. Basic understanding of Cardiac cycle, electrocardiogram. Blood pressure and its regulation. Brief outline of cardiovascular disorder like	

hypertension, hypotension, arteriosclerosis, angina, myocardial infarction, congestive heart failure and cardiac arrhythmias.

MODULE-V

08 Hrs.

NERVOUS AND ENDOCRINE SYSTEM:

Role of nervous system; Types of neurons. Types of glial cells and its function. Main properties of nervous tissue Mode of action of nerves; Conduction of nerve impulses; Central nervous system; The brain; The spinal cord; Peripheral nervous system Endocrine systems of vertebrates; Pituitary gland; Thyroid gland; Parathyroid gland; Pancreas; Adrenal or suprarenal glands; Sex glands; Gastrointestinal mucosa; Thymus gland; Pineal gland; Summary of different endocrine glands; their hormones and influence; Summary of the effect of hyper secretion and hyposecretion of some important endocrine glands.

REFERENCE BOOKS

- 1) Human Physiology by Stuart Fox, Krista Rompolksi, McGraw-Hill eBook. 16th Edition, 2022.
- 2) Ross and Wilson Anatomy and Physiology in Health and Illness by Anne Waugh, Allison Grant. Churchill Livingstone 11th Edition, 2010.
- 3) Fundamentals of Human Physiology by Lauralee Sherwood Brooks/Cole, Belmont 4th Edn, 2012.
- 4) Anatomy and Physiology for nurses (including notes on their clinical application) by Evelyn Pearce. JAYPEE Publishers, 1993.
- 5) Essentials of human physiology for pharmacy by Laurie Kelly Mccorrey. CRC Press 2nd Edn, 2008.
- 6) Concise Medical Physiology by Sujit K Chaudhari, New Central Book Agency Pvt. Ltd 5th Edn, 2003.

Course Outcomes	Programme Outcomes											Programme Specific Outcomes		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
CO 1	3 (WK 1, WK2 , WK3 , and WK4)	2 (WK1, WK2, WK3, andWK4)	-	-	-	2 (WK1 , WK5, and WK7)	-	-	-	-	2 (WK8)	2	-	-
CO 2	3 (WK 1, WK2 , WK3 , and WK4)	3 (WK1, WK2, WK3, andWK4)	2 (W K5)	-	-	3 (WK1 , WK5, and WK7)	-	-	-	-	2 (WK8)	2	-	-
CO 3	3 (WK 1, WK2 ,	3 (WK1, WK2, WK3, andW	3 (W K5)	2 (W K8)	1 (WK 2 and WK6	3 (WK, WK5, and WK7)	-	-	-	-	2 (WK8)	2	-	-

Course Code		:	22UBT318C	PLANT PHYSIOLOGY AND PHYTO-HORMONE	Semester	:	03
L:T:P*		:	3:0:0		Course Type	:	ESC
Hours/Sem.	Teaching	:	42 Hrs.		CIE Marks	:	50
	Learning (TW+SL)	:	42 Hrs.		SEE Marks	:	50
	Exam	:	06 Hrs.		Total Marks	:	100
	Total Hrs.	:	90 Hrs.		Credits	:	03

Professional Competency:

To comprehend and interpret the fundamental biochemical and physiological principles governing plant life.

Course Outcomes:

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

- 1) Comprehend the fundamental principles of plant physiology.
- 2) Examining the mechanisms of plant hormone action.
- 3) Analyzing the interaction between phytohormones and the environment.

MODULE-I

08 Hrs.

INTRODUCTION TO PLANT PHYSIOLOGY: Definition and scope of plant physiology, Plant anatomy and morphology, Plant growth and development, Water Relations and Mineral Nutrition, Water potential and its measurement, Water uptake and transport in plants, Mineral nutrients and their roles in plant growth, Nutrient uptake and transport mechanisms.

MODULE-II

10 Hrs.

PHOTOSYNTHESIS, RESPIRATION AND ENERGY METABOLISM: Light absorption and chlorophyll pigments, Photosynthetic pigments and their functions, Calvin cycle and carbon fixation, Factors affecting photosynthesis, Respiration and Energy Metabolism - Cellular respiration and ATP production, Glycolysis, Krebs cycle, and electron transport chain, Aerobic and anaerobic respiration.

MODULE-III

08 Hrs.

PLANT HORMONES: Introduction to phytohormones, Auxins: functions and physiological effects, Gibberellins: functions and physiological effects, cytokinins: functions and physiological effects, Absciscic acid: functions and physiological effects, Ethylene: functions and physiological effects.

MODULE-IV

08 Hrs.

PLANT GROWTH, DEVELOPMENT & PLANT MOVEMENTS: Seed germination and dormancy, Photomorphogenesis and photoperiodism, Flowering and reproduction, Senescence and aging, Tropisms: phototropism, gravitropism, thigmotropism, Nastic movements: nyctinasty, eismonasty, Movements in response to environmental cues.

MODULE-V

08 Hrs.

PLANT-ENVIRONMENT INTERACTIONS AND STRESS PHYSIOLOGY: Plant responses to abiotic stress (e.g., temperature, light, drought), Plant responses to biotic stress (e.g., pathogens, herbivores), Plant defence mechanisms, Signal transduction pathways in stress responses, Plant responses to light and photomorphogenesis, Plant responses to temperature, Water, and nutrients

REFERENCE BOOKS

- 1) Plant Hormones: Physiology, Biochemistry and Molecular Biology" by P.J. Davies and H.G. Davies
- 2) A Textbook of Plant Physiology by S. K. Sinha
- 3) Plant Physiology and Biochemistry" by S. Mohan Jain and A. K. Gupta
- 4) Principles of Plant Physiology by K. V. Madhava Rao:

Course Outcomes	Programme Outcomes											Programme Specific Outcomes		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
CO 1	3 (WK1, WK2, WK3, andWK4)						1(WK9)				2 (WK8)	2		
CO 2	3 (WK1, WK2, WK3, andWK4)	2 (WK1, WK2, WK3, andWK4)		2 (WK8)							2 (WK8)	2		
CO 3	3 (WK1, WK2, WK3, andWK4)	3 (WK1, WK2, WK3, andWK4)	2 (WK5)			2 (WK1, WK5, and WK7).	3(WK9)				2 (WK8)	2		

Course Code		:	22UHS317L	SOCIAL CONNECT & RESPONSIBILITY LAB	Semester	:	03
L:T:P*		:	0:0:3:1		Course Type	:	PCCL
Hours/Sem.	Teaching	:	26 Hrs.		CIE Marks	:	50
	Learning (TW+SL)	:	-		SEE Marks	:	50
	Exam	:	4 Hrs.		Total Marks	:	100
	Total Hrs.	:	30 Hrs.		Credits	:	01

Course objectives: The course will enable the students to:

1. Provide a formal platform for students to communicate and connect to the surrounding.
2. Create a responsible connection with the society.
3. Understand the community in general in which they work.
4. Identify the needs and problems of the community and involve them in problem –solving.
5. Develop among themselves a sense of social & civic responsibility & utilize their knowledge in finding practical solutions to individual and community problems.
6. Develop competence required for group-living and sharing of responsibilities & gain skills in mobilizing community participation to acquire leadership qualities and democratic attitudes.

General Instructions - Pedagogy :

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

1. In addition to the traditional lecture method, different types of innovative teaching methods may be adopted so that the activities will develop students' theoretical and applied social and cultural skills.
2. State the need for activities and its present relevance in the society and Provide real-life examples.
3. Support and guide the students for self-planned activities.
4. You will also be responsible for assigning homework, grading assignments and quizzes, and documenting students' progress in real activities in the field.
5. Encourage the students for group work to improve their creative and analytical skills.

Contents :

The course is mainly activity-based that will offer a set of activities for the student that enables them to connect with fellow human beings, nature, society, and the world at large.

The course will engage students for interactive sessions, open mic, reading group, storytelling sessions, and semester-long activities conducted by faculty mentors.

In the following a set of activities planned for the course have been listed:

Social Connect & Responsibility - Contents

UNIT I

Plantation and adoption of a tree:

Plantation of a tree that will be adopted for four years by a group of BE / B.Tech students. (ONE STUDENT ONE TREE) They will also make an excerpt either as a documentary or a photo blog describing the plant's origin, its usage in daily life, its appearance in folklore and literature -- Objectives, Visit, case study, report, outcomes.

UNIT II

Heritage walk and crafts corner:

Heritage tour, knowing the history and culture of the city, connecting to people around through their history, knowing the city and its craftsman, photo blog and documentary on evolution and practice of various craft forms -- Objectives, Visit, case study, report, outcomes.

UNIT III

Organic farming and waste management:

Usefulness of organic farming, wet waste management in neighboring villages, and

implementation in the campus – Objectives, Visit, case study, report, outcomes.
UNIT IV
Water conservation: Knowing the present practices in the surrounding villages and implementation in the campus, documentary or photoblogpresenting the current practices – Objectives, Visit, case study, report, outcomes.
UNIT V
Food walk: City's culinary practices, food lore, and indigenous materials of the region used in cooking – Objectives, Visit, case study, report, outcomes.
Course outcomes (Course Skill Set):
At the end of the course, the student will be able to: CO1: Communicate and connect to the surrounding. CO2: Create a responsible connection with the society. CO3: Involve in the community in general in which they work. CO4: Notice the needs and problems of the community and involve them in problem –solving. CO5: Develop among themselves a sense of social & civic responsibility & utilize their knowledgein finding practical solutions to individual and community problems. CO6: Develop competence required for group-living and sharing of responsibilities & gain skills in mobilizing community participation to acquire leadership qualities and democratic attitudes.
Activities: Jamming session, open mic, and poetry: Platform to connect to others. Share the stories with others. Share the experience of Social Connect. Exhibit the talent like playing instruments, singing, one-act play, art-painting, and fine art.
Pedagogy: The pedagogy will include interactive lectures, inspiring guest talks, field visits, social immersion, and a course project. Applying and synthesizing information from these sources to define the social problem to address and take up the solution as the course project, with your group. Social immersionwith NGOs/social sections will be a key part of the course. Will all leadto the course project that will address the needs of the social sector?
Course Topics: The course will introduce social context and various players in the social space, and present pproaches to discovering and understanding social needs. Social immersion and inspiring conversional will culminate in developing an actual, idea for problem-based intervention, based on an in-depth understanding of a key social problem.
Duration: A total of 40 - 50 hrs engagement per semester is required for the 3rd semester of the B.E. /B.Tech. program. The students will be divided into groups. Each group will be handled by faculty mentor. Faculty mentor will design the activities (particularly Jamming sessions open mic ,and poetry) Faculty mentors has to design the evaluation system as per VTU guidelines ofscheme & syllabus.
Guideline for Assessment Process:
Continuous Internal Evaluation (CIE): After completion of the course, the student shall prepare, with daily diary as reference, a comprehensive report in consultation with the mentor/s to indicate what he has observed and learned in the social connect period. The report should be signed by the mentor. The report shall be evaluated on the basis of the following criteria and/or other relevant criteria pertaining to the activity completed. Marks allotted for the diary are out of 50. Planning and scheduling the social connect Information/Data collected during the social connect Analysis of the information/data and report writing Considering all above points allotting the marks as mentioned below
Excellent : 80 to 100

Good : 60 to 79
Satisfactory : 40 to 59
Unsatisfactory and fail : <39

Special Note :

NO SEE – Semester End Exam – Completely Practical and activities based evaluation

Pedagogy – Guidelines :

It may differ depending on local resources available for the study as well as environment and climatic differences, location and time of execution.

Sl No	Topic	Group size	Location	Activity execution	Reporting	Evaluation Of the Topic
1.	Plantation and adoption of a tree:	May be individual or team	Farmers land/ parks / Villages / roadside/ community area / College campus etc.....	Site selection /proper consultation/Continuous monitoring/ Information board	Report should be submitted by individual to the concerned evaluation authority	Evaluation as per the rubrics Of scheme and syllabus by Faculty
2.	Heritage walk and crafts corner:	May be individual or team	Temples / monumental places / Villages/ City Areas / Grama panchayat/ public associations/Government Schemes officers/ campus etc.....	Site selection /proper consultation/Continuous monitoring/ Information board	Report should be submitted by individual to the concerned evaluation authority	Evaluation as per the rubrics Of scheme and syllabus by Faculty
3.	Organic farming and waste management:	May be individual or team	Farmers land / parks /Villages visits / roadside/ community area / College campus etc.....	Group selection / proper consultation / Continuous monitoring / Information board	Report should be submitted by individual to the concerned evaluation authority	Evaluation as per the rubrics Of scheme and syllabus by Faculty
4.	Water conservation : & conservation techniques	May be individual or team	Villages/ City Areas / Grama panchayat/ public associations/Government Schemes officers / campus etc.....	site selection / proper consultation/Continuous monitoring/ Information board	Report should be submitted by individual to the concerned evaluation authority	Evaluation as per the rubrics Of scheme and syllabus by Faculty

5.	Food walk: Practices in society	May be individual or team	Villages/ City Areas / Grama panchayat/ public associations/Government Schemes officers/ campus etc.....	Group selection / proper consultation / Continuous monitoring / Information board	Report should be submitted by individual to the concerned evaluation authority	Evaluation as per the rubrics of scheme and syllabus by Faculty
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Plan of Action (Execution of Activities)

Sl.NO	Practice Session Description
1	Lecture session in field to start activities
2	Students Presentation on Ideas
3	Commencement of activity and its progress
4	Execution of Activity
5	Execution of Activity
6	Execution of Activity
7	Execution of Activity
8	Case study based Assessment, Individual performance
9	Sector/ Team wise study and its consolidation
10	Video based seminar for 10 minutes by each student At the end of semester with Report.

- Each student should do activities according to the scheme and syllabus.
- At the end of semester student performance has to be evaluated by the faculty for the assigned activity progress and its completion.
- At last consolidated report of all activities from 1st to 5th, compiled report should be submitted as per the instructions and scheme.

Assessment Details for CIE (both CIE and SEE)

Weightage	CIE – 100%	• Implementation strategies of the project (NSS work). • The last report should be signed by NSS Officer, the HOD and principal. • At last report should be evaluated by the NSS officer of the institute. • Finally the consolidated marks sheet should be sent to the university and also to be made available at LIC visit.
Field Visit, Plan, Discussion	10 Marks	
Commencement of activities and its progress	20 Marks	
Case study based Assessment Individual performance with report	20 Marks	
Sector wise study & its consolidation 5*5 = 25	25 Marks	
Video based seminar for 10 minutes by each student At the end of semester with Report. Activities 1 to 5, 5*5 = 25	25 Marks	
Total marks for the course in each semester	100 Marks	
For each activity, 20 marks CIE will be evaluated for IA marks at the end of semester, Report and assessment copy should be made available in the department.		
Students should present the progress of the activities as per the schedule in the prescribed practical session in the field.		
There should be positive progress in the vertical order for the benefit of society in general through activities.		

Course Code		:	22UBT320L	ANALYSIS OF DAIRY PRODUCTS LAB	Semester	:	03
L:T:P*		:	0:0:2		Course Type	:	AEC
Hours/Sem.	Teaching	:	26 Hrs.		CIE Marks	:	50
	Learning (TW+SL)	:	-		SEE Marks	:	50
	Exam	:	04 Hrs.		Total Marks	:	100
	Total Hrs.	:	30 Hrs.		Credits	:	01

Professional Competency:

The ability to perform qualitative and quantitative assays to identify standard ingredients, nutritional components, and chemical adulterants in milk and milk products in compliance with food safety standards.

Course Outcomes:

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

1. Prepare various milk and milk products for analysis.
2. Learn to detect ingredients present and adulterants added to milk and milk product.

LIST OF EXPERIMENTS

1. Preparation of sample for milks.
 2. Detection of adulterants in milk.
 3. Detection and quantification of starch in milk.
 4. Detection of cellulose in milk.
 5. Detection of added urea in milk.
 6. Detection of foreign fat in milk.
 7. Detection of gelatine in milk.
 8. Determination of pH in Whey powder.
- Demonstration Experiments
9. Preparation sample of curd and determination of total solids, moisture and fats.
 10. Preparation sample of curd condensed/flavored milk and determination of tradable acidity.
 11. Preparation sample of dried milk and determination of carbohydrates, protein and ash.
 12. Preparation sample of butter and determination of free fatty acids and moisture.

REFERENCE BOOKS

1. FSSAI, Manual of Methods of Analysis Of Foods: Milk And Milk Products, Food Safety And Standards Authority of India, Ministry of Health And Family Welfare, Government of India, New Delhi, 2015.
2. Handbook of Dairy Foods Analysis, Fidel Toldra, Leo M.L. Nollet, Routledge Tyler and Francis, 2021

Course Outcome s	Programme Outcomes											Programme Specific Outcomes		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
CO 1	3 (WK1, WK2, WK3, andWK4)	3 (WK1, WK2, WK3, and WK4)	3 (WK 5)	2 (WK 8)	-	-	-	-	-	-	1 (Wk8)	3	3	1
CO 2	3 (WK1,	2	3 (WK	2 (WK	-	-	-	-	-	-	1 (Wk8)	3	2	1

[illegible]

Course Code		:	22UBT319C	BIO-LAB MANAGEMENT AND RISK ASSESSMENT	Semester	:	03
L:T:P*		:	1:0:0		Course Type	:	AEC
Hours/Sem.	Teaching	:	14 Hrs.		CIE Marks	:	50
	Learning (TW+SL)	:	13 Hrs.		SEE Marks	:	50
	Exam	:	03 Hrs.		Total Marks	:	100
	Total Hrs.	:	30 Hrs.		Credits	:	01

Professional Competency

To apply biological principles to identify, analyze, and assess biohazardous risks associated with biotechnological workflows.

Course Outcomes:

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

1. Apply principles of biology to understand risk and its assessment.
2. Deduce methods to minimize and mitigate the risks.
3. Evaluate risk-benefit analysis of different genetic engineering interventions based upon case studies.
4. Correlate laws pertaining to biological risk to the sustainable use of GMOs in different applications.

MODULE-I

03 Hrs.

BIO LABORATORY MANAGEMENT:

Essentials of lab management- Designing the lab, spacing, inventory organization and its management, automation via use of technology, documentation, safety requirements, biosafety levels, planning experiments, storage space, waste generation and its disposal. Case studies.

MODULE-II

03 Hrs.

INTRODUCTION TO RISK ASSESSMENT:

Definition and meaning of Risk. Difference between risk and hazard. Probability of occurrence of risk. Risk assessment, risk control, risk review, risk management tools, HACCP, risk ranking and filtering. Case studies.

MODULE-III

03 Hrs.

BASICS OF BIOSAFETY:

Biosafety- meaning, levels of biosafety- BSL 1, BSL2, BSL 3 and BSL 4, examples, applications of each and hazards involved there in for products derived out of biotechnology. International protocols and Case studies.

MODULE-IV

03 Hrs.

BIOSAFETY AND RISK ASSESSMENT:

Principles of safety assessment (for infectious organisms, agents, microbes- genetically altered/ metabolically engineered, transgenic plants, GMOs /LMOs used in food, pharma, bioremediation etc., Sequential steps in risk assessment; concepts of familiarity and substantial equivalence; environmental risk assessment and food and feed safety assessment. Case studies.

MODULE-V

02 Hrs.

RISK MINIMIZATION AND/OR RISK MITIGATION:

Risk assessment through omics approach. Ethical, legal, and social implications of health privacy and policy laws for mitigation/minimization (Indian and Global contexts). Risk characterization and development of analysis plan. Case studies.

REFERENCE BOOKS

1. Biotechnology risk: Complete Self-Assessment Guide, by Gerardus Blokdyk, 2018.
2. Laboratory Biorisk Management Biosafety and Biosecurity, Reynolds M. Salerno, Jennifer Gaudioso, 2015.

Course Outcome s	Programme Outcomes											Programme Specific Outcomes		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
CO 1	3 (WK1, WK2, WK3, andW K4)	2				2(WK1, WK5, and WK7).					2 (WK 8)	2		
CO 2	2 (WK1, WK2, WK3, andW K4)	3 (WK1, WK2, WK3, andWK 4)	3			2(WK1, WK5, and WK7).	2(WK 9)				2 (WK 8)	2		
CO 3	2 (WK1, WK2, WK3, andW K4)	3 (WK1, WK2, WK3, andWK 4)	2 (WK 5)			2 (WK1, WK5, and WK7).	3(WK 9)				2 (WK 8)	2		
CO 4	2 (WK1, WK2, WK3, andW K4)					3 (WK1, WK5, and WK7).	3(WK 9)	3			2 (WK 8)	2		

Course Code		:	22UBT321C	DATA PRESENTATION, ERROR ANALYSIS AND INFERENCES	Semester	:	03
L:T:P*		:	1:0:0		Course Type	:	AEC
Hours/Sem.	Teaching	:	14 Hrs.		CIE Marks	:	50
	Learning (TW+SL)	:	13 Hrs.		SEE Marks	:	50
	Exam	:	03 Hrs.		Total Marks	:	100
	Total Hrs.	:	30 Hrs.		Credits	:	01

Professional Competency	
Ability to source, validate, clean, and analyze datasets to extract statistically sound, data-driven inferences and present them visually for impactful decision-making.	
Course Outcomes:	
At the end of the course, the student will be able to: - Understand the sources of data, present the data for specific purposes/application. - Gain ability to analyze the occurrence of errors in data sets. - Demonstrate the ways to draw inferences from data.	
MODULE-I	03 Hrs.
INTRODUCTION TO DATA: Definition. Representation of data in mathematical (quantitative) terms. Characteristics of data, its types. Occurrence of data across BT sectors and disciplines. Practical applications and discussion of case studies based upon real-time data.	
MODULE-II	02 Hrs.
DATA PRESENTATION: Techniques to present data in textual, tabular, and graphical forms. Purposes and Key methods to present the data. Use of MS Excel and Google sheets. Practical applications and discussion of case studies based upon real-time data gathered from lab sessions.	
MODULE-III	03 Hrs.
DATA ANALYSIS: Meaning and processing data for analysis by using statistical or logical techniques in BT. Methods of data analysis: descriptive, diagnostic, inferential, predictive and prescriptive. Practical applications and discussion of case studies based upon real-time data gathered from lab sessions.	
MODULE-IV	03 Hrs.
ERROR ANALYSIS: Sources of errors. Types of errors (massive, specific and incidental) in Biotechnology labs, research and industrial scales. Meaning of error analysis and its stages. Methods and means to minimize errors. Practical applications and discussion of case studies based upon real-time data gathered from lab sessions	
MODULE-V	03 Hrs.
DATA INFERENCE: Need to identify trends and key points in data presentation (highlighting the inference, using relevant images for enhancing impact of presentation, visually presentation the numbers, stepwise or stage wise presentation of information). Practical applications and discussion of case studies based upon real-time data gathered from lab sessions	
REFERENCE BOOKS	
- Introduction to data and data analysis, Deepak Shrivastava, 2020 - A General Introduction to Data Analytics, Moreira Joao. John Wiley and Sons Ltd. Anonym, 2018 - Does presentation format matter? The impact of data presentation on decision making, By Anonym, Grin Verlag GmbH. 2015	

Course Outcomes	Programme Outcomes											Programme Specific Outcomes		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
CO 1	2 (WK1, WK2, WK3, andWK4)	1 (WK1, WK2, WK3, andWK4)			3 (WK2 and WK6)					3	2 (WK8)	2		
CO 2	2 (WK1, WK2, WK3, andWK4)	3 (WK1, WK2, WK3, andWK4)	1 (WK5)	2 (WK8)	2 (WK2 and WK6)						2 (WK8)	2		
CO 3	3 (WK1, WK2, WK3, andWK4)	3 (WK1, WK2, WK3, andWK4)	2 (WK5)	3 (WK8)	2 (WK2 and WK6)					1	2 (WK8)	2		

Course Code		:	22UBT322C	BIODIVERSITY AND CONSERVATION LAW	Semester	:	03
L:T:P*		:	1:0:0		Course Type	:	AEC
Hours/Sem.	Teaching	:	14 Hrs.		CIE Marks	:	50
	Learning (TW+SL)	:	13 Hrs.		SEE Marks	:	50
	Exam	:	03 Hrs.		Total Marks	:	100
	Total Hrs.	:	30 Hrs.		Credits	:	01

Professional Competency	
Apply ecological principles and valuation frameworks to analyze the drivers of faunal extinction across diverse ecosystems, implementing legally compliant and ethically sound conservation strategies to protect biodiversity.	
Course Outcomes:	
At the end of the course, the student will be able to:	
1. Understand ecological systems and apply the same to Biodiversity and evolution of species. 2. Comprehend Ecological economics and analyze the values of biodiversity. 3. Analyze the impacts of species, terrestrial and aquatic ecosystems towards extinction of fauna. 4. Apply Environmental law and ethical guidelines towards conservation of species.	
MODULE-I	
03 Hrs.	
BIODIVERSITY: Concept and definition Scope and Constraints of Biodiversity Science, Composition and Scales of Biodiversity: Genetic Diversity, Species/Organismal Diversity, Ecological/Ecosystem Diversity, Landscape/Pattern Diversity, Agrobiodiversity, Biocultural Diversity and Urban Biodiversity. Case studies.	
MODULE-II	
02 Hrs.	
CAUSES OF BIODIVERSITY ORIGIN OF SPECIES /SPECIATION: History of the Earth and Biodiversity patterns through Geological times; Current Centers of Biodiversity. Values of Biodiversity Instrumental/Utilitarian value and their categories, Direct use value; Indirect/ Non- consumptive use value. Case studies.	
MODULE-III	
03 Hrs.	
ECOLOGICAL ECONOMICS: Monetizing the value of Biodiversity; Intrinsic Value; Ethical and aesthetic values, Anthropocentrism, Biocentrism, Ecocentrism and Religions. Threats to Biodiversity Habitat Destruction, Fragmentation, Transformation, Degradation and Loss: Causes, Patterns and consequences on the Biodiversity of Major Land and Aquatic Systems, Case studies.	
MODULE-IV	
03 Hrs.	
INVASIVE SPECIES: Biological impacts of invasive species on terrestrial and aquatic systems. Pollution: Impacts of Pesticide pollution, Water pollution and Air Pollution on biodiversity, Overexploitation: Impacts of Exploitation on Target and Non-target Terrestrial and Aquatic species and Ecosystems Extinction, Types of Extinctions, Processes responsible for Species Extinction. Case studies.	
MODULE-V	
03 Hrs.	
ENVIRONMENT AND LAWS: Traditional Knowledge and Environment, International Convention for the Protection of New Varieties of Plants (UPOV Convention), Emergence of International Environmental Law, Fundamental Principles, Application of International Environmental Law, Introduction to Trade & Environment, UNFCCC - 1992 & Kyoto Protocol - 1997, Treaty on Antarctic & Polar Regions – 1961, UN Convention	

of Law of the Sea – 1982 and Regional Seas Convention, Convention on Biodiversity (CBD) and its key elements.

REFERENCE BOOKS

1. Principles of Conservation Biology. Groom, M. J., Meffe, G. R. and C. R. Carroll. Sinauer Associates, Inc.2006.
2. Textbook of Biodiversity. Krishnamurthy, K. V. Science Publication. 2003.
3. Essentials of Conservation Biology. Primack, R. Sinauer Associates, Inc., USA,2006.
4. Conservation, 2nd Edition, Clive Hambler, University of Oxford, Susan M. Canney, 2013.
5. Conservation Biology: Foundations, Concepts, Applications by Fred Van Dyke, Springer. 2010

Course Outcomes	Programme Outcomes											Programme Specific Outcomes		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
CO 1	3 (WK1, WK2, WK3, andWK4)	1 (WK1, WK2, WK3, andWK4)	-	2- (WK8)	-	-	3 (WK9)	-	-	-	2 (WK8)	2	-	-
CO 2	2 (WK1, WK2, WK3, andWK4)	2 (WK1, WK2, WK3, andWK4)	-	-	-	3 (WK1 , WK5, and WK7)	3 (WK9)	1	-	-	2 (WK8)	2	-	-
CO 3	2 (WK1, WK2, WK3, andWK4)	3 (WK1 , WK2, WK3, and WK4)	2 (WK5)	3 (WK8)	-	1 (WK1, WK5, and WK7)	3 (WK9)	-	-	-	2 (WK8)	2	-	-
CO 4	2 (WK1, WK2, WK3, andWK4)	-	3 (WK5)	-	-	3 (WK1, WK5, and WK7)	3 (WK9)	3	-	-	-	-	-	-

Course Code		:	22UBT316L	MICROBIOLOGY LAB	Semester	:	03
L:T:P*		:	0:0:2		Course Type	:	PCCL
Hours/Sem.	Teaching	:	26 Hrs.		CIE Marks	:	50
	Learning (TW+SL)	:	-		SEE Marks	:	50
	Exam	:	4 Hrs.		Total Marks	:	100
	Total Hrs.	:	30 Hrs.		Credits	:	01

Professional Competency:

Apply standard microbiological laboratory techniques and instruments for the safe cultivation, isolation, identification, characterization, enumeration, and analysis of microorganisms, and interpret experimental results for microbiological, clinical, environmental, and industrial applications.

Course Outcomes:

- CO1: Operate equipment used in a microbiology laboratory.
CO2: Prepare growth media and isolate microorganisms from various sources.
CO3: Perform aseptic transfers of microorganisms.
CO4: Identify microorganisms using morphological and physiological tests.
CO5: Carry out antibiotic susceptibility testing of bacteria.

LIST OF EXPERIMENTS

- Study of major laboratory instruments: Compound microscope, Autoclave, Hotair oven, Incubator, biosafety cabinet and centrifuge
- Aseptic techniques in laboratory preparations and analysis: Sterilisation, disinfection and sanitization
- Culture techniques: Types of culture media, inoculation, incubation and isolation of pure colonies.
- Cultural characterization: Study of strain colony morphology (homogeneity, size, shape, colour, Opacity and texture of colonies)
- Microscopic characteristics: Microscopic observation of shape and cell size, mobility.
- Enumeration techniques: Enumeration of microbes (Plate count, haemocytometer)
- Fixation and staining: Isolation of microbes using staining techniques (Simple, Gram staining and spore staining).
- Staining techniques: Acid Fast Staining, Negative staining and Fungal staining.
- Biochemical Characterization of bacteria: IMViC, Starch hydrolysis, Carbohydrate Assimilation.
- Biochemical Characterization of bacteria: Catalase, Urease, hydrogen sulphide, Gelatin Liquefaction tests.
- Bacterial Growth curve studies.
- Antibiotic susceptibility test of a selected bacterium.
- DIY experiment (To be designed and executed by students themselves).

Text books:

- Aneja, K.R. (2018). Laboratory Manual of Microbiology and Biotechnology. 2nd Edition, Medtech
- Harley, J. (2016). Laboratory Exercises in Microbiology. 10th Edition, McGraw-Hill

Reference books / Manuals:

- Experiments in Microbiology, Plant Pathology and Biotechnology by K. R. Aneja, New Age International, 2003
- Microbiology: A Lab Manual by Cappuccino, Pearson Education, 2007

Course Outcome	Programme Outcomes											Programme Specific Outcomes		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
CO1	2 (WK1, WK2, WK3, andWK4)	2 (WK, WK2, WK3, and WK4)	2 (WK5)	-	-	2	-	-	-	-	1	1	1	1
CO2	2 (WK1, WK2, WK3, andWK4)	2 (WK, WK2, WK3, and WK4)	2 (WK5)	-	2 (WK6)	3 (WK1, WK5 and WK7)	-	-	-	-	3 (Wk8)	2	1	2
CO3	3 (WK1, WK2, WK3, andWK4)	2 (WK, WK2, WK3, and WK4)	2 (WK5)	-	2 (WK6)	-	1 (wk9)	-	-	-	2	2	2	3
CO4	3 (WK1, WK2, WK3, andWK4)	2 (WK, WK2, WK3, and WK4)	2 (WK5)	-	2 (WK6)	2 (WK1, WK5 and WK7)	2 (wk9)	-	-	-	3 (Wk8)	2	2	3
CO5	2(WK1, WK2, WK3, andWK4)		1 (WK5)		1 (WK6)	1 (WK5 and WK7)		-	-	-	3 (WK8)	1	2	1

IV SEMESTER

	Code	:	22UBT411C	MOLECULAR BIOLOGY & GENETIC ENGINEERING	Semester	:	04
	LTP	:	3:0:0		Course Type	:	PCC
Hours/Sem	Teaching	:	42 Hrs.		CIE Marks	:	50
	Learning (TW+SL)	:	42 Hrs.		SEE Marks	:	50
	Exam	:	06 Hrs.		Total Marks	:	100
	Total Hrs.	:	90 Hrs.		Credits	:	03

Professional Competency:

Demonstrate proficiency in molecular biology techniques, recombinant DNA technology, gene cloning, PCR, gene expression analysis, and genome editing for applications in healthcare, agriculture, and biopharmaceutical industries.

Course Outcomes:

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

CO1: Acquire working knowledge on the mechanism of replication, transcription, translation along with their applications in research.

CO2: Identify the various mechanism of gene regulation in prokaryotes and eukaryotes for disease diagnosis.

CO3: Apply the knowledge of various tools used in genetic engineering experiments for gene cloning

CO4: Identify different methods of various gene transfer techniques in plants, animals and microbes and apply the knowledge of methods of nucleic acid detection, hybridization and amplification and library construction in research.

CO5: Identify the applications of genetic engineering in the field of biopharmaceuticals.

MODULE-I

9 Hrs.

CENTRAL DOGMA OF MOLECULAR BIOLOGY:

Central Dogma, Replication of DNA in Prokaryotic cell and Eukaryotic cell. Mechanism of action of telomerase, DNA damage, and repair: photo-reactivation, excision repair, recombination repair, and SoS repair. Transcription in the prokaryotic and eukaryotic cell: Initiation, elongation, and termination. Processing of mRNA. Translation in the prokaryotic and eukaryotic cell: Initiation, elongation, and termination. Post-translational modification of proteins.

MODULE-II

9 Hrs.

GENE REGULATION :

Regulation of gene expression in prokaryotes: Operon model-structure and function, Lactose operon, cyclic AMP effect/catabolism repression. Positive versus negative regulation, tryptophan Operon-regulation by Repression and attenuation mechanism, Regulation of gene expression in eukaryotes: Gene regulation- transcriptional control-by chromatin modification, RNA processing control- micro RNAs, Translational control, and post-translational level control. Hormonal control of gene expression in eukaryotes (steroid hormone and peptide hormones), Gene silencing: Antisense RNA technology.

MODULE-III

8 Hrs.

INTRODUCTION TO GENETIC ENGINEERING:

Basics of Genetic Engineering, Method of Recombinant DNA technology, Natural and Artificial plasmids-Vectors for gene cloning: Plasmids, Phages, Cosmids. Molecular tools for gene cloning: Restriction and Modification systems: Restriction Endonuclease, Ligases. Polynucleotide kinases, Alkaline Phosphatases, Reverse transcriptase, Terminal transferase, DNases (Extremophiles), Nuclease. RNases. Linkers and adapters.

MODULE-IV

8 Hrs.

GENE TRANSFER TECHNIQUES:

Physical, chemical and biological methods, (Microinjection, Electroporation, calcium

phosphatase DNA coprecipitation, Engineered Embryonic stem cell method, Microprojectile gun bombardment method, Agrobacterium mediated gene transfer, Ti plasmid based vectors-Binary and Cointegrate Vectors. Construction of Complementary DNA, genomic and cDNA libraries, Polymerase chain reaction (PCR) - techniques and requirements, types of PCR, applications. Blotting techniques (Southern, Northern and Western), *Bacillus thuringiensis* and its mode of action.

MODULE-V

8 Hrs.

APPLICATIONS OF GENETIC ENGINEERING:

Engineering microbes for the production of insulin, production of vaccine and monoclonal antibodies. Cloning by Somatic Cell Nuclear transfer-Dolly, Transgenic technology for plant and animal improvement- Viral, fungal, insect, drought and salinity resistant transgenic plants, Transgenic mice and transgenic cow. Bio pharming- Animals and plants as bioreactors for recombinant proteins.

Text Books:

1. **James D. Watson, Tania A. Baker, Stephen P. Bell, Alexander Gann, Michael Levine, and Richard Losick**, Molecular Biology of the Gene, 5th Edition, Pearson edition
2. David Nelson and Michael Cox, Lehninger, Principles of Biochemistry (6th Edition), W.H. Freeman, 2017.
3. B.R. Glick, J.J. Pasternak and C.L Patten, "Molecular Biotechnology – Principles and applications of recombinant DNA", ASM Press, 6th edition, 2022

Reference Books:

1. Lewin's genes XII Burlington, Massachusetts: Krebs, Jocelyn E., Goldstein, Elliott S., Kilpatrick, Stephen T., Jones & Bartlett Learning, 2018.
2. Gene Cloning and DNA Analysis – An Introduction, T.A. Brown, Wiley-Blackwell Science, 7th edition, 2018.
3. Sambrook & Russell, Molecular Cloning, (3rd Edition), Cold Spring Harbor Lab, 2002

Web links and Video Lectures (e-Resources)

1. https://onlinecourses.swayam2.ac.in/cec19_bt02/preview
2. Molecular Biology of the gene by **James D. Watson, Tania A. Baker, Stephen P. Bell, Alexander Gann, Michael Levine, and Richard Losick** –Interactive Animations

Course Outcomes:

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

	and WK4)	and WK4)												
CO4	2 (WK1, WK2, WK3, and WK4)	2 (WK1, WK2, WK3, and WK4)	3 (W K5)	2 (WK8)	3 (WK2, WK6)	3 (WK1 ,WK5, WK7)	1 (WK9)	-	-	-	3 (WK8)	3	3	1
CO5	2 (WK1, WK2, WK3, and WK4)	2 (WK1, WK2, WK3, and WK4)	3 (W K5)	2 (WK8)	3 (WK2, WK6)	3 (WK1 ,WK5, WK7)	1 (WK9)	-	-	-	3 (WK8)	3	3	3

Practical Module

1. Measurement and Sampling: To select a simple random sample from the population and enter these data into SPSS/Minitab/or any other statistical software.
2. Diagrammatic & Graphical representation: To plot line diagrams, bar diagram. Pie chart, Histogram and frequency distribution of the collected data.
3. Summary Statistics: To calculate and interpret summary statistics for the data in your sample.
4. Correlation: Calculation & interpretation of correlation and regression between variables
5. Hypothesis testing: To test a hypothesis by determining a significance difference for mean and proportion.
6. t – test: To use t- test for determining a significance difference between two groups.
7. Chi – Square test: Use of Chi – Square test of independent of Attributes for 2 X 2 contingency table.
8. Experimental Design: Design and analysis of experiments based on factorial design and calculate main effect, interaction effect.
9. Experimental Design: Design and analysis of mixture experiments using different factors.
10. Experimental Design: Design and analysis of screening experiments using Plackett–Burman designs
11. Experimental Design: Design and analysis of experiments based on response surface methodology (RSM)

Text Books:

1. Khan and Khanum, (2008), Fundamentals of Biostatistics(3rd edition), Ukaaz Publication
2. Kapur J.N. (2001), Mathematical Models in Biology and Medicine (1st edition), New age international Pvt. Ltd.
3. Design of Experiments 1st Edition Bradley Jones, Douglas C. Montgomery

Reference Books:

1. Agarwal B.L. (2009), Basic statistics(5th edition), New age international Publishers
2. Rastogi V. B.(2006), Fundamentals of Biostatistics, Ane Books
3. Fundamentals of Statistics (Paperback, SC GUPTA) Edition, 6; Publisher, Himalaya, 1984.

Web links and Video Lectures (e-Resources)

- VTU EDUSAT / SWAYAM / NPTEL / MOOCS / Coursera / MIT-open learning resource
- <https://archive.nptel.ac.in/courses/102/106/102106051/>
- https://onlinecourses.nptel.ac.in/noc21_mg48/preview
- <https://archive.nptel.ac.in/noc/courses/noc18/SEM1/noc18-mg01/>

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

CO4	2 (WK1, WK2, WK3, and WK4)	-	-	3 (WK5)	-	-	-	-	-	-	2 (WK8)	1	-	-
CO5	2 (WK1, WK2, WK3, and WK4)	-	-	3 (WK5)							2 (WK8)	1	-	-

Course Code		:	22UBT413C	IMMUNOTECHNOLOGY	Semester	:	04
L:T:P		:	3:0:2		Course Type	:	IPCC
Hours/Sem.	Teaching	:	42 + 26 Hrs.		CIE Marks	:	50
	Learning (TW+SL)	:	44 Hrs.		SEE Marks	:	50
	Exam	:	08 Hrs.		Total Marks	:	100
	Total Hrs.	:	120 Hrs.		Credits	:	04

Professional Competency:

Analyze immune system functions, diagnose immunological disorders, develop vaccines, and perform advanced lab techniques for clinical and research purposes.

Course Outcomes:

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

1. Interpret the Structure, properties and functions of immune system.
2. Understand the mechanism of humoral and cell mediated immune system.
3. Detail the cause, challenges and treatment for Immune System Pathologies and Dysfunctions.
4. Examine the mechanism of transplantation and its immunological basis.
5. Apply the major immunological laboratory techniques and their application to both clinical analysis and experimental research.

MODULE-I

10 Hrs.

IMMUNE SYSTEM: Introduction; Immunity-innate and acquired immunity; Haematopoiesis; Cells of immune system – lymphoid cells, mononuclear cells, granulocytes, dendritic cells & mast cells; organs of immune system - primary and secondary lymphoid organs; Humoral and Cell mediated immunity; Antigens: Chemical and biological Factors affecting antigenicity/Immunogenicity and molecular nature, Haptens, adjuvants; Antibodies: structure and function, Immunoglobulin classes and subclasses (isotypic, allotypes, idiotypes and anti-idiotypic antibodies).

MODULE-II

08 Hrs.

HUMORAL AND CELL MEDIATED IMMUNITY: B-lymphocytes and their activation, development and maturation. Antibody genes and generation of diversity, Class Switching mechanism; production of monoclonal antibodies, polyclonal antibodies and applications; Thymus derived lymphocytes (T cells): activation, development and maturation, their ontogeny and types. Major histocompatibility Complex (MHC) Complex, MHC Class I and II molecules. Antigen processing and presentation process.

MODULE-III

08 Hrs.

IMMUNE SYSTEM IN HEALTH AND DISEASE: Complement system, pathways of complement activation and its functions, Hypersensitivity: Gell and Coombs classification of Hypersensitivity, Autoimmune disorders-types, animal model and treatment; Immune response to infections: immunity to viruses, bacteria, fungi and parasites; Immunodeficiency disorders: Primary and secondary immunodeficiencies (AIDS); Injury and inflammation, Vaccines and their types, production of recombinant vaccine, Vaccine for hepatitis B surface antigen.

MODULE-IV

08 Hrs.

TRANSPLANTATION AND TUMOR IMMUNOLOGY: Transplantation and its classification, Immunologic basis of graft rejection and its mechanism, transplantation antigens, tissue typing, role of MHC molecules in allograft rejection, Clinical transplantations, bone marrow, HSC transplantation and immunosuppressive therapy; Tumours of the immune system-tumour antigens and immune response to tumours, tumour immune-therapy.

MODULE-V

08 Hrs.

MOLECULAR IMMUNOLOGY & IMMUNODIAGNOSIS: Antigen antibody interaction – Precipitation reactions, Agglutination reactions; ABO Blood typing principles; Principles and applications of ELISA, Radio Immuno Assay (RIA), western blot analysis, immunoelectrophoresis, Immunofluorescence, Fluorescence Activated Cell Sorting (FACS) analysis. Role of stem cells technology in immunology, Production of humanized monoclonal antibodies (Single chain fragment variable).

LIST OF EXPERIMENTS

1. Agglutination Technique: ABO typing
2. Bacterial Agglutination reaction-Widal test (slide agglutination)
3. Ouchterlony Double Diffusion (ODD)
4. Rocket immune-electrophoresis (RIEP)
5. Counter-current immune-electrophoresis (CCIEP)
6. Enzyme-linked immunosorbent assay (ELISA)
7. Western blotting
8. Radial Immunodiffusion (RID)

Text Books:

1. Roitts, "Essential Immunology" 13th edition, Wiley Blackwell, 2017
2. Kubly, J., "Immunology", 8th edition, W H Freeman Publishers, 2019
3. Rastogi, S. C., "Immunodiagnosics", 1st Edition, New Age International, 2005

Reference Books:

1. Chakravarthy, A.K., "Immunology & Immunotechnology", Oxford University Press, 2006

Course Outcomes	Programme Outcomes											Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
CO1	3 (WK1 to WK4)	2 (WK 1 to WK4)	2 (WK 5)	1 (WK 8)	3 (WK2 and WK6)	-	-	-	-	-	3 (WK8)	3	3	-
CO2	3 (WK1 to WK4)	2 (WK 1 to WK4)	2 (WK 5)	2 (WK 8)	3 (WK2 and WK6)	-	-	-	-	-	3 (WK8)	3	3	-
CO3	3 (WK1 to WK4)	3 (WK 1 to WK4)	3 (WK 5)	2 (WK 8)	3 (WK2 and WK6)	-	-	1	-	-	3 (WK8)	3	3	2
CO4	3 (WK1 to WK4)	2 (WK 1 to WK4)	2 (WK 5)	1 (WK 8)	3 (WK2 and WK6)	-	-	-	-	-	3 (WK8)	3	3	-
CO5	3 (WK1 to WK4)	2 (WK 1 to WK4)	2 (WK 5)	2 (WK 8)	3 (WK2 and WK6)	2 (WK1, WK5, and WK7)	-	1	-	-	3 (WK8)	3	3	2

Course Code		:	22UBT441C	BIOLOGY FOR ENGINEERS	Semester	:	04
L:T:P*		:	3:0:0		Course Type	:	BSC
Hours/Sem.	Teaching	:	42 Hrs.		CIE Marks	:	50
	Learning (TW+SL)	:	42 Hrs.		SEE Marks	:	50
	Exam	:	06 Hrs.		Total Marks	:	100
	Total Hrs.	:	90 Hrs.		Credits	:	03

Professional Competency:

The ability to apply fundamental biological principles, cellular mechanisms, and evolutionary designs to solve complex engineering problems, develop sustainable technologies, and design bio-inspired materials or systems.

Course Outcomes:

After completion of the course, students will be able to

1. Elucidate the basic biological concepts required for engineering applications.
2. Evaluate the principles of design and development, for exploring novel bioengineering projects.
3. Behold the bioinspiration from nature and create biomimetics for specific applications.
4. Think critically about exploring innovative biobased solutions for eco-friendly and socially relevant problems.

MODULE – I

08 Hrs.

INTRODUCTION TO BIOLOGY:

The cell: Structure, and functions of a cell. Biomolecules: Properties and functions of Carbohydrates, Nucleic acids, proteins, lipids. Importance of special biomolecules; Enzymes -Properties and functions, vitamins and hormones.

BIOMOLECULES AND THEIR APPLICATIONS:

Carbohydrates in cellulose-based water filters production, PHA and PLA in bioplastics production, Nucleic acids in vaccines and diagnosis, Proteins in food production, lipids in biodiesel and detergents production, Enzymes in biosensors fabrication, food processing, detergent formulation and textile processing.

MODULE – II

08 Hrs.

BIO INSPIRATION MODELS USED IN ENGINEERING:

Bio inspiration - Introduction, Alliance between Engineering and Biology, Biomimicry - Science mimicking nature.

Bird flying (GPS and aircrafts), Lotus leaf effect (Super hydrophobic and self-cleaning surfaces), Gecko Feet, Plant burrs (Velcro), Shark skin (Friction reducing swimsuits), Kingfisher beak (Bullet train), Fire fly LED.

MODULE – III

08 Hrs.

NATURE BIOINSPIRED MATERIALS AND MECHANISMS

BioEcholocation (ultrasonography, sonars), Photosynthesis (photovoltaic cells, bionic leaf), Respiration (MFCs) Human Blood substitutes-hemoglobin based oxygen carriers (HBOCs) and perfluorocarbons (PFCs). Artificial Intelligence for disease diagnosis. Biochips & their applications. Biosensors & their applications. Nanobiomolecules in medical science. Biofilms in dental treatment.

MODULE – IV

10 Hrs.

HUMAN ORGAN SYSTEMS AND BIO DESIGNS

Brain as a CPU system (architecture, CNS and Peripheral Nervous System, signal transmission, EEG, Robotic arms for prosthetics. Engineering solutions for Parkinson's disease).

Heart as a pump system (architecture, electrical signalling - ECG monitoring and heart related issues, reasons for blockages of blood vessels, design of stents, pace makers, defibrillators).

Lungs as purification system gas exchange mechanisms, spirometry, Ventilators, Heart-lung

machine).

Eye as a Camera system, bionic eye. **Kidney** as a filtration system - dialysis systems. **Muscular and Skeletal Systems** as scaffolds, bioengineering solutions for muscular dystrophy and osteoporosis.

MODULE – V

08 Hrs.

TRENDS IN BIOENGINEERING

Bioprinting techniques and materials, 3D printing of ear, bone and skin. 3D printed foods, electrical tongue and electrical nose in food science, DNA origami and Biocomputing, Bioimaging and Self-healing Bioconcrete (based on bacillus spores, calcium lactate nutrients and biomineralization processes) and Bioremediation and Biomining via microbial surface adsorption.

REFERENCE BOOKS

- 1) Biology for Engineers, Rajendra Singh C and Rathnakar Rao N, Rajendra Singh C and Rathnakar Rao N Publishing, Bengaluru, 2023.
- 2) Biology for Engineers, Thyagarajan S., Selvamurugan N., Rajesh M.P., Nazeer R.A., Thilagaraj W., Barathi S., and Jaganthan M.K., Tata McGraw-Hill, New Delhi, 2012.
- 3) Biology for Engineers, Arthur T. Johnson, CRC Press, Taylor and Francis, 2011
- 4) Biomedical Instrumentation, Leslie Cromwell, Prentice Hall 2011.
- 5) Biology for Engineers, Sohini Singh and Tanu Allen, Vayu Education of India, New Delhi, 2014.
- 6) Biomimetics: Nature-Based Innovation, Yoseph Bar-Cohen, 1st edition, 2012, CRC Press.
- 7) Bio-Inspired Artificial Intelligence: Theories, Methods and Technologies, D. Floreano and C. Mattiussi, MIT Press, 2008.
- 8) Bioremediation of heavy metals: bacterial participation, by C R Sunilkumar, N Geetha A
- 9) Udayashankar Lambert Academic Publishing, 2019.
- 10) 3D Bioprinting: Fundamentals, Principles and Applications by Ibrahim Ozbolat, Academic Press, 2016.
- 11) Electronic Noses and Tongues in Food Science, Maria Rodriguez Mende, Academic Press, 2016

Course Outcomes	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
CO1	2 (WK1, WK2, WK3, and WK4)	2 (WK1, WK2, WK3, and WK4)	1 (W K5)	-	2 (WK2, WK6)		2 (W K9)	-	-	-	2 (WK8)	2	2	2
CO2	2 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	2 (W K5)	-	2 (WK2, WK6)		2 (W K9)	-	-	-	2 (WK8)	3	2	2
CO3	2 (WK1, WK2, WK3, and WK4)	2 (WK1, WK2, WK3, and WK4)	3 (W K5)	-	2 (WK2, WK6)		2 (W K9)	-	-	-	2 (WK8)	2	1	2
CO4	2 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	2 (W K5)	-	2 (WK2, WK6)		2 (W K9)	-	-	-	2 (WK8)	3	2	2

Course Code		:	22UBT415C	BIOCHEMICAL THERMODYNAMICS	Semester	:	04
L:T:P*		:	3:0:0		Course Type	:	ESC
Hours/Sem.	Teaching	:	42 Hrs.		CIE Marks	:	50
	Learning (TW+SL)	:	42 Hrs.		SEE Marks	:	50
	Exam	:	6 Hrs.		Total Marks	:	100
	Total Hrs.	:	90 Hrs.		Credits	:	03

Professional Competency

Thermodynamic Process & Bioenergetics Analysis — The ability to apply fundamental laws of thermodynamics, equations of state, and biochemical energy principles to model, evaluate, and optimize industrial chemical and bioprocess systems.

Course Outcomes:

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

1. Describe the concepts of system, surroundings, process, entropy and laws of thermodynamics.
2. Explain the PVT behaviour of pure fluids & gases and derive equations of state for real gases.
3. Determine the partial molar properties and activity coefficients of the solution.
4. Illustrate the phase rule for reacting systems and the effect of temperature, pressure on equilibrium constants.
5. Correlate these aspects to biochemical reactions and energetics.

MODULE – I

8 Hrs.

BASIC CONCEPTS & LAWS OF THERMODYNAMICS:

System, Surrounding & Processes, Closed and Open systems, State Properties, Intensive & Extensive Properties, State and Path functions, Equilibrium state, enthalpy, specific heat, Reversible and Irreversible processes. Zeroth law of Thermodynamics, General statement of First law of Thermodynamics, First law for Cyclic Process, Non- Flow Process, Flow process, Heat capacity. Heat reservoir and Heat engines. General statements of the second law, Concept of entropy, Carnot principle, Calculation of entropy changes, Third law of Thermodynamics. Numericals.

MODULE – II

9 Hrs.

PVT BEHAVIOUR AND COMPRESSIBILITY CHARTS:

PVT Behavior of pure fluids, equations of state & ideal gas law, Processes involving ideal gas law: Constant volume, constant pressure, constant temperature, adiabatic & polytropic processes, Equations of state for real gases: Vander Waals equation, Redlich-Kwong equation, Peng-Robinson equation, virial equation. Numericals. Principles of corresponding states, generalized compressibility charts, Heat effects accompanying chemical reactions, Standard heat of reaction, formation, combustion, Hess's law of constant heat summation, effect of temperature on standard heat of reaction. Numericals.

MODULE –III

9 Hrs.

PROPERTIES OF PURE FLUIDS:

Reference properties, energy properties, derived properties, work function, Helmholtz free energy, Gibbs free energy, Relationships among thermodynamic Properties: Exact differential equations, fundamental property relations, Maxwell's equations, Clapeyron equations, modified equations for internal energy (U) & enthalpy(H), Effect of temperature on U, H & Entropy(S). Gibbs-Helmholtz equation. Concept of Fugacity, Fugacity coefficient, effect of temperature and pressure on fugacity, Determination of fugacity of pure gases, solids and liquids, Activity: Effect of temperature and pressure on activity. Numericals.

MODULE – IV**8 Hrs.****PROPERTIES OF SOLUTIONS & PHASE EQUILIBRIA:**

Partial molar properties of solution and its determination, chemical potential –effect of temperature and pressure, Lewis – Randall rule, Raoult's law for ideal solutions, fugacity in solutions, Henry's law and dilute solutions, ideal behavior of real solutions and Henry's law, Activity in solutions, Activity coefficients: effect of temperature and pressure, Gibbs -Duhem equation, calculation of activity coefficients using Gibbs-Duhem equation. Numericals. Criteria of phase Equilibria, criterion of stability, Duhem's theorem, Vapour-Liquid Equilibria in ideal and non-Ideal solutions. Numericals.

MODULE – V**8 Hrs.****BIOCHEMICAL ENERGETICS:**

Bioenergetics and Energy Flow, Coupled reactions and energy rich compounds, Reaction Stoichiometry, criteria of biochemical reaction equilibrium, equilibrium constant and standard free energy change, effect of temperature, pressure on equilibrium constants and other- factors affecting equilibrium conversion – Le – Chatelier's principle, liquid phase reactions, heterogeneous bioreaction equilibria, phase rule for reacting systems, Liquid- Liquid Equilibrium diagrams. Numericals.

REFERENCES

- 1.Introduction to Chemical Engineering thermodynamics by J. M. Smith, H.C. Van Ness& M.M. Abbott.GH Publication, 6th Edition. 2003.
2. Biochemical Calculations by Irwin H. Segel. John Wiley & Sons 2nd Edition.1976.
3. Engineering Thermodynamics by RK Singal and Mridul Singal. IKIntl.2010.
4. Chemical Engineering Thermodynamics by Y.V.C. Rao, New Age International. 1997.
5. A Textbook of Chemical Engineering Thermodynamics by K. V. Narayanan. PHI 1st Edition, 2001

Web links and Video Lectures (e-Resources)

1. <https://www.classcentral.com/subject/thermodynamics>
2. <https://learncheme.com/screencasts/kinetics-reactor-design/>
3. <https://www.udemy.com/course/an-introduction-to-mechanical-engineering-thermodynamics/?>
4. VTU EDUSAT / SWAYAM / NPTEL / MOOCS / Coursera / MIT-open learning resource

Course Outcomes	Programme Outcomes											Programme Specific Outcomes		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
CO 1	2 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	3 (WK5)	2 (WK8)	2 (WK2, WK6)	-	-	-	-	-	1 (WK 8)	2	3	1

CO 2	2 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	2 (WK5)	3 (WK8)	1 (WK2, WK6)	-	-	-	-	-	1 (WK 8)	2	3	1
CO 3	2 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	3 (WK5)	2 (WK8)	2 (WK2, WK6)	-	-	-	-	-	1 (WK 8)	2	3	1
CO 4	2 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	3 (WK5)	3 (WK8)	2 (WK2, WK6)	-	-	-	-	-	1 (WK 8)	2	3	1
CO5	2 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	2 (WK5)	2 (WK8)	1 (WK2, WK6)	-	-	-	-	-	1 (WK 8)	2	3	1

Course Code		:	22UBT416C	MARINE BIORESOURCES AND APPLICATIONS	Semester	:	03
L:T:P		:	3:0:0		Course Type	:	ESC
Hours/Sem.	Teaching	:	42 Hrs.		CIE Marks	:	50
	Learning (TW+SL)	:	42 Hrs.		SEE Marks	:	50
	Exam	:	06 Hrs.		Total Marks	:	100
	Total Hrs.	:	90Hrs.		Credits	:	03

Professional Competency:

Exploit marine biological resources for pharmaceuticals, aquaculture, bioenergy, and environmental remediation within global regulatory frameworks.

Course Outcomes:

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

- CO1:** Mapl Marine Ecosystems & Resources Classify marine living resources and analyze how distinct oceanic zones, ecological factors, and global cycles affect their distribution and biological productivity.
- CO2:** Apply Molecular & Genetic Tools Evaluate genetic engineering, environmental DNA (eDNA) sampling, and metagenomic techniques to manipulate or analyze marine microbial and biological systems.
- CO3:** Execute Bioprospecting & Natural Product Analysis Demonstrate downstream processing methods to isolate, extract, and analyze high-value bioactive compounds, extreme enzymes, and biomaterials for pharmaceutical applications.
- CO4:** Design Sustainable Food & Bioenergy Systems Formulate sustainable strategies for marine aquaculture management, optimize seafood processing quality control, and appraise marine biomass for biofuel production.
- CO5:** Formulate Environmental Solutions & Policy Compliance Develop bioremediation strategies for marine pollution (like oil spills and plastics) while interpreting international marine conservation policies and ecosystem management frameworks.

MODULE-I

08 Hrs

THE OCEANIC ENVIRONMENT:

Classification of the marine environment – Geography of the Global Ocean, biotic and abiotic divisions, Marine life: Marine microbes, Marine algae and plants (seaweeds, sea grasses, mangrove plants), Invertebrates: sponges, cnidarians, polychaetes, crustaceans, molluscs, echinoderms, arthropods, Noncraniate (non-vertebrate) chordates, Vertebrates, Marine fishes (bony, cartilaginous, jawless fishes) Marine tetrapods, Marine zoogeography with reference to Indian, Arctic and Antarctic oceans, Adaptations of organisms to different habitats. Wealth of the sea-Economically important marine animals-fin fishes, shrimp, crab, edible oysters and pearl oysters.

MODULE-II

08 Hrs.

BIOACTIVE COMPOUNDS FROM THE OCEAN:

Important products isolated from marine organisms and their uses, Seaweed: Nutritional Value, Bioactive Properties, and Uses. Seafood Processing Wastes: Chitin, Chitosan, and other compounds, Seaweed Hydrocolloids; agarose, agar, alginates, carrageenans, chitin, chitosans and glucosamines-Biological Activities, uses and importance, Marine enzymes; Isolation and applications, Marine Enzymes in Cancer, Biotechnological Applications of Marine Enzymes from Algae, Bacteria, Fungi, and Sponges, Antifreeze Proteins, Cold-Adapted Enzymes, applications. marine flavourants, lectins, heparin and carotene. Microbial Enzymes in Biotechnology. Probiotics for Animal Health, Production and Applications for Human Health, Biomedical Applications of Enzymes from Marine Actinobacteria.

MODULE-III

08 Hrs.

PHARMACEUTICALLY IMPORTANT PRODUCTS: Need, importance and potentialities of marine drugs and sources. Drugs and Pharmaceuticals from Marine Sources, Development and problems in Marine Drug Development, Global Interests and Commercial Status. Marine Microalgae, Bioactive compounds from

Microalgae, Bioactive natural products – anti-bacterial, anti-fungal, anti-viral, anti-inflammatory, antitumour, antiparasitic and antihelminthic, nutraceuticals. Marine Sources of Carotenoids, Isolation, Characterization, Antioxidant Activities of carotenoids. Marine Products; B-carotene, vitamins, immunomodulators, anticancer and cytotoxic compounds from marine sources- their extraction process and characterization. Marine Lipids, PUFA, Omega-3 PUFA-Rich Oils from Marine Fish, Health Benefits. Seafood Proteins as Dietary Component, Bioactive Peptides from Seafood, Isolation of Seafood Peptides, Functional Roles of Marine Peptides in Foods. Marine Sources of Vitamins and Minerals with examples. Marine.

MODULE-IV

10 Hrs.

Marine Bioenergy and Environmental Biotechnology

Marine Biofuels: Generation of third-generation biofuels (biodiesel, bioethanol, methane) from marine macroalgae and microalgae.

Biomimicry & Biomaterials: Development of marine-derived biomaterials (e.g., bone substitutes, marine collagen, and bio-adhesives).

Biofouling: Mechanisms of marine biofouling, economic impacts, and the development of eco-friendly antifouling coatings.

Bioremediation: Utilizing marine microbes for the cleanup of heavy metals, plastics, and xenobiotics.

MODULE-V

08 Hrs.

Marine Pollution and Conservation Management

Pollution Dynamics: Sources, transport paths, and environmental fates of domestic, industrial, and agricultural discharges in the marine environment.

Oil Pollution: Sources, chemical composition, environmental toxicity, and physical/biological treatment methods.

Microplastics: Emergence and bioaccumulation of microplastics in marine food webs.

Resource Management: Sustainable utilization strategies, global conservation efforts, and international framework standards for marine ecosystem preservation.

REFERENCE BOOKS

1. S.-K. Kim, Ed., Essentials of Marine Biotechnology. Cham, Switzerland: Springer, 2015.
2. M. D. Shah, S. S. Ahmad, and M. I. Khan, Eds., Marine Biotechnology: Applications in Food, Drugs and Energy. Boca Raton, FL, USA: CRC Press, 2023.
3. K. K. A. Sanjeewa, Exploring the Blue Bioeconomy: Marine Bioresources and Sustainable Applications. London, UK: Academic Press, 2024.
4. S.-K. Kim, Ed., Springer Handbook of Marine Biotechnology. Berlin, Germany: Springer, 2015.
5. S.-K. Kim, Ed., Marine Microbiology: Bioactive Compounds and Biotechnological Applications. Weinheim, Germany: Wiley-VCH, 2013.

Course Outcomes	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
CO1	3 (WK1, WK2, WK3, and WK4)	1 (WK1, WK2, WK3, and WK4)	-	-	-	-	2		-	-	1 (WK8)	3	1	-

CO2	3 (WK1, WK2, WK3, and WK4)	2 (WK1, WK2, WK3, and WK4)	2 (WK 5)	2 (WK 8)	3 (W K2 and WK 6)	-	-		-	-	1 (WK8)	3	1	-
CO3	2 (WK1, WK2, WK3, and WK4)	2 (WK1, WK2, WK3, and WK4)	3 (WK 5)	3 (WK 8)	2 (WK2 and WK6)	2(WK , WK5, and WK7)	-		-	-	1 (WK8)	3	1	-
CO4	2 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	3(W K5)	2 (WK 8)	-	1 (WK, WK5, and WK7)	3		-	-	1 (WK8)	3	1	-
CO5	2 (WK1, WK2, WK3, and WK4)	2 (WK1, WK2, WK3, and WK4)	2 (WK 5)	-	-	3(WK , WK5, and WK7)	3		-	-	1 (WK8)	3	1	

Course Code		:	22UBT417C	BIOPROCESS PRINCIPLES AND STOICHIOMETRY	Semester	:	04
L:T:P*		:	3:0:0		Course Type	:	ESC
Hours/Sem.	Teaching	:	42 Hrs.		CIE Marks	:	50
	Learning (TW+SL)	:	42 Hrs.		SEE Marks	:	50
	Exam	:	6 Hrs.		Total Marks	:	100
	Total Hrs.	:	90 Hrs.		Credits	:	03

Professional Competency:

Process Engineering Analysis & Stoichiometric Quantification: Ability to formulate, analyze, and solve steady-state mass and energy balances for physical, chemical, and biological transformation processes to optimize plant operations, and yield estimation.

Course Outcomes:

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

1. Perform biochemical calculations involving compositions of mixtures and solutions
2. Competent to solve bioprocess engineering problems involving unit operations
3. Apply the material balances to give solutions for bioprocess development involving unit processes
4. Solve energy balance problems to provide solutions for bioprocess development.
5. Develop the flowsheet for general processes operating in the bioprocess industry and appreciate the stoichiometry of microbial growth and product formation involved in bioprocess technology

MODULE – I

8 Hrs.

BASIC CHEMICAL CALCULATIONS AND MATERIAL BALANCE:

Concept of atom and mole; Atomic, Molecular, and Equivalent weights; Gram atom, Gram mole; Equivalent Weight; Method of Expressing the Composition of Mixtures and solutions; Weight fraction, Mole fraction, Percentage by weight, Mole percentage, and Volume percentage; Concept of PPM (Parts Per Million); Normality, Molarity, Molality; Conceptual Numericals.

Gases, Ideal Gas Law, Dalton's Law, Partial Pressure, Amagat's Law, Gaseous Mixtures, Relationship between Partial Pressure and Mole Fraction of Component Gas; Average Molecular Weight of Gas Mixture; Density of Gas Mixture; Conceptual Numericals.

MODULE – II

9 Hrs.

MATERIAL BALANCE WITHOUT CHEMICAL REACTIONS AND FUELS

Generalized Block Diagram and Material balance equations for distillation, absorption, extraction, crystallization, mixing, drying & evaporation;

Material balance calculations in Distillation, Absorption, Extraction, Crystallization, Drying, Mixing, and Evaporation Unit Operations; Conceptual Numericals.

MODULE – III

9 Hrs.

MATERIAL BALANCE INVOLVING CHEMICAL REACTIONS:

Generalized material balance equations, Principles of stoichiometry, Definitions of limiting and excess reactants, fractions, percentage conversion, yield and percentage yield, Selectivity;

Unit process – neutralization, oxidation, nitration, hydrolysis, and problems relating to these unit processes; Material balance calculation involving bypass and recycle operations.

MODULE – IV

8 Hrs.

ENERGY BALANCE:

General energy balance equation for steady state. Heat capacity, estimation of heat capacity for solids, liquids, gases, and their mixtures. Enthalpy, Standard Heat of formation, standard heat of reaction, Standard heat of combustion, and calorific value.

Calculation of heat of reaction at elevated temperature

MODULE – V**8 Hrs.****BIOPROCESS PRINCIPLES & STOICHIOMETRY OF BIOPROCESS:**

Historical development of bioprocess technology; Bioprocess principles and operations, and generalized process flow sheets.

General material balance equation for steady state (for the manufacture of penicillin and ethanol) - outline of a bioprocess and the various (upstream and downstream) unit operations involved in bioprocesses.

Stoichiometry of microbial growth and product formation.

REFERENCES

1. Chemical Process Calculations by D. C. Sikdar, PHI Learning Private Limited, Delhi, 2013.
2. Basic Principles and Calculations in Chemical Engineering by David Himmelblau and James B. Riggs, Eighth edition, Prentice Hall International Series, Pearson Education, Inc. 2012.
3. Bioprocess Engineering Principles by Pauline M. Doran, Academic Press, 2012
4. Biochemical Engineering Fundamentals: by J. E. Bailey & D. F. Ollis, Second edition, McGraw Hill, 1986.
5. Bioprocess Engineering: Basic Concepts by Michael L. Shuler and Fikret Kargi, Third edition, Prentice Hall International Series, Pearson Education, Inc., 2017
6. Stoichiometry by B. I. Bhatt and S. M. Vora, Tata McGraw Hill Publishing, 4th Edition, 2004.

Web links and Video Lectures (e-Resources)

1. NPTEL: Core Video Lecture Series (NPTEL / SWAYAM): Mass Balance Book keeping: Mass Transfer Operations I (IIT Bombay)
2. NPTEL: Bioprocess Engineering (IIT Roorkee)

Course Outcomes	Programme Outcomes											Programme Specific Outcomes		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
CO 1	3 (WK1, WK2, WK3, and WK4)	2 (WK1, WK2, WK3, and WK4)	2 (WK5)	2 (WK8)	1 (WK2, WK6)		-	-	-	-	1 (WK8)	3	2	1
CO 2	3 (WK1, WK2, WK3, and WK4)	2 (WK1, WK2, WK3, and WK4)	3 (WK5)	2 (WK8)	1 (WK2, WK6)		-	-	-	-	1 (WK8)	3	2	1

CO 3	2 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	2 (WK5)	2 (WK8)	1 (WK2, WK6)	2 (WK1, WK5, WK7)	-	-	-	-	2 (WK8)	2	3	1
CO 4	2 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	2 (WK5)	1 (WK8)	1 (WK2, WK6)			-	-	-	1 (WK8)	2	2	1
CO 5	2 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	2 (WK5)	2 (WK8)	1 (WK2, WK6)		-	-	-	-	1 (WK8)	2	3	1
	2.4	2.6	2.2	1.6	1	-	-	-	-	-	1	2.4	2.4	1

Course Code		:	22UBT418C	STRUCTURAL BIOLOGY AND BIOPHYSICAL TECHNIQUES	Semester	:	03
L:T:P		:	3:0:0		Course Type	:	ESC
Hours/Sem.	Teaching	:	42 Hrs.		CIE Marks	:	50
	Learning (TW+SL)	:	42 Hrs.		SEE Marks	:	50
	Exam	:	06 Hrs.		Total Marks	:	100
	Total Hrs.	:	90 Hrs.		Credits	:	03

Professional Competency:

Analyze macromolecular structures, solve complex biochemical problems, and drive innovation in modern biopharmaceutical and AI-driven drug discovery pipelines.

Course Outcomes:

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

CO1: Analyze the structural hierarchies, conformational dynamics, and stabilizing non-covalent forces of proteins and nucleic acids using computational and graphical validation tools.

CO2: Evaluate macromolecular crystal systems and diffraction data to resolve the phase problem, construct electron density maps, and validate atomic-resolution models.

CO3: Interpret multidimensional NMR spectra, circular dichroism (CD) profiles, and fluorescence/FRET data to quantify macromolecular secondary structures and distance vectors in solution.

CO4: Appraise modern high-resolution imaging modalities (Cryo-EM, Cryo-ET, AFM) and native mass spectrometry workflows to characterize the architecture of large macromolecular complexes.

CO5: Quantify the thermodynamic parameters, binding kinetics, and hydrodynamic behavior of biological systems using biophysical calorimetry (ITC/DSC) and analytical ultracentrifugation (AUC).

MODULE-I

08 Hrs

Structural Principles and Dynamics of Biomolecules

Protein Structure Hierarchy: Amino acids; ϕ and ψ dihedral angles; Ramachandran Plot; primary, secondary, tertiary, and quaternary conformations.

Nucleic Acid Conformations: Purines and pyrimidines; Watson-Crick and non-canonical base pairing; stabilizing geometries and forces; A, B, and Z-DNA topologies.

Higher-Order Complexes: Ribose puckering, tRNA tertiary structure, and structural variations in lipid cell membranes.

Intermolecular Forces: Hydrogen bonding, hydrophobic effects, van der Waals forces, and electrostatic interactions.

MODULE-II

08 Hrs.

X-Ray Crystallography and Diffraction Techniques

Crystal Physics: Crystal systems, Bravais lattices, symmetry, space groups, and macromolecular crystallization strategies.

X-Ray Diffraction Theory: Bragg's Law, Reciprocal lattice, Fourier transforms, and structure factors.

The Phase Problem: Solution methods including Molecular Replacement (MR), Isomorphous Replacement (SIR/MIR), and Anomalous Dispersion (SAD/MAD).

Model Building and Refinement: Electron density maps, R-factor calculation, and structural validation.

Alternative Diffraction Methods: Fiber diffraction and Neutron Diffraction.

MODULE-III

08 Hrs.

Spectroscopy and Chiroptical Methods

Nuclear Magnetic Resonance (NMR): Chemical shift, spin-spin coupling, and the Nuclear Overhauser Effect (NOE); multidimensional NMR (2D/3D) strategies for protein structure determination.

Chiroptical Methods: Principles of Optical Rotatory Dispersion (ORD) and Circular Dichroism (CD) for secondary structure estimation.

Vibrational and Resonance Spectroscopy: Infrared (IR), Fourier Transform IR (FTIR), Laser Raman spectroscopy, and Electron Spin Resonance (ESR/EPR).

Fluorescence Spectroscopy: Steady-state and time-resolved fluorescence; Förster Resonance Energy Transfer (FRET) as a biological ruler.	
MODULE-IV	10 Hrs.
Advanced Structural Resolution and Imaging Cryo-Electron Microscopy (Cryo-EM): Principles of Single Particle Analysis (SPA) and Cryo-Electron Tomography (Cryo-ET). Scanning Probe Microscopy: Principles and applications of Atomic Force Microscopy (AFM) and Scanning Electron Microscopy (SEM/TEM). Mass Spectrometry in Structural Biology: Native mass spectrometry, Hydrogen-Deuterium Exchange (HDX-MS), LC-MS, and MALDI-TOF for macromolecular weight and topology mapping.	
MODULE-V	08 Hrs.
Hydrodynamic and Thermodynamic Characterization Hydrodynamic Techniques: Analytical Ultracentrifugation (AUC) (sedimentation velocity and equilibrium); viscometry and Rayleigh light scattering. Biophysical Calorimetry: Principles and applications of Isothermal Titration Calorimetry (ITC) for binding kinetics, and Differential Scanning Calorimetry (DSC) for thermal stability. Electrophysiological Measurements: Voltage Clamp and Patch Clamp techniques for investigating ion channel kinetics and membrane potentials.	
REFERENCE BOOKS	
1. D. Sheehan, <i>Physical Biochemistry: Principles and Applications</i> , 2nd ed. Chichester, UK: Wiley-Blackwell, 2009. 2. G. Rhodes, <i>Crystallography Made Crystal Clear: A Guide for Users of Macromolecular Models</i> , 3rd ed. Burlington, MA, USA: Academic Press, 2006. 3. J. Cavanagh, W. J. Fairbrother, A. G. Palmer III, and N. J. Skelton, <i>Protein NMR Spectroscopy: Principles and Practice</i> , 2nd ed. Burlington, MA, USA: Academic Press, 2007. 4. T. Polenova, Ed., <i>Integrated Structural Biology</i> (New Developments in NMR, vol. 30). Cambridge, UK: Royal Society of Chemistry, 2023.	

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

CO3	3 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	1 (WK5)	3 (WK8)	2 (WK2 and WK6)	-	-	-	-	-	1 (WK8)	3	1	-
CO4	3 (WK1, WK2, WK3, and WK4)	2 (WK1, WK2, WK3, and WK4)	-	3 (WK8)	3 (WK2 and WK6)	1 (WK, WK5, and WK7)	-	-	1	1	1 (WK8)	3	1	-
CO5	3 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	2 (WK5)	3 (WK8)	2 (WK2 and WK6)	-	-	-	-	-	1 (WK8)	3	1	-

Hours/Se	Code	:	22UBT419C	HYDROPONICS, AQUAPONICS AND AEROPONICS	Semester	:	04
	LTP	:	1:0:0		Course Type	:	AEC
	Teaching	:	14 Hrs.		CIE Marks	:	50
	Learning (TW+SL)	:	13 Hrs.		SEE Marks	:	50
	Exam	:	03Hrs.		Total Marks	:	100
	Total Hrs.	:	30 Hrs.		Credits	:	01

Professional Competency:

Design, operation and management of hydroponic, aquaponic and aeroponic systems, including nutrient management, crop cultivation, diagnostic testing, problem solving, sustainable resource utilization, technological innovation and entrepreneurial application in controlled-environment agriculture.

Course Outcomes:

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

CO1: Comprehend the principles, benefits, and different systems of hydroponic/soilless culture for sustainable food production.

CO2: Apply the principles of hydroponic media, macro- and micronutrients, nutrient mixing, and nutrient-deficiency management for hydroponic crop production.

CO3: Analyze the applications, pest-control strategies, diagnostic procedures, post-harvest handling, and greenhouse management practices in hydroponic cultivation.

CO4: Design and manage basic aquaponic systems by integrating fish culture, plant selection, nutrient requirements, seed germination, and plant physiological processes.

CO5: Evaluate the principles, innovations, business potential, current research, and practical applications of aeroponics for sustainable crop production.

MODULE-I

2Hrs.

HYDROPONICS:

History of hydroponics, General hydroponics, benefits, food production, organic foods versus hydroponics foods, Systems of Hydroponic/Soilless Culture.

MODULE-II

3 Hrs.

MEDIA FOR HYDROPONICS:

Build your own system, Media and supplies, Minerals, macro and micro Nutrients, mixing, Advanced nutrients, super nutrients, Mineral deficiencies, case studies of foods grown via hydroponics, Hydroponic Cropping.

MODULE-III

3Hrs.

APPLICATION OF HYDROPONICS:

CO₂ utilization, Problems in hydroponics, Pest Control, post-harvest handling, hydroponic terminologies, Diagnostic Testing Procedures, The Hydroponic Greenhouse, Educational Role for Hydroponics.

MODULE-IV

3 Hrs.

AQUAPONICS:

History of Aquaponics, System design and management, Establishing and Maintaining the Fish Tank, Seed Germination and Planting, Plant Selection and Care, Plant Nutrient Requirements, Photosynthesis, Transpiration and Light, Plant Physiology & Light and its mode of action.

MODULE-V

3 Hrs.

AEROPONICS:

History of Aeroponics, The Aeroponic Value Proposition, Aeroponic Science. Aeroponics Innovations, Aeroponic Business, Practice of Aeroponics. Current research. Case studies. recombinant proteins.

Text Books:												
- Hydroponics and aquaponics for beginners, by Viktor Garden, Independent Publishing, 2021. - DIY Hydroponic Gardens: How to Design and Build an Inexpensive System for Growing Plants in Water by Tyler Baras - Cool Springs Press, 2018. - Aquaponic Gardening: A Step-By-Step Guide to Raising Vegetables and Fish Together by Sylvia Bernstein - New Society Publishers, 2011.												
Reference Books:												
- Hydroponic Food Production: A Definitive Guidebook of Soilless Food-growing Methods by Howard M. Resh -Woodbridge Press Publishing Co, U.S. 1980. - Hydroponics: Hydroponics Essential Guide: by Andy Jacobson, Createspace Independent Publishing Platform, 2016. - Hydroponics by Kevin Espiritu, Cool Springs Press, 2019. - Aeroponics, by Thomas W. Gurley CRC Press, 2020.												
Web links and Video Lectures (e-Resources)												
https://rocketskills.in/course/best-hydroponics-course? https://www.udemy.com/topic/hydroponics/ https://www.edx.org/course/aquaponics-the-circular-food-production-system https://www.acseduonline.com/courses/horticultural-crops-20/aquaponic-production-bht319-569.aspx https://mycourseguru.in/hydroponic-courses/												

Course Outcomes	Programme Outcomes											Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
CO1	2(WK1, WK2, WK3, and WK4)	2(WK1, WK2, WK3, and WK4)	2(WK5)	–	1(WK2, WK6)	2 (WK1 ,WK5, WK7)	1 (WK9)	-	-	-	1 (WK8)	3	2	2
CO2	2(WK1, WK2, WK3, and WK4)	2(WK1, WK2, WK3, and WK4)	2(WK5)	2 (WK8)	2(WK2, WK6)	1(WK1 ,WK5, WK7)	1 (WK9)	-	-		2(WK8)	3	2	2
CO3	2(WK1, WK2, WK3, and WK4)	2(WK1, WK2, WK3, and WK4)	2(WK5)	3 (WK8)	2(WK2, WK6)	2(WK1 ,WK5, WK7)	1 (WK9)	-	-	-	2(WK8)	3	2	2
CO4	2(WK1, WK2, WK3, and WK4)	2(WK1, WK2, WK3, and WK4)	2(WK5)	2 (WK8)	2(WK2, WK6)	2(WK1 ,WK5, WK7)	1 (WK9)	-	-	-	3(WK8)	3	2	2
CO5	2(WK1, WK2, WK3, and WK4)	2(WK1, WK2, WK3, and WK4)	2(WK5)	2 (WK8)	3(WK2, WK6)	2(WK1 ,WK5, WK7)	1 (WK9)	-	-	-	3(WK8)	3	2	2

Course Code		:	22UBT420L	WATER ANALYSIS LAB	Semester	:	04
L:T:P		:	0:0:2		Course Type	:	AEC
Hours/Sem.	Teaching	:	26 Hrs.		CIE Marks	:	50
	Learning (TW+SL)	:	00		SEE Marks	:	50
	Exam	:	04 Hrs.		Total Marks	:	100
	Total Hrs.	:	30 Hrs.		Credits	:	01

Professional Competency:

The methods for the analysis of various types of water and the methods of water analysis and the analytical instruments used to measure the quality of drinking water.

Course Outcomes:

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

1. Describe the physical, chemical and microbial compositions of natural waters,
2. Explain how and why the compositions vary based on the main sources of water pollution.
3. Determine the microbes present in different forms of water
2. Identify the criteria for drinking water acceptability in India

List of Experiments

1. To determine colour, odour, pH, taste, turbidity and total dissolved solids of given sample of water
3. To determine total hardness, alkalinity, acidity, total solids of given sample of water.
4. To determine chloride content and residual chlorine of given sample of water
5. Aerobic Microbial count of given sample of water
6. Detection of Esh.coli. of given sample of water
7. Detection of Staphylococcus aureus of given sample of water
8. Detection of Salmonella and Shigella of given sample of water
9. Detection of Pseudomonas aeruginosa of given sample of water
10. Proteolytic Plate count and Lipolytic Plate count of water for processed food industry.
11. Test for Coliforms
12. Thermolytic bacterial count and Slim forming Bacteria
13. DO, COD and BOD of given sample of water

Text Books:

1. Manual of Methods of Analysis of Foods: Water, Food Safety and Standards Authority of India, Ministry of Health and Family Welfare, Government of India, 2016
2. Handbook of Water Analysis, Leo M. L. Nollet, Leen S. P. De Gelder, CRC Books, 2000.
3. Water Analysis A Practical Guide to Physico-Chemical, Chemical and Microbiological Water Examination and Quality Assurance, SpringerLink, 1988

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

CO2	3 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	2 (WK5)	-	3 (WK2 and WK6)	-	2 (WK9)	-	-	-	3 (WK8)	3	3	3
CO3	3(WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	3 (WK5)	-	3 (WK2 and WK6)	-	3 (WK9)	-	-	-	3 (WK8)	3	3	3
CO4	3(WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	3 (WK5)	-	3 (WK2 and WK6)	-	3 (WK9)	-	-	-	3 (WK8)	3	3	3

Course Code		:	22UBT421L	EXTRACTION METHODS AND HERBAL PRODUCTS LAB	Semester	:	4
L:T:P*		:	0:0:2		Course Type	:	PCCL
Hours/Sem.	Teaching	:	26 Hrs.		CIE Marks	:	50
	Learning (TW+SL)	:	-		SEE Marks	:	50
	Exam	:	4 Hrs.		Total Marks	:	100
	Total Hrs.	:	30 Hrs.		Credits	:	1

Professional Competency:

Apply standard microbiological laboratory techniques and instruments for the safe cultivation, isolation, identification, characterization, enumeration, and analysis of microorganisms, and interpret experimental results for microbiological, clinical, environmental, and industrial applications.

CO1: Explain and apply principles of extraction and isolation of phytoconstituents from herbal resources using suitable extraction techniques.

CO2: Perform qualitative and quantitative analysis of major phytoconstituents such as alkaloids, tannins, aldehydes, phenolics and flavonoids.

CO3: Prepare and evaluate herbal formulations and assess the suitability of natural excipients for pharmaceutical applications.

CO4: Evaluate the biological activity of herbal extracts using appropriate antimicrobial assays and interpret the experimental results

(LIST OF EXPERIMENTS IN LABORATORY)

1. Maceration of natural herbal.
2. Extraction of phyto constituents from herbal resources using water (Reflux).
3. Extraction of phyto constituents from herbal resources using alcohol (Soxhlet).
4. Determination of alkaloid content in herbal extract
5. Determination of tannin content in herbal extract
6. Determination of aldehyde content in herbal extract
7. Determination of phenolic compounds in herbal extract
8. Determination of flavonoid content in herbal extract
9. Preparation and evaluation of turmeric cream
10. Preliminary phytochemical analysis aqueous extract of neem
11. Evaluation of excipient of natural origins such as acacia, starch, honey, tragacanth, jackfruit
12. Antimicrobial activity of the herbal extract

Text books:

1. Aneja, K.R. (2018). Laboratory Manual of Microbiology and Biotechnology. 2nd Edition, Medtech

Web Resources: 1. World Health Organization – Herbal medicine guidelines and quality standards.

2. Ministry of AYUSH – Pharmacopoeias, regulatory guidelines, and medicinal plant resources.

3. Food Safety and Standards Authority of India – Nutraceutical and functional food regulations.

4. National Medicinal Plants Board – Cultivation, conservation, and commercialization

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

CO2	3(WK1, WK2, WK3, andWK4)	3(WK1, WK2, WK3, andWK4)	2(WK 5)	3(WK 8)	3(WK6)	1(WK5 and WK7)	1(WK9)	1	2	2	1(WK8)	2	1	2
CO3	3(WK1, WK2, WK3, andWK4)	2(WK1, WK2, WK3, andWK4)	3(WK 5)	3(WK 8)	2(WK6)	3(WK5 and WK7)	2(WK9)	2	2	3	2(WK8)	2	2	3
CO4	3(WK1, WK2, WK3, andWK4)	3(WK1, WK2, WK3, andWK4)	2(WK 5)	3(WK 8)	3(WK6)	3(WK5 and WK7)	2(WK9)	2	2	3	1(WK8)	2	2	3

Course Code		:	22UBT422C	BIOPESTICIDES AND BIOFERTILIZERS	Semester	:	04
L:T:P*		:	1:0:0		Course Type	:	AEC
Hours/Sem.	Teaching	:	14 Hrs.		CIE Marks	:	50
	Learning (TW+SL)	:	13Hrs.		SEE Marks	:	50
	Exam	:	03 Hrs.		Total Marks	:	100
	Total Hrs.	:	30 Hrs.		Credits	:	01

Professional Competency:

To familiarize the students on biopesticides and biofertilizers that are free from harmful chemicals and are more environment friendly for the purposes of achieving better crop production

Course Outcomes:

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

CO1: Correlate the principles of Microbiology towards Biofertilizers and Bioinsecticides.

CO2: Comprehend Pest-Plant interactions and apply the same in Agriculture

CO3: Strain selection and apply the same to scale up production of Biofertilizers and Bioinsecticides

MODULE-I

3 Hrs.

PATHOGENS AND PESTS MANAGEMENT:

Pathogens and Pests Management, Natural Enemies, Reduviids and Their Merits in Biological Control, Weaver Ants and Biocontrol of the Nuisance Pest *Lupropstristis* (Coleoptera: Tenebrionidae), Ground Beetles (Coleoptera: Carabidae): Their Potential as Bio-agents in Agro ecosystems, Eco-friendly Control of Three Common Mosquito Larvae Species by Odonata Nymphs, Spiders as Potential Eco-friendly Predators Against Pests.

MODULE-II

3 Hrs.

BIOFERTILIZERS:

Types and importance of biofertilizers, Biopesticides and bioagents in agriculture and organic farming system, History of biofertilizers production Classification of biofertilizers microorganisms used in biofertilizer production

MODULE-III

2 Hrs.

NITROGENFIXATION:

Concept of Nitrogen fixation. Structure and characteristic feature of bacterial biofertilizers- *Azotobacter*, *Bacillus*, *Rhizobium*; *Cynobacteria*/biofertilizers- *Anabaena*, and fungal biofertilizers- VAM.

MODULE-IV

3Hrs.

BIOPESTICIDES:

General account of microbes used as bioinsecticides and their advantages over synthetic pesticides, *Bacillus thuringiensis*, Mechanism of phosphate solubilization and phosphate mobilization, K solubilization. Botanicals: botanical pesticides and biorationals. Botanicals and their uses. Plant Essential Oils and Pest Management

MODULE-V

3 Hrs.

PRODUCTION AND QUALITY CONTROL:

Strain selection, sterilization, growth and fermentation, mass production of biofertilizers. Storage, shelf life, quality control and marketing. Factors influencing the efficacy of biofertilizers/Biopesticides, FCO, Specifications and quality control of biofertilizers. Application technology for seeds, seedlings, tubers, etc.

Text Books:

1. Motsara, I.M.R., Bhattacharyya, P. and Srivastava, B. Biofertilizer Technology, Marketing and Usage

1995.

2. SubbaRao, N.S Biofertilizers in Agriculture and Forestry. Oxford and IBH.Publ.Co., New Delhi.1993.

3. Shalini Suri, Biofertilizer and Biopesticide by Aph Publishing Corporation 2011.

4. Coppel H.C. and J. W. Martin Biological control of insect pest suppression. Springer. 1977.

5. Krishnendu Acharya, Surjit Sen, Biofertilizers and Biopesticides TechnoWorld; 2019.

Web links: VTU EDUSAT/SWAYAM/NPTEL/MOOCs/Coursera/MIT-open learning resource Features of Risk

- <http://courseware.cutm.ac.in/courses/certificate-course-bio-fertilizer-preparation/>
- https://onlinecourses.swayam2.ac.in/cec21_ag03/preview
- <https://www.udemy.com/course/basics-of-fertilizers/>
- <https://www.youtube.com/watch?v=Qxv-IEGucFs>
- <https://knowledge.unccd.int/e-learning-course-organic-fertilizer-sustainable-agriculture>
- <http://www.digimat.in/nptel/courses/video/102105058/L55.html>

Course	Programme Outcomes											Programme Specific Outcomes		
Outcome	1	2	3	4	5	6	7	8	9	10	11	1	2	3
CO1	3 (WK1, WK2, WK3, and WK4)	2(WK1, WK2, WK3, and WK4)	(WK5)	“ ”	“ ”	“ ”	“ ”	1	“ ”	“ ”	2	3	3	3
CO2	3 WK1, WK2, WK3, and WK4)	3(WK1, WK2, WK3, and WK4)	2 (WK5)	“ ”	2 (WK6)	3(WK1, WK5 and WK7)	“ ”	“ ”	“ ”	“ ”	3 (Wk8)	2	2	3
CO3	3 (WK1, WK2, WK3, and WK4)	2(WK1, WK2, WK3, and WK4)	2 (WK5)	“ ”	2 (WK6)	“ ”	1 (wk9)	“ ”	“ ”	“ ”	2	2	2	3
CO4	3 (WK1, WK2, WK3, and WK4)	2(WK1, WK2, WK3, and WK4)	2 (WK5)	“ ”	2 (WK6)	2(WK1, WK5 and WK7)	2 (wk9)	“ ”	“ ”	“ ”	3 (Wk8)	2	2	3
CO5	2(WK1, WK2, WK3, and WK4)	1 (WK1, WK2, WK3, and WK4)	1(WK5)		1(WK6)	1(WK5 and WK7)					3(WK8)	1	2	1

Hours/Se	Code	:	22UBT414L	MOLECULAR BIOLOGY AND GENETIC ENGINEERING LABORATORY	Semester	:	4
	LTP	:	0:0 :2		Course Type	:	PCCL
	Teaching	:	26 Hrs.		CIE Marks	:	50
	Learning (TW+SL)	:	-		SEE Marks	:	50
	Exam	:	4 Hrs.		Total Marks	:	100
	Total Hrs.	:	30 Hrs.		Credits	:	01

Professional Competency:

Demonstrate proficiency in molecular biology techniques, recombinant DNA technology, gene cloning, PCR, gene expression analysis, and genome editing for applications in healthcare, agriculture, and biopharmaceutical industries.

Course Outcomes:

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

1. Conduct observations and experiments including Genomic DNA/plasmid DNA.
2. Conduct and analyze Agarose gels by gel electrophoresis.
3. Demonstrate proficiency in Transformation and screening of transformants.
4. Apply the knowledge of PCR in amplification of DNA
5. Use research-based knowledge of restriction digestion, Ligation and Southern blotting in the field of Biotechnology.

List of Experiments OR Programs List

1. Preparations of common molecular biology lab buffers (TAE, TBE, TE, etc.)
2. Isolation of genomic DNA (plant sources /microbial or animal sources)
3. Agarose gel electrophoresis
4. Purity analysis of DNA
5. Estimation of RNA
6. Thermal denaturation of DNA(Melting Temperature (T_m) of DNA)
7. Isolation of plasmid DNA from bacteria
8. Restriction Digestion of DNA
9. Ligation
10. Amplification of DNA by PCR
11. Transformation (Genetic transformation of E.coli)
12. Blue-white screening
13. Southern Blotting

Reference Books:

1. Sambrook & Russell, (2002), Molecular Cloning (3rd Edition), Cold Spring Harbor Lab.
2. Sadashiva and Manickam, (2017), Biochemical methods (2nd Edition), W.H. Freeman
3. Palanivelu P (2001), Analytical Biochemistry and separation techniques, Twenty first Century Publications.

Web Links and Video Lectures (e-Resources):

https://ncbi.nlm.nih.gov/books/NBK21129/?utm_source

https://www.ncbi.nlm.nih.gov/books/NBK26837/?utm_source

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

	and WK4)	and WK4)												
CO2	3 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	3 (WK5)	2 (WK8)	3 (WK2, WK6)	2 (WK1 ,WK5, WK7)	1 (WK9)	-	-	-	3(WK8)	3	3	3
CO3	3 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	2 (WK5)	2 (WK8)	3 (WK2, WK6)	2 (WK1 ,WK5, WK7)	1 (WK9)	-	-	-	3(WK8)	3	3	3
CO4	3 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	2 (WK5)	2 (WK8)	3 (WK2, WK6)	3 (WK1 ,WK5, WK7)	1 (WK9)	-	-	-	3(WK8)	3	3	3
CO5	3 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	2 (WK5)	1 (WK8)	3 (WK2, WK6)	3 (WK1 ,WK5, WK7)	1 (WK9)	-	-	-	3(WK8)	3	3	3

V SEMESTER

Course Code		:	22UBT501C	BIOINFORMATICS	Semester	:	5
L:T:P*		:	3:0:0		Course Type	:	PCC
Hours/Sem.	Teaching	:	42Hrs.		CIE Marks	:	50
	Learning (TW+SL)	:	42Hrs.		SEE Marks	:	50
	Exam	:	6Hrs.		Total Marks	:	100
	Total Hrs.	:	90Hrs.		Credits	:	03

UNIT-I		12 Hrs.
INTRODUCTION TO BIOINFORMATICS AND BIOLOGICAL DATABASE Introduction to bioinformatics, Components of bioinformatics and interdisciplinary nature of bioinformatics, Classification of biological databases; Primary database: NCBI, GenBank, DDBJ and EMBL, PIR, Uniprot; Secondary databases: PROSITE, PRINTS, BLOCKS and Pfam; Structure databases: Protein Data Bank (PDB), MMDB, CATH, SCOP; Specialized databases: PubMed, OMIM, Metabolic Pathway-KEGG; ExPasy and PubChem databases, File format: GenBank flat file, PDB flat file. Tutorials: Practices on other primary and secondary databases		
UNIT-II		10 Hrs.
SEQUENCE ALIGNMENT AND DATABASE SEARCHES: Introduction, Types of sequence alignment, Comparison between global and local alignment, Pairwise sequence alignment: Dot matrix analysis, Dynamic programming, Global alignment-Needleman- Wunch algorithm, Local Alignment-Smith & Waterman algorithm, Substitution matrix-BLOSUM and PAM; GAP Penalty; Low complexity regions; Word/k-tuple method- BLAST, FASTA. Multiple Sequence Alignment: Introduction, applications of MSA; Types of MSA: Progressive method of MSA-Clustal W; Iterative method of MSA; Motifs and Patterns; Statistical models of MSA-Position Specific Scoring Matrix (PSSM) and Profiles. Tutorials: Solving problems on pairwise sequence alignment		
UNIT-III		10 Hrs.
PHYLOGENETIC ANALYSIS AND PREDICTIVE METHODS USING SEQUENCES Introduction, concepts of trees, types of evolutionary trees, Rooted and unrooted trees, Steps in constructing phylogenetic trees, Tree building methods - Distance based methods: Neighbor Joining (NJ) method, Fitch-Margoliash (FM) method; Character based method: Maximum parsimony; Tree Evaluation methods, Phylogenetic Softwares. Predictive Methods using sequences: Structure of Prokaryote and Eukaryote genes; Algorithms for Prokaryotic and Eukaryotic gene prediction, Web based tools for gene prediction (ORF finder, GenScan). Protein Secondary Structure Prediction, Tertiary Structure Predictions: Homology modelling. Tutorials: Practices on prediction of phylogenetic trees		
UNIT-IV		10 Hrs.

PLASMID MAPPING AND PRIMER DESIGNING & MOLECULAR MODELLING TECHNIQUES

Restriction mapping, Web based tools: Restriction Mapper and REBASE. Utilities of Mac Vector and Vector NTI; Basics of Primer designing, Primer design softwares (PRIME3). Rational Approaches in Drug Design, molecular docking, deriving the Pharmacophoric Pattern, quantitative structure-activity relationship (QSAR), deriving bioactive conformations, Calculation of Molecular Properties, Docking softwares (AUTODOCK, HEX), **genome** assembly and annotation:

Databases: Specialized databases like KEGG, WIT, and COGs can function as annotation tools, Tools for domain identification: CDD and SMART, BUSCO

Tutorials: Solving problems related to Restriction mapping and Primer designing

REFERENCE BOOKS

1. Introduction to Bioinformatics – Arthur Lesk, Oxford, 2nd Edition, 2006.
2. Bioinformatics – Stuart M Brown, NYU Medical Center, NY USA. 2000.
3. Fundamental Concepts of Bioinformatics – D E Krane & M L Raymer, Pearson, 2006.
4. Computational methods for macromolecular sequence analysis – R F Doolittle. Academic Press, 1996.

COURSE OUTCOMES

After completion of the course student will be able to

1. Importance of databases involved in bioinformatics along with their file formats
2. Will have idea on searching similar sequences in databases and find similarity between given set of sequences
3. Derive evolutionary relationship between genes and proteins by phylo-genetic analysis
4. Explain various statistical tools involved in predicting the structure of genes and proteins
5. Will understand restriction mapping and primer designing, approaches involved in silico drug design and genome assembly

Course Outcomes	Programme Outcomes											Programme Specific Outcomes		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
CO 1	3 (WK, WK2, WK3, WK4)	2 (WK 1, WK2, WK3, and WK4)	-	-	2 (WK 1, WK2, WK3, WK4)	1 (WK 1, WK5, WK6, WK7)	2 (WK 1, WK5, WK6, WK7)	2	-	-	3 (WK 8)	2	2	3
CO 2	3 (WK, WK2, WK3, WK4)	2 (WK 1, WK2, WK3, and WK4)	2 (WK 5)	2 (WK 8)	2 (WK 1, WK2, WK3, WK4)	1 (WK 1, WK5, WK6, WK7)	2 (WK 1, WK5, WK6, WK7)	-	-	-	3 (WK 8)	2	2	3
CO 3	3 (WK, WK2, WK3, WK4)	2 (WK 1, WK2, WK3, and WK4)	-	1 (WK 8)	-	-	2 (WK 1, WK5, WK6, WK7)	-	-	-	3 (WK 8)	2	2	3

		WK4)					)							
CO 4	2 (WK1, WK2, WK3, and WK4)	2 (WK 1, WK2, WK3, and WK4)	-	1(W K8).	-	2 (WK 1,W K5, WK7)	-	-	-	-	3 (W K8)	1	-	2
CO 5	2 (WK1, WK2, WK3, and WK4)	2 (WK 1, WK2, WK3, and WK4)	2 (W K5)	1 (WK 8).	-	2 (WK 1,W K5, WK7)	-	2	-	-	1 (W K8)	2	-	2

Hours/Sem.	Code	:	22UBT502C	GENETIC ENGINEERING & APPLICATIONS	Semester	:	05
	LTP	:	3:0:2		Course Type	:	IPCC
	Teaching	:	42 Hrs+26 Hrs		CIE Marks	:	50
	Learning (TW+SL)	:	44		SEE Marks	:	50
	Exam	:	08 Hrs.		Total Marks	:	100
	Total Hrs.	:	120 Hrs.		Credits	:	04
Professional Competency:							
Apply the principles and techniques of molecular biology to analyze gene structure and gene expression, for solving problems in biotechnology, healthcare, agriculture, and research.							
Course Outcomes:							
After completion of the course, student will be able to:							
CO1: Apply the knowledge of various tools used in genetic engineering experiments.							
CO2: Select and apply recombinant DNA techniques including nucleic acid detection, hybridization and amplification for gene cloning and molecular analysis.							
CO3: Identify different methods of various gene transfer techniques in plants, animals and microbes for genetic improvement.							
CO4: Apply the knowledge of various strategies of Gene therapy in therapeutics and engineer microbes for the production of biopharmaceuticals.							
UNIT-I						10 Hrs.	
INTRODUCTION							
Tools of genetic engineering- vectors in recombinant DNA technology, biology and salient features of vectors, Types of vectors - plasmids, cosmids, bacteriophage lambda vectors.							
ENZYMES IN GENETIC ENGINEERING:							
Introduction- Restriction Endonucleases-classification, mode of action, applications. Enzymes used in nucleic acid modification – Alkaline phosphatase, polynucleotide Kinase, Ligases, terminal deoxy nucleotidyl transferase							
UNIT-II						10 Hrs.	
NUCLEIC ACID HYBRIDIZATION AND AMPLIFICATION							
Methods of nucleic acid detection, Fluorescent In situ hybridization (FISH), colony hybridization, polymerase chain reaction (PCR), its types and applications, methods of nucleic acid hybridization, Southern, Western and Northern hybridization techniques.							
CONSTRUCTION OF CDNA LIBRARIES:							
Construction of Complementary DNA (cDNA), genomic DNA libraries and cDNA libraries.							
UNIT-III						10 Hrs.	
GENE TRANSFER TECHNIQUES							
Gene transfer techniques in plants, animals and microbes –Transformation, microinjection, electroporation, microprojectile system, and liposome mediated transfer, embryonic stem cell method. Agrobacterium-mediated gene transfer in plants – Ti & Ri Plasmid: structure and functions, Ti based vectors- Binary vectors and Cointegrate vectors.							
TRANSGENIC SCIENCE AND GENETIC IMPROVEMENT							
Transgenic science in plant improvement, Antisense RNA technology (Flavr savr tomatoes). Application of plant transformation for productivity and performance – Herbicide resistance - glyphosate. insect resistance - Bt genes(Bacillus thuringiensis and its mode of action), Cry proteins – mechanism of action.							
UNIT-IV						10 Hrs.	
GENE THERAPY							
Introduction, Methods of Gene therapy-gene targeting, gene augmentation, assisted killing, prodrug therapy and gene silencing. Gene therapy in the treatment of cancer, SCID, muscular dystrophy. Use							

of thrombolytic agents in blood clotting. Challenges in gene therapy.

APPLICATIONS

Engineering microbes for the production of Insulin, growth hormones, Monoclonal Antibodies

List of experiments

1. Transformation
2. Blue white colony screening
3. Thermal denaturation of DNA
4. Restriction Digestion
5. Ligation Experiment.
6. Southern Blotting – Agarose Gel Electrophoresis
7. Electrophoresis and analysis
8. Lyophilization of biologic samples (fluids, microbial samples)
9. SOP for UV-Spectrophotometer
10. SDS-PAGE
11. PCR (Amplification with specific primers)

Text Books:

1. B.R. Glick, J.J. Pasternak and C.L Patten, "Molecular Biotechnology – Principles and applications of recombinant DNA", ASM Press, 6th edition, 2022
2. Watson et al., Recombinant DNA, second edition, Freeman Publishers 2010.
3. Primrose S.B, Principles of gene manipulation,., Blackwell Scientific Publications, 2010.
4. B.D.Singh, Biotechnology Expanding Horizon, 3rd revised edition, Kalyani Publishers, 2010

https://onlinecourses.swayam2.ac.in/cec19_bt02/preview

Reference Books:

1. Sambrook & Russell, Molecular Cloning, (3rd Edition), Cold Spring Harbor Lab, 2002.
2. Sadashiva and Manickam, Biochemical Methods, (2nd Edition), W.H. Freeman, 2017,
3. David S Latchman, From Genetics to Gene Therapy – the molecular pathology of human disease by, BIOS scientific publishers, 2010.
4. Analytical Biochemistry And Separation Techniques P. Palanivelu V Edition, Digital Printing Press, 2016

Web links and Video Lectures (e-Resources)

https://onlinecourses.swayam2.ac.in/cec19_bt02/preview

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

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

Course Code		:	22UBT505C	VALIDATION AND QUALITY ASSURANCE	Semester	:	5
L:T:P*		:	2:0:0		Course Type	:	PCC
Hours/Sem.	Teaching	:	28 Hrs.		CIE Marks	:	50
	Learning (TW+SL)	:	26Hrs.		SEE Marks	:	50
	Exam	:	6Hrs.		Total Marks	:	100
	Total Hrs.	:	60 Hrs.		Credits	:	2

Professional Competency:

Apply validation, regulatory compliance, quality assurance, and quality control principles to ensure the quality, safety, consistency, and regulatory compliance of pharmaceutical manufacturing processes and products.

Course Outcomes:

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

- CO1:** Explain and apply regulatory requirements, validation principles and qualification procedures used in pharmaceutical manufacturing.
- CO2:** Analyse different validation approaches and their application to pharmaceutical utilities, facilities, processes, analytical methods and computerized systems.
- CO3:** Apply ISO standards and quality assurance principles for documentation, audits, CAPA and continual improvement.
- CO4:** Analyse quality control practices, process and product characteristics, inspection and quality improvement for consistent product quality.

UNIT-I

06 Hrs.

Introduction

Validation and Regulatory Affairs in Bio (Pharmaceutical) Manufacturing: An Introduction to FDA Operations & Industry Compliance Regulations, The Fundamentals of Regulatory Compliance with respect to Good Clinical Practice (GCP), Good Manufacturing Practice (GMP) & Good Laboratory Practice (GLP). An Introduction to the Basic Concepts of Process Validation, how it Differs from Qualification (IQ, OQ & PQ) Procedures, FDA and ICH guidelines. Validation life cycle and validation master plan.

UNIT-II

07 Hrs.

TYPES OF VALIDATION

A Review of Prospective, Concurrent, Retrospective Validation & Revalidation Validation of Water, Thermal Systems, including HVAC Facilities & Cleaning Validation. Validation of Active Pharmaceutical Ingredients (APIs) Packaging Validation Issues, Validation of Analytical Methods,. Good Automated Manufacturing Practice (GAMP), Validation of computer and automated systems.

UNIT-III

07 Hrs.

STANDARDS:

Introduction, ISO 9000 Series of Standards, Management Responsibility, Quality System, Contract Review, Design Control, Document and Data Control, Preservation and Delivery, Control of Quality Records, ISO-9001-2000, Scope, Normative Reference, Terms and Definitions, Quality Management, System, Documents Requirements, Management & # 39;s Responsibility, Resource Management, Infrastructure, Product Realization, Measurement, Analysis and Improvement, ISO-14001 - Environmental Management Systems.

QUALITY ASSURANCE: Quality System, Contract Review, Design Document and Data Control, Purchasing, Control of Customer Supplied Product, Process Control, Corrective and Preventive Action,

Handling, Storage, Packaging, Preservation and Delivery, Control of Quality Records, Internal Quality Audits.	
UNIT-IV	06 Hrs.
QUALITY CONTROL: Quality Objectives, Quality Planning, Quality Control, Quality Improvement Efficiency; Relating to Process and Product, Process characteristics, Quality Characteristics, documentation, Information, Specification, Quality Manual, Quality Plan, Record of Examination, Objective, Inspection. Quality Requirement, Customer Satisfaction, Capability; Management System, Quality Management System, Quality Policy, Continual Improvement.	
Text Books:	
1. Validation of Pharmaceutical Processes: Sterile Products, Frederick J. Carlton (Ed.) and James Agalloco (Ed.), Marcel Dekker, 2nd Ed., 1998.	
Reference Books:	
1. Pharmaceutical Process Validation, 3rd Edition, Edited by Robert Nash and Alfred Wachter, Marcel Dekker, 2003 2. Good Manufacturing Practices for Pharmaceuticals: A Plan for Total Quality Control From Manufacturer to Consumer, Sidney J. Willig, Marcel Dekker, 5th Ed., 2000 3. Validation Standard Operating Procedures: A Step by Step Guide for Achieving Compliance 4. Pharmaceutical Equipment Validation: The Ultimate Qualification Handbook, 5. Phillip A. Cloud, Inter pharm Press, 1998. 6. Commissioning and Qualification, ISPE Pharmaceutical Engineering Baseline Guides Series,	

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

CO4	-	2 (WK1, WK2, WK3, and WK4)	2 (W K5)	-	-	1 (WK1, WK5 and WK7)	-	1	1	-	1 (WK 8)	-	2	
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	Code	:	22UBT511E	ENVIRONMENTAL BT	Semester	:	05
	LTP	:	3:0:0		Course Type	:	PEC
Hours/Sem.	Teaching	:	42 Hrs.		CIE Marks	:	50
	Learning (TW+SL)	:	42 Hrs.		SEE Marks	:	50
	Exam	:	06 Hrs.		Total Marks	:	100
	Total Hrs.	:	90 Hrs.		Credits	:	03

Professional Competency:

Apply advanced environmental biotechnology principles to assess contaminant pathways, engineer biological treatment systems for liquid and solid waste streams, deploy targeted bioremediation and resource recovery processes, and implement molecular tools for ecological conservation in alignment with regulatory standards.

Course Outcomes:

After completion of the course student will be able to

CO1: Interpret the concepts of Bioaccumulation.

CO2: Develop different treatment methods for waste water and solid waste by using BT approach.

CO3: Select bioleaching process for metal recovery and bioremediation processes to remove environmental contaminants.

CO4: Use BT approach for biodiversity conservation.

UNIT-I

10 Hrs.

MICROORGANISMS

Issues and scope of Environmental BT. Characteristics of soil, microbial flora of soil, interactions among soil microorganisms, biogeochemical role of soil microorganisms.

BIOACCUMULATION OF TOXICANTS

Characteristics of Xenobiotics, Relationship of Bioaccumulation with Chemical Structure, Ecophysiology of Bioaccumulation, Process of toxicants uptake, Factors affecting bioaccumulation, measurement of bioaccumulation.

UNIT-II

12 Hrs.

BIOLOGICAL TREATMENT OF WASTE WATER

Waste water characteristics BOD, COD, Primary & Secondary treatment, nanofiltration, ultrafiltration and microfiltration. Microbial removal of phosphorous and Nitrogen, Nutrient removal by Biomass production Wastewater treatment of food processing industries like sugar factories, vegetable oil industries, potato processing industries, dairy industries, beverages industries, and distilleries.

SOLID WASTE MANAGEMENT

Basic aspects, general composition of urban solid wastes, aerobic treatment, anaerobic treatment, biogas generation; Solid waste management through Biotechnological processes involving Hazardous wastes, Biomedical wastes, MoEF rules.

UNIT-III

10 Hrs.

BIOLEACHING & BIOMINING

Microbes in Bioleaching- types, methods of bioleaching, Microbial recovery of metal, phosphate, petroleum.

BIOREMEDIATION:

Major contaminants of air, water and soil, Biomonitors of environment (Bioindicators), Bioremediation

using microbes, Phytoremediation, Biofilms its applications. Bio-stimulation of Naturally occurring microbial activities, Bio-augmentation.

UNIT–IV

10 Hrs.

BIOTECHNOLOGY IN BIODIVERSITY CONSERVATION

Value of biodiversity, threats to biodiversity, Biosphere reserves and Ecosystem Conservation, Approaches to Bioresource conservation programme, Biotechnological processes for bioresource assessment, BT in ex situ conservation of Biodiversity, BT and its role in utilization of Biodiversity, International initiatives for biodiversity management.

REFERENCE BOOKS

1. Mahopatra P K, Textbook of Environmental Biotechnology, I K International Publishing House Pvt. Ltd, 2006
2. Dubey R C and Maheshwari D K, Text book of microbiology (5th edition), S Chand and Company Ltd. 2022.

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

Hours/Sem.-	Code	:	22UBT512E	NUTRACEUTICALS	Semester	:	5
	LTP	:	3:0:0		Course Type	:	PEC
	Teaching	:	42Hrs.		CIE Marks	:	50
	Learning (TW+SS)	:	42Hrs.		SEE Marks	:	50
	Exam	:	6Hrs.		Total Marks	:	100
	Total Hrs.	:	90Hrs.		Credits	:	03

UNIT-I		10 Hrs.
INTRODUCTION TO NUTRACEUTICAL AND DIETETICS Organizational elements, classification of nutraceuticals, dietary supplements, fortified foods, functional foods and phytonutraceuticals. Scope involved in the industry, Indian and global scenario. Recommended dietary intake (RDA), acceptable dietary intake, nitrogen balance, protein efficiency ratio, net protein utilisation. Basics of energy balance - Basal Metabolic Rate (BMR), Body Mass Index (BMI) and Standard Dynamic Action (SDA) with special reference to nutraceutical industry.		
UNIT-II		10 Hrs.
NUTRITION RELATED DISEASES AND DISORDERS Carbohydrates, Protein, amino acids, Fat, vitamins and minerals - Excess and deficiency, symptoms, prevention and management. Role of nutraceuticals with special reference to diabetes mellitus, hypertension, hypercholesterolemia, cancer, glands in the prevention and treatment. Concept of antioxidants - use of antioxidants as dietary supplements in prevention and treatment of cancer, obesity and stress. Role of nutraceuticals and functional foods in pediatrics, geriatrics, sports, pregnancy and lactation.		
UNIT-III		12 Hrs.
NUTRACEUTICALS OF MICROBIAL, PLANT AND ANIMAL ORIGIN Concept of prebiotics and probiotics - principle, mechanism, production and technology involved, applications - examples of bacteria used as probiotics, use of prebiotics in maintaining the useful microflora - extraction from plant sources. Synbiotics for maintaining good health. Algae as source of omega - 3 fatty acids, antioxidants and minerals - extraction and enrichment. Plant secondary metabolites, classification and sub-classification - Alkaloids, phenols, Terpenoids. Animal metabolites - Sources and extraction of nutraceuticals of animal origin. Examples: chitin, chitosan, glucosamine, chondroitin sulphate and other polysaccharides		
UNIT-IV		10 Hrs.
BIOTECHNOLOGY IN PHYTONUTRACEUTICALS Role of medicinal and aromatic plants in nutraceutical industry – propagation - conventional and tissue culture, cultivation, post harvest technology and strategies for crop improvement, development of high yielding lines and yield enhancement, plant genomics and metabolomics. Biofortification and nutritional enhancement. GM foods with enhanced nutraceutical properties. Golden rice, GM Tomatoes		

REFERENCE BOOKS

1. Israel Goldberg (Ed.) (1999) Functional foods, designer foods, pharma foods, Nutraceuticals, Aspen publishers Inc., USA.
2. L. Rapport and B. Lockwood, Nutraceuticals, Pharmaceutical Press., 2nd Edition, 2002.
3. M. Maffei, Dietary Supplements of Plant Origin, Taylor & Francis, 1st Edition, 2003.
4. Shahidi and Weerasinghe, Nutraceutical beverages Chemistry, Nutrition and health Effects, American Chemical Society, 1st Edition, 2004.
5. Richard Neeser & J. Bruce German (2004) Bioprocesses and Biotechnology for Functional Foods and Nutraceuticals, Jean, Marcel Dekker, Inc.
6. Timothy S. Tracy, Richard L. Kingston, Herbal Products 2nd Edition, 2007.

COURSE OUTCOMES

After completion of the course student will be able to

1. Aware of basic concepts of nutraceuticals and nutrition.
2. Have a general idea of scope of nutraceuticals and functional foods.
3. Have brief idea about nutrition related health disorders and the role of Nutraceuticals.
4. Classify nutraceuticals and the role of nutraceuticals among different age groups.
5. Learn about the basic aspects of nutraceuticals derived from microbial, plant and animal origin.
6. Know about the role of biotechnology in production of plant secondary metabolites

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

Hours/Sem.	Code	:	22UBT513E	COMPUTATIONAL BIOLOGY	Semester	:	05
	LTP	:	3:0:0		Course Type	:	PEC
	Teaching	:	42Hrs.		CIE Marks	:	50
	Learning (TW+SL)	:	42Hrs.		SEE Marks	:	50
	Exam	:	6Hrs.		Total Marks	:	100
	Total Hrs.	:	90Hrs.		Credits	:	03

UNIT – I		12 Hrs.
NATURE AND SCOPE OF COMPUTATIONAL BIOLOGY: Basic algorithms in Computational Biology, Biological and Computer algorithm, Fibonacci problem, Dynamic Programming, Time and space complexity of algorithms, Laplace's Rule. Search Algorithms: Random walk, Hill climbing, simulated annealing. Combinatorial Pattern Matching: Hash Tables, Repeat Finding, Exact Pattern Matching; Genetic Algorithm: Basic Concepts, Reproduction, Cross over, Mutation, Fitness Value, Optimization using GAs; Applications of GA in bioinformatics.		
UNIT – II		10 Hrs.
COMBINATORIAL PATTERN MATCHING: Hash Tables, Repeat Finding, Exact Pattern Matching; Genetic Algorithm: Basic Concepts, Reproduction, Cross over, Mutation, Fitness Value, Optimization using GAs; Applications of GA in bioinformation.		
UNIT – III		10 Hrs.
HIDDEN MARKOV MODEL: Markov processes and Markov Models, Hidden Markov Models. Forward and Backward Algorithms, Most probable state path: Viterbi algorithm, Parameter Estimation for HMMs:-Baum-Welch Algorithm, Applications of profile HMMs for multiple alignment of proteins and for finding genes in the DNA.		
UNIT – IV		10 Hrs.
INSILICO DRUG DESIGN AND BIOPYTHON APPLICATIONS IN COMPUTATIONAL BIOLOGY Insilico Drug Design: Basic Concepts, importance and application, Molecular force fields and energy minimization, Molecular Dynamics Simulation methods, Methods of Insilico Drug Design: structure and ligand based drug design approach, structure based drug design: Molecular docking. Biopython: Introduction, important features and application of biopython in computational biology, Create a simple sequence in Biopython for DNA, RNA and Protein Alphabets, Sequence Alignment Tools in Biopython, PDB Module of Biopython.		
REFERENCE BOOKS		

1. Introduction to bioinformatics by Teresa K. Attwood, David J. Parry-Smith, 1999, Pearson Education.
2. Arthur M. Lesk, Introduction to Bioinformatics, Oxford University Press, New Delhi, 2003.
3. Higgins and W. Taylor (Eds), Bioinformatics-Sequence, Structure and databanks, Oxford University Press, New Delhi, 2000
4. An introduction to bioinformatics algorithms by Neil C. Jones, Pavel Pevzner. MIT Press.2004 2.
5. Biological sequence analysis: Probabilistic models of proteins and nucleic acids by Richard Durbin, Eddy, Anders Krogh, 1998
6. Algorithms for Molecular Biology by Ron Shamir Lecture, Fall Semester, 20014.
7. Bioinformatics- a practical guide to the analysis of Genes and Proteins by Baxevanis, A.D. and Francis Ouellette, B.F., 1998, John Wiley & Sons, UK.
8. Introduction to bioinformatics by Teresa K. Attwood, David J. Parry-Smith, 1999,Pearson Education.
9. Arthur M. Lesk, Introduction to Bioinformatics, Oxford University Press, New Delhi, 2003
10. D. Higgins and W. Taylor (Eds), Bioinformatics-Sequence, Structure and databanks, Oxford University Press, New Delhi, 2000.
11. Bioinformatics: the machine learning approach by Pierre Baldi, Søren Brunak. MIT Press.2001 2.
12. Bioinformatics: Sequence and Genome Analysis: by David Mount, University of Arizona, Tucson

COURSE OUTCOMES

After completion of the course student will be able to

1. Understand the nature, scope of computational biology and biological and computer algorithms.
2. Know about the Combinatorial Pattern Matching, Genetic algorithms and their applications.
3. Analyze various Markov processes and Markov Models.
4. Learn about the Insilico Drug Design and Biopython applications in Computational Biology

Course Outcomes	Programme Outcomes											Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
CO1	3 (WK 1, WK2, WK3 and WK4)	3 (WK 1, WK2 and WK4)	3 (WK 5)	-	(WK 2,W K6)	-	-	-	-	-	2 (WK8)	2	1	-
CO2	2 (WK 1, WK2 ,WK3	3 (WK 1, WK2 WK3	3 (WK 5)	-	(WK 2,W K6)	-	-	-	-	-	2 (WK8)	2	1	-
CO3	3 (WK 1, WK2 WK3 and WK4)	3 (WK1, WK2 WK3 and WK4)	3 (WK 5)	-	(WK 2,W K6)	-	-	-	-	-	1 (WK8)	2	1	-
CO4	3 (WK 1 WK2 WK3 and WK4)	3 (WK 1, WK2 WK3 and WK4)	3 (WK 5)	-	(WK 2,W K6)	-	-	-	-	-	1 (WK8)	2	1	-

COMPUTER - ASSISTED DRUG DISCOVERY

The Drug Development Process, Introduction, The Discovery and Development Process, New Lead Discovery Strategies, Composition of Drug Discovery Teams, The Practice of Computer-Assisted Drug Discovery (CADD), Current Practice of CADD in the pharmaceutical Industry, Management Structures of CADD Groups, Contributions and Achievements of CADD Groups, Limitations of CADD Support, Inherent Limitations of CADD Support, State of Current Computational Models, Software and Hardware Constraints.

REFERENCE BOOKS

1. Bioinformatics Methods & Applications: Genomics, Proteomics & Drug Discovery, S C Rastogi, Mendiratta & P Rastogi, PHI, 4th Edition, 2013
2. Moody P.C.E. and A.J. Wilkinson Protein Engineering, IRL Press, Oxford, 3rd Edition, 2010.
3. Creighton T.E. Proteins, Freeman W.H. Second Edn, 1993.
4. Branden C. and Tooze R. Introduction of protein structure, Garland, 1993.
5. The molecular modeling perspective in drug design by N Claude Cohen, 2008, Academic Press.

COURSE OUTCOMES

After completion of the course student will be able to

1. Study protein structure prediction and protein engineering and design
2. Understand molecular modeling
3. Know computer assisted new lead design
4. Study docking methods and computer - assisted drug discovery

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

BIOFUELS TECHNOLOGY

Graduate will apply the principles of biofuel science and technology to evaluate feedstocks, production processes, technological innovations, and the economic and environmental sustainability of biofuels for renewable energy applications

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

CO2: Diagnose the types of feed stocks used for biofuels.

CO4: Understand and recall current issues related with production and use of biofuels, Research opportunities, economic feasibility of the biofuels

10 Hrs.

Basic principle of light energy conversion to chemical energy & carbon fixation. Biochemistry involved in conversion of sugars to alcohols. Renewable and non-renewable resources.

Introduction to Biofuels - definition, advantages and disadvantages. Biofuel life cycle. Biomass as an energy core and its different mode of utilization. Conventional fuels and their environmental impacts. Modern fuels and their environmental impacts. Biofuel energy content. World scenario of biofuel production and use.

12 Hrs.

Starch feed stocks-cereal grains, tubers & roots; Sugars feed stocks-sugarcane & sugarbeet; cellulosic feed stocks - forest residues, agricultural residues, Agricultural processing by-products, dedicated energy crops, municipal solid waste and paper waste. Lipid feed stocks :-Oilseed crops with examples, Algae, Waste oil, Animal fats. Next generation feed stocks. Environmental impacts of feed stocks.

First generation biofuels-vegetable oil biodiesel, bioalcohols, bioethers, biogas syngas, solid biofuels.
Second generation biofuels and third generation biofuels.

10 Hrs.

Historical background. Biochemical platform – bioethanol production, standardization, emissions and properties of bioethanol. Thermochemical platforms - biodiesel production, standardization, properties and emissions of biodiesel. BtL fuels -production, properties and emissions. Biohydrogen processing and uses. Converting solid wastes to pipeline gas. Biomethanation, Microbial fuel cells. Blending of biofuels

UNIT-IV												10 Hrs.		
BIOFUELS IN PERSPECTIVE														
Integrated refining concepts with reference to ethanol production. Economic feasibility of producing biodisel, Issues with biofuel production & use. Impact of biofuel in global climate change & food production. 1 st versus 2 nd generation biofuels. Strategies for new vehicle technologies. Current research on biofuel production. Market barriers of biofuels.														
Text Books:														
1. Foster C. F., John ware D.A.Environmental Biotechnology by, Ellis Horwood Limited, 1987.														
2. Larry Anderson and David A Fuels from Waste by Tillman. Academic Press, 1977.														
Reference Books:														
1. Biotechnology, Economic & Social Aspects: E.J. Dasilva, C Ratledge & A Sasson, Cambridge Univ. Press, Cambridge, 2000.														
2. Environmental Biotechnology by Pradipta Kumar Mahopatra, 2007.														
Web links and Video Lectures (e-Resources)														
Course Outcomes:														
Course Outcomes	Programme Outcomes											Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
CO1	3 (WK1, WK2, WK3, and WK4)	2 (WK1, WK2, WK3, and WK4)	-	-	2 (WK2 and WK6)		1 (WK9)	-	-	-	1 (WK8)	3	2	-
CO2	3 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	-	3 (WK8)			2 (WK9)	-	-	-	1 (WK8)	2	-	-
CO3	3 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	-	3 (WK8)	3 (WK2 and WK6)		2 (WK9)	-	-	-	3 (WK8)	-	2	-
CO4	3 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	-	3 (WK8)			2 (WK9)	-	-	-	3 (WK8)	-	1	-

Hours/Sem.	Code	:	22UHS521C	QUANTITATIVE APTITUDE AND PROFESSIONAL SKILLS	Semester	:	5
	LTP	:	2:0:0		Course Type	:	AEC
	Teaching	:	28 Hrs		CIE Marks	:	100
	Learning (TW+SL)	:	26 Hrs		SEE Marks	:	00
	Exam	:	06 Hrs		Total Marks	:	100
	Total Hrs.	:	60 Hrs		Credits	:	02
Professional Competency:							
Demonstrate competency in enhancing vocabulary, improving verbal ability, analyzing problems systematically, and solving quantitative problems using appropriate language and numerical techniques.							
Course Outcomes:							
1. Enhance vocabulary and apply techniques to further improve word usage and language proficiency.							
2. Apply techniques to improve verbal ability in communication and comprehension tasks.							
3. Analyze problems step-by-step and develop appropriate methods for solving them effectively.							
4. Solve quantitative problems by applying appropriate concepts and techniques to improve numerical ability.							
UNIT-I							7 Hrs.
Vocabulary Development: Vocabulary Building Techniques, Root Words, Antonyms & Synonyms, Sentence Completion, Error Detection & Correction, Reading Comprehension							
UNIT-II							7 Hrs.
Numbers, Proportion & Finance: Number System, Factors & Multiples, The God of Math—Linear Equations, Ratio-Proportion -Variation, Percentages, Profit & Loss, Interest, Averages & Alligations							
UNIT-III							7 Hrs.
Time & Probability: Time & Work, Time Speed, & Distance, Permutations & Combinations, Probability							
UNIT-IV							7 Hrs.
Verbal, Analytical, and Visual Reasoning: Human Relations, Direction Tests, Coding Decoding, Clocks and Calendars, Visual Reasoning, Analytical Puzzles, Mathematical, Arrangement & Classification Puzzles							
Text Books:							
1. R.S. Aggarwal, "A Modern Approach to Verbal and Non-Verbal Reasoning", Sultan Chand and Sons, New Delhi, 2018							
2. R. S. Aggarwal, "Quantitative Aptitude", Sultan Chand and Sons, New Delhi, 2018							
3. Chopra, "Verbal and Non-Verbal Reasoning", MacMillan India							
4. M Tyra, "Magical Book on Quicker Maths", BSC Publications, 2018							
5. George J Summers, "The Great Book of Puzzles & Teasers", Jaico Publishing House, 1989							
6. Shakuntala Devi, "Puzzles to Puzzle You", Orient Paper Backs, New Delhi, 1976							
7. R. S. Aggarwal, "A Modern Approach to Logical Reasoning", Sultan Chand and Sons, New Delhi, 2018							
8. Cambridge Advanced Learner's Dictionary, Cambridge University Press. Kaplan's G R E guide							

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	Code	:	22UBT523C	ENVIRONMENTAL STUDIES	Semester	:	05
	LTP	:	1:0:0		Course Type	:	MC
Hours/Sem.	Teaching	:	14 Hrs.		CIE Marks	:	50
	Learning (TW+SL)	:	13 Hrs.		SEE Marks	:	50
	Exam	:	03 Hr.		Total Marks	:	100
	Total Hrs.	:	30 Hrs.		Credits	:	01

Professional Competency:

Develop the ability to analyze environmental issues and implement sustainable solutions by applying environmental science principles, pollution control measures, and environmental legislation.

Course Outcomes:

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

CO1: Identify natural resources and its uses.

CO2: Understand pollution and its effects on environment and to implement sustainable future in the work place.

CO3: Analyze current environmental issues.

CO4: Apply the waste management techniques in various fields.

UNIT-I	10 Hrs.
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UNIT-I	10 Hrs.
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Natural Resources:

Human activities and their impacts. Environmental Impact Assessment, **Renewable Energy**: Solar, Wind, Hydropower, Tidal, Ocean thermal, Geo thermal, Biomass energy, Biogas, Biodiesel, Bioethanol, Hydrogen as fuel.

Non renewable Energy: Coal, Petroleum, Natural gas, Nuclear energy.

UNIT-II	12 Hrs.
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UNIT-II	12 Hrs.
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Environmental Pollution:

Water pollution, water quality standards, water borne diseases, Fluoride problem, Air pollution, Noise pollution. Effect of electromagnetic waves.

Sustainable future: Concept of sustainable development, threats to sustainability, strategies for sustainable development, Sustainable development goals (SDGs). Environment economics – concept of green building, Circular Economy.

UNIT-III		10 Hrs.
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UNIT-III		10 Hrs.
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Current Environmental Issues of concern:

Greenhouse Effect- Greenhouse gases and Global Warming, Climate change, ozone layer depletion, Acid rain, Eutrophication

Environmental policy legislation rules & regulations

UNIT-IV	10 Hrs.
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UNIT-IV	10 Hrs.
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Fundamentals of Waste management:

Solid waste management: Sources, classification, characteristics, collection & transportation, disposal, and processing methods. Hazardous waste management and handling.

Concept of waste water treatment, Bioremediation.

Industrial waste management (Case studies: Cement, plastic, chemical, E-waste, food & construction industry waste management).

Text Books:

1. Benny Joseph, Environmental Studies, 3rd Edition, McGraw Hill Education (India) Pvt. Ltd., 2017.
2. Manjunath, D. L., Environmental Studies, 1st Edition, Pearson Education, New Delhi, 2007.
3. Anubha Kaushik and C. P. Kaushik, *Perspectives in Environmental Studies*, 8th Edition, New Age International (P) Ltd., New Delhi, 2025.
4. P. Meenakshi, Elements of Environmental Science and Engineering, 2nd Edition, PHI Learning Pvt. Ltd., New Delhi, 2012.

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

Hours/Sem.	Code	:	22UBT503L	BIOINFORMATICS LAB	Semester	:	5
	LTP	:	0:0 :2		Course Type	:	PCCL
	Teaching	:	26 Hrs.		CIE Marks	:	50
	Learning (TW+SL)	:	-		SEE Marks	:	50
	Exam	:	4 Hrs.		Total Marks	:	100
	Total Hrs.	:	30 Hrs.		Credits	:	01

LIST OF EXPERIMENTS

1. Bibliographic search from PUBMED, SCIRUS and MEDMINER
2. Sequence retrieval from Nucleic acid and Protein databases.
3. Sequence searches using BLAST – Retrieval of homologs, paralogs, orthologs, and Xenologs
4. Pair wise comparison of sequences – Analysis of parameters affecting alignment.
5. Multiple alignments of sequences and pattern determination using PROSITE
6. Evolutionary studies / Phylogenetic analysis – Analysis of parameters affecting trees.
7. Identification of functional sites in Genes / Genomes.
8. Secondary structure prediction of proteins and comparison with PDB.
9. Restriction mapping: Analysis of maps for suitable molecular biology experiment.
10. Primer Design: Factors affecting primer design.
11. PDB structure retrieval and visualization: Analysis of homologous structures.
12. Determination of ligand-protein interactions using SPDBV/ LIGPLOT
13. Superposition of structures – Calculation of RMSD.
14. Docking studies – Analysis of substrate / ligand binding using homologous structures.

REFERENCE BOOKS

1. Bioinformatics – Andreas D Boxevanis. Wiley Interscience, 1998.
2. Bioinformatics – David W Mount, cold spring harbor, 2001.
3. Bioinformatics – A biologist's guide to biocomputing and the internet. Stuart M brown,
4. Fundamental Concepts of Bioinformatics – D E Krane & M L Raymer, Pearson, 2006.
5. Computational methods in Molecular Biology – S.L.Salzberg, D B Searls, S Kasif, Elsevier, 1998.
6. Bioinformatics – methods and applications: Genomics, proteomics and drug Discovery – s c Rastogi, N. mendiratta & prastogi, phi, 2006.

COURSE OUTCOMES

After completion of the course student will be able to

1. Search literature and sequence databases
2. Retrieve and search sequences from databases
3. Align pair wise and multiple sequences
4. Identify evolutionary and relationships and functional sites in genomes
5. Evaluate primer designing and restriction mapping
6. Docking and superimpose the structures

Course Outcomes	Programme Outcomes											Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
CO1	3 (WK1,	3 (WK1	3 (W	-	3 (WK2,	1 (WK1	-	3	-	-	-	3	3	1

	WK2, WK3, and WK4)	, WK2, WK3, and WK4)	K5)		WK6)	,WK5, WK7)								
CO2	3 (WK1, WK2, WK3, and WK4)	3 (WK1 , WK2, WK3, and WK4)	3 (W K5)	-	3 (WK2, WK6)	1 (WK1 ,WK5, WK7)	-	-	-	-	-	2	3	1
CO3	3 (WK1, WK2, WK3, and WK4)	3 (WK1 , WK2, WK3, and WK4)	2 (W K5)	2 (WK8)	3 (WK2, WK6)	1 (WK1 ,WK5, WK7)	1 (WK9)	-	-	-	-	3	3	1
CO4	3 (WK1, WK2, WK3, and WK4)	3 (WK1 , WK2, WK3, and WK4)	2	2(WK 8)	3 (WK2, WK6)	1 (WK1 ,WK5, WK7)	-	-	-	-	-	3	3	2

Hours/Sem.	Code	:	22UBT504P	MINI PROJECTS	Semester	:	05
	LTP	:	0-0-2		Course Type	:	PP
	Teaching	:	-		CIE Marks	:	50
	Learning (TW+SL)	:	-		SEE Marks	:	50
	Exam	:	04Hrs		Total Marks	:	100
	Total Hrs.	:	60Hrs		Credits	:	02

Professional Competency:

Apply fundamental biotechnological principles, research methodology, ethical practices, and scientific communication skills to plan, execute, analyze, and present a mini research project that addresses a defined biotechnology problem using a systematic and professional approach.

Course Outcomes:

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

CO 1: Apply Biotechnological principles and techniques to design and conduct experiments.

CO2: Able to develop research skills and methodical approach to maintain for the collection, storage and analysis of data.

CO 3: Able to demonstrate an awareness of ethical issues associated with their chosen field of research.

CO 4: Able to develop and demonstrate the ability to effectively communicate written and oral presentations scientifically

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

B.E. VI SEMESTER

Course Code		:	22UBT601C	BIOPROCESS AND BIOREACTION ENGINEERING	Semester	:	06
L:T:P*		:	3:0:0		Course Type	:	PCC
Hours/Sem.	Teaching	:	42 Hrs.		CIE Marks	:	50
	Learning (TW+SL)	:	42 Hrs.		SEE Marks	:	50
	Exam	:	6 Hrs.		Total Marks	:	100
	Total Hrs.	:	90 Hrs.		Credits	:	03

Professional Competency:

Ability to apply Engineering and Biological principles to design, scale up, optimize, and operate bioreactor systems for the efficient production of biopharmaceuticals, biofuels, and industrial biomolecules while ensuring economic viability, safety, and regulatory compliance.

Course Outcomes:

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

- CO1: Apply principles of chemical and biochemical kinetics to derive rate laws, determine reaction molecularity/order, and evaluate temperature dependency using the Arrhenius relationship.
- CO2: Analyze batch bioreactor experimental kinetic data using integral, differential, and half-life methods to determine rate constants and reaction orders.
- CO3: Formulate performance design equations and calculate sizing parameters (space-time, space-velocity, batch cycle time) for ideal single reactors (Batch, CSTR, and PFR).
- CO4: Evaluate the performance of multiple reactor configurations (series/parallel) and assess engineering challenges in bioprocess scale-up, including mixing, heat/mass transfer.

UNIT-I

10 Hrs.

Kinetics of Homogeneous reactions:

Basic Concepts of Bioreaction and Bioprocess Engineering, Classification of Chemical reactions, Rate of Chemical reaction, Rate Equations, Factors affecting Rate of reaction, Concentration-dependent term of a rate equation: Molecularity and Order of the reaction, Rate law, Rate Constant, Elementary and non-elementary reactions, Representation of elementary and non-elementary reactions, Temperature-dependent term of a rate equation: Temperature dependency from Arrhenius law, Activation Energy, Graphical Determination of the Activation Energy, Collision theory.

UNIT-II

11 Hrs.

Interpretation of Batch Bioreactor Data:

Constant volume batch reactor, Integral method of analysis of rate equations; Integrated rate laws: Concentration changes over time for first order, second order, zero order reactions, Graphical representation for all the orders, Numericals, Determining reaction order from initial rate data-problem, Units of the rate constant for several overall reaction orders, Half-life of reactions, Integrated equations for half-life of reactions, Numericals, Integrated Arrhenius equation and equation at different temperature, Numericals.

UNIT-III

11 Hrs.

Single Ideal Bioreactor

General features of Ideal Batch Reactor, Semi Batch (Fed-Batch reactor), Continuous (Mixed flow reactor), Plug flow Reactor, Basic design equation, the relation between Concentration and conversion, General and Performance equation for the Steady-state Batch reactor at constant volume and density,

Batch cycle time, Space-Time and Space-Velocity, Performance equation for the Steady-state Mixed Flow reactor/CSTR and Plug Flow reactor, Graphical representation of Performance equation for the Batch, Mixed Flow reactor/CSTR and Plug Flow reactor, Holding time and space-time for flow reactors.

UNIT-IV

10 Hrs.

Analysis of Bioreactors:

Size comparison of single reactors, Batch reactor with Plug flow reactor, Mixed/CSTR with Plug flow reactor, Multiple reactor Systems, CSTR/ Mixed flow reactors in series and CSTRs in Parallel; Plug flow reactors in series and parallel, Reactors of different types in series, Challenges and issues in bioprocess industries- mixing, interphase mass and heat transfer, Bioreactor instrumentation and control, Bioreactor considerations for animal cell cultures and plant cell cultures.

Reference Books

1. Scott Fogler, H (2016) Elements of Chemical Reaction Engineering, 6th edn., Prentice Hall India Pvt. Ltd.
2. Levenspiel O (2006) Chemical Reaction Engineering, Wiley Eastern, 3rd edn, New Delhi.
3. Kargi and Shuler (2015) Bioprocess Engineering. 3rd edn., Prentice Hall PTR.
4. Bailey J E and Ollis DF (2010) Biochemical Engineering Fundamentals, 2nd edn. Mc Graw- Hill.
5. Charles D. Holland (1990) Fundamentals of Chemical Reaction Engineering, John Wiley and Sons.
6. Pauline M Doran., Bioprocess Engineering Principles, 2nd Edition, Academic Press, USA, 2013.
7. Tapobrata Panda., Bioreactors: Analysis and Design, 1st Edition, Tata McGraw Hill Education Private Limited, New Delhi, 2011.

Web links and Video Lectures (e-Resources)

1. NPTEL: Fundamentals of Bioprocess Engineering (IIT Guwahati)

Course Outcomes	Programme Outcomes											Programme Specific Outcomes		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
CO 1	2 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	3 (WK5)	2 (WK8)	2 (WK2, WK6)	-	-	-	-	-	1 (WK8)	2	2	1
CO 2	2 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	2 (WK5)	3 (WK8)	1 (WK2, WK6)	-	-	-	-	-	1 (WK8)	2	3	1
CO 3	2 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	3 (WK5)	2 (WK8)	2 (WK2, WK6)	-	-	-	-	-	1 (WK8)	2	3	1
CO 4	2 (WK1,	3 (WK1,	3 (WK5)	3 (WK8)	2 (WK2,W	-	-	-	-	-	1 (WK8)	2	3	1

[illegible]

Course Code		:	22UBT602C	UPSTREAM PROCESSING TECHNOLOGY	Semester	:	06
L:T:P		:	3:0:0		Course Type	:	PCC
Hours/Sem.	Teaching	:	42 Hrs		CIE Marks	:	50
	Learning (TW+SL)	:	42 Hrs		SEE Marks	:	50
	Exam	:	06 Hrs		Total Marks	:	100
	Total Hrs.	:	90 Hrs		Credits	:	03

Professional Competency:

Develop the knowledge and skills to design, operate, monitor, and optimize upstream bioprocesses, including media preparation, sterilization, inoculum development, bioreactor operation, and process control for efficient and safe production of bioproducts.

Course Outcomes:

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

1. Identify the component parts of fermentor and fermentation system.
2. Select the raw material, prepare and sterilize the media and also to optimize the industrial media using Design of experiments.
3. Develop/design the industrially important microbes for industrial scale processes.
4. Operate the reactors for Plant, Animal and GMOs.

UNIT-I

12 Hrs.

FERMENTATION PROCESS

Range of fermentation processes, chronological development of fermentation industry, component of the fermentation process. Basic functions of a fermenter for microbial, plant and animal cell culture. Body parts of fermentor, aseptic operation and containment. Sterilization of fermentors. Classification of Fermentation Systems: Batch, fed batch and continuous process and their applications, Types of Fermentors.

Scale Up: Process engineering concepts, engineering considerations, mechanical considerations, energy considerations. Process GMP considerations of scale up, operations and quality.

UNIT-II

10 Hrs.

RAW MATERIALS AND MEDIA

Media requirement for typical fermentation process, selection of typical raw materials, types of fermentation media. Preparation and handling of fermentation media, sterilization and its practical limits, Batch sterilization, Continuous sterilization and Filter sterilization. Different methods for optimization (Plackett-Burman Design, RSM)

UNIT-III

10 Hrs.

MICROBIAL SYSTEM

Isolation of industrially important microorganisms, Strain development methods, Preservation of industrially important microorganisms. Development of inoculum from laboratory scale to pilot scale and large scale fermentation (for bacterial, yeast, mycelial processes). Criteria for the transfer of inoculum. Aseptic transfer of inoculum to the fermentor. Trouble shooting during fermentation process (microbial contamination).

SECONDARY METABOLITE PRODUCTION: secondary metabolite production in bacteria, yeast and fungi. Production of lactic acid, butanol, antibiotics and enzymes.

UNIT-IV

10 Hrs.

PLANT CELL SYSTEM

Isolation and culture of single cells, Bioprocess using plant cell cultures. Bioreactors for suspension cultures, immobilized cells and organized tissues. Secondary metabolite enhancement techniques (alkaloids, steroids, phenolics).

ANIMAL CELL SYSTEM

Scale up in suspension (stirred and static), monolayer (roller bottles, nunc cell factory microcarriers culture) and Perfusion culture (fixed and fluidized bed reactors). Factors affecting cell culture, Growth monitoring. Genetically

engineered cells for bioprocessing; process, selection of host vectors, process constraints- genetic instability, mass transfer and others. Large scale production of insulin by mammalian cell culture. Cellbank preparation & cell reviving techniques.

MONOCLONAL ANTIBODY PRODUCTION: SUDBRCS (Single use disposable bioreactor configuration, types of production (perfusion culture, submerged culture, suspended adhered culture).

Text Books:

1. Principles of fermentation Technology by P.F. Stanbury and A. Whitaker, Aditya books (P) Ltd. New Delhi 1997.
2. Bioprocess Engineering by Michael L. Shuler, 2nd Edition Shuler & Kargi, Fikret Kargi, Academic Internet Publishers, 2006.
3. Culture of animal cells by Ian Freshney 4th Edition. John Willey & Sons Publ, 2008
4. Animal Biotechnology by Murray Moo-Young Pergamon Press, , 2008

Reference Books:

1. Introduction to plant Biotechnology by H.S. Chawla, Second edition, Oxford & IBH Publisher
2. Plant tissue Culture : Theory and Practice by S.S. Bhojwani and M.K. Razdan (1996). Elsevier

Course Outcomes:

Course Outcomes	Programme Outcomes											Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
CO1	3(WK1 WK2, WK3 ,WK4)	1(WK1 WK2, WK3 ,WK4)	-	-	-	-	-	-	-	-	-	1	3	-
CO2	-	3(WK1 WK2, WK3 ,WK4)	-	-	-	-	-	-	-	-	-	-	3	3
CO3	2(WK1 WK2, WK3 ,WK4)	2(WK1 WK2, WK3 ,WK4)	3(WK 5)	1(WK 8)	1(WK2 and WK6)	-	-	-	-	2	1	3(W K8)	3	-
CO4	2(WK1 WK2, WK3 ,WK4)	-	-	-	-	-	-	-	-	3	1	-	3	-

Course Code		:	22UBT603C	BIOTRANSFORMATION AND ENZYME TECHNOLOGY	Semester	:	06
L:T:P		:	3:0:0		Course Type	:	PCC
Hours/Sem.	Teaching	:	42 Hrs.		CIE Marks	:	50
	Learning (TW+SL)	:	42 Hrs.		SEE Marks	:	50
	Exam	:	06 Hrs.		Total Marks	:	100
	Total Hrs.	:	90		Credits	:	03

Professional Competency:

Derive the kinetic expressions for the enzyme catalysed reactions. Estimate the activity and specific activity of free and immobilized enzymes, comprehend the importance of enzymes in disease diagnosis and industrial application.

Course Outcomes

After completion of the course student will be able to

1. Understand mechanism of enzyme and its reactions.
2. Know enzymatic techniques to characterize the enzymes and apply the techniques of immobilization of enzymes.
3. Understand the importance of enzymes in diagnostics.
4. Apply knowledge of using enzymes in detergent, wool, leather and food industries.

UNIT-I

10 Hrs.

ENZYME ACTION:

Mechanism of enzyme action. Derivations of K_m value (Michaelis-Menton constant), Lineweaver-Burk plot., Enzyme inhibition and kinetics.

MULTI-SUBSTRATE REACTIONS:

Introduction to enzyme catalyzed reaction Ping-pong mechanism, Sequential mechanism (ordered and random), Enzyme models - Host guest complexation chemistry.

UNIT-II

12 Hrs.

ENZYMATIC TECHNIQUES:

Strategies of purification of enzymes: choice of source, methods of homogenization, Criteria of purity: tests for purity, tests for catalytic activity, active site titrations, Molecular weight determination and characterization of enzymes.

IMMOBILIZATION OF ENZYMES:

Techniques of enzyme immobilization; design and configuration of immobilized enzyme reactions, Kinetics of immobilized enzymes, immobilized enzymes in bioconversion processes (uses). The design and construction of novel enzymes.

UNIT-III

10 Hrs.

ENZYMES OF BIOLOGICAL IMPORTANCE:

Enzyme pattern in diseases like in Myocardial infarctions (SGOT, SGPT, & LDH) Acetylcholinesterase, angiotensin converting enzyme (ACE), 5'- nucleotidase (5NT), glucose-6-phosphate dehydrogenase (GPD). Use of isozymes as markers in cancer.

UNIT-IV

10 Hrs.

INDUSTRIAL USES OF ENZYMES:

Enzymes used in detergents, use of proteases, leather and wool industries; methods involved in production of glucose syrup from starch (using starch hydrolyzing enzymes). Uses of lactase in dairy industry, glucose oxidase and catalase in food industry. Uses of proteases in food industries.

REFERENCE BOOKS

1. Trevor Palmer (2008). Enzymes: Biochemistry, Biotechnology, Clinical Chemistry. Horwood Publishing Ltd, East-West Press, 5th Edition.
2. David L. Nelson and Michael Cox (2017). "Lehninger Principles of Biochemistry" –7th Edition.
3. Nicholas C. Price and Lewis Stevens (2009). Fundamentals of Enzymology, Oxford university Press, 3rd edition.
4. James R Hanson (2017). "An Introduction to Biotransformation in Organic Chemistry" 5th edition , Oxford university Press,
5. Daniel L. Purich, Melvin I. Simon, John N. Abelson (2009). Contemporary Enzyme Kinetics and Mechanism" Academic press, 3rd edition.
6. K. Faber (2018). Biotransformations in Organic: Springer- Verlag. 4th Edition,.
7. Bailey and Ollis (2017). "Biochemical Engineering Fundamentals", McGraw Hill 2nd Ed.

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

Course Code		:	22UBT604C	GENOMICS AND PROTEOMICS	Semester	:	6
L:T:P		:	3:0:0		Course Type	:	PCC
Hours/Sem.	Teaching	:	42Hrs.		CIE Marks	:	50
	Learning (TW+SL)	:	42Hrs.		SEE Marks	:	50
	Exam	:	6Hrs.		Total Marks	:	100
	Total Hrs.	:	90Hrs.		Credits	:	03

UNIT-I		10 Hrs.
INTRODUCTION Genes and Proteins, Polymorphisms – types of polymorphism, commercializing the Genome - Revenue opportunities: a) genome sequences and database subscriptions, b) prediction of new genes and their function by databases. c) prediction of new genes and their function by databases, d) potential revenue in the area diagnostic and biomedical applications, e) biosimilars market and implications. Sequencing & genome projects: Early sequencing efforts. Methods of preparing genomic DNA for sequencing, DNA sequence analysis methods, Sanger Dideoxy method, Fluorescence method, shotgun approach. Next generation sequencing Genome projects on <i>E.coli.</i> , Arabidopsis and rice; Human genome project.		
UNIT-II		10 Hrs.
FUNCTIONAL GENOMICS Gene variation and Single Nucleotide Polymorphisms (SNPs) genotyping tools -DNA Chips, comparative genomics. Functional genomic studies with model systems such as Drosophila, Yeast or C. elegans. Applications in Functional genomics, medicine and Gene Knockdown. Metagenomics- definition & concept. C-Value and paradox of genomes, Repetitive and coding sequences, Genetic and physical maps, chromosome walking Methods of molecular mapping, Marker assisted selection, map based cloning, Bioinformatics analysis- clustering methods. Approaches to physical mapping		
UNIT -III		10 Hrs.
STRUCTURE OF PROTEINS Conformational analysis and forces that determine protein structures, geometries, phi, psi, omega angles, Ramachandran diagram, allowed chi angles of side chains in proteins, hydrogen bonding, disulphide bonds, Vanderwaal's force , salt bridges hydrophobic interactions, alpha helices, beta sheets, helix to coil transition, general features and thermodynamic aspects of protein folding, folding kinetics, protein-ligand interactions (Examples of bio-molecular interactions), fibrous proteins (structure of collagen, keratin) and Quaternary structures.		
UNIT-IV		10 Hrs.
PROTEOMICS Introduction to proteomics, Sample preparation, protein extraction Denovo protein synthesis, LCMS/MS, M/Z ratio, sequencing and identification, Predictive Methods using Protein sequences: Protein Identity based on composition, Related web based software (JPRED, PROSEC, NNPREDDICT and SOPMA) Proteome analysis "Protein Chip" - interactions and detection techniques, two dimensional PAGE for proteome analysis, Applications of proteome analysis to drug development and toxicology. Crisper-cas. Challenges in proteomics.		
REFERENCE BOOKS		

1. Genetic Analysis – Principles, Scope and Objectives by JRS Finchman, Blackwell Science, 1st Edition, 1994.
2. A M Campbell & L J Heyer Discovering Genomics, Proteomics & Bioinformatics –, Pearson Education, 2nd Edition, 2006.
3. Albala J S & I Humprey-Smith Protein Arrays, Biochips and Proteomics, CRC Press, 1st Edition, 2003.
4. Sabesan, Genomics & Proteomics –Ane Books, 2007. 5. Pennington S. R. and M J Dunn Proteomics.

COURSE OUTCOMES

After completion of the course student will be able to

1. Know about genes, brief history, polymorphism, prediction methods, Biosimilars, business opportunities in diagnostic and medicine.
2. Understand about the Human genome project, tools in DNA sequencing methods and other advanced techniques, Comparative genomics using model organisms, functional genomics of different organisms and molecular markers, gene and physical mapping techniques.
3. Know about Protein structure analysis and molecular interactions.
4. Analysis of proteins, quantification, sequencing, identification, protein predictive methods and proteomics in medicine.

Course Outcomes:														
Course Outcomes	Programme Outcomes											Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
CO1	3 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	2 (W K5)	-	-	2 (WK1, WK5, and WK7).	2 (W K9)	-			1 (WK8)	-	2	3
CO2	3 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	1 (W K5)	-	-	2 (WK1, WK5, and WK7).		-			2 (WK8)	1	-	3
CO3	3 (WK1, WK2, WK3, and WK4)	2 (WK1, WK2, WK3, and WK4)	2 (W K5)	1 (W K8) .	2 (W K2 and WK 6)	-		-			1 (WK8)	1	2	2
CO4	2 (WK1, WK2, WK3, and WK4)	2 (WK1, WK2, WK3, and WK4)	2 (W K5)	2 (W K8) .	2 (W K2 and WK 6)	2 (WK1, WK5, and WK7).	2 (W K9)	2			1 (WK8)	1	2	2

Course Code		:	22UBT621E	BIOFUELS TECHNOLOGY	Semester	:	06
L:T:P		:	3:0:0		Course Type	:	PEC
Hours/Sem.	Teaching	:	42 Hrs		CIE Marks	:	50
	Learning (TW+SL)	:	42 Hrs		SEE Marks	:	50
	Exam	:	06 Hrs		Total Marks	:	100
Total Hrs.		:	90	Credits	:	03	
Professional Competency:							
Graduate will apply the principles of biofuel science and technology to evaluate feedstocks, production processes, technological innovations, and the economic and environmental sustainability of biofuels for renewable energy applications.							
Course Outcomes:							
After completion of the course, student will be able to:							
CO1: Understand the basic principle involved in bioconversion process in energy and to differentiate the conventional fuels with biofuels .							
CO2: Diagnose the types of feed stocks used for biofuels.							
CO3: Produce the biofuels (biodiesel, bio alcohol biogas and biohydrogen) using current technologies and innovations involved							
CO4: Understand and recall current issues related with production and use of biofuels, Research opportunities, economic feasibility of the biofuels							
UNIT-I						10 Hrs.	
BIOCHEMISTRY OF BIOFUELS AND ENERGY RESOURCES							
Basic principle of light energy conversion to chemical energy & carbon fixation. Biochemistry involved in conversion of sugars to alcohols. Renewable and non-renewable resources.							
BIOFUELS							
Introduction to Biofuels - definition, advantages and disadvantages. Biofuel life cycle. Biomass as an energy core and its different mode of utilization. Conventional fuels and their environmental impacts. Modern fuels and their environmental impacts. Biofuel energy content. World scenario of biofuel production and use.							
UNIT-II						12 Hrs.	
BIOFUEL FEED STOCKS							
Starch feed stocks-cereal grains, tubers & roots; Sugars feed stocks-sugarcane & sugarbeet; cellulosic feed stocks - forest residues, agricultural residues, Agricultural processing by-products, dedicated energy crops, municipal solid waste and paper waste. Lipid feed stocks:-Oilseed crops with examples, Algae, Waste oil, Animal fats. Next generation feed stocks. Environmental impacts of feed stocks.							
TYPES OF BIOFUELS							
First generation biofuels-vegetable oil biodisel, bioalcohols, bioethers, biogas syngas, solid biofuels. Second generation biofuels and third generation biofuels.							
UNIT-III						10 Hrs.	
TECHNOLOGIES FOR BIOFUELS							
Historical background. Biochemical platform – bioethanol production, standardization, emissions and properties of bioethanol. Thermochemical platforms - biodiesel production, standardization, properties and emissions of biodiesel. BtL fuels -production, properties and emissions. Biohydrogen processing and uses. Converting solid wastes to pipeline gas. Biomethanation, Microbial fuel cells. Blending of biofuels							
UNIT-IV						10 Hrs.	
BIOFUELS IN PERSPECTIVE							

Integrated refining concepts with reference to ethanol production. Economic feasibility of producing biodiesel, Issues with biofuel production & use. Impact of biofuel in global climate change & food production. 1st versus 2nd generation biofuels. Strategies for new vehicle technologies. Current research on biofuel production. Market barriers of biofuels.

Text Books:

1. Foster C. F., John ware D.A.Environmental Biotechnology by, Ellis Horwood Limited, 1987.
2. Larry Anderson and David A Fuels from Waste by Tillman. Academic Press, 1977.

Reference Books:

1. Biotechnology, Economic & Social Aspects: E.J. Dasilva, C Ratledge & A Sasson, Cambridge Univ. Press, Cambridge, 2000
2. Environmental Biotechnology by Pradipta Kumar Mahopatra, 2007

Web links and Video Lectures (e-Resources)

Course Outcomes:

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

Course Code		:	22UBT622E	FOOD BIOTECHNOLOGY	Semester	:	06
L:T:P		:	3:0:0		Course Type	:	PEC
Hours/Sem.	Teaching	:	42 Hrs		CIE Marks	:	50
	Learning (TW+SL)	:	42 Hrs		SEE Marks	:	50
	Exam	:	06 Hrs		Total Marks	:	100
	Total Hrs.	:	90 Hrs		Credits	:	03

Professional Competency:

Apply biotechnology principles and modern molecular techniques to develop, improve, process, and ensure the safety, quality, and nutritional value of food products while addressing global food security and regulatory requirements.

Course Outcomes:

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

CO1: Explain the principles of food biotechnology, nutrigenomics, novel food bioprocesses, and their role in improving food quality and addressing global food security.

CO2: Apply microbial biotechnology concepts for the production of food ingredients, enzymes, nutraceuticals, microbial polysaccharides, and fermented food products.

CO3: Analyze molecular and genetic approaches for improving the nutritional quality, shelf life, and functional properties of plant-derived food products.

CO4: Evaluate transgenic animal technologies, chloroplast engineering, food safety regulations, genetically modified foods, and intellectual property rights in food biotechnology.

UNIT-I

**10
Hrs.**

INTRODUCTION

Hunger, Technology and World food needs-nutritional problems, approaches to combat world hunger, roles of technology. Recent Developments in food biotechnology, introduction to molecular food biotechnology.

NOVEL BIOPROCESSING

Biosensors for food quality assessment, cold active enzymes in food processing, biotransformation in food industries.

NUTRIGENOMICS

Definition of Nutriomics, Nutrigenetics, and its applications, Nutritional genomics and applications in brief. Nutrigenetics and cancer.

UNIT-II

**11
Hrs.**

MICROBIAL BIOTECHNOLOGY OF FOOD

Metabolic engineering of bacteria for food ingredients (Amino acids, organic acids, vitamins). Introduction to technologies for microbial production of food ingredients. Solid-state fermentation for food applications (enzymes, pigments). Biotechnology of microbial polysaccharides- natural occurrence of microbial polysaccharides in foods, additives (xanthan) and its future, Microbial biotechnology of food flavor, oils and fats. Food applications of algae-nutritional value, source of neutraceuticals and industrial production processes (chlorella, spirulina, Agar, alginate). Genetics of Dairy starter cultures.

UNIT-III

**11
Hrs.**

PLANT FOOD APPLICATIONS

Genomic basics for food improvement, molecular design of soybean proteins for enhanced food quality, Genetic modifications of plant starches, plant oils, for food applications. Bioprocessing of starch using

enzyme technology. Molecular biotechnology for nutraceutical enrichment of food crops, Biotechnology of nonnutritive sweeteners, metabolic redesign of vitamin -E biosynthesis, production of new metabolites, Engineering of provitamin- A ,biosynthetic pathway into rice(Golden rice), Engineering of carotenoid biosynthesis for antioxidants, approaches to improve nutritional quality and shelf life of fruits and vegetables.

UNIT-IV

**10
Hrs.**

Enhancement of leaf quality protein for ruminant animals. Methods of chloroplast transformation, markers for transformation, engineering chloroplast for the production of edible vaccine, Transplastomic maize- a case study.

ANIMAL FOOD APPLICATIONS: Genetic modification of production traits in farm animals, Foods made from GM animals, applications of transgenic fish technology in sea food production, enzymatic synthesis of oligosaccharides-progress and recent trends.

FOOD SAFETY: international aspects of the quality and safety, [genetically modified food controversies](#). Regulation of the release of genetic modified organisms, patenting inventions in food biotechnology.

Text Books:

1. Kalidas s, Gopinadhan P, Anthony P and Robert E.Levin- “ Food Biotechnology”- second edition, CRC press, 2006
2. Gustavo F.G and Gustavo V.B,-“ Food Science and Food Biotechnology”- CRC press, 2003

Reference Books:

1. Mahesh S.-“ Plant Molecular Biotechnology”- first edition, New age international publishers, , 2008
2. Norman N.Potter and Joseph H. Hotchkiss- Food Science- fifth edition- CBS publishers and distributors, 2007.

Course Outcomes:

Course Outcomes	Programme Outcomes											Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
CO1	3 (WK1, WK2, WK3, and WK4)	2 (WK1, WK2, WK3, and WK4)	–	1 (W K8)	2 (WK2, WK6)	2 (WK1, WK5, WK7)	3 (WK 9)	2	–	–	1 (WK8)	2	3	2
CO2	3(WK1, WK2, WK3, and WK4)	3(WK1, WK2, WK3, and WK4)	2 (W K5)	2(WK 8)	3 (WK2, WK6)	1 (WK1, WK5, WK7)	2(W K9)	1	–	–	1 (WK8)	2	3	2
CO3	3(WK1, WK2, WK3, and WK4)	3(WK1, WK2, WK3, and WK4)	3 (W K5)	2(WK 8)	3 (WK2, WK6)	2 (WK1, WK5, WK7)	3(W K9)	2	–	–	1 (WK8)	2	3	3
CO4	2(WK1, WK2, WK3, and WK4)	3(WK1, WK2, WK3, and WK4)	2 (W K5)	3(WK 8)	2 (WK2, WK6)	3 (WK1, WK5, WK7)	3(W K9)	3	1	2	1 (WK8)	2	3	3

Course Code			:	22UBT623E	BIOPYTHON	Semester	:	03
L:T:P			:	3:0:0		Course Type	:	PEC
Hours/Sem.	Teaching	:	42 Hrs	CIE Marks		:	50	
	Learning (TW+SL)	:	42 Hrs	SEE Marks		:	50	
	Exam	:	06 Hrs	Total Marks		:	100	
	Total Hrs.	:	90 Hrs	Credits		:	03	

UNIT-I		10 Hrs.
Introduction and brief history of Biopython, Biopython modules, Tools and GNU/Linux, Nucleic Acid Bioinformatics, Sequences, Strings, and the Genetic Code, Sequences File Formats, Introduction to Biological Sequence Database, Sequence Motifs, Introduction to Motifs, String Matching, Consensus Sequences, Motif Finding, Promoters, De novo Motif Finding.		
UNIT-II		12 Hrs.
Sequence Alignments, Alignment Algorithms and Dynamic Programming, Alignment Software, Alignment Statistics, Short Read Mapping Multiple Sequence Alignments, Molecular Evolution, and Phylogenetics, Multiple Sequence Alignment, Phylogenetic Trees, Models of mutations, Practices Lab 4: Using BLAST on the command line, Lab 5: Phylogenetics		
UNIT-III		10 Hrs.
Genomics, The Three Fundamental “Gotchas” of Genomics, Genomic Data and File Formats, Genome Browsers, Transcriptomics, High-throughout Sequencing (HTS), RNA Deep Sequencing, Small RNA sequencing, Long RNA sequencing, Single-Cell Transcriptomics, Transcription Initiation, Transcription, Elongation, RNA Seq, Noncoding RNAs, Small Noncoding RNAs (srcRNAs), Long Noncoding RNAs, RNA Structure Prediction, Destabilizing energies. Practices: Lab 6: Genome Annotation Data, Lab 7: RNA-seq, Lab 8: RNA Structure, Lab 9: Proteins.		
UNIT-IV		10 Hrs.
Protein Alignment, Functional Annotation of Proteins, Secondary Structure prediction, Gene Ontology, Gene Regulation, Transcription Factors and ChIP-seq, MicroRNA regulation and Small RNA-seq, Regulatory Networks. Practices: Lab 8: RNA Structure, Lab 9: Proteins, Lab 10: ChIP-seq		
REFERENCE BOOKS		
1. Prof. David A. Hendrix Deep Learning with Python, Francois Chollet		
COURSE OUTCOMES		
After completion of the course student will be able to		
- Obtain knowledge on the biopython-GNU/Linux, modules, tools, commands and Motifs. - Acquire the skills of Sequence Alignments using the Softwares, Statistics, Short Read Mapping, Multiple Sequence Alignments, Molecular Evolution, - Understand and Analyze the Phylogenetics, Phylogenetic Trees, and Models of mutations. - Utilize the biopython in analysis of the Genomic and transcriptomics data. - Conduct the Protein Alignment, Functional Annotation, Secondary Structure prediction, Gene Ontology, Gene Regulation.		

Course Outcomes (CO)	Programme Outcomes (PO)											Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
CO1	2	2	2	-	3	-	-	-	-	-	3	3	2	-
CO2	2	2	2	-	3	-	-	-	-	-	3	2	2	-
CO3	2	2	2	-	3	-	-	-	-	-	3	2	2	-
CO4	2	2	2	-	3	-	-	-	-	-	3	2	2	-
CO5	2	2	2	-	3	-	-	-	-	-	3	2	2	-

Course Code		:	22UBT624E	BIOREACTOR DESIGN	Semester	:	06
L:T:P		:	3:0:0		Course Type	:	PEC
Hours/Sem.	Teaching	:	42 Hrs		CIE Marks	:	50
	Learning (TW+SL)	:	42 Hrs		SEE Marks	:	50
	Exam	:	06 Hrs		Total Marks	:	100
	Total Hrs.	:	90		Credits	:	03

Professional Competency:

Ability to apply mathematical, kinetic, and engineering transport principles to size, select, model, and operate scaled industrial bioreactor systems, translating cell line requirements into functional, stable, and highly productive automated fermentation equipment.

Course Outcomes:

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

- CO1: Bioreactor Fundamentals & Configurations: Analyze microbial, plant, and animal cell rate expressions alongside fundamental material and energy balances to select and categorize appropriate bioreactor configurations for submerged and solid-state fermentations.
- CO2: Operational Management & Control: Identify and optimize critical environmental and physical control factors required to ensure the smooth, aseptic operation of bioreactors handling free or immobilized biocatalysts and shear-sensitive cultures
- CO3: Sizing and Design of Submerged Systems: Formulate kinetic and transport design equations to size, configure, and evaluate the performance parameters of industrial Batch, Fed-Batch (Semi-continuous) and continuous flow (CSTR and PFR) bioreactors.
- CO4: Advanced Reactor Synthesis: Design specialized bioreactor configurations—including cell recycle loops, multi-stage cascading systems, and packed/fluidized beds—to maximize product yields in enzyme reactions and highly demanding biological processes.

UNIT-I

10 Hrs

BASICS OF BIOREACTORS

Overview of bioreactions, Elements in bioreactor design, Rate expression in biological systems, Basic concept of material and energy balances, Development and significance of bioreactors, Bioreactor configurations, Classification of bioreactors, Bioreactors for solid-state fermentation, plant and animal cell cultures

UNIT-II

10 Hrs

Common operations of bioreactor, Identification of common factors for smooth operation of bioreactors, Spectrum of basic bioreactor operations, Bioreactor operation for immobilised systems, plant and animal cell cultures.

UNIT-III

12 Hrs

BATCH, SEMICONTINUOUS AND CONTINUOUS BIOREACTOR DESIGN

Overview of bioreactor design, Batch and semi-continuous bioreactors for submerged fermentation of microbes, Continuous flow stirred tank and plug flow tubular bioreactors for submerged fermentation of microbes, Recycle bioreactors, Multistage bioreactors, Bioreactors for enzyme reactions and immobilized systems

UNIT-IV

10 Hrs

CASE STUDIES AND SCALE-UP

Design of packed bed, fluidized bed, airlift, hollow fibre, plant cell, mammalian cell bioreactors for various applications, Scale-up – Criteria, Similarity criteria, Methods, Generalized approaches.

Reference Books:

1. PBioreactor Design and Product Yield: Authors: BIOTOL Series (Butterworth-Heinemann).
2. Solid-State Fermentation Bioreactors: Authors: David A. Mitchell, Dr. Marin Berovič, and Dr. Nadia Krieger (Springer).
3. Bioreactor Engineering Research Horizon: Author: Samuel R. Catcheside (Nova Science Publishers).

Web links and Video Lectures (e-Resources)

1. NPTEL: Bioreactor Design and Analysis (IIT Madras): Instructor: Prof. Smita Srivastava
2. NPTEL: Aspects of Biochemical Engineering (IIT Kharagpur): Instructor: Prof. Debabrata Das
3. Interactive Process Design & Simulation Modules: LearnChemE - Biokinetics & Bioreactor Simulations (University of Colorado Boulder)

Course Outcomes:

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

Course Code		:	22UBT632N	ENVIRONMENTAL TECHNOLOGY	Semester	:	VI
L:T:P*		:	3: 0:0		Course Type	:	OEC
Hours/Sem.	Teaching	:	42Hrs.		CIE Marks	:	50
	Learning (TW+SL)	:	42 Hrs.		SEE Marks	:	50
	Exam	:	6Hrs.		Total Marks	:	100
	Total Hrs.	:	90 Hrs.		Credits	:	3

Professional Competency:

Apply environmental biotechnology principles and techniques to analyze environmental challenges, manage waste and pollution, evaluate remediation and resource recovery methods, and promote renewable energy, biodiversity conservation, and sustainable development.

Course Outcomes:

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

- CO1:** Analyze current environmental issues, environmental impact, bioaccumulation processes, and sustainable development concepts.
- CO2:** Apply principles of environmental biotechnology for wastewater treatment, solid waste management, and pollution control.
- CO3:** Evaluate bioleaching, biomining, and bioremediation technologies for environmental restoration and resource recovery.
- CO4:** Analyse biofuel production technologies and biodiversity conservation strategies for sustainable environmental management.

UNIT-I

12 Hrs.

Introduction:

Current Environmental Issues and scope of Environmental science and technology biogeochemical role of soil microorganisms, Bioconcrete, Environment Impact Assessment

Bioaccumulation of toxicants

Characteristics of Xenobiotics, Relationship of Bioaccumulation with Chemical Structure, Ecophysiology of Bioaccumulation Process of toxicants uptake, Factors affecting bioaccumulation, measurement of bioaccumulation

Sustainable future: Green building concept, Carbon foot print, crediting, trading and its calculation, Water foot print, Rain water harvesting .

UNIT-II

10 Hrs.

Waste water treatment:

Waste water characteristics BOD, COD, Primary & Secondary treatment, nanofiltration. Ultrafiltration and microfiltration Microbial removal of phosphorous and Nitrogen Wastewater treatment of industries like sugar factories, food industries, beverages industries, and distilleries.

Solid waste management

Basic aspects, general composition of municipal solid wastes, aerobic treatment, anaerobic treatment biogas generation Solid waste management. Hazardous wastes, Biomedical Wastes, E waste

management, MoEF rules.

UNIT-III

10 Hrs.

Bioleaching & Biomining:

Microbes in Bioleaching- types, methods of bioleaching, Microbial recovery of phosphate, petroleum.

Bioremediation:

Major contaminants of air, water and soil, Biomonitors of environment (Bioindicators), using microbes, Phytoremediation, Biofilms its applications Bio-stimulation of Naturally occurring microbial activities, Bio-augmentation

UNIT-IV

10 Hrs.

Biofuels:

Definition, Renewable and nonrenewable resources Advantages and disadvantages of biofuels Biofuel feed stocks-sugar starch, cellulose, lipid Types of biofuel- first, second and third generation Technologies for bio-fuel production-transesterification, gasification 2G technology, Biomethanation, Issues of biofuel production and its use. Microbial fuel cells.

Biodiversity: Value of biodiversity, threats to biodiversity approaches of biodiversity conservation

Text Books:

1. Pradipta Kumar Mahopatra, Text Book of Environmental Biotechnology, I K Publishers, 2006.
2. R.C Dubey and D K Maheshwari, Text book of Microbiology, S Chand and Company Ltd, 2013

Reference Books:

1. M Y Young, Comprehensive Biotechnology Vol 1-4 (Eds). Pergamon Press, 2004
2. EJ Dasilva, C Ratledge & A Sasson, , Biotechnology, Economic & Social Aspects Cambridge Univ Press, 2003
3. Indu Shekhar Thakur, 2012, Environmental Biotechnology Basic concepts and applications, Second Edition, I K international Publishing House, Pvt, Ltd.

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

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

Course Code		:	22UHS600C	INDIAN KNOWLEDGE SYSTEM	Semester	:	VI
L:T:P		:	01:0:0		Course Type	:	AEC
Hours/Sem.	Teaching	:	14Hrs		CIE Marks	:	50
	Learning (TW+SL)	:	13Hrs		SEE Marks	:	50
	Exam	:	03Hrs		Total Marks	:	100
	Total Hrs.	:	30Hrs		Credits	:	01

Professional competency

Apply the principles of the Indian Knowledge System to appreciate, preserve, and utilize traditional knowledge for addressing contemporary societal and professional challenges.

COURSE OUTCOMES

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

CO1: Provide an overview of the concept of the Indian Knowledge System and its importance

CO2: Appreciate the need and importance of protecting traditional knowledge.

CO3: Recognize the relevance of Traditional knowledge in different domains.

CO4: Establish the significance of Indian Knowledge systems in the contemporary world

UNIT I

3 Hrs.

Indian Knowledge Systems (IKS)

Overview, Vedic Corpus, Philosophy in Indian Knowledge system.

UNIT II

4 Hrs.

Traditional Knowledge in Mathematics

Introduction to Indian Mathematics, Unique aspects of Indian Mathematics, Indian Mathematicians and their Contribution. Number Systems and Units of Measurement.

UNIT III

4 Hrs.

Traditional Knowledge in Science

Measurements for time, distance and weight, Astronomy, Indian contributions in astronomy, Astrology, The celestial coordinate system, Elements of the Indian calendar, Notion of years and month, Panchanga – The Indian calendar system

UNIT IV

4 Hrs.

Traditional Knowledge in Professional domain

Town Planning and Architecture, Agriculture, Governance and Public Administration

Text Books:

1. Mahadevan. B. Bhat Vinayak Rajat, Nagendra Pavana R.N. "Introduction to Indian Knowledge System: Concepts and Applications", PHI Learning Private Ltd. Delhi (2022). Pride of India: A Glimpse into India's Scientific Heritage, Samskrita Bharati, New Delhi

REFERENCE BOOKS

1. Sampad and Vijay "The Wonder that is Sanskrit", Sri Aurobindo Society, Puducherry. (2011).
2. Acarya. P.K. Indian Architecture, MunshiramManoharlal Publishers, New Delhi. (1996).
3. Kapoor Kapil, Singh Avadhesh "Indian Knowledge Systems Vol – I & II", Indian Institute of Advanced Study, Shimla, H.P. (2021).
4. Dasgupta, S. A History of Indian Philosophy- Volume 1, Motilal Banarsidass, New Delhi. (1975).
5. PLofer. K. (1963). Mathematics in India, Princeton University Press, New Jersey, USA"

Web Links and Video Lectures:

1. <https://www.youtube.com/watch?v=LZP1StpYEPm>
2. <http://nptel.ac.in/courses/121106003/>
3. <http://www.iitkgp.ac.in/departement/KS;jsessionid=C5042785F727F6EB46CBF432D7683B63>
(Centre of Excellence for Indian Knowledge System, IIT Kharagpur)
4. https://www.wipo.int/pressroom/en/briefs/tk_ip.html
5. https://unctad.org/system/files/official-document/ditcted10_en.pdf
6. http://nbaindia.org/uploaded/docs/traditionalknowledge_190707.pdf
development goals/?gclid=EALalQobChMlnpJtb_p8gIVTeN3Ch2
7. <https://unfoundation.org/what-we-do/issues/sustainable>
developmentgoals/?gclid=EALalQobChMlnp-

Course Outcomes	Programme Outcomes											Programme Specific Outcomes		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
CO 1	2 WK1	2 WK2 &7	-	1 WK4	-	2 WK7	1	3	-	2 WK1 0	2 WK 11	-	-	-
CO 2	1 WK1	2 WK2 &7	-	-	-	3 WK7	2 WK 8	3 WK 9	-	1 WK1 0	2 WK 11	-	-	-
CO 3	2 WK1	2 WK2 &7	1 WK3& 8	-	1	3 WK7	3 WK 8	3 WK 9	-	2 WK1 0	2 WK 11	-	-	-
CO 4	2 WK1	2 WK2 &7	2 WK3& 8	-	1	3 WK7	2 WK 8	3 WK 9	1 WK 10	2 WK1 0	3 WK 11	-	-	-

Course Code		:	22UBT605L	BIOKINETICS & ENZYME TECHNOLOGY LAB	Semester	:	06
L:T:P		:	0:0:2		Course Type	:	PCCL
Hours/Sem.	Teaching	:	26		CIE Marks	:	50
	Learning (TW+SL)	:	-		SEE Marks	:	50
	Exam	:	04 Hrs.		Total Marks	:	100
	Total Hrs.	:	30		Credits	:	01

Professional competency

Derive the kinetic expressions for the enzyme catalysed reactions. Estimate the activity and specific activity of free and immobilized enzymes, comprehend the importance of enzymes in disease diagnosis and industrial application

COURSE OUTCOMES

After completion of the course student will be able to

1. Isolate enzymes and plot calibration curves for estimation the enzyme activity and specific activity.
2. Evaluate the optimum pH and temperature required for enzyme activity and analyze the effect of inhibitors for enzyme activity.
3. Apply knowledge of K_m & V_{max} for enzyme activity.
4. Immobilize enzymes and find the activity of enzymes.

LIST OF EXPERIMENTS

1. Isolation of alpha-amylase from sweet potato or saliva
2. Maltose calibration curve by DNS method
3. Determination of activity of Salivary alpha-amylase
4. Determination of Specific activity of an enzyme
5. Effect of pH and temperature on enzyme activity
6. Determination of Kinetics constants (K_m & V_{max})
7. Urea calibration curve
8. Determine the activity of enzyme Urease
9. Effect of inhibitors on enzyme activity
10. Immobilization of enzyme and determination of immobilized enzyme activity
11. Prediction of % error, standard deviation need to be calculated from expt. no 5 and 6)

12 Hrs.

REFERENCE BOOKS

1. Pattabiraman 2017. Laboratory manual of Biochemistry, 4th Edition, International Book Publishers, India.
2. Sadasivam and Manickam, 2017, Biochemical methods, 2nd Edition, New age International Publishers.

Course Outcomes	Programme Outcomes											Programme Specific Outcomes		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3

CO 1	1 (WK 1, WK2, WK3, and WK4)	2 (WK1, WK2, WK3, and WK4)	3 (WK5)	2 (WK8)	2 (WK2 and WK6)	3 (WK1, WK5 & WK7)	3	2	-	-	3 (WK8)	3	3	3
CO 2	2 (WK 1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	3 (WK5)	2 (WK8)	2 (WK2 and WK6)	2 (WK1, WK5 & WK7)	2	2	-	-	3 (WK8)	3	3	3
CO 3	2 (WK 1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	2 (WK5)	3 (WK8)	2 (WK2 and WK6)	3 (WK1, WK5 & WK7)	2	2	-	-	2 (WK8)	3	1	2
CO 4	3 (WK 1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	3 (WK5)	2 (WK8)	2 (WK2 and WK6)	2 (WK1, WK5 & WK7)	2	2	-	-	2 (WK8)	2	1	2

VII SEMESTER

Course Code		:	21UBT701C	BIOETHICS, BIOSAFETY AND REGULATORY AFFAIRS	Semester	:	07
L:T:P		:	3:0:0		Course Type	:	PCC
Hours/Sem.	Teaching	:	42 Hrs		CIE Marks	:	50
	Learning (TW+SL)	:	42 Hrs		SEE Marks	:	50
	Exam	:	06Hrs		Total Marks	:	100
	Total Hrs.	:	90		Credits	:	03

Professional Competency:

Graduates will apply principles of Bioethics, Biosafety protocols and national/international regulatory guidelines to plan, conduct and evaluate research and biotechnological applications responsibly.

Course Outcomes:

1. Apply the knowledge of the basic aspects of hazards and safety in Industries and use the safety measures at work place.
2. Apply the basics of Bioethics & Legal Issues in the field of Biotechnology.
3. Apply the knowledge of Biosafety and Biosafety regulation guidelines for the research pertaining to applications in Biotechnology.
4. Comprehend the various regulatory requirements and Regulatory Affairs required in the field of Biotechnology.

UNIT-I

10 Hrs.

Safety:

Need for safety, importance of occupational safety, unsafe conditions, Factors contributing to unsafe conditions. Good Lab Practices (GLP).

Accidents: Accident preventive measure, Measurement and control of safety performance, 5E's for accident prevention Safety policy Engineering, Education, Enthusiasm, Enforcement and Evaluation. Hierarchy of Controls. Conflict resolution techniques.

Fire: Classification of fire, Fire extinguishers, fire extinguishing agents, Evacuation procedure for workers during emergency.

Chemical Hazards- Classification of chemicals based on their nature, routes to exposure of chemicals, Health effects of harmful chemicals in the work environment, Control of chemical hazards. Classification of Occupational health hazards.

UNIT-II

10 Hrs.

Introduction to Bioethics & Legal Issues:

Scope of bioethics. Legal and Socio- Economic impacts of Biotechnology. Convention on biological weapons. Bioterrorism-classification of biological agents with examples. Bioethics vs. business ethics. Procedure to apply patent, Copy right, Plant Breeder's Right. Risk groups, risk assessment during laboratory research. Laboratory associated infections and other hazards. Recombinant organisms and transgenic crops with examples. Genetically modified organisms and their release in environment, Containments; Physical and Biological. Field trial methods using transgenic Plants. Guideline for labeling GM crops.

UNIT-III

10 Hrs.

Introduction to Biosafety and Biosafety regulation guidelines:

Definition and scope of biosafety need for biosafety, Biosafety guidelines- national guidelines, Recombinant DNA Advisory Committee (RDAC), Institutional Biosafety committee (IBC), Review Committee on Genetic Modification (RCGM), Genetic Engineering Approval Committee (GEAC), Biosafety assessment procedures for biotech foods. Cartagena Protocol on Biosafety. HAACP system, Biosafety levels for microorganism BL1, BL2, BL3, BL4) plants (BL1-P, BL2-P, BL3-P, BL4-P) animals (BL1-N, BL2-N, BL3-N, BL4-N). Classification of dangerous materials with pictorial

symbols. Safety in transportation of dangerous materials by road, rail, ships and pipelines.

UNIT-IV

10 Hrs.

Regulatory Affairs:

The Fundamentals of Regulatory Compliance with respect to Good Clinical Practice (GCP) & Good Manufacturing Practice (GMP) FDA, FAO, CDER. ICH guidelines- Storage conditions, Photostability testing, Introduction to the Basic Concepts of Process Validation & how it Differs from Design Qualification (DQ), Installation Qualification (IQ), Operation Qualification (OQ), Performance Qualification (PQ) Procedures. A Review of Prospective, Concurrent, Retrospective Validation & Revalidation.

Text Books:

1. Sateesh M.K.(2012), Bioethics and Biosafety, I.K. International Publication

Reference Books:

1. Singh B.D. (2010), Biotechnology Expanding Horizon (3rd revised edition), Kalyani Publishers.
2. Goel D and Parashar S (2010), IPR-Biosafety and Bioethics (2nd edition), Pearson Education India

Web links and Video Lectures (e-Resources)

1. https://www.nptel.ac.in/?utm_source
2. https://nptel.ac.in/courses/127106136?utm_source

Course Outcomes:

Course Outcomes	Programme Outcomes											Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
CO1	3 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	3 (W K5)	3 (W K8)	3 (WK 2, WK6)	3 (WK1 ,WK5, WK7)	3 (W K9)		-	-	3 (WK 8)	3	3	3
CO2	3 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	3 (W K5)	3 (W K8)	2 (WK 2, WK6)	3 (WK1 ,WK5, WK7)	3 (W K9)		-	-	3 (WK 8)	3	3	3
CO3	3 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	3 (W K5)	3 (W K8)	2 (WK 2, WK6)	3 (WK1 ,WK5, WK7)	3 (W K9)		-	-	3 (WK 8)	3	3	3
CO4	3 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	3 (W K5)	3 (W K8)	3 (WK 2, WK6)	3 (WK1 ,WK5, WK7)	-		-	-	3 (WK 8)	3	3	3

Course Code		:	21UBT702C	DOWNSTREAM PROCESSING TECHNOLOGY	Semester	:	07
L:T:P*		:	2:0:0		Course Type	:	PCC
Hours/Sem.	Teaching	:	28 Hrs.		CIE Marks	:	50
	Learning (TW+SL)	:	26 Hrs.		SEE Marks	:	50
	Exam	:	6 Hrs.		Total Marks	:	100
	Total Hrs.	:	60 Hrs.		Credits	:	02

Professional Competency:

Ability to formulate and design experiments and scale for primary isolation, chromatographic purification, and handle finishing operations—to achieve high recovery yield, purity, and stability for biopharmaceuticals, enzymes, and industrial biomolecules.

Course Outcomes:

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

- CO1: Evaluate cell disruption techniques and apply centrifugal separation principles for the primary harvest of intracellular and extracellular bioproducts.
- CO2: Formulate primary recovery strategies using fractional precipitation, liquid-liquid/solid-liquid extraction, and membrane-based ultrafiltration for partial purification and concentration of crude biomolecules.
- CO3: Analyze and select high-resolution chromatographic methods alongside selective extraction systems for target bioproduct isolation and analytical purity assessment.
- CO4: Conduct product finishing operations to ensure structural stability and long-term shelf life of bioproducts.

UNIT-I

7 Hrs.

Introduction:

Role and Importance of Downstream Processing in Biotechnological processes; Range and characteristics of bioproducts; Downstream processing and steps- primary, product purification, and finishing process with flowchart; Cell disruption methods for intracellular products- physical, chemical, and mechanical methods; Centrifugation, Ultracentrifugation (preparative and analytical), Types of centrifuges and rotors; Differential, Density gradient (zonal and isopycnic).

UNIT-II

7 Hrs.

Primary Recovery or Partial Purification:

Precipitation of Proteins, Nucleic acids, and Bioproducts by Ammonium sulfate, Polyethylene Glycol, and Solvents; Dialysis; Conventional Solid-Liquid extraction, Advanced Methods like Ultrasound, Microwave-assisted, Supercritical fluid Extractions; Solid-phase Extraction (Adsorption); Liquid-liquid Extraction; Ultrafiltration and Membrane-based separations.

UNIT-III

7 Hrs.

Product Purification:

Selective Separation Techniques- Aqueous Two-phase Extraction, Micellar and Reverse Micellar Extraction; Chromatographic Techniques- Liquid chromatography - Thin layer, Ion Exchange, Gel Filtration, Affinity Chromatography; High-Performance Liquid Chromatography- Normal and Reverse Phase; Gas Chromatography.

UNIT-IV

5 Hrs.

Product Finishing

Drying- Spray drying; Evaporation-Rotary evaporation; Crystallization; and Lyophilization

Reference Books

1. Bioseparations: Downstream Processing for Biotechnology: Authors: Paul A. Belter, E. L. Cussler, and Wei-Shou Hu (John Wiley & Sons).
2. Bioseparations Science and Engineering: Authors: Roger G. Harrison, Paul W. Todd, Scott R. Rudge, and

Demetri P. Petrides (Oxford University Press).

3. Bioseparations: Principles and Techniques: Author: B. Sivasankar (PHI Learning).

4. Biophysical chemistry principles and Techniques by Upadhyay and Nath, Himalaya Publishing House.

Web links and Video Lectures (e-Resources)

1. NPTEL: 1. Comprehensive Video Lecture Series (NPTEL / SWAYAM)

Principles of Downstream Techniques in Bioprocess (IIT Madras) Instructor: Prof. Mukesh Doble

Course Outcomes	Programme Outcomes											Programme Specific Outcomes		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
CO 1	1 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	3 (WK5)	2 (WK8)	2 (WK2 ,WK6)	1 (WK1 ,WK5 ,WK7)	-	-	-	-	1 (WK8)	2	3	1
CO 2	1 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	3 (WK5)	2 (WK8)	2 (WK2 ,WK6)	1 (WK1 ,WK5 ,WK7)	-	-	-	-	1 (WK8)	2	3	1
CO 3	2 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	3 (WK5)	3 (WK8)	2 (WK2 ,WK6)	1 (WK1 ,WK5 ,WK7)	-	-	-	-	1 (WK8)	2	3	1
CO 4	2 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	3 (WK5)	2 (WK8)	2 (WK2 ,WK6)	1 (WK1 ,WK5 ,WK7)	-	-	-	-	1 (WK8)	2	3	1

Hours/Sem.	Code	:	21UBT703H	BIOENTREPRENEURSHIP DEVELOPMENT	Semester	:	7
	LTP	:	3:0:0		Course Type	:	HSMC
	Teaching	:	42 Hrs.		CIE Marks	:	50
	Learning (TW+SL)	:	42 Hrs.		SEE Marks	:	50
	Exam	:	6 Hrs.		Total Marks	:	100
	Total Hrs.	:	90 Hrs.		Credits	:	3
Professional Competency:							
Demonstrate the ability to understand entrepreneurial skills, market analysis, management functions, product and personnel management, material management, and preparation of project feasibility reports for successful venture creation and management.							
Course Outcomes:							
At the end of the course, the student will be able to:							
CO1. Explain the concepts, characteristics, types and processes of entrepreneurship, technology readiness levels, innovation life cycle, design thinking and the role of incubation and government support systems in biotechnology entrepreneurship							
CO2. Identify and evaluate biotechnology-based business opportunities using market survey techniques, data collection methods, production planning and business plan development approaches.							
CO3. Apply principles of production, financial, personnel, material and marketing management for effective planning and operation of a biotechnology enterprise.							
CO4. Develop a preliminary business plan for a biotechnology venture by integrating opportunity assessment, costing and pricing, financial analysis, marketing strategy, regulatory requirements and available government commercialization schemes.							
UNIT-I							10 Hrs.
INTRODUCTION TO BIOENTREPRENEURSHIP:							
Entrepreneur & Entrepreneurship: Definition, History, Concept, Characteristics, Need & Importance, Types of entrepreneurship, Entrepreneurial process.							
Technology readiness levels (TRLs); Innovation life cycle; Design thinking for biotechnology innovations; Startup ecosystem—Startup India, Make in India, Atal Innovation Mission, BIRAC, DBT, DST, MSME schemes.							
Technology Business Incubators (TBIs): NIDHI, BioNEST and incubation support systems. Biotechnology entrepreneurship bridges science with commercialization and is increasingly emphasized in engineering curricula.							
Soft Skills for entrepreneurs: Soft skills - Communicative skills, Creativity & Problem solving skills, & other managerial & leadership skills.							
UNIT-II							12 Hrs.
BUSINESS OPPORTUNITY IDENTIFICATION:							
Identification of business opportunity, Market survey tools, preparation of schedule and techniques of data collection. Production programme, plant capacity, manpower requirements and layout. Business plan format for micro and small enterprises.							
ENTREPRENEURSHIP MANAGEMENT AND ITS FUNCTIONS:							
Principle functions of management: planning, organizing, staffing, coordinating & controlling. Concept of Authority & Responsibility. Social responsibilities of the management: to the owners, employees, customers, community & government.							
Administration: Definition, Nature, Principles & Elements of management. Management VS administration.							
UNIT-III							10 Hrs.
PRODUCTION MANAGEMENT:							
Concept of productivity, measuring productivity, Productivity improvement techniques.							
Concept of budget, classifications of the budget, components of budget, effective budgetary control. Break even analysis. Manufacturing /material planning, factory planning. Systems of wage payments, bonus, automation. Organization of production planning.							

PERSONNEL MANAGEMENT:

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

Employer - Employee relationship. Settlement of disputes.

UNIT-IV**10 Hrs.****MATERIAL AND MARKETING MANAGEMENT :**

Material Functions of purchasing & materials management, quality, quality standard & inspection, sources of supply, pricing, principles & practices, Inventory management (ABC analysis), product promotional strategy Entrepreneurship in Biobusiness: BioMedical field, Clinical research, Agriculture. Government schemes for commercialization of technology. Legal requirements

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

Text Books:

1. Craig D. Shimasaki, *Biotechnology Entrepreneurship: Leading, Managing and Commercializing Innovative Technologies*, 2nd Ed., Elsevier/Academic Press, 2020, ISBN: 978-0-12-815585-1.
2. Robert D. Hisrich, Michael P. Peters, Dean A. Shepherd and Sabyasachi Sinha, *Entrepreneurship*, 11th Ed., McGraw Hill Education, 2020, ISBN: 978-93-90113-30-9.
3. Bruce R. Barringer and R. Duane Ireland, *Entrepreneurship: Successfully Launching New Ventures*, 7th Ed., Pearson, 2024, ISBN: 978-0-13-828769-6.
4. Donald F. Kuratko, *Entrepreneurship: Theory, Process, Practice*, 12th Ed., Cengage Learning, 2024, ISBN: 978-0-357-89950-2.
5. S. S. Khanka, *Entrepreneurial Development*, 5th Ed., S. Chand Publishing, 2026, ISBN: 978-93-69582-39-6

Reference Books:

1. Poornima Charanthimath – Entrepreneurship Development –small business enterprises, Pearson Education, 5th Edition,- 2009.
2. NSTEDB material for entrepreneurship development programme, EDI, Ahmadabad

Reference/Web Resources

- BIRAC
- Department of Biotechnology (DBT)
- Department of Science and Technology (DST)
- Startup India
- Ministry of MSME
- NITI Aayog – Atal Innovation Mission
- NIDHI Programme
- BioNEST Incubation Programm

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

CO3	1 (WK1, WK2, WK3 andWK4)				2 (WK2, andWK6)			2		3	3 (wk8)	-	-	-
CO4	1 (WK1, WK2, WK3 andWK4)	1 (WK1, WK2, WK3 andWK 4)			2 (WK2, andWK6)			1		3	3 (wk8)	-	-	-

Reference Books:

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

Course Outcomes	Programme Outcomes											Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
CO1	3(WK1, WK2, WK3 andWK4)	2(WK1, WK2,WK3 andWK4)	1(WK 5)	1(WK 8)	""	1(WK1, WK53 andWK7)	""	""	""	""	2(WK 8)	1	2	1
CO2	3((WK1, WK2,WK 3 andWK4)	3(WK1, WK2,WK3 andWK4)	2(WK 5)	2(WK 8)	1	1(WK1, WK53 andWK7)	1(WK 9)	""	""	""	2(WK 8)	1	2	2
CO3	3(WK1, WK2,WK 3 andWK4)	3(WK1, WK2,WK3 andWK4)	2(WK 5)	3(WK 8)	2	2 (WK1, WK53 andWK7)	2(WK 9)	1	1	""	2(WK 8)	1	2	1
CO4	3(WK1, WK2,WK 3 andWK4)	3(WK1, WK2,WK3 andWK4)	2(w k5)	2(WK 8)	3	2(WK1, WK53 andWK7)	1(WK 9)	1	1	1	2(WK 8)	1	2	2

Course Code : 21UBT732E			FOOD PROCESSING TECHNOLOGY	Semester : 7
L:T:P : 3: 0:0				Course Type : PEC
Hours/Sem.	Teaching : 42 Hrs.			CIE Marks : 50
	Learning (TW+SL) : 42 Hrs.			SEE Marks : 50
	Exam : 6 Hrs.			Total Marks : 100
	Total Hrs. : 90 Hrs.		Credits : 3	
Professional Competency:				
Ability to analyze food composition, quality, safety, spoilage, preservation, processing, packaging, and product development while applying food engineering principles and adhering to professional, ethical, regulatory, and sustainability requirements in the food industry.				
Course Outcomes:				
After completion of the course, student will be able to:				
CO1:Analyze the basic constituents and importance various nutrients in food				
CO2: Examine the techniques involved in detection of microbes in food industry, and analyse the steps in food production				
CO3: Differentiate the microbes causing food spoilage and exhibit the preservation techniques and to know the Characteristics of food industry and scope				
CO4: Apply the concepts of food Engineering and food waste management				
UNIT-I				10 Hrs.
Introduction				
Constituents of food, soluble fibres, protein rich foods, popular fats and oils in foods, Food flavors, Browning reactions and its effects. Intrinsic and extrinsic parameters of foods, effect of inhibitors, pH and temperature. Minerals in foods. Aroma compounds in foods. Food additives, Vitamins, aminoacids, Sweeteners, Food colours. Toxic-trace elements in food.				
UNIT-II				12 Hrs.
Detection of Microorganisms				
Culture, Microscopic and Sampling Methods, Conventional; SPC, Membrane Filters, Microscope colony Counts, Agar Droplets, Dry Films, Most probable Numbers (MPN), Dye reduction, Roll Tubes, Direct, Microscopic Count (DMC), Microbiological Examination of surfaces, Air Sampling, Metabolically Injured Organisms, Enumeration and Detection of Food-borne Organisms. Dairy products: Composition of milk, Sterilization of milk (Pasteurization and UHT), Cheese production, Acidophilus milk Yoghurt, Kumiss and Kefir. Marketingscopeofdairy&foodproductsFruitandvegetableprocessing:Jam,jelly,Juice, squash, wine, pickles and sauerkraut				
UNIT-III				10 Hrs.
Food Spoilage &Preservation				
The Role and Significance of Microorganisms, Primary Sources of Microorganisms found in Foods Synopsis of common borne bacteria, Molds& Yeasts. Microbial Spoilage of Vegetables, Fruits, Fresh and Processed Meats, Poultry, and Seafood. Spoilage of Miscellaneous Foods, Food Preservation: Principles Underlying in spoilage and preservation, Application, Effect and Legal Status of Food Irradiation, Food Preservation with Low Temperatures, High Temperatures and Drying. Food Industry: Characteristics of Food Industry. Nutritional food supplements. Food packaging, New trends in packing, edible films. Factors influencing food product development, marketing and promotional strategies, Risks and benefits of food industry				
UNIT-IV				10 Hrs.
Food Engineering				
Properties of fluid foods, Measurement of rheological parameters .Thermal properties of frozen foods. Food freezing equipment, storage of frozen foods. Food dehydration: Freeze Dehydration Calculation of drying times. Food waste management				

Text Books:

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

Reference Books:

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

Course Outcomes:

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

Course Code		:	21UBT733E	BIOSIMULATIONS	Semester	:	7
L:T:P		:	3:0:0		Course Type	:	PEC
Hours/Sem.	Teaching	:	42 Hrs		CIE Marks	:	50
	Learning (TW+SL)	:	42 Hrs		SEE Marks	:	50
	Exam	:	06 Hrs		Total Marks	:	100
	Total Hrs.	:	90 Hrs		Credits	:	3

Professional Competency:

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

Course Outcomes:

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

- CO1:** Explain the principles of mathematical modeling and apply fundamental conservation laws, transport equations, and reaction kinetics to biological and biochemical systems.
- CO2:** Develop and analyze mathematical models for biochemical engineering processes including batch, continuous, and continuous stirred tank reactor (CSTR) systems.
- CO3:** Apply bioprocess simulation software such as SuperPro Designer, COPASI, and COBRA to perform material, energy, and metabolic flux balance analyses.
- CO4:** Use MATLAB and SIMULINK to analyze experimental data, solve engineering problems numerically, and simulate dynamic biochemical systems.

UNIT-I

10 Hrs.

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

UNIT-II

11 Hrs.

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

UNIT-III

11 Hrs.

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

UNIT-IV

10 Hrs.

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

Text Books:

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

Reference Books:

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

Course Outcomes:

Course	Programme Outcomes	Program Specific Outcomes
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Outcomes												(PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
CO1	3(WK1, WK2, WK3 WK4)	2(WK1, WK2, WK3 WK4)	-	1(WK8)	-	-	-	-	-	-	1(WK8)	1	2	2
CO2	3(WK1, WK2, WK3 WK4)	3(WK1, WK2, WK3 WK4)	2(WK 5)	2(WK8)	1(WK 6)	-	-	-	-	-	1(WK8)	1	2	2
CO3	2(WK1, WK2, WK3 WK4)	3(WK1, WK2, WK3 WK4)	22(WK 5)	3(WK8)	3(WK 6)	-	-	-	1	-	1(WK8)	2	2	2
CO4	2(WK1, WK2, WK3 WK4)	3(WK1, WK2, WK3 WK4)	22(WK 5)	3(WK8)	3(WK 6)	-	-	-	1	1	1(WK8)	2	2	2

Course Code :		21UBT734E	BIOANALYTICAL TECHNIQUES	Semester :	07
L:T:P* :		3:0:0		Course Type :	PEC
Hours/Sem.	Teaching :	42 Hrs.		CIE Marks :	50
	Learning (TW+SL) :	42 Hrs.		SEE Marks :	50
	Exam :	6 Hrs.		Total Marks :	100
	Total Hrs. :	90 Hrs.		Credits :	03

Professional Competency:

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

Course Outcomes:

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

- CO1: Optical Spectroscopy & Centrifugation: Apply the principles of preparatory/analytical centrifugation to isolate cell fractions, and utilize UV-Visible and Fluorescence spectroscopy to quantify biomolecule concentrations and probe protein binding sites.
- CO2: Advanced Structural Spectroscopy & Spectrometry: Interpret analytical data from advanced spectroscopic instruments (FTIR, ORD/CD, NMR) and mass spectrometers (LC-MS, GC-MS) to elucidate the molecular mass, functional groups, and 3D conformations of biological macromolecules.
- CO3: Chromatographic Separations: Evaluate and select appropriate chromatographic techniques (Gel Filtration, Ion-Exchange, Affinity, GC, and HPLC) to design high-resolution purification strategies and estimate the molecular weight of target bioproducts.
- CO4: High-Resolution Electrophoresis & Crystallography: Resolve complex proteomic and genomic mixtures using advanced electrophoretic systems (2D-PAGE, Capillary, PFGE), and determine the atomic-level structural coordinates of biological crystals using X-ray diffraction mechanics.

UNIT-I

10 Hrs.

SPECTROSCOPY :

(i) Absorption Spectroscopy

Simple theory of absorption of light by molecules, Chromophore and terminologies associated with absorption of molecules The Beer-Lambert Law and its deviations

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

Empirical rule for the absorption spectra of biological macromolecules

Chemical Analysis by absorption spectroscopy using Visible and Ultraviolet light

(ii) Fluorescence Spectroscopy

Simple theory of Fluorescence Instrumentation and Technology of Fluorescence Spectroscopy **(Fluorescence spectrometer)** Intrinsic Fluorescence measurements for information about the conformation and binding sites of proteins Extrinsic fluorescence measurements for information about the conformation and binding sites of proteins

UNIT-II

10 Hrs.

(iii) Infrared Spectroscopy

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

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

Theory of Optical Rotatory Dispersion (ORD) & Circular Dichroism (CD)

Relative values of ORD and CD measurements, Advantages of CD over ORD

Instrumentation for measuring ORD and CD, Applications of ORD and CD

(v) Nuclear Magnetic Resonance (NMR) Spectroscopy

Nuclear Magnetic Resonance (NMR) Spectroscopy : Principle Basic Instrumentation of NMR Spectrometer Applications of NMR Spectroscopy (vi) Mass spectrometry Mass spectrometry: Basic Principle Instrumentation and main components of mass spectrometers Ionization source, Mass analyzers, and Detectors (LC-MS and GC-MS) Applications of Mass Spectrometry	
UNIT-III	12 Hrs.
CHROMATOGRAPHY Adsorption Chromatography: Simple Theory & Types Operations of columns : Terminologies and concept Elution : Types of elution methods Supports : Concept of mesh size and mesh screen Gas Chromatography: Principle, Basic set up of Gas chromatography system, Detectors and Uses of Gas chromatography Gel Chromatography (molecular-sieve chromatography): Simple Theory, Materials (dextran, agarose and polyacrylamide gels), Advantages of gel chromatography, Estimation of molecular weight and applications of gel chromatography Ion-Exchange Chromatography: Principle, Properties of Ion Exchangers, Choice of Ion Exchangers, Technique and application of Ion Exchange chromatography. HIGH-PERFORMANCE OF LIQUID CHROMATOGRAPHY (HPLC): Principle, Application of pressure in HPLC, Advantages and uses of HPLC. Affinity Chromatography: Principle, Methods of Ligand immobilization (Cyanogen-bromide-activated agarose, Aminoethyl- and hydrazide-activated polyacrylamide), uses of affinity chromatography.	
UNIT-IV	10 Hrs.
ELECTROPHORESIS Iso-electric focusing (IEF): Principle, Technique and application, 2-D PAGE: Steps involved in 2-D PAGE, application in proteomics Pulse-field gel electrophoresis: Principle, Technique and Application Capillary electrophoresis: Principle, Technique and Application X-RAY CRYSTALLOGRAPHY Interaction of X-ray with matter: Absorption, Scattering and diffraction (Bragg' s Law) Preparation of crystals : Hanging and sitting drop vapor diffusion methods X-ray diffraction methods Application of X-ray Diffraction in Crystal structure	
Reference Books	
1. Fundamentals of Bioanalytical Techniques And Instrumentation, Ghosal, Sabari, Avasthi, Anupama Sharma, Second Edition, Phi Learning Pvt. Ltd., 2018. 2. Bioanalytical Techniques, Abhilasha Shourie, Shilpa S. Chapadgaonkar, The Energy and Resources Institute, 2015 3. Biomolecular and Bioanalytical Techniques: Theory, Methodology and Applications, Vasudevan Ramesh, John Wiley & Sons Ltd, 2019 4. Handbook of Analytical Techniques, Helmut Günzler, Alex Williams, WILEY, 2001 5. Analytical Techniques in Biotechnology, Suzy Hill, Syrawood Publishing House, 2016 6. Analytical Techniques In Biotechnology, Goutam Bhowmik, Tata McGraw Hill Education Private Limited, 2010 7. Instrumental Methods of Chemical Analysis, G. R. Chatwal and A. K. Sham, 5th edition Himalaya Publishing House, 2005. 8. Instrumental Analysis, D. A. Skoog, F. J. Holler, S. R. Crouch, 11th edition, Brooks/Cole, a part of Cengage Learning, 2012.	
Web links and Video Lectures (e-Resources)	

- 1. NPTEL: Bioanalytical Techniques and Bioinformatics (IIT Guwahati):** Instructors: Dr. Nitin Chaudhary and Dr. Vishal Trivedi
- 2. NPTEL: Biophysical Chemistry (IIT Delhi):** Instructor: Prof. Pramit Kumar Chowdhury

Course Outcomes	Programme Outcomes											Programme Specific Outcomes		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
CO 1	3 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	2 (WK5)	2 (WK8)	2 (WK2 ,WK6)	1 (WK1, WK5, WK7)	-	-	-	-	1 (WK 8)	2	3	-
CO 2	3 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	2 (WK5)	2 (WK8)	1 (WK2 ,WK6)	1 (WK1, WK5, WK7)	-	-	-	-	1 (WK 8)	2	3	-
CO 3	3 (WK1, WK2, WK3, and WK4)	2 (WK1, WK2, WK3, and WK4)	3 (WK5)	3 (WK8)	3 (WK2 ,WK6)	-	-	-	-	-	2 (WK 8)	2	3	1
CO 4	3 (WK1, WK2, WK3, and WK4)	2 (WK1, WK2, WK3, and WK4)	3 (WK5)	2 (WK8)	1 (WK2 ,WK6)	2 (WK1, WK5, WK7)	1 (W K9)	-	-	2	1 (WK 8)	2	3	2

Course Code		:	21UBT741E	NANOBIOTECHNOLOGY AND BIOMATERIALS	Semester	:	07
L:T:P		:	3:0:0		Course Type	:	PCC
Hours/Sem.	Teaching	:	42 Hrs		CIE Marks	:	50
	Learning (TW+SL)	:	42 Hrs		SEE Marks	:	50
	Exam	:	06Hrs		Total Marks	:	100
	Total Hrs.	:	90		Credits	:	03

Professional Competency:

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

COURSE OUTCOMES

After completion of the course student will be able to

1. Explain the characterization techniques and importance of nano-particles in drug delivery system of nanotechnology.
2. Understand the importance of biopolymers and Differentiate biopolymer and synthetic polymer.
3. Understand the importance of biocompatibility.
4. Apply the methods to test the implants and use in medical devices.

UNIT-I

12 Hrs.

INTRODUCTION TO NANOTECHNOLOGY:

A

BRIEF HISTORY OF THE NANO PARTICLES: Bottom-Up versus Top-Down; What Is Nanobiotechnology. Discussions on nanofabrication, nanolithography, nanotubes, buckyballs, structure-property relationships in materials, materials characterization techniques, scanning electron, scanning tunneling and atomic force microscopy(SEM,STM & AFM), biomolecule-surface interactions, quantum dots,

APPLICATIONS OF NANOTECHNOLOGY IN THE LIFE SCIENCES:

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

UNIT-II

10 Hrs.

BIOPOLYMERS:

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

UNIT-III

10 Hrs.

SYNTHETIC POLYMERS:

Polymers

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

UNIT-IV

10 Hrs.

BIOCOMPATIBILITY:

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

MEDICAL DEVICES:

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

REFERENCE BOOKS

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

3. K Eric Drexler (1993). "Unbounding the future" Quill.
4. Stephen Lee and Lynn M Savage (2010). "Biological molecules in Nanotechnology".

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

Course Code		:	21UBT742E	FOOD PRODUCT DEVELOPMENT	Semester	:	7
L:T:P		:	3:0:0		Course Type	:	PEC
Hours/Sem.	Teaching	:	42 Hrs.		CIE Marks	:	50
	Learning (TW+SL)	:	42 Hrs.		SEE Marks	:	50
	Exam	:	6 Hrs.		Total Marks	:	100
	Total Hrs.	:	90 Hrs.		Credits	:	3
Professional Competency:							
Develop innovative, safe, and market-oriented food products by applying principles of food formulation, processing, quality assurance, regulatory compliance, and commercialization while demonstrating professional and entrepreneurial skills.							
Course Outcomes:							
After completion of the course, student will be able to:							
CO1: Demonstrate the principles, stages, regulations, and market aspects involved in food product development.							
CO2: Apply formulation, processing, packaging, and quality assurance principles for developing safe and high-quality food products.							
CO3: Evaluate food products using sensory, nutritional, physicochemical, and microbiological quality assessment techniques, and prepare technical documentation.							
CO4: Apply the concepts of functional food development, product commercialization, entrepreneurship, and industrial scale-up to develop innovative food products.							
UNIT-I						12 Hrs.	
INTRODUCTION TO FOOD PRODUCT DEVELOPMENT							
Food industry trends and market opportunities , Consumer needs and market research, Product development processes : Idea generation, screening, concept development, prototype development, commercialization ,Product life cycle ,Competitor analysis and benchmarking, Intellectual Property Rights (IPR) in food products ,Food regulations and labeling requirements Food standards (FSSAI, Codex Alimentarius) The product development process, privacy policies and Knowledge of basic laboratory procedures, Standard Operating Procedure (SOPs), process flows in manufacturing, product life cycle and competitor studies.							
UNIT-II						10 Hrs.	
FOOD FORMULATION AND PROCESSING							
Selection of raw materials and ingredients, Functional properties of food ingredients, Product formulation techniques, Standardization of recipes, Processing methods for food products, Product optimization, Food packaging materials and technologies, Shelf-life studies and storage conditions Quality assurance and Good Manufacturing Practices (GMP)							
UNIT-III						10 Hrs.	
FOOD FORMULATION AND PROCESSING SELECTION OF RAW MATERIALS AND INGREDIENTS							
Functional properties of food ingredients, Product formulation techniques, Standardization of recipes Processing methods for food products, Product optimization, Food packaging materials and technologies, Shelf-life studies and storage conditions, Quality assurance and Good Manufacturing Practices (GMP)							
UNIT-IV						10 Hrs.	
FUNCTIONAL FOODS AND PRODUCT COMMERCIALIZATION							
Functional foods and nutraceuticals, Probiotics and prebiotics, Fortified foods, Sports nutrition products, Geriatric and pediatric foods, Plant-based and alternative protein products, Product branding and marketing, Entrepreneurship in food product development, Scale-up from laboratory to pilot plant, Case studies on successful food product innovations.							

Text Books:														
1. Food Science & Nutrition, by Sunetra Roady, Oxford University Press, 2007.														
2. FoodmicrobiologybyWilliamFrazierandWesthoffD.C,4 th Edn,TATAMcGrawHill Pub(2005)														
Reference Books:														
1. Modern Food Micro-Biology by James M.Jay, CBS Publishers. 2005.														
2. Food Microbiology by K. Vijay Ramesh M J P Publishers, 2007.														
Web links and Video Lectures (e-Resources)														
1. https://www.coursera.org/?utm_sourceWEB														
2. https://swayam.gov.in/?utm_source														
3. https://nptel.ac.in/?utm_source														
Course Outcomes	Programme Outcomes											Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
CO1	3 (WK1, WK2, WK3 WK4)	2 (WK1, WK2,W K3 WK4)	1 (WK5)	-	-	1 (WK1 WK5, and WK7)	1 (WK 9)	-	1	-	2 (W K8)	2	3	2
CO2	3 (WK1, WK2, WK3 WK4)	3 (WK1, WK2,W K3 WK4)	3 (WK5)	2 (WK 8)	2 (WK2 and WK6)	3 (WK1, WK5, and WK7)	1 (WK 9)	1	1	1	2 (W K8)	2	3	2
CO3	2 (WK1, WK2, WK3 WK4)	3 (WK1, WK2,W K3 WK4)	2 (WK5)	3 (WK 8)	3 (WK2 and WK6)	3 (WK1, WK5, and WK7)	1 (WK 9)	2	3	1	2 (W K8)	2	3	3
CO4	2 (WK1, WK2, WK3 WK4)	2 (WK1, WK2,W K3 WK4)	3 (WK5)	2 (WK 8)	2 (WK2 and WK6)	3 (WK1 WK5, and WK7)	2 (WK 9)	2	2	3	3 (W K8)	2	3	3

Course Code		:	21UBT743E	CLINICAL RESEARCH & DATA MANAGEMENT	Semester	:	7
L:T:P		:	3:0:0		Course Type	:	PEC
Hours/Sem.	Teaching	:	42 Hrs.		CIE Marks	:	50
	Learning (TW+SL)	:	42 Hrs.		SEE Marks	:	50
	Exam	:	6 Hrs.		Total Marks	:	100
	Total Hrs.	:	90 Hrs.		Credits	:	3

Professional Competency:

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

Course Outcomes:

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

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

UNIT-I

12 Hrs.

INTRODUCTION

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

CLINICAL PHARMACOLOGY

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

UNIT-II

10 Hrs.

THERAPEUTICS

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

MANAGEMENT OF DRUGS

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

UNIT-III

10 Hrs.

HEALTHCARE MARKETPLACE

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

SOCIAL, ETHICAL ISSUES

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

UNIT-IV												10 Hrs.		
CLINICAL RESEARCH														
Types of Epidemiology study designs, ecological (correlation) studies, Case reports and case series, prevalence surveys or cross-sectional studies, case control studies, Clinical Trials, Small Clinical Trials, Placebo Responses in Clinical Trials, Large Clinical Trials and Registries – Clinical Research Institutes, Data Management in Clinical Research : General Principles and Guide to Sources, Clinical Research from Pharmaceutical Industry Perspective.														
Text Books:														
1. Gary Walsh., Biochemistry and Biotechnology, 2002, John Wiley & Sons Ltd. 2. Gallin and J. I. Ognibene F. P, 2007 Principles and Practice of Clinical Research by, 2nd Edition, Elsevier Publication														
Reference Books:														
1. William J. Williams, Ernest Beutler, Allan JU. Erslev, Marshall A. Lichtman,2005, Hematology 2. John Wiley & Sons Ltd by Arunabha Ray & Kavitha Gulati, 2007,Current Trends in Pharmacology IK Intl.														
Web links and Video Lectures (e-Resources)														
Course Outcomes	Programme Outcomes											Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
CO1	1 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	3 (WK5)	-	2 (WK2 and WK6)	-	2 (WK9)	1	-	-	2 (WK8)	2	2	1
CO2	1 (WK1, WK2, WK3, and WK4)	2 (WK1, WK2, WK3, and WK4)	3 (WK5)		1 (WK2 and WK6)		2 (WK9)	1			3 (WK8)	3	1	1
CO3	1 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	3 (WK5)	-	1 (WK2 and WK6)	-	1 (WK9)	1	-	-	2 (WK8)	2	1	1
CO4	1 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	3 (WK5)	-	1 (WK2 and WK6)	-	2 (WK9)				3 (WK8)	3	3	3

Course Code		:	21UBT744E	PHARMACEUTICAL BT	Semester	:	07
L:T:P		:	3:0:0		Course Type	:	PEC
Hours/Sem.	Teaching	:	42 Hrs		CIE Marks	:	50
	Learning (TW+SL)	:	42 Hrs		SEE Marks	:	50
	Exam	:	06 Hrs		Total Marks	:	100
	Total Hrs.	:	90 Hrs		Credits	:	03
Professional Competency:							
Develop the knowledge and skills to apply biotechnological principles, molecular techniques, and bioprocess technologies for the development, production, quality evaluation, and regulatory compliance of biopharmaceutical products while adhering to ethical and biosafety standards.							
Course Outcomes:							
After completion of the course, student will be able to:							
CO1: Apply the basics of biology in drug discovery, drug formulation and analyze the Pharmacokinetics and Pharmacodynamics parameters of drugs along with drug metabolism							
CO2: Select and apply the knowledge of the techniques used in the manufacture of pharmaceutical products in the field of Biopharmaceuticals.							
CO3: Select and apply appropriate techniques and advanced techniques in drug delivery system and understand the role of biotherapeutics and stem cells in Biopharmaceuticals.							
CO4: Demonstrate an ability to apply principles of Pharmaceutical Biotechnology to protect the global community from various dreadful diseases.							
UNIT-I						10 Hrs.	
Introduction:							
Introduction to Pharmaceutical Biotechnology, History of Pharmaceutical Industry. Drug design and development process, Fundamental principles and processes involved in preclinical and clinical development of a chemical or biological entity. Orphan drugs, Provisions for and use of unlicensed medicines, Drug abuse and dependence, Prescriptive and Non-prescriptive drugs.							
Drug metabolism:							
Evolution of Drug Metabolism as a Science, Phase I Metabolism (microsomal oxidation, Reduction, Hydrolysis), Phase II Metabolism (Drug conjugation reactions). Pharmacodynamics and Pharmacokinetics of drugs.							
UNIT-II						11 Hrs.	
Toxicology:							
Branches of Toxicology-In vivo toxicity tests- Acute, Sub acute and chronic toxicity tests.							
Manufacturing principles and formulations:							
Tablets-Types of tablets, Role and composition of tablets, Preformulation of tablets-organoleptic, physical properties, compressibility and flowability, evaluation of tablets-hardness, disintegration, and friability. Preparation of tablets- Granulation and compression method, Tablet coating and its applications, Parental preparations, herbal extracts, Oral liquids, Ointments, Quality control, storage and stability of biotech products. Short study of current biotech products. Adverse drug reactions.							
UNIT-III						11 Hrs.	

Biosimilars:

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

Stem cells and tissue engineering:

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

Drug delivery system:

Delivery of biopharmaceuticals-Use of Artificial Intelligence in drug delivery, Advanced drug Delivery Systems, Liposomes and Nanoparticles Drug Delivery System, Hydrogel based Drug Delivery System.

UNIT-IV**10 Hrs.****Analysis of biologicals & pharmaceuticals:**

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

Advanced pharmacology:

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

Text Books:

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

Reference Books:

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

Course Outcomes	Programme Outcomes											Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
CO1	3 (WK1, WK2, WK3 WK4)	3 (WK1, WK2, WK3 WK4)	3 (WK5)	2(W K8)	3 (WK2 and WK6)	3 (WK1, WK5, and WK7)	3(WK 9)	-	-		3	3	3	3
CO2	3 (WK1, WK2, WK3 WK4)	3(WK1, WK2, WK3 WK4)	3 (WK5)	2(W K8)	3 (WK2 and WK6)	3 (WK1, WK5, and WK7)	2(WK 9)	-	-		3	3	3	3
CO3	3(WK1, WK2, WK3 WK4)	3(WK1, WK2, WK3 WK4)	3 (WK5)	2(W K8)	3(WK2 and WK6)	3 (WK1, WK5, and WK7)	2(WK 9)	-	-		3	3	3	3

CO4	3(WK1, WK2, WK3 WK4)	3(WK1, WK2, WK3 WK4)	3 (WK5)	3(W K8)	3(WK 2 and WK6)	3 (WK1, WK5, and WK7)	3(WK 9)	-	-		2	3	3	3
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Course Code		:	21UBT704L	UPSTREAM AND BIOSEPARATION TECHNIQUES LAB	Semester	:	07
L:T:P*		:	0:0:2		Course Type	:	PCCL
Hours/Sem.	Teaching	:	26 Hrs.		CIE Marks	:	50
	Learning (TW+SL)	:	00 Hrs.		SEE Marks	:	50
	Exam	:	4Hrs.		Total Marks	:	100
	Total Hrs.	:	30 Hrs.		Credits	:	01

Professional Competency:

Ability to independently design, operate, and optimize end-to-end biomanufacturing workflows from production to purification and analytical characterization using HPLC and GC.

Course Outcomes:

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

- CO1. Apply bioprocess engineering principles to operate bench-scale fermenters, cultivate microbial systems and evaluate biokinetic parameters including growth rates, substrate consumption, and product yield.
- CO2: Select and optimize unit operations—including mechanical cell disruption, cross-flow membrane filtration, and centrifugation—to achieve solid-liquid separation and primary harvesting of intracellular and extracellular bioproducts.
- CO3: Design and execute product enrichment strategies—such as fractional precipitation, aqueous two-phase extraction (ATPE), and advanced solid-liquid extraction methods—to isolate high-value bioactive compounds with maximum yield and purity.
- CO4: Perform lyophilisation process for bioproduct stabilization and qualitative and quantitative analytical analysis using HPLC and Gas Chromatography (GC).

LIST OF EXPERIMENTS

26 per batch Hrs.

1. Production and estimation of citric acid from *Aspergillus niger*.
2. Preparation and production of ethanol in a fermenter: Study of growth, product formation, and substrate utilization.
3. Solid-liquid separation method: Removal of Intracellular Proteins by cell disruption methods.
4. Solid-liquid separation method: Separation of biomass and extracellular components by Filtration (cross-flow) and Centrifugation.
5. Product enrichment operations: Precipitation of a proteins/bioprocess from crude solution or the extract.
6. Solid-Liquid extraction of Bioactive compounds using advanced extraction techniques
7. Product enrichment operations: Liquid-liquid and Aqueous two – phase extraction of bio-products from biological sources.
8. Extraction and estimation of bioactive compounds from natural sources.
9. Lyophilization of any bioproduct
10. Analysis of biomolecules/bioactive compounds by HPLC / GC

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

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

Reference Books

1. Protein Purification by Scopes R.K., IRL Press, 1993.
2. Rate controlled separations by Wankat P.C., Elsevier, 1990
3. Bioseparations by Belter P.A. and Cussier E., Wiley, 1985.

4. Bio-separations Science & Engineering By Roger G Harrison, Paul Todd, Scott R Rudge, Demetri.
5. Product Recovery in Bioprocess Technology - BIOTOL Series, VCH, 1990
6. Separation processes in Biotechnology by Asenjo J. and Dekker M. 1993

Web links and Video Lectures (e-Resources)

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

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

Course Code		:	21UBT705P	PROJECT	Semester	:	07
L:T:P		:	0-0-2		Course Type	:	PP
Hours/Sem.	Teaching	:	-		CIE Marks	:	50
	Learning (TW+SL)	:	-		SEE Marks	:	50
	Exam	:	4Hrs		Total Marks	:	100
	Total Hrs.	:	180Hrs		Credits	:	6

Professional Competency:

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

Course Outcomes:

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

CO1 Able to improve industrial processes using biotechnological methods.

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

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

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

Course Outcomes	Programme Outcomes											Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
CO1	3 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	3 (WK5)	3 (WK8)	3 (WK2 and WK6)	3 (WK1, WK5 & WK7)	2 (WK 9)	2	2	3	2 (W K8)	3	3	3
CO2	3 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	3 (WK5)	3 (WK8)	3 (WK2 and WK6)	2 (WK1, WK5 & WK7)	3 (WK 9)	2	2	3	3 (W K8)	3	3	3
CO3	3 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	3 (WK5)	3 (WK8)	3 (WK2 and WK6)	2 (WK1, WK5 & WK7)	3 (WK 9)	3	2	2	2 (W K8)	3	3	3
CO4	3 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	3 (WK5)	3 (WK8)	3 (WK2 and WK6)	3 (WK1, WK5 & WK7)	3 (WK 9)	3	2	2	3 (W K8)	3	3	3

B. E. VIII SEMESTER

Sl. No	Category	Subject Code	Subject Title	Credits	HOURS/ WEEK			EXAMINATION MARKS		
					L	T	P	CIE	SEE	TOTAL
1.	AEC	21UBT0XXO	MOOCs*	03	-	-	-	50	50	100
2.	INT	21UBT802I	Industrial Internship	10	0	0	20	50	50	100
3.	TS	21UBT803S	Technical Seminar	01	0	0	2	50	50	100
4.	HSS	21UHS800C	Research Methodology & IPR	02	2	0	0	50	50	100
Total				16	2	0	22	200	200	400

21UHS800C	RESEARCH METHODOLOGY & IPR	Credits: 02
L:P:T :2:0:0		CIE Marks: 50
Total Hours/Week: 2		SEE Marks: 50

COURSE OBJECTIVES:

1. To understand the basics of research and its types.
2. To learn the concept of Literature Review, Technical Reading, Attributions and Citations.
3. To learn Ethics in Engineering Research.
4. To Integrate Intellectual Property Rights with engineering sciences to cater to R&D Requirements.

UNIT-I	7Hrs.
INTRODUCTION TO ENGINEERING RESEARCH Fundamentals of Research: Meaning, objectives, and motivation in engineering research. Types of Engineering Research: Basic, applied, and translational research; identifying and solving Worthwhile problems. Research Ethics: Ethics in engineering research and practice, types of research misconduct, and ethical issues in authorship.	
UNIT-II	6Hrs.
LITERATURE REVIEW AND CITATIONS Technical Reading & Analysis: Methods for reviewing literature, analyzing prior art, and synthesizing new and existing knowledge. Bibliographic Databases: Web of Science, Google, Google Scholar, effective search strategies. Conceptualizing Research: Critical and creative reading, taking notes, reading mathematical models, algorithms, and datasheets. Citations & Acknowledgments: Attribution, citation styles, impact of keywords, citing datasets, and knowledge dissemination.	
UNIT-III	7Hrs.
INTELLECTUAL PROPERTY RIGHTS (IPR) & PATENTS: Introduction to Intellectual Property: Concepts of property and rights, forms of IPR, role in research and economic development, IP governance, and global innovation indicators. Patents: Definition, objectives, criteria for patentability, software/business method patents, infringement, compulsory licensing, and government use of inventions. Patent Process: Prior art search strategies, patent databases (free and paid), drafting specifications and claims, filing requirements, jurisdiction, opposition procedures, and renewal. Filing Requirement of patent: Patent Application Forms. Work flow chart in obtaining Patents, Jurisdiction of Filing Patent Application. Pre-grant & Post-grant Opposition. Forms to be submitted, filing mechanism through Individual patent office and PCT route. Need for a Patent Attorney/Agent Revocation. Term of Patent, Patent renewal and Fee Structure National Bodies Dealing with Patent Affairs. Utility Models	
UNIT-IV	8Hrs.

COPYRIGHTS, TRADEMARKS, INDUSTRIAL DESIGN & GI

Copyrights: Nature, subject matter, authorship, digital copyright, fair use, infringement, enforcement, and international agreements.

Trademarks: Meaning, functions, distinctiveness, registration, non-conventional marks, infringement, and domain name issues.

Industrial Design: Definition, registration process in India, infringement, and case laws.

Geographical Indications (GI): Acts, laws, ownership rights, registered GIs in India, protection, certification marks, enforcement, and registration process.

IP Organizations & Policies: Overview of IP schemes, national programs, and regulatory bodies in India.

Case Studies & Applications

Patents: Case studies on Curcuma (Turmeric), Neem, and Basmati patents.

Copyright & Trademark Disputes: Interesting Copyrights Cases, Case studies (e.g., Coca-Cola vs. Bisleri, Apple vs. Samsung).

REFERENCE BOOKS

1. Dr. Santosh M Nejar, Dr. Harish Bendigeri "Research Methodology and Intellectual Property Rights", ISBN 978-93-5987-928-4, Edition: 2023-24.
2. David V. Thiel "Research Methods for Engineers" Cambridge University Press, 978-1-107-03488-4
3. Intellectual Property Rights by N.K.Acharya Asia Law House 6th Edition. ISBN: 978-93-81849-30-9
4. P. Naryan, "Intellectual Property Law", 3rd Ed, Eastern Law House, 2007.
5. Dr. S.R. Myneni, "Law of Intellectual Property", 9th edition, Asia law House, 2019.
6. Dr. G.B Reddy, "Intellectual Property Rights and Law", Gogia Law Agency. Hyderabad, Reprint edition 2020.
7. N.R. Subbaram. S. Viswanathan, "Hand book Indian Patent Law and, Practice" Printers and publishers Pvt, Ltd, 2008.
8. Cornish, "Intellectual Property Rights", Universal publications.
9. Dr. B. L. Wadehra, "Law Relating to Intellectual Property" 5th edition, Universal Law publishing Co, Dehli.
10. SWAYAM / NPTL/ MOOCS/ We blinks/ Internet sources/ YouTube videos and other materials / notes
- 11.

COURSE OUTCOMES:

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

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

CO2: Exhibit reflective thinking in problem solving exercises.

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

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

Course Outcomes	Programme Outcomes													
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
CO1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO2	-	2	2	-	1	2	2	3	-	2	2	-	-	-
CO3	-	-	-	-	-	3	2	2	-	2	1	-	-	-
CO4	-	-	-	-	3	-	-	-	1	1	2	-	-	-

Course Code		:	21UBT802I	INDUSTRIAL INTERNSHIP	Semester	:	08
L:T:P		:	0-0-2		Course Type	:	Int.
Hours/Sem.	Teaching	:	-		CIE Marks	:	50
	Learning (TW+SL)	:	-		SEE Marks	:	50
	Exam	:	6Hrs.		Total Marks	:	100
	Total Hrs.	:	300 Hrs		Credits	:	10

Professional Competency:

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

Course Outcomes:

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

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

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

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

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

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

	(WK1 ,WK2, WK3,WK4)	(WK1 ,WK2, WK3WK4)	(WK5)	(WK8)	(WK2 and WK6)	(WK1, WK5, and WK7)	(WK9)				(WK8)			
CO4	1 (WK1 ,WK2, WK3,WK4)	1 (WK1 ,WK2, WK3WK4)	—	—	—	—	3 (WK9)	3	3	3	3 (WK8)	2	3	2