GOVERNMENT COLLEGE OF TECHNOLOGY

(An Autonomous Institution Affiliated to Anna University)

Coimbatore - 641 013

Curriculum For

B. Tech. Industrial Biotechnology

(Full Time)

2022

Regulations

OFFICE OF THE CONTROLLER OF EXAMINATIONS
GOVERNMENT COLLEGE OF TECHNOLOGY
THADAGAM ROAD, COIMBATORE - 641 013
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VISION AND MISSION OF THE INSTITUTION

VISION

To emerge as a centre of excellence and eminence by imparting futuristic technical education in keeping with global standards, making our students technologically competent and ethically strong so that they can readily contribute to the rapid advancement of society and mankind.

MISSION

- To achieve academic excellence through innovative teaching and learning practices.
- To enhance employability and entrepreneurship.
- To improve the research competence to address societal needs.
- To inculcate a culture that supports and reinforces ethical, professional behaviours for a harmonious and prosperous society.

GOVERNMENT COLLEGE OF TECHNOLOGY
(An Autonomous Institution Affiliated to Anna University, Chennai)
COIMBATORE-641 013

DEPARTMENT OF INDUSTRIAL BIOTECHNOLOGY

VISION AND MISSION

VISION

To achieve the highest caliber in Biotechnology research and innovation to develop intellectual leaders to meet out the societal, environmental, and industrial needs.

MISSION

To provide quality education with global competence and molding the students as technologically sound and ethically motivated technocrats through advanced skill based learning.

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DEPARTMENT OF INDUSTRIAL BIOTECHNOLOGY

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

The following Programmeeducational objectives are designed based on the department mission.

PEO 1: Graduates will possess necessary skills and knowledge in the frontier areas of biotechnology.

PEO 2: Graduates will be able to implement the engineering principles to biological systems for the development of industrial applications as well as entrepreneurship skills to start biotech industries.

PEO 3: Graduates will think critically and creatively about the use of biotechnology to address local and global problems.

PEO 4: Graduates will consider the social implication of their work as it affects the health, safety and environment of human population.

PEO 5: Graduates will have adequate knowledge in various fields of biotechnology, enabling them to pursue higher education in relevant areas to enhance their professionalism.

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DEPARTMENT OF INDUSTRIAL BIOTECHNOLOGY

PROGRAMME OUTCOMES (POs)

Students in the Industrial Biotechnology Programme should possess the following POs at the time of their graduation.

PO1 **Engineering knowledge**: Apply the concepts of mathematics, science, engineering fundamentals to identify the solution of complex engineering problems.

PO2 **Problem analysis**: Identify, formulate, review research literature and analyze complex engineering problems providing substantiated conclusions using basic principles of mathematics, Natural sciences and engineering sciences.

PO3 **Design/development of solutions**: Design and develop processes to meet the emerging technological demands with suitable consideration of public health, the cultural, societal, and environmental safety.

PO4 **Conduct investigations of complex problems**: Conduct effective research including design of experiments, analysis and interpretation of data and synthesis of the information to provide valid conclusions.

PO5 **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

PO6 **The engineer and society:**Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7 **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge and need for sustainable development.

PO8 **Ethics:**Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9 **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams and in multidisciplinary settings.

PO10 **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11 **Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles to apply the strategies on one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12 **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological innovation.

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DEPARTMENT OF INDUSTRIAL BIOTECHNOLOGY

PROGRAMME SPECIFIC OUTCOMES (PSOs)

PSO 1 : Demonstrate competence in Biological sciences and technology courses to pursue higher education.

PSO 2 : Demonstrate an ability to acquire technical skills and work ethics to meet the industry needs and to become an entrepreneur.

GOVERNMENTCOLLEGE OF TECHNOLOGY, COIMBATORE–641 013
B.Tech. INDUSTRIAL BIOTECHNOLOGY (FULL TIME)
FIRST SEMESTER

Sl. No.	Course Code	CourseTitle	Category	CA Marks	End Sem Marks	Total Marks	Hours/Week			
							L	T	P	C
THEORY										
	22BMC1Z0	Induction Programme	MC	-	-	-	-	-	-	0
1	22BHS1Z1	தமிழர் மரபு Heritage of Tamils	HSMC	40	60	100	1	0	0	1
2	22BHS1Z2	Values and Ethics	HSMC	40	60	100	3	0	0	3
3	22BBS1Z1	Linear Algebra and Calculus	BS	40	60	100	3	1	0	4
4	22BBS1Z2	Engineering Physics	BS	40	60	100	3	0	0	3
5	22BBS103	Chemistry for Biotechnology	BS	40	60	100	3	0	0	3
6	22BES101	Basics of Electrical and Electronics Engineering	ES	40	60	100	3	0	0	3
PRACTICAL										
7	22BHS1Z3	Cambridge English	HSMC	100	-	100	0	0	2	1
8	22BBS1Z4	Chemistry Laboratory	BS	60	40	100	0	0	3	1.5
9	22BES1Z2	Engineering Graphics	ES	60	40	100	1	0	4	3
			TOTAL	**460**	**440**	**900**	**17**	**1**	**9**	**22.5**

SECOND SEMESTER

Sl. No.	Course Code	Course Title	Category	CA Marks	End Sem Marks	Total Marks	Hours/Week			
							L	T	P	C
THEORY										
1	22BHS2Z4	தமிழரும் தொழில்நுட்பமும் Tamils and Technology	HSMC	40	60	100	1	0	0	1
2	22BHS2Z5	Professional English	HSMC	40	60	100	2	1	0	3
3	22BBS205	Differential Equations and Numerical Methods	BS	40	60	100	3	1	0	4
4	22BES203	Programming in C	ES	40	60	100	3	0	0	3
5	22BPC201	Biomolecules	PC	40	60	100	3	0	0	3
6	22BMC2Z1	Environmental Science and Engineering	MC	40	60	100	3	0	0	0
	22BNC201	NCC Credit Course Level-I (Optional)		100	-	100	3	0	0	3
PRACTICAL										
7	22BBS2Z6	Physics Laboratory	BS	60	40	100	0	0	3	1.5
8	22BES2Z4	Workshop Practice	ES	60	40	100	0	0	3	1.5
9	22BES205	Programming in C Laboratory	ES	60	40	100	0	0	3	1.5
			TOTAL	**420**	**480**	**900**	**15**	**2**	**9**	**18.5**

THIRD SEMESTER

Sl. No	Course Code	Course Title	Category	CA Marks	End Sem Marks	Total Marks	Hours/Week			
							L	T	P	C
THEORY										
1	22BBS307	Transform Calculus and Partial Differential Equations (*Common to Civil & IBT*)	BS	40	60	100	3	1	0	4
2	22BBS308	Cell Biology	BS	40	60	100	3	0	0	3
3	22BES306	Process Calculations and Heat transfer	ES	40	60	100	3	1	0	4
4	22BPC302	Industrial Microbiology	PC	40	60	100	3	0	0	3
5	22BPC303	Biochemistry	PC	40	60	100	3	0	0	3
6	22BPC304	Genetics	PC	40	60	100	3	0	0	3
PRACTICAL										
7	22BBS309	Cell biology Laboratory	BS	60	40	100	0	0	3	1.5
8	22BPC305	Microbiology Laboratory	PC	60	40	100	0	0	3	1.5
9	22BPC306	Biochemistry Laboratory	PC	60	40	100	0	0	3	1.5
			TOTAL	**420**	**480**	**900**	**18**	**2**	**9**	**24.5**

FOURTH SEMESTER

Sl. No	Course Code	Course Title	Category	CA Marks	End Sem Marks	Total Marks	Hours/Week			
							L	T	P	C
THEORY										
1	22BES407	Fluid Mechanics	ES	40	60	100	3	0	0	3
2	22BPC407	Molecular Biology	PC	40	60	100	3	0	0	3
3	22BPC408	Biochemical Thermodynamics	PC	40	60	100	3	0	0	3
4	22BPC409	Enzyme Engineering and Technology	PC	40	60	100	3	0	0	3
THEORY COURSE WITH PRACTICAL COMPONENT										
5	22BPC410	Analytical Techniques in Biotechnology	PC	50	50	100	3	0	2	4
PRACTICAL										
6	22BES408	Engineering Exploration For Industrial Biotechnology	ES	100	-	100	0	0	3	1.5
7	22BES409	Chemical Engineering Laboratory	ES	60	40	100	0	0	3	1.5
8	22BPC411	Molecular Biology Laboratory	PC	60	40	100	0	0	3	1.5
			TOTAL	**430**	**370**	**800**	**15**	**0**	**11**	**20.5**

FIFTH SEMESTER

Sl. No	Course Code	Course Title	Category	CA Marks	End Sem Marks	Total Marks	Hours/Week			
							L	T	P	C
THEORY										
1	22BES510	Mass Transfer operations	ES	40	60	100	3	1	0	4
2	22BPC512	Bioprocess Principles	PC	40	60	100	3	0	0	3
3	22BPC513	Genetic Engineering	PC	40	60	100	3	0	0	3
4	22BPC514	Protein Engineering	PC	40	60	100	3	0	0	3
5	22BPE$XX	Professional Elective I	PE	40	60	100	3	0	0	3
6	22BMC5Z2	Constitution of India	MC	40	60	100	3	0	0	0
PRACTICAL										
7	22BPC515	Bioprocess Laboratory I	PC	60	40	100	0	0	3	1.5
8	22BPC516	Genetic Engineering Laboratory	PC	60	40	100	0	0	3	1.5
			TOTAL	**360**	**440**	**900**	**18**	**1**	**6**	**19**

SIXTH SEMESTER

Sl. No	Course Code	CourseTitle	Category	CA Marks	End Sem Marks	Total Marks	Hours/Week			
							L	T	P	C
THEORY										
1	22BES611	Chemical Reaction Engineering	ES	40	60	100	3	1	0	4
2	22BPC617	Immunology	PC	40	60	100	3	0	0	3
3	22BPC618	Bioprocess Engineering	PC	40	60	100	3	0	0	3
4	22BPE$XX	Professional Elective II	PE	40	60	100	3	0	0	3
5	22#OE$XX/ 22BPE$XX	Open Elective I/Professional Elective VII	OE/PE	40	60	100	3	0	0	3
THEORY COURSE WITH PRACTICAL COMPONENT										
6	22BPC619	Bioinformatics	PC	50	50	100	3	0	2	4
PRACTICAL										
7	22BPC620	Bioprocess Engineering Laboratory	PC	60	40	100	0	0	3	1.5
8	22BPC621	Immunology Laboratory	PC	60	40	100	0	0	3	1.5
9	22BES612	Design Thinking for Industrial Biotechnology	ES	100	-	100	0	0	3	1.5
			TOTAL	**470**	**430**	**900**	**18**	**1**	**11**	**24.5**

SEVENTH SEMESTER

Sl. No	Course Code	Course Title	Category	CA Marks	End Sem Marks	Total Marks	Hours/Week			
							L	T	P	C
THEORY										
1	22BHS704	Safety and Quality Management in Biotechnology	HS	40	60	100	3	0	0	3
2	22BES713	Bioprocess Economics and Plant Design	ES	40	60	100	3	0	0	3
3	22BPC722	Downstream Processing	PC	40	60	100	3	0	0	3
4	22BPE$XX	Professional Elective III	PE	40	60	100	3	0	0	3
5	22BPE$XX	Professional Elective IV	PE	40	60	100	3	0	0	3
6	22BOE$XX/ 22BPESXX	Open Elective II/Professional Elective VIII	OE/PE	40	60	100	3	0	0	3
PRACTICAL										
7	22BPC723	Downstream Processing Laboratory	PC	60	40	100	0	0	3	1.5
8	22BEE701	Engineering Projects in Community Service	EEC	60	40	100	0	0	4	2
9	22BEE702	Internship*	EEC	100	-	100	-	-	-	4
			TOTAL	**360**	**440**	**800**	**18**	**0**	**7**	**25.5**

EIGHTH SEMESTER

Sl. No	Course Code	CourseTitle	Category	CA Marks	EndSem Marks	Total Marks	Hours/Week			
							L	T	P	C
THEORY										
1	22BPE$XX	Professional ElectiveV	PE	40	60	100	3	0	0	3
2	22BPE$XX	Professional ElectiveVI	PE	40	60	100	3	0	0	3
PRACTICAL										
3	22BEE803	Capstone Project	EEC	60	40	100	0	0	16	8
			TOTAL CREDITS	**140**	**160**	**300**	**6**	**0**	**16**	**14**

INTERNSHIP / INDUSTRIAL TRAINING : 4Credits

<u>Note:</u>

* Internship of four consecutive weeks or two 2 consecutive weeks which are completed during the vacation of fourth (and/or) fifth (and/or) sixth semester shall be considered here.

TOTAL CREDITS: 169

HUMANITIES AND SOCIAL SCIENCE INCLUDING MANAGEMENT (HSMC)

Sl. No	Course Code	CourseTitle	Category	CA Marks	End Sem Marks	Total Marks	Hours/Week L	T	P	C
1	22BHS1Z1	தமிழர் மரபு Heritage of Tamils	HS	40	60	100	1	0	0	1
2	22BHSIZ2	ValuesandEthics	HS	40	60	100	3	0	0	3
3	22BHS1Z3	CambridgeEnglish	HS	100	-	100	0	0	2	1
4	22BHS2Z4	தமிழரும் தொழில்நுட்பமும் Tamils and Technology	HS	40	60	100	1	0	0	1
5	22BHS2Z5	Professional English	HS	40	60	100	2	1	0	3
6	22BHS704	Safety and Quality Management in Biotechnology	HS	40	60	100	3	0	0	3
									TOTAL	**12**

BASIC SCIENCE (BS)

Sl. No	Course Code	CourseTitle	Category	CA Marks	End Sem Marks	Total Marks	Hours/Week L	T	P	C
1	22BBS1Z1	Linear Algebra and Calculus	BS	40	60	100	3	1	0	4
2	22BBS1Z2	Engineering Physics	BS	40	60	100	3	0	0	3
3	22BBS103	Chemistry for Biotechnology	BS	40	60	100	3	0	0	3
4	22BBS1Z4	Chemistry Laboratory	BS	60	40	100	0	0	3	1.5
5	22BBS205	Differential Equations and Numerical Methods	BS	40	60	100	3	1	0	4
6	22BBS2Z6	Physics Laboratory	BS	60	40	100	0	0	3	1.5
7	22BBS307	Transform Calculus and Partial Differential Equations	BS	40	60	100	3	1	0	4
8	22BBS308	Cell Biology	BS	40	60	100	3	0	0	3
9	22BBS309	Cell Biology Laboratory	BS	60	40	100	0	0	3	1.5
									TOTAL	**25.5**

ENGINEERING SCIENCE (ES)

Sl. No	Course Code	Course Title	Category	CA Marks	End Sem Marks	Total Marks	Hours/Week L	T	P	C
1	22BES101	Basics of Electrical and Electronics Engineering	ES	40	60	100	3	0	0	3
2	22BES1Z2	Engineering Graphics	ES	60	40	100	1	0	4	3
3	22BES203	Programming in C	ES	40	60	100	3	0	0	3
4	22BES2Z4	Workshop Practice	ES	60	40	100	0	0	3	1.5
5	22BES205	Programming in C Laboratory	ES	60	40	100	0	0	3	1.5
6	22BES306	Process Calculations and Heat Transfer	ES	40	60	100	3	1	0	4
7	22BES407	Fluid Mechanics	ES	40	60	100	3	0	0	3
8	22BES408	Engineering Exploration for Industrial Biotechnology	ES	100	-	100	0	0	3	1.5
9	22BES409	Chemical Engineering Laboratory	ES	60	40	100	0	0	3	1.5
10	22BES510	Mass Transfer Operations	ES	40	60	100	3	1	0	4
11	22BES611	Chemical Reaction Engineering	ES	40	60	100	3	1	0	4
12	22BES612	Design Thinking for Industrial Biotechnology	ES	60	40	100	0	0	3	1.5
13	22BES713	Bioprocess Economics and Plant Design	ES	40	60	100	3	0	0	3
									TOTAL	**34.5**

PROFESSIONAL CORE (PC)

Sl. No	Course Code	Course Title	Category	CA Marks	End Sem Marks	Total Marks	Hours/Week			
							L	T	P	C
1	22BPC201	Biomolecules	PC	40	60	100	3	0	0	3
2	22BPC302	Industrial Microbiology	PC	40	60	100	3	0	0	3
3	22BPC303	Biochemistry	PC	40	60	100	3	0	0	3
4	22BPC304	Genetics	PC	40	60	100	3	0	0	3
5	22BPC305	Microbiology Laboratory	PC	60	40	100	0	0	3	1.5
6	22BPC306	Biochemistry Laboratory	PC	60	40	100	0	0	3	1.5
7	22BPC407	Molecular Biology	PC	40	60	100	3	0	0	3
8	22BPC408	Biochemical Thermodynamics	PC	40	60	100	3	0	0	3
9	22BPC409	Enzyme Engineering and Technology	PC	40	60	100	3	0	0	3
10	22BPC411	Molecular Biology Laboratory	PC	60	40	100	0	0	3	1.5
11	22BPC512	Bioprocess Principles	PC	40	60	100	3	0	0	3
12	22BPC513	Genetic Engineering	PC	40	60	100	3	0	0	3
13	22BPC514	Protein Engineering	PC	40	60	100	3	0	0	3
14	22BPC515	Bioprocess Laboratory I	PC	60	40	100	0	0	3	1.5
15	22BPC516	Genetic Engineering Laboratory	PC	60	40	100	0	0	3	1.5
16	22BPC617	Immunology	PC	40	60	100	3	0	0	3
17	22BPC618	Bioprocess Engineering	PC	40	60	100	3	0	0	3
18	22BPC620	Bioprocess Engineering Laboratory	PC	60	40	100	0	0	3	1.5
19	22BPC621	Immunology Laboratory	PC	60	40	100	0	0	3	1.5
20	22BPC722	Downstream Processing	PC	40	60	100	3	0	0	3
21	22BPC723	Downstream Processing Laboratory	PC	60	40	100	0	0	3	1.5
THEORY COURSE WITH PRACTICAL COMPONENT										
22	22BPC410	Analytical Techniques in Biotechnology	PC	50	50	100	3	0	2	4
23	22BPC619	Bioinformatics	PC	50	50	100	3	0	2	4
							TOTAL			**59**

Professional Electives: Verticals

S.No.	Vertical I Medical Biotechnology	Vertical II rDNA Technology	Vertical III Bioprocess Technology	Vertical IV Quality and Regulatory Affairs	Vertical V Biosciences (Minor Degree)
1.	22BPE$01 Immunotechnology	22BPE$09 Genomics and Proteomics	22BPE$17 Aspects of Biochemical Engineering	22BPE$25 Clinical trials and health care policies in Biotechnology	22BPE$33 Human Anatomy and Physiology
2.	22BPE$02 Neurobiology and cognitive sciences	22BPE$10 Metabolic Engineering	22BPE$18 Fermentation Technology	22BPE$26 Biotechnological products and its validation	22BPE$34 Bioethics
3.	22BPE$03 Molecular Pathogenesis	22BPE$11 Plant Biotechnology	22BPE$19 Food Process Engineering	22BPE$27 Quality assurance and quality control in Biotechnology	22BPE$35 Biomass and Bioenergy
4.	22BPE$04 Cancer Biology	22BPE$12 Animal Biotechnology	22BPE$20 Bioreactor design and scale up process	22BPE$28 Entrepreneurship and patent design	22BPE$36 Environmental Biotechnology
5.	22BPE$05 Biopharmaceutical Technology	22BPE$13 Stem cells technology	22BPE$21 Bioreactor consideration for recombinant products	22BPE$29 Intellectual property rights in Biotechnology	22BPE$37 Biopolymer technology
6.	22BPE$06 Tissue Engineering	22BPE$14 Marine Biotechnology	22BPE$22 Bio process control and instrumentation	22BPE$30 Biosafety and Hazard management	22BPE$38 Nanobiotechnology
7.	22BPE$07 Molecular forensics	22BPE$15 Pharmacogenomics	22BPE$23 Bioprocess modelling and simulation	22BPE$31 Conservation economics	22BPE$39 Biomass conversion and Biorefinery
8.	22BPE$08 Medicinal chemistry	22BPE$16 Genome editing	22BPE$24 Solid State Bioprocessing	22BPE$32 Chemical Process safety	22BPE$40 Introduction to Biostatistics

PROFESSIONAL ELECTIVES (PE)

VERTICAL I - Medical Biotechnology

Sl. No	Course Code	Course Title	CA Marks	End Sem Marks	Category	Total Marks	Hours/Week			
							L	T	P	C
1	22BPE$01	Immunotechnology	40	60	PE	100	3	0	0	3
2	22BPE$02	Neurobiology and cognitive sciences	40	60	PE	100	3	0	0	3
3	22BPE$03	Molecular Pathogenesis	40	60	PE	100	3	0	0	3
4	22BPE$04	Cancer Biology	40	60	PE	100	3	0	0	3
5	22BPE$05	Biopharmaceutical Technology	40	60	PE	100	3	0	0	3
6	22BPE$06	Tissue Engineering	40	60	PE	100	3	0	0	3
7	22BPE$07	Molecular forensics	40	60	PE	100	3	0	0	3
8	22BPE$08	Medicinal chemistry	40	60	PE	100	3	0	0	3

VERTICAL II - rDNA Technology

Sl. No	Course Code	Course Title	CA Marks	End Sem Marks	Category	Total Marks	Hours/Week			
							L	T	P	C
1	22BPE$09	Genomics and Proteomics	40	60	PE	100	3	0	0	3
2	22BPE$10	Metabolic Engineering	40	60	PE	100	3	0	0	3
3	22BPE$11	Plant Biotechnology	40	60	PE	100	3	0	0	3
4	22BPE$12	Animal Biotechnology	40	60	PE	100	3	0	0	3
5	22BPE$13	Stem cells technology	40	60	PE	100	3	0	0	3
6	22BPE$14	Marine Biotechnology	40	60	PE	100	3	0	0	3
7	22BPE$15	Pharmacogenomics	40	60	PE	100	3	0	0	3
8	22BPE$16	Genome editing	40	60	PE	100	3	0	0	3

VERTICAL III - Bioprocess Technology

Sl. No	Course Code	Course Title	CA Marks	End Sem Marks	Category	Total Marks	Hours/Week			
							L	T	P	C
1	22BPE$17	Aspects of Biochemical Engineering	40	60	PE	100	3	0	0	3
2	22BPE$18	Fermentation Technology	40	60	PE	100	3	0	0	3
3	22BPE$19	Food Process Engineering	40	60	PE	100	3	0	0	3
4	22BPE$20	Bioreactor design and scale up process	40	60	PE	100	3	0	0	3
5	22BPE$21	Bioreactor consideration for recombinant products	40	60	PE	100	3	0	0	3
6	22BPE$22	Bio process control and instrumentation	40	60	PE	100	3	0	0	3
7	22BPE$23	Bioprocess modelling and simulation	40	60	PE	100	3	0	0	3
8	22BPE$24	Solid State Bioprocessing	40	60	PE	100	3	0	0	3

VERTICAL IV - Quality and Regulatory Affairs

Sl. No	Course Code	Course Title	CA Marks	End Sem Marks	Category	Total Marks	Hours/Week			
							L	T	P	C
1	22BPE$25	Clinical trials and health care policies in Biotechnology	40	60	PE	100	3	0	0	3
2	22BPE$26	Biotechnological products and its validation	40	60	PE	100	3	0	0	3
3	22BPE$27	Quality assurance and quality control in Biotechnology	40	60	PE	100	3	0	0	3
4	22BPE$28	Entrepreneurship and patent design	40	60	PE	100	3	0	0	3
5	22BPE$29	Intellectual property rights in Biotechnology	40	60	PE	100	3	0	0	3
6	22BPE$30	Biosafety and Hazard management	40	60	PE	100	3	0	0	3
7	22BPE$31	Conservation economics	40	60	PE	100	3	0	0	3
8	22BPE$32	Chemical Process safety	40	60	PE	100	3	0	0	3

VERTICAL V - Biosciences (Minor Degree)

Sl. No	Course Code	Course Title	CA Marks	End Sem Marks	Category	Total Marks	Hours/Week			
							L	T	P	C
1	22BPE$33	Human Anatomy and Physiology	40	60	PE	100	3	0	0	3
2	22BPE$34	Bioethics	40	60	PE	100	3	0	0	3
3	22BPE$35	Biomass and Bioenergy	40	60	PE	100	3	0	0	3
4	22BPE$36	Environmental Biotechnology	40	60	PE	100	3	0	0	3
5	22BPE$37	Biopolymer technology	40	60	PE	100	3	0	0	3
6	22BPE$38	Nanobiotechnology	40	60	PE	100	3	0	0	3
7	22BPE$39	Biomass conversion and Biorefinery	40	60	PE	100	3	0	0	3
8	22BPE$40	Introduction to Biostatistics	40	60	PE	100	3	0	0	3

OPEN ELECTIVES (OE)

Sl. No	Course Code	Course Title	Category	CA Marks	End Sem Marks	Total Marks	Hours/Week			
							L	T	P	C
1.	22COE$01	Disaster Management and Mitigation	OE	40	60	100	3	0	0	3
2.	22COE$02	Water Sanitation and Health	OE	40	60	100	3	0	0	3
3.	22MOE$03	Nanotechnology and Surface Engineering	OE	40	60	100	3	0	0	3
4.	22MOE$04	Industrial Safety Management	OE	40	60	100	3	0	0	3
5.	22EOE$05	Renewable Power Generation Systems	OE	40	60	100	3	0	0	3
6.	22EOE$06	Smart Grid Technology	OE	40	60	100	3	0	0	3
7.	22LOE$07	CMOS VLSI Design	OE	40	60	100	3	0	0	3
8.	22LOE$08	Mobile Communication	OE	40	60	100	3	0	0	3
9.	22POE$09	Rapid Prototyping	OE	40	60	100	3	0	0	3
10	22POE$10	Managerial Economics	OE	40	60	100	3	0	0	3
11.	22NOE$11	Measurement and Control	OE	40	60	100	3	0	0	3
12.	22NOE$12	Industrial Automation	OE	40	60	100	3	0	0	3
13.	22SOE$13	Programming in Java	OE	40	60	100	3	0	0	3
14.	22SOE$14	Network Essential	OE	40	60	100	3	0	0	3
15.	22I0E$15	Video creation and editing	OE	40	60	100	3	0	0	3
16.	22IOE$16	Digital marketing	OE	40	60	100	3	0	0	3
17.	22BOE$17	Principles Of Food Technology	OE	40	60	100	3	0	0	3
18.	22BOE$18	Biology For Engineers	OE	40	60	100	3	0	0	3

EMPLOYABILITY ENHANCEMENT COURSE (EEC)

Sl. No	Course Code	CourseTitle	Category	CA Marks	End Sem Marks	Total Marks	Hours/Week			
							L	T	P	C
1	22BEE701	Engineering Projects in Community Service	EEC	60	40	100	0	0	4	2
2	22BEE702	Internship	EEC	100	-	100	-	-	-	4
3	22BEE803	Capstone Project	EEC	60	40	100	0	0	16	8

MANDATORY COURSE (MC)

Sl. No	Course Code	CourseTitle	Category	CA Marks	End Sem Marks	Total Marks	Hours/Week			
							L	T	P	C
1	22BMC1Z0	Induction Programme	MC	-	-	-	-	-	-	-
2	22BMC2Z1	Environmental Science and Engineering	MC	40	60	100	3	0	0	0
3	22BMC5Z2	Constitution of India	MC	40	60	100	3	0	0	0

VALUE ADDED COURSE (VA)

Sl. No	Course Code	CourseTitle	Category	CA Marks	End Sem Marks	Total Marks	Hours/Week			
							L	T	P	C
1		Swayam/NPTEL Courses	EEC	100	-	100	1	0	0	1
2		Coursera (Online Courses)	EEC	100	-	100	1	0	0	1
3	22BVA$03	Research Publications	EEC	100	-	100	1	0	0	1
4	22BVA$04	Next generation sequence Analysis	EEC	100	-	100	1	0	0	1
5	22BVA$05	Patents & Copyrights	EEC	100	-	100	1	0	0	1
6	22BVA$06	Vermicomposting	EEC	100	-	100	1	0	0	1
7	22BVA$07	Mushroom cultivation	EEC	100	-	100	1	0	0	1
8	22BVA$08	Pharmacovigilance	EEC	100	-	100	1	0	0	1
9	22BVA$09	Basics of Yoga for Youth Empowerment	EEC	100	-	100	1	0	0	1
10	22BVA$10	Bioindustries trade and Policy regulations	EEC	100	-	100	1	0	0	1
11	22BVA$11	Professional Skills and Career Readiness	EEC	100	-	100	0	0	2	1
12	22BVA$12	Placement Training	EEC	100	-	100	0	0	2	1

CURRICULAM DESIGN FOR CBCS 2022 REGULATIONS
FULL TIME B.TECH. INDUSTRIAL BIOTECHNOLOGY (UG)
SUMMARY

SI. No.	Course Category	Credits Per Semester									Total Credits	Total Credits in %	Credit as per AICTE Model Curricula
		I	II	III	IV	V	VI	VII	VIII	Internship/Industrial Training			
1	HS/HSMC	5	4	-	-	-	-	3	-		12	7.10	12
2	BS	11.5	5.5	8.5	-	-	-	-	-	-	25.5	15.09	25
3	ES	6	6	4	6	4	5.5	3	-	-	34.5	20.41	24
4	PC	-	3	12	14.5	12	13	4.5	-	-	59	34.91	48
5	PE	-	-	-	-	3	3	6	6	-	18	10.65	18
6	OE	-	-	-	-	-	3	3	-	-	6	3.55	18
7	EEC	-	-	-	-	-	-	2	8	4	14	8.28	15
8	MC	0	0	-	-	0	-	-	-	-	**0**	0	-
	Total	**22.5**	**18.5**	**24.5**	**20.5**	**19**	**24.5**	**21.5**	**14**	**4**	**169**	**100**	**160**

GOVERNMENTCOLLEGEOFTECHNOLOGY
(AnAutonomousInstitutionAffiliatedtoAnnaUniversity)
Coimbatore–641013.
INDUSTRIAL BIOTECHNOLOGY

22BMC1Z0	**INDUCTION PROGRAMME**	**SEMESTER I**

Details of the Programme:

Day0: College Admission

Day1:Orientation Programme

Day2 Onwards : Induction Programme

Activities:
Physicalactivity,Playgroun
d Events,
YogaPractices,
Literary,Proficiencymodules,
TeamBuilding,
Lecturesby Eminent people,
Familiarizationtodepartment,
Branch oriented information,
Motivationalspeakers,
Talent exposure,
Quiz completion,
Visit to local areas….etc.

22BHS1Z1	தமிழர்மரபு **Heritage of Tamils** *(Common to all Branches)*	**SEMESTER I**

PREREQUISITES	**CATEGORY**	**L**	**T**	**P**	**C**
NIL	**HSMC**	**1**	**0**	**0**	**1**

UNIT – I	**LANGUAGE AND LITERATURE**	**3 Periods**
Language Families in India - Dravidian Languages – Tamil as a Classical Language – ClassicalLiterature in Tamil – Secular Nature of Sangam Literature – Distributive Justice in Sangam Literature- Management Principles in Thirukural - Tamil Epics and Impact of Buddhism & Jainism in Tamil Land - Bakthi Literature Azhwars and Nayanmars - Forms of minor Poetry - Development of Modern literature in Tamil - Contribution of Bharathiyar and Bharathidhasan.		
UNIT – II	**HERITAGE - ROCK ART PAINTINGS TO MODERN ART – SCULPTURE**	**3 Periods**
Hero stone to modern sculpture - Bronze icons - Tribes and their handicrafts - Art of temple carmaking - Massive Terracotta sculptures, Village deities, Thiruvalluvar Statue at Kanyakumari,Making of musical instruments - Mridhangam, Parai, Veenai, Yazh and Nadhaswaram - Role ofTemples in Social and Economic Life of Tamils.		
UNIT – III	**FOLK AND MARTIAL ARTS**	**3 Periods**
Therukoothu, Karagattam, VilluPattu, KaniyanKoothu, Oyillattam, Leather puppetry, Silambattam, Valari, Tiger dance - Sports and Games of Tamils.		
UNIT – IV	**THINAI CONCEPT OF TAMILS**	**3 Periods**
Flora and Fauna of Tamils &Aham and Puram Concept from Tholkappiyam and Sangam Literature- Aram Concept of Tamils - Education and Literacy during Sangam Age - Ancient Cities and Ports of Sangam Age - Export and Import during Sangam Age - Overseas Conquest of Cholas.		
UNIT – V	**CONTRIBUTION OF TAMILS TO INDIAN NATIONAL MOVEMENT AND INDIAN CULTURE**	**3 Periods**
Contribution of Tamils to Indian Freedom Struggle - The Cultural Influence of Tamils over the other parts of India – Self-Respect Movement - Role of Siddha Medicine in Indigenous Systems ofMedicine – Inscriptions & Manuscripts – Print History of Tamil Books.		
Contact Periods: **Lecture: 15Periods** **Tutorial:0 Periods** **Practical:0Periods** **Total: 15 Periods**		

TEXT BOOK:

1	தமிழக வரலாறு – மக்களும் பண்பாடும் – கே.கே. பிள்ளை (வெளியீடு : தமிழ்நாடு பாடநூல் மற்றும் கல்வியியல் பணிகள் கழகம்).
2	கணினித்தமிழ் – முனைவர்இல.சுந்தரம். (விகடன்பிரசுரம்).
3	கீழடி – வைகை நதிக்கரையில் சங்ககாலநகர நாகரிகம் (தொல்லியல் துறை வெளியீடு)
4	பொருநை – ஆற்றங்கரைநாகரிகம். (தொல்லியல்துறைவெளியீடு)

REFERENCES:

1	Social Life of Tamils (Dr.K.K.Pillay) A joint publication of TNTB & ESC and RMRL – (in print)
2	Social Life of the Tamils - The Classical Period (Dr.S.Singaravelu) (Published by:International Institute of Tamil Studies.
3	Historical Heritage of the Tamils (Dr.S.V.Subatamanian, Dr.K.D. Thirunavukkarasu)(Published by: International Institute of Tamil Studies).
4	The Contributions of the Tamils to Indian Culture (Dr.M.Valarmathi) (Published by:International Institute of Tamil Studies.)
5	Keeladi - 'Sangam City C ivilization on the banks of river Vaigai' (Jointly Published by:Department of Archaeology & Tamil Nadu Text Book and Educational Services Corporation,Tamil Nadu)
6	Studies in the History of India with Special Reference to Tamil Nadu (Dr.K.K.Pillay)(Published by: The Author)
7	Porunai Civilization (Jointly Published by: Department of Archaeology & Tamil Nadu Text Book and Educational Services Corporation, Tamil Nadu)
8	Journey of Civilization Indus to Vaigai (R.Balakrishnan) (Published by: RMRL) –Reference Book.

22BHS1Z1	**தமிழர்மரபு Heritage of Tamils** *(Common to all Branches)*	**SEMESTER I**

PREREQUISITES	CATEGORY	L	T	P	C
NIL	HSMC	1	0	0	1

அலகு I	**மொழி மற்றும் இலக்கியம்**	**3 Periods**
இந்திய மொழிக் குடும்பங்கள்- திராவிட மொழிகள்- தமிழ் ஒரு செம்மொழி- தமிழ் செவ்விலக்கியங்கள்–சங்க இலக்கியத்தின் சமயச் சார்பற்ற தன்மை- சங்கஇலக்கியத்தில் பகிர்தல்அறம்-திருக்குறளில் மேலாண்மைக் கருத்துக்கள்- தமிழ்க்காப்பியங்கள், தமிழகத்தில் சமண பௌத்தசமயங்களின் தாக்கம்-பக்தி இலக்கியம், ஆழ்வார்கள் மற்றும் நாயன்மார்கள்-சிற்றிலக்கியங்கள்-தமிழில் நவீன இலக்கியத்தின் வளர்ச்சி-தமிழ் இலக்கிய வளர்ச்சியில் பாரதியார் மற்றும் பாரதிதாசன் ஆகியோரின்பங்களிப்பு.		
அலகு II	**மரபு – பாறை ஓவியங்கள் முதல் நவீன ஓவியங்கள் வரை–சிற்பக்கலை**	**3 Periods**
நடுகல் முதல் நவீன சிற்பங்கள் வரை – ஐம்பொன் சிலைகள்– பழங்குடியினர் மற்றும் அவர்கள் தயாரிக்கும் கைவினைப் பொருட்கள்-பொம்மைகள் – தேர் செய்யும்கலை – சுடுமண் சிற்பங்கள் – நாட்டுப்புறத்தெய்வங்கள்–குமரிமுனையில் திருவள்ளுவர்சிலை – இசைக்கருவிகள் – மிருதங்கம், பறை, வீணை, யாழ், நாதஸ்வரம் – தமிழர்களின் சமூக பொருளாதார வாழ்வில் கோவில்களின் பங்கு.		
அலகு III	**நாட்டுப்புறக்கலைகள் மற்றும் வீர விளையாட்டுகள்**	**3 Periods**
தெருக்கூத்து, கரகாட்டம் – வில்லுப்பாட்டு – கணியான்கூத்து – ஒயிலாட்டம் - தோல்பாவைக்கூத்து-சிலம்பாட்டம்–வளரி-புலியாட்டம்-தமிழர்களின் விளையாட்டுகள்.		
அலகு IV	**தமிழர்களின் திணைக்கோட்பாடுகள்**	**3 Periods**
தமிழகத்தின் தாவரங்களும், விலங்குகளும் – தொல்காப்பியம் மற்றும் சங்க இலக்கியத்தில் அகம் மற்றும் புறக்கோட்பாடுகள் – தமிழர்கள்போற்றிய அறக்கோட்பாடு–சங்ககாலத்தில் தமிழகத்தில் எழுத்தறிவும், கல்வியும் –சங்ககால நகரங்களும் துறைமுகங்களும் – சங்ககாலத்தில் ஏற்றுமதி மற்றும் இறக்குமதி – கடல்கடந்தநாடுகளில்சோழர்களின்வெற்றி.		
அலகு V	**இந்திய தேசிய இயக்கம் மற்றும் இந்திய பண்பாட்டிற்குத் தமிழர்களின்பங்களிப்பு**	**3 Periods**
இந்திய விடுதலை போரில் தமிழர்களின் பங்கு – இந்தியாவின் பிறப்பகுதிகளில் தமிழ்ப்பண்பாட்டின் தாக்கம் – சுயமரியாதை இயக்கம் – இந்திய மருத்துவத்தில் சித்த மருத்துவத்தின் பங்கு – கல்வெட்டுகள், கையெழுத்துப்படிகள் - தமிழ்ப் புத்தகங்களின் அச்சு வரலாறு.		

Contact Periods:			
Lecture: 15 Periods	**Tutorial:0 Periods**	**Practical:0Periods**	**Total: 15 Periods**

TEXT BOOK:

1	தமிழக வரலாறு – மக்களும் பண்பாடும் – கே.கே. பிள்ளை (வெளியீடு: தமிழ்நாடு பாடநூல் மற்றும் கல்வியியல் பணிகள் கழகம்).
2	கணினித்தமிழ் – முனைவர் இல.சுந்தரம் . (விகடன்பிரசுரம்).
3	கீழடி – வைகை நதிக்கரையில் சங்ககால நகரநாகரிகம் (தொல்லியல்துறை வெளியீடு)
4	பொருநை – ஆற்றங்கரை நாகரிகம். (தொல்லியல்துறைவெளியீடு)

REFERENCES:

1	Social Life of Tamils (Dr.K.K.Pillay) A joint publication of TNTB & ESC and RMRL – (in print)
2	Social Life of the Tamils - The Classical Period (Dr.S.Singaravelu) (Published by:International Institute of Tamil Studies.
3	Historical Heritage of the Tamils (Dr.S.V.Subatamanian, Dr.K.D. Thirunavukkarasu)(Published by: International Institute of Tamil Studies).
4	The Contributions of the Tamils to Indian Culture (Dr.M.Valarmathi) (Published by:International Institute of Tamil Studies.)
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6	Studies in the History of India with Special Reference to Tamil Nadu (Dr.K.K.Pillay)(Published by: The Author)
7	Porunai Civilization (Jointly Published by: Department of Archaeology & Tamil Nadu Text Book and Educational Services Corporation, Tamil Nadu)
8	Journey of Civilization Indus to Vaigai (R.Balakrishnan) (Published by: RMRL) –Reference Book.

22BHS1Z2	VALUES AND ETHICS *(Common to all Branches)*	SEMESTER I

PREREQUISITES	CATEGORY	L	T	P	C
NIL	HSMC	3	0	0	3

Course Objectives	1. To understand and appreciate the ethical issues faced by an individual in profession, society and polity 2. To learn about Engineering Ethics and case studies 3. To understand the negative health impacts of certain unhealthy behaviors 4. To appreciate the need and importance of physical, emotional health and social health 5. To get familiar with the global issues	
UNIT – I	**BEING GOOD AND RESPONSIBLE**	**9 Periods**
Morals, Values and Ethics - Integrity - Work Ethics - Service Learning - Civic Virtue - Respect for Others - Living Peacefully - Caring - Sharing - Honesty - Courage - Valuing Time - Cooperation - Commitment - Empathy - Self-Confidence – Character.		
UNIT – II	**ENGINEERING AS SOCIAL EXPERIMENTATION**	**9 Periods**
Engineering Ethics: Senses of 'Engineering Ethics' - variety of moral issued - types of inquiry - moral dilemmas - moral autonomy - Models of Professional Roles. Engineering as Experimentation – Engineers as responsible Experimenters – Research Ethics - Codes of Ethics – Industrial Standards - A Balanced Outlook on Law – Case studies: Chernobyl disaster and Titanic disaster.		
UNIT – III	**ADDICTIONANDHEALTH**	**9 Periods**
Peerpressure-Alcoholism:Ethicalvalues,causes,impact,laws,prevention–illeffectsofsmoking-PreventionofSuicides;SexualHealth:Preventionandimpactofpre-maritalpregnancyandSexuallyTransmittedDiseases. Drug Abuse: Abuse of different types of legal and illegal drugs: Ethical values, causes, impact, laws and prevention.		
UNIT – IV	**PROFESSIONALETHICS**	**9 Periods**
Abuse of Technologies**:** Hacking and other cybercrimes, Addiction to mobile phone usage, Video games and Social networking websites.		
UNIT – V	**GLOBAL ISSUES**	**9 Periods**
Multinational corporations - Environmental ethics - computer ethics - weapons development - engineers as managers - consulting engineers - engineers as expert witnesses and advisors - Code of Conduct – Corporate Social Responsibility.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOK:

1	*Mike W Martin and Roland Schinzinger, **"Ethics in Engineering"**, 4th Edition, McGraw-Hill, New York 2017.*
2	*Govindarajan M, Natarajan S and Senthil Kumar VS, **"Engineering Ethics"**, Prentice Hall of India, New Delhi, 2013.*

REFERENCES:

1	*Dhaliwal, K.K,* ***"Gandhian Philosophy of Ethics: A Study of Relationship between his Presupposition and Precepts",*** *Writers Choice, New Delhi, India, 2016.*
2	*Jayshreesuresh, B.S.Raghavan,* ***"Human values and professional ethics"****,S.Chand& company Ltd, New Delhi, 2th Edition, 2007.*
3	*L.A. and Pagliaro, A.M,* ***"Handbook of Child and Adolescent Drug and Substance Abuse: Pharmacological, Developmental and Clinical Considerations",*** *Wiley Publishers, U.S.A, 2012.*
4	*Pandey, P. K(2012),* ***"Sexual Harassment and Law in India"****, Lambert Publishers, Germany,2012.*
5	*Kiran D.R,* ***"Professional ethics and Human values",*** *Tata McGraw Hill, New Delhi, 2007.*
6	*Edmund G See Bauer and Robert L Barry,* ***"Fundamentals of Ethics for Scientists and Engineers"****,Oxford University Press, Oxford, 2001.*
7	*David Ermann and Michele S Shauf,* ***"Computers, Ethics and Society"****,Oxford University Press, 2003.*
8	*Govindarajan M, Natarajan S, Senthil Kumar V. S,* ***"Engineering Ethics"****,Prentice Hall of India, New Delhi, 2004.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Follow sound morals and ethical values scrupulously to prove as good citizens.	K3
CO2	Assess the relevance of ethics and morals in engineering and to learn case studies.	K3
CO3	Describe the concept of addiction and how it will affect the physical and mental health.	K2
CO4	Identify ethical concerns while using advanced technologies.	K2
CO5	Judge the code of conduct, Environmental ethics and computer ethics.	K3

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO2**
CO1	-	-	-	-	-	3	3	3	3	3	3	-	-	1
CO2	-	-	-	-	-	3	1	3	3	-	-	-	-	1
CO3	-	-	-	-	-	3	1	3	3	2	3	-	-	1
CO4	-	-	-	-	-	3	3	3	3	1	3	1	-	1
CO5	-	-	-	-	-	3	3	3	3	-	1	3	-	1
22BHS1Z2	**-**	**-**	**-**	**-**	**-**	**3**	**3**	**3**	**3**	**2**	**2**	**1**	**-**	**1**

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	6.1.1,6.2.1,7.1.1,7.1.2,7.2.1,7.2.2,8.1.1,8.2.1,8.2.2,9.1.1,9.1.2,9.2.1,9.2.2,9.2.3,9.2.4,9.3.1,10.1.1,10.1.2, 10.1.3,10.2.1,10.2.2,10.3.1,10.3.2, 11.1.1,11.1.2,11.2.1,11.3.1
CO2	6.1.1,6.2.1,7.1.1,8.1.1,8.2.1,8.2.2,9.1.1,9.1.2,9.2.1,9.2.2,9.2.3,9.2.4,9.3.1
CO3	6.1.1,6.2.1,7.1.1,8.1.1,8.2.1,8.2.2,9.1.1,9.1.2,9.2.1,9.2.2,9.2.3,9.2.4,9.3.1,10.2.1,10.3.1,10.3.2, 11.1.1, 11.1.2, 11.2.1, 11.3.1
CO4	6.1.1,6.2.1,7.1.1,7.1.2,7.2.1,7.2.2,8.1.1,8.2.1,8.2.2,9.1.1,9.12,9.2.1,9.2.2,9.2.3,9.2.4,9.3.1,10.3.1,10.3.2, 11.1.1, 11.1.2,11.2.1,11.3.1,11.3.2,12.1.1
CO5	6.1.1,6.2.1,7.1.1,7.1.2,7.2.1,7.2.2,8.1.1,8.2.1,8.2.2,9.1.1,9.1.2,9.2.1,9.2.2,9.2.3,9.2.4,9.3.1,11.1.1,12.1.2,12.2.1,12.2.2,12.3.1,12.3.2

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	30	30	20	20	-	-	100
CAT2	30	30	20	20	-	-	100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	30	30	20	20	-	-	100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	30	30	20	20	-	-	100
ESE	30	30	20	20	-	-	100

22BBS1Z1	**LINEAR ALGEBRA AND CALCULUS** *(Common to all Branches)*	**SEMESTER I**

PREREQUISITES	CATEGORY	L	T	P	C
NIL	BS	3	1	0	4

Course Objectives	1. To acquire knowledge of system of equations, eigenvalues, eigenvectors,diagonalization of matrices and reduction of quadratic forms to canonical forms. 2. To obtain the knowledge of analyze the functions using Limits and derivative recognize the appropriate tools of differential calculus to solve applied problems. 3. To obtain the knowledge of definite and improper integration and recognize the appropriate tools of Integral Calculus to solve applied problems 4. To develop the skills in solving the functions of several variables by partial derivatives. 5. To acquire knowledge of multiple integration and related applied problems in various geometry	
UNIT – I	**LINEAR ALGEBRA**	**9+3 Periods**
Consistency of System of Linear Equations - Eigen values and eigenvectors - Diagonalization of matrices by orthogonal transformation - Cayley-Hamilton Theorem - Quadratic to canonical forms.		
UNIT – II	**DIFFERENTIAL CALCULUS**	**9+3 Periods**
Limit and continuity of function - Rolle's theorem - Mean value theorems - Taylor's and Maclaurin's theorems. Application of Differential Calculus: Radius of curvature, Centre of curvature, Circle of curvature and Evolutes of a curve.		
UNIT – III	**INTEGRAL CALCULUS**	**9+3 Periods**
Evaluation of definite integral by trigonometric substitution - Convergence and Divergence of improper integrals - Beta & Gamma functions and their properties - Applications of definite integrals to evaluate surface areas and volume of revolution (Cartesian coordinates only).		
UNIT – IV	**PARTIAL DERIVATIVES AND ITS APPLICATIONS**	**9+3 Periods**
Partial derivatives - total derivative - Taylor's series – Jacobians - Maxima, minima and saddle points - Method of Lagrange multipliers.		
UNIT – V	**MULTI VARIABLE INTEGRAL CALCULUS**	**9+3 Periods**
Double integral - Area as double integral - change of order of integration in double integrals - Triple Integrals - Volume as Triple Integral. Change of variables: Cartesian to polar, Spherical polar coordinates, Cylindrical polar coordinates.		
Contact Periods: **Lecture: 45 Periods Tutorial: 15 Periods Practical: 0 Periods Total: 60 Periods**		

TEXT BOOK

1	*VeerarajanT., **"Engineering Mathematics I"**, Tata McGraw-Hill Education(India)Pvt. Ltd, New Delhi,2015.*
2	*David C.Lay, **"Linear Algebra and Its Application"**, Pearson Publishers, 6th Edition,2021.*

REFERENCES

1	*B.S.Grewal, **"Higher Engineering Mathematics"**, Khanna Publishers, 44th Edition, 2017.*
2	*Howard Anton, **"Elementry Linear Algebra"**, 11th Edition,Wiley Publication, 2013.*
3	*Narayanan.S and Manicavachagom Pillai. T.K. – **"Calculas Vol I and Vol II",** S.chand& Co, Sixth Edition, 2014.*
4	*H.K. Dass, **"Advance Engineering Mathematics"**, S. Chand and company, Eleventh Edition, 2015.*
5	*Jain R.K. and Iyengar S.R.K., **"Advanced Engineering Mathematics"**, NarosaPublicaitons, Eighth Edition, 2012.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Solve the linear system of equations, diagonalize matrix by orthogonal transformation and reduce quadratic form to canonical form.	K5
CO2	Compare and contrast the ideas of continuity and differentiability and use them to solve engineering problems.	K5
CO3	Acquire fluency in integration of one variable and apply them to find surface area and volumes.	K5
CO4	Apply the techniques of partial derivatives in functions of several variables.	K5
CO5	Use multiple integration for finding area, surface and volume of different geometry.	K5

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	3	3	1	1	-	-	-	-	-	-	-	1	-	1
CO2	3	3	1	1	-	-	-	-	-	-	-	1	-	1
CO3	3	3	1	1	-	-	-	-	-	-	-	1	-	1
CO4	3	3	1	1	-	-	-	-	-	-	-	1	-	1
CO5	3	3	1	1	-	-	-	-	-	-	-	1	-	1
22BBS1Z1	3	3	1	1	-	-	-	-	-	-	-	1	**-**	**1**

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.1.1, 1.1.2, 2.1.1, 2.1.3, 2.2.1, 2.2.3, 2.3.1, 2.3.2, 2.4.1, 2.4.3, 2.4.4, 3.1.1, 3.2.1, 3.3.1, 4.1.1, 4.1.2, 12.2.1
CO2	1.1.1, 1.1.2, 2.1.1, 2.1.3, 2.2.1, 2.2.3, 2.3.1, 2.3.2, 2.4.1, 2.4.3, 2.4.4, 3.1.1, 3.2.1, 3.3.1, 4.1.1, 4.1.2, 12.2.1
CO3	1.1.1, 1.1.2, 2.1.1, 2.1.3, 2.2.1, 2.2.3, 2.3.1, 2.3.2, 2.4.1, 2.4.3, 2.4.4, 3.1.1, 3.2.1, 3.3.1, 4.1.1, 4.1.2, 12.2.1
CO4	1.1.1, 1.1.2, 2.1.1, 2.1.3, 2.2.1, 2.2.3, 2.3.1, 2.3.2, 2.4.1, 2.4.3, 2.4.4, 3.1.1, 3.2.1, 3.3.1, 4.1.1, 4.1.2, 12.2.1
CO5	1.1.1, 1.1.2, 2.1.1, 2.1.3, 2.2.1, 2.2.3, 2.3.1, 2.3.2, 2.4.1, 2.4.3, 2.4.4, 3.1.1, 3.2.1, 3.3.1, 4.1.1, 4.1.2, 12.2.1

ASSESSMENT PATTERN – THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	20	40	30	10	-	-	100
CAT2	20	40	30	10	-	-	100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	20	40	30	10	-	-	100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	20	40	30	10	-	-	100
ESE	20	40	30	10	-	-	100

22BBS1Z2	ENGINEERING PHYSICS *(Common to all Branches)*	SEMESTER I

PREREQUISITES	CATEGORY	L	T	P	C
NIL	BS	3	0	0	3

Course Objectives	1. To understand the basics about crystal systems and defects 2. To understand the principle, characteristics, working and applications of laser and optical fiber 3. To solve problems in bending of beams 4. To solve quantum mechanical problems with the understanding of Quantum Principles 5. To understand the properties, production and applications of ultrasonic waves.	
UNIT – I	**CRYSTAL PHYSICS**	**9 Periods**
Introduction – Crystalline and amorphous materials – Lattice – Unit Cell –Crystal system - Bravais lattices – Miller indices – Reciprocal lattice - d spacing in cubic lattice – Calculation of number of atoms per unit cell – Atomic radius – Coordination number – Packing factor for SC, BCC, FCC and HCP structures – Crystal defects – Point, line and surface defects.		
UNIT – II	**LASER PHYSICS AND FIBER OPTICS**	**9 Periods**
Introduction- Principle of laser action - characteristics of laser - Spontaneous emission and Stimulated emission –Einstein's coefficients - population inversion – methods of achieving population inversion – Optical Resonator -Types of Lasers – Principle, construction and working of CO_2 Laser - applications of laser. Introduction – Basic Principles involved in fiber optics- Total internal reflection–Propagation of light through optical fiber –Derivation for Numerical Aperture and acceptance angle - fractional index change.		
UNIT – III	**PROPERTIES OF MATTER**	**9 Periods**
Elasticity- Hooke's law- stress-strain diagram - Factors affecting elasticity – Moment (Q) - Couple (Q) – Torque (Q) – Beam - Bending moment - Depression of a cantilever – Twisting Couple- Young's modulus by uniform bending - I shaped girders.		
UNIT – IV	**QUANTUM PHYSICS AND APPLICATIONS**	**9 Periods**
Limitations of classical Physics - Introduction to Quantum theory - Dual nature of matter and radiation- de-Broglie wavelength in terms of voltage, energy and temperature –Heisenberg's Uncertainty principle – verification – physical significance of a wave function- Schrödinger's Time independent and Time dependent wave equations –- Particle in a one dimensional potential well - Scanning Electron Microscope (SEM)-Transmission Electron Microscope (TEM).		
UNIT – V	**ULTRASONICS**	**9 Periods**
Introduction - properties of ultrasonic waves - production of ultrasonic waves - Magnetostriction effect- Magnetostriction generator- Piezoelectric effect- Piezoelectric generator- Acoustic grating - Determination of wavelength and velocity of ultrasonic waves- cavitation - applications- ultrasonic drilling- ultrasonic welding- ultrasonic soldering and ultrasonic cleaning- Non- destructive Testing- Pulse echo system.		
Contact Periods: **Lecture: 45 Periods** **Tutorial: 0 Periods** **Practical: 0 Periods** **Total: 45 Periods**		

TEXT BOOK:

1	*K. Rajagopal, **"Engineering Physics"**, PHI Learning Private Limited, 2015.*
2	*P. K. Palanisamy, "**Engineering Physics-I",** Scitech publications Private Limited, 2015.*
3	*M. Arumugam, "**Engineering Physics"**, Anuradha Publishers, 2010.*

REFERENCES:

1	*Arthur Beiser, "**Concepts of Modern Physics**", Tata McGraw-Hill, 2010.*
2	*D. Halliday, R. Resnick and J. Walker,"**Fundamentals of Physics**", 6th Edition, John Wiley and Sons, 2001.*
3	*William T. Silfvast, "**Laser Fundamentals**", 2nd Edition, Cambridge University Press, New York 2004.*
4	*M. N. Avadhanulu and P.G. Kshirsagar, "**A Textbook of Engineering Physics**", S. Chand and Company Ltd, 2010.*
5	*R. K. Gaur and S. L. Gupta, "**Engineering Physics",**Dhanpat Rai Publishers, 2009.*

COURSEOUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Interpret the crystal structure and analyse the type of defect	K4
CO2	Explain the principle, characteristics, working and applications of laser and optical fiber Analyse and solve problems in laser and optical fiber	K4
CO3	Solve problems in bending of beams Apply the knowledge in construction of buildings	K3
CO4	Explain the importance of quantum mechanics Solve problems in basic quantum physics Apply the wave equations in real time problems	K3
CO5	Explain the properties and production of ultrasonic waves Apply ultrasonic waves for industrial problems	K3

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	2	2	-	-	-	-	-	-	-	-	-	-	1	-
CO2	3	1	-	-	-	-	-	-	-	-	-	-	1	-
CO3	3	2	-	-	-	-	-	-	-	-	-	-	1	-
CO4	2	2	-	-	-	-	-	-	-	-	-	-	1	-
CO5	2	1	-	-	-	-	-	-	-	-	-	-	1	-
22BBS1Z2	**3**	**2**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**1**	**-**

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.1.1, 1.2.1, 1.3.1, 2.1.1, 2.1.3, 2.2.3, 2.3.1, 2.4.1
CO2	1.1.1, 1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.3, 2.3.1, 2.4.1
CO3	1.1.1, 1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.3, 2.2.1, 2.2.3, 2.2.4, 2.3.1, 2.4.1
CO4	1.1.1, 1.2.1, 1.3.1, 2.1.1, 2.1.3, 2.2.3, 2.3.1, 2.4.1
CO5	1.1.1, 1.2.1, 1.3.1, 2.1.1, 2.1.3, 2.3.1, 2.4.1

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	30	30	15	15	10	-	100
CAT2	30	30	15	15	10	-	100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	40	40	20	-	-	-	100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	40	40	20	-	-	-	100
ESE	30	30	15	15	10	-	100

22BBS103	CHEMISTRY FOR BIOTECHNOLOGY	SEMESTERI

PREREQUISITES		CATEGORY	L	T	P	C
NIL		BS	3	0	0	3
Course Objectives	1. To acquaint the student with the principles of organic chemistry of nucleophilic and electrophilic reactions. 2. To introduce about the concepts of stereochemistry and its configuration, synthesis and important reactions of five- and six-member hetero cyclic compounds. 3. To inculcate sound understanding of preparations, properties of bio-molecules like carbohydrate, amino acids. 4. To acquire basic knowledge about the nuclear reactions, transmutations and few tracer techniques. 5. To impart the knowledge about the nanoparticles, its preparations, properties, types and applications in various field.					
UNIT – I	**BASIC PRINCIPLES OF ORGANIC CHEMISTRY**	**9 Periods**				
Bonding in organic molecules – inductive effect, electrometric effect and mesomeric effect – Intermediates of organic reactions: carbocation, free radicals and carbene – Nucleophilic substitution – SN_1 and SN_2, Electrophilic substitution – Elimination reaction–E_1 and E_2.						
UNIT – II	**STEREOCHEMISTRYANDHETEROCYCLIC COMPOUNDS**	**9 Periods**				
Stereoisomerism – classification – enantiomers and diastereosiomers – chirality, optical activity –Optical isomerism (D&L, R&S configuration) – Geometrical (E&Z configuration). Hetero cyclic compounds – pyrrole, pyridine, quinoline and indole – aromaticity, synthesis and reactions of the compounds.						
UNIT – III	**INTRODUCTION TO BIO-MOLECULES**	**9 Periods**				
Basic principles – Bio-molecules, structure and properties of important bio-molecules: Carbohydrates– classification, structure of mono saccharides (Glucose &Fructose), Disaccharides: Sucrose, Maltose - Polysaccharides: Starch, Cellulose, occurrence and functions – Preparation, properties and uses of amino acids and proteins.						
UNIT – IV	**NUCLEAR CHEMISTRY**	**9 Periods**				
Nuclear fission (Nuclear reactor) and fusion (solar energy) – Nuclear reactions: Q value, cross sections, types of reactions, nuclear transmutations, radioactive techniques – tracer technique, neutron activation analysis – Radiolysis of water – G Value and applications of radioactivity.						
UNIT – V	**NANOMATERIALS**	**9 Periods**				
Nanomaterials and bulk materials; Size-dependent properties (optical, electrical, mechanical and magnetic); Types of nanomaterials: Definition, properties and uses of – nanoparticle, nanorod and nanotube. Preparation of nanomaterials: chemical vapour deposition, electrochemical deposition. Applications of nanomaterials in medicine, agriculture and electronics.						
Contact Periods: **Lecture: 45 Periods** **Tutorial: 0 Periods** **Practical: 0 Periods** **Total:45 Periods**						

TEXT BOOKS:

1	*Cox M. M. and Nelson D. L, Lehninger**"Principles of Bio chemistry"**, W H Freernan and Co., New York, 2021.*
2	*Jain. P.C. and Monica Jain, "**Engineering Chemistry**", Dhanpat Rai Publications. Pvt. Ltd. New Delhi, 16^{th} Edition, 2017*

REFERENCES:

1	*Robert Neilson Boyd,Saibalkanti Robert, Thornton Morrison "**Organic Chemistry**" kindle Edition 2014.*
2	*Murray, R.K, Kennelly P.J, Rodwell V.W, et al. "**Harper's Illustrated Biochemistry**", 29th Edition, McGraw–Hill, 2011*
3	*Charles P.Poole, Jr., Frank J.Owens"**''Introduction to NanoTechnology",** Wiley-India Edition,2006.*
4	*Said SalaheldeenElnashaie, FiroozehDanafar, Hassan Hashemipour Rafsanjani **"Nanotechnology for Chemical Engineers"**1st Edition 2015, Kindle Edition.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Make the students conversant with the basic concepts in nucleophilic substitution, electrophilic substitution, and elimination reaction.	K2
CO2	Assign the different types of stereoisomerism, configurations preparations and properties of heterocyclic compounds.	K3
CO3	Apply the mechanism of organic reactions in synthesis of biomolecules.	K3
CO4	Recognize and apply the concepts of nuclear chemistry with different tracer techniques.	K3
CO5	Implement the basic concepts of nanoscience and nanotechnology in designing the synthesis of nanomaterials for bio technological field.	K2

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	2	-	1	-	-	-	-	-	-	-	-	-	-	-
CO2	1	-	1	-	-	-	-	-	-	-	-	-	1	-
CO3	2	1	1	-	-	-	-	-	-	-	-	-	1	-
CO4	1	1	1	1	-	2	-	1	-	-	-	-	-	-
CO5	1	1	1	1	1	-	-	-	-	-	-	1	1	-
22BBS103	**2**	**1**	**1**	**1**	**1**	**1**	**-**	**1**	**-**	**-**	**-**	**1**	**1**	**-**

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.2.1, 1.4.1, 3.1.3
CO2	1.2.1, 3.1.3
CO3	1.2.1, 1.3.1, 1.4.1, 2.3.1, 3.1.3, 3.1.5
CO4	1.2.1, 2.1.3, 2.3.1, 3.1.3, 3.2.3, 4.1.2, 4.1.3, 6.2.1, 8.2.2
CO5	1.2.1, 2.4.2, 3.1.3, 4.2.1, 4.3.1, 5.1.2, 12.2.3

ASSESSMENT PATTERN – THEORY							
Test / Bloom’s Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Tota l %**
CAT1	20	40	20	20	-	-	100
CAT2	20	40	20	20	-	-	100
Individual Assessment 1/ Case Study 1/ Seminar 1 / Project1	20	40	20	20	-	-	100
Individual Assessment 2/ Case Study 2/ Seminar 2 / Project 2	20	40	20	20	-	-	100
ESE	20	40	20	20	-	-	100

22BES101	BASICS OF ELECTRICAL AND ELECTRONICS ENGINEERING *(Common toCIVIL, MECH, PRODN, CSE, IT & IBT Branches)*	SEMESTER I

PREREQUISITES	CATEGORY	L	T	P	C
NIL	ES	3	0	0	3

Course Objectives

1. To study the basic concepts of electric circuits, electronic devices and communication engineering.
2. To know the fundamentals of DC and AC machines.
3. To familiar with the basics of analog and digital electronics.
4. To understand the basics of house wiring.
5. To introduce the components of electrical installations and energy conservation.

UNIT – I **ELECTRICAL CIRCUITS** **9 Periods**

Electrical circuit elements (R,L and C) - Voltage and Current sources – Ohm's Law – Kirchoff laws – Time domain analysis of First order RL and RC circuits – Representation of sinusoidal waveforms – Average, RMS and Peak values – Phasor representation – Real, Reactive, Apparent power and power factor.

UNIT – II **ELECTRICAL MACHINES AND MEASUREMENTS** **9 Periods**

Construction, Principle of Operation, basic equations and Types, Characteristics and Applications of DC generators, DC motors, Single phase Transformer, Single phase and Three phase Induction motor. Operating principles of Moving coil, Moving iron Instruments (Ammeter and Voltmeters).

UNIT – III **ANALOG AND DIGITAL ELECTRONICS** **9 Periods**

Analog Electronics: Semiconductor devices – P-N junction diode, Zener diode, BJT, Operational amplifier – principle of operation, Characteristics and applications. Digital Electronics: Introduction to numbers systems, basic Boolean laws, reduction of Boolean expressions and implementation with logic gates.

UNIT – IV **FUNDAMENTAL OF COMMUNICATION AND TRANSDUCERS** **9 Periods**

Types of Signals: Analog and Digital Signals – Modulation and Demodulation: Principles of Amplitude and Frequency Modulations – Resistive, Inductive, capacitive Transducers- Introduction.

UNIT – V **ELECTRICAL INSTALLATIONS AND ENERGY CONSERVATION** **9 Periods**

Single phase and three phase system – phase, neutral and earth, basic house wiring -tools and components, different types of wiring - basic safety measures at home and industry – Energy efficient lamps - Energy billing. Introduction to UPS and SMPS.

Contact Periods:
Lecture: 45 Periods Tutorial: 0 PeriodsPractical: 0 Periods Total: 45 Periods

TEXT BOOKS:

1	*R.Muthusubramaniam,R.Salivaganan, Muralidharan K.A., "**Basic Electrical and Electronics Engineering**" Tata McGraw Hill , Second Edition 2010*
2	*Mittle V.N and Aravind Mittal, "**Basic Electrical Engineering**", Tata McGraw Hill, Second Edition, New Delhi, 2005*

REFERENCES:

1	*D.P.Kothari, I.J. Nagrath, "**Basic Electrical Engineering**", Tata McGraw Hill, 2010*
2	*Nagsarkar T.K and Sukhija M.S, "**Basic Electrical Engineering**", Oxford Press, 2005*
3	*E.Hughes,"**Electrical and Elecronics Technology**", Pearson, 2010*
4	*MohmoodNahvi and Joseph A.Edminister, "**Electric Circuits**", Shaum Outline series, McGraw Hill, Sixth edition, 2014*
5	*Premkumar N and Gnanavadivel J, "**Basic Electrical and Electronics Engineering**", Anuradha Publishers, 4th Edition, 2008*
6	*Allan S Morris, "**Measurement and Instrumentation Principles**" Elsevier, First Indian Edition, 2008.*
7	*S.L. Uppal ,"**Electrical Wiring Estimating and Costing**", Khanna publishers, New Delhi, 2006.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Analyze the DC and AC circuits	K4
CO2	Describe the operation and characteristics of electrical machines	K4
CO3	Classify and compare various semiconductor devices and digital electronics	K3
CO4	Infer the concept of communication engineering and Transducers.	K2
CO5	Assemble and implement electrical wiring and electrical installations	K6

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/POs	**PO1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**
CO1	2	3	3	2	1	-	-	-	-	-	-	-	2	-
CO2	2	2	3	2	1	-	2	1	-	-	-	-	3	-
CO3	3	2	3	2	1	-	-	-	-	1	-	-	2	-
CO4	2	3	3	2	-	-	3	-	-	-	-	1	2	-
CO5	2	2	3	2	-	-	-	-	-	-	-	-	3	-
22BES101	**3**	**3**	**3**	**2**	**1**	**-**	**1**	**1**	**-**	**1**	**-**	**1**	**3**	**-**

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.1.1, 1.2.1, 1.3.1, 2.1.1, 2.1.2, 2.1.3, 2.2.3, 2.3.1, 2.3.2, 2.4.1, 2.4.2, 2.4.3, 2.4.4, 3.1.1, 3.1.2, 3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.2, 3.2.3, 3.3.1, 3.3.2, 3.4.1, 3.4.2, 4.1.1, 4.1.2, 4.1.3, 4.1.4, 4.3.3, 5.2.1, 5.2.2.
CO2	1.1.1, 1.2.1, 1.3.1, 2.1.1, 2.1.2, 2.1.3,2.3.1, 2.3.2, 2.4.1, 2.4.2, 2.4.3, 2.4.4, 3.1.1, 3.1.2, 3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.2, 3.2.3, 3.3.1, 3.3.2, 3.4.1, 3.4.2, 4.1.1, 4.1.2, 4.1.3, 4.1.4, 4.3.1, 5.2.1, 5.2.2, 7.2.1, 7.2.2, 8.1.1.
CO3	1.1.1, 1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.3.1, 2.3.2, 2.4.1, 2.4.2, 2.4.3, 2.4.4, 3.1.1, 3.1.2, 3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.2, 3.2.3, 3.3.1, 3.3.2, 3.4.1, 3.4.2, 4.1.1, 4.1.2, 4.1.3, 4.1.4, 5.2.1, 5.2.2, 10.3.1.
CO4	1.1.1, 1.2.1, 1.3.1, 2.1.1, 2.1.2, 2.1.3, 2.2.3, 2.3.1, 2.3.2, 2.4.1, 2.4.2, 2.4.3, 2.4.4, 3.1.1, 3.1.2, 3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.2, 3.2.3, 3.3.1, 3.3.2, 3.4.1, 3.4.2, 4.1.1, 4.1.2, 4.1.3, 4.1.4, 7.1.1, 7.1.2, 7.2.1, 12.3.1, 12.3.2.
CO5	1.1.1, 1.2.1, 1.3.1, 2.1.1, 2.1.2, 2.1.3,2.3.1, 2.3.2, 2.4.1, 2.4.2, 2.4.3, 2.4.4, 3.1.1, 3.1.2, 3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.2, 3.2.3, 3.3.1, 3.3.2, 3.4.1, 3.4.2, 4.1.1, 4.1.2, 4.1.3, 4.1.4, 4.3.3.

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	30	30	40	-	-	-	100
CAT2	35	35	20	10	-	-	100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	25	25	50		-	-	100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	25	25	40	10	-	-	100
ESE	35	35	20	10	-	-	100

22BBS1Z4	CHEMISTRY LABORATORY *(Common to all Branches)*	SEMESTERI

PREREQUISITES	CATEGORY	L	T	P	C
NIL	BS	0	0	3	1.5

COURSE OBJECTIVES:

To inculcate the practical applications of Chemistry to students and make them apply in the fields of engineering and technology.

LIST OF EXPERIMENTS	
1.	Estimation of hardness by EDTA method.
2	Conductometric titration of mixture of strong acid and weak acid using strong base.
3.	Estimation of chloride by Argentometric method.
4.	Potentiometric titration of ferrous iron by dichromate.
5.	Determination of Saponification value of an oil.
6.	Estimation of Iron by Spectrophotometry.
7.	Estimation of Dissolved Oxygen.
8.	Estimation of HCl by pH titration.
9.	Estimation of Copper in brass sample.
10.	Estimation of Manganese in Pyrolusite ore.
11.	Anodiziation of aluminium.
12.	Determination of corrosion rate and inhibitor efficiency of mild steel in acid media by weight loss method.

Contact Periods:

Lecture: 0 PeriodsTutorial: 0 Periods Practical: 45 PeriodsTotal: 45 Periods

REFERENCE BOOKS:

1	*A.O. Thomas, "**Practical Chemistry**", Scientific Book Centre, Cannanore, 2006.*
2	*Vogel's "**Text book of Quantitative Analysis**", Jeffery G H, Basset J. Menthom J, Denney R.C.,6th Edition, EBS, 2009.*

COURSE OUTCOMES: Upon the completion of the course, the student will be able to		**Bloom's Taxonomy Mapped**
CO1	Analyze the quality of water samples with respect to their hardness and DO.	K3
CO2	Determine the amount of metal ions through potentiometric and spectroscopic techniques.	K3
CO3	Infer the strength of acid, mixtures of acids by pH meter and conductivity cell.	K3
CO4	Estimate the chloride, manganese and copper from various samples.	K3
CO5	Interpret the corrosion rate determination and anodizing method.	K2

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**
CO1	2	1	1	-	-	-	-	-	-	-	-	-	1	-
CO2	2	1	-	-	-	-	-	-	-	-	-	-	1	-
CO3	2	1	-	1	-	-	-	-	-	-	-	-	1	-
CO4	2	1	-	-	-	-	-	-	-	-	-	-	1	-
CO5	2	1	1	1	-	-	1	-	-	-	-	-	-	-
22BBS1Z4	**2**	**1**	**1**	**1**	**-**	**-**	**1**	**-**	**-**	**-**	**-**	**-**	**1**	**-**

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.1.1, 1.2.1, 2.3.1, 3.1.5
CO2	1.1.1, 1.2.1, 1.3.1, 2.1.2
CO3	1.1.1, 1.2.1, 2.1.3, 4.1.3
CO4	1.2.1, 1.3.1, 2.3.1
CO5	1.1.1, 1.2.1, 1.3.1, 2.3.1, 3.1.5, 4.2.1, 7.1.1

22BES1Z2	**ENGINEERING GRAPHICS** *(Common toall Branches)*	**SEMESTER I**

PREREQUISITES	CATEGORY	L	T	P	C
NIL	ES	1	0	4	3

Course Objectives	1. To understand the geometrical constructions. 2. To study the various types of projections. 3. To identify different section of solids. 4. To perform the development of surfaces and view of solids. 5. To familiarize with CAD packages.	
UNIT – I	**GEOMETRICAL CONSTRUCTIONS AND PLANE CURVES**	**3+12 Periods**
Principles of Engineering Graphics and their significance - Basic geometrical constructions. Conics – Construction of ellipse, parabola and hyperbola by eccentricity method – Drawing of tangents and normal to the above curves.		
UNIT – II	**ORTHOGRAPHIC PROJECTIONS**	**3+12 Periods**
Introduction to Orthographic Projection - Conversion of pictorial views to orthographic views. Projection of points - Projection of straight lines with traces - Projection of planes (polygonal and circular surfaces) inclined to both the principal planes.		
UNIT – III	**PROJECTION AND SECTION OF SOLIDS**	**3+12 Periods**
Projection of simple solids like prisms, pyramids, cylinder, cone and truncated solids, when the axis is inclined to both the principal planes by rotating object method. Sectioning of prisms, pyramids, cylinder and cone in simple vertical position when the cutting plane is inclined to the one of the principal planes and perpendicular to the other – obtaining true shape of section.		
UNIT – IV	**DEVELOPMENT OF SURFACES AND ISOMETRIC PROJECTIONS**	**3+12 Periods**
Development of lateral surfaces of simple and sectioned solids – prisms, pyramids, cylinder and cone. Principles of isometric projection – isometric scale – isometric projections of simple solids and truncated solids - prisms, pyramids, cylinder, cone- combination of two solid objects in simple vertical positions.		
UNIT – V	**COMPUTER AIDED DRAFTING**	**(3+12 Periods)**
Introduction to computer aided drafting package to make 2D Drawings. Object Construction: Page layout – Layers and line types – Creating, editing and selecting the geometric objects. Mechanics: Viewing, annotating, hatching and dimensioning the drawing – Creating blocks and attributes. Drafting: Create 2D drawing. A number of chosen problems will be solved to illustrate the concepts clearly. (Demonstration purpose only, not to be included in examination).		
Contact Periods: **Lecture: 15 Periods Tutorial: 0 Periods Practical: 60 Periods Total: 75 Periods**		

TEXT BOOKS:

1	*K.Venugopal, **"Engineering Graphics"**, New Age International (P) Limited, 2016.*
2	*K.V.Natarajan, **"A text book of Engineering Graphics"**, Dhanalakashmi Publishers, Chennai, 2016.*

REFERENCES:

1	*K.L.Narayana and P.Kannaiah,* ***"Text book on Engineering Drawing"****, 2nd Edition, SciTech Publications (India) Pvt. Ltd, Chennai, 2009.*
2	*N.S.Parthasarathy and Vela Murali,* ***"Engineering Graphics"****, Oxford University Press, New Delhi, 2015.*
3	*K.R.Gopalakrishna,* ***"Engineering Drawing" (Vol. I&II combined),*** *Subhas Publications, Bangalore, 2014.*
4	*Basant Agarwal and C.M.Agarwal,* ***"Engineering Drawing"****, Tata McGraw Hill Publishers, New Delhi, 2013.*
5	*Kevin Lang and Alan J.Kalameja, "****AutoCAD 2012 Tutor for Engineering Graphics"****, Cengage Learning Publishers, 1st Edition, 2011.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Acquire on representing solids as per international standards.	K3
CO2	Impart knowledge on different types of projections.	K3
CO3	Generate and interrupt the true shape of section.	K3
CO4	Develop the various surfaces according to the standards.	K3
CO5	Know the concept of computers in drafting engineering diagrams.	K6

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**
CO1	3	1	1	1	1	2	-	3	1	3	1	3	2	2
CO2	3	1	1	1	1	2	-	3	1	3	1	3	1	2
CO3	3	1	1	1	1	2	-	3	1	3	1	3	1	1
CO4	3	1	1	1	1	2	-	3	1	3	1	3	2	2
CO5	3	1	1	1	1	2	-	3	1	3	1	3	2	3
22BES1Z2	3	1	1	1	1	**2**	**-**	**3**	**1**	3	**1**	3	**2**	**2**

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.1.1, 1.2.1, 1.3.1, 1.4.1, 2.1.3, 2.4.2, 3.1.2, 3.1.4, 3.2.1, 4.3.3, 5.1.1, 6.2.1, 8.1.1, 8.2.1, 8.2.2, 9.2.1, 9.2.4, 10.1.1, 10.1.2, 10.2.1, 10.2.2, 10.3.1, 10.3.2, 11.3.1, 12.1.1, 12.2.1, 12.2.2, 12.3.1, 12.3.2
CO2	1.1.1, 1.2.1, 1.3.1, 1.4.1, 2.1.3, 2.4.2, 3.1.2, 3.1.4, 3.2.1, 4.3.3, 5.1.1, 6.2.1, 8.1.1, 8.2.1, 8.2.2, 9.2.1, 9.2.4, 10.1.1, 10.1.2, 10.2.1, 10.3.1, 10.3.2, 11.3.1, 12.1.1, 12.2.1, 12.2.2, 12.3.1, 12.3.2
CO3	1.1.1, 1.2.1, 1.3.1, 1.4.1, 2.1.3, 2.4.2, 3.1.2, 3.1.4, 3.2.1, 4.3.3, 5.1.1, 6.2.1, 8.1.1, 8.2.1, 8.2.2, 9.2.1, 9.2.4, 10.1.1, 10.1.2, 10.2.1, 10.2.2, 10.3.1, 10.3.2, 11.3.1, 12.1.1, 12.2.1, 12.2.2, 12.3.1, 12.3.2
CO4	1.1.1, 1.2.1, 1.3.1, 1.4.1, 2.1.3, 2.4.2, 3.1.2, 3.1.4, 3.2.1 ,4.3.3, 5.1.1, 6.2.1, 8.1.1, 8.2.1, 8.2.2, 9.2.1, 9.2.4, 10.1.1, 10.1.2, 10.2.1, 10.2.2, 10.3.1, 10.3.2, 11.3.1, 12.1.1, 12.2.1, 12.2.2, 12.3.1, 12.3.2
CO5	1.1.1, 1.2.1, 1.3.1, 1.4.1, 2.1.3, 2.4.2, 3.1.2, 3.1.4, 3.2.1, 4.3.3, 5.1.1, 6.2.1, 8.1.1, 8.2.1, 8.2.2, 9.2.1, 9.2.4, 10.1.1, 10.2.1, 10.2.2, 10.3.1, 10.3.2, 11.3.1, 12.1.1, 12.2.1, 12.2.2, 12.3.1, 12.3.2

22BHS2Z4	தமிழரும் தொழில்நுட்பமும் **TAMILS AND TECHNOLOGY** *(Common to all Branches)*	**SEMESTER II**

PREREQUISITES	**CATEGORY**	**L**	**T**	**P**	**C**
NIL	**HSMC**	**1**	**0**	**0**	**1**

UNIT – I	**WEAVING AND CERAMIC TECHNOLOGY**	**3 Periods**
Weaving Industry during Sangam Age – Ceramic technology – Black and Red Ware Potteries (BRW)– Graffiti on Potteries.		
UNIT – II	**DESIGN AND CONSTRUCTION TECHNOLOGY**	**3 Periods**
Designing and Structural construction House & Designs in household materials during Sangam Age- Building materials and Hero stones of Sangam age – Details of Stage Constructions in Silappathikaram - Sculptures and Temples of Mamallapuram - Great Temples of Cholas and other worship places - Temples of Nayaka Period - Type study (Madurai Meenakshi Temple)- Thirumalai Nayakar Mahal - Chetti Nadu Houses, Indo - Saracenic architecture at Madras during British Period.		
UNIT – III	**MANUFACTURING TECHNOLOGY**	**3 Periods**
Art of Ship Building - Metallurgical studies - Iron industry - Iron smelting, steel -Copper and gold- Coins as source of history - Minting of Coins – Beads making-industries Stone beads -Glass beads - Terracotta beads -Shell beads/ bone beats - Archeological evidences - Gem stone types described in Silappathikaram.		
UNIT – IV	**AGRICULTURE AND IRRIGATION TECHNOLOGY**	**3 Periods**
Dam, Tank, ponds, Sluice, Significance of KumizhiThoompu of Chola Period, Animal Husbandry - Wells designed for cattle use - Agriculture and Agro Processing - Knowledge of Sea - Fisheries – Pearl - Conche diving - Ancient Knowledge of Ocean - Knowledge Specific Society.		
UNIT – V	**SCIENTIFIC TAMIL & TAMIL COMPUTING**	**3 Periods**
Development of Scientific Tamil - Tamil computing – Digitalization of Tamil Books – Development of Tamil Software – Tamil Virtual Academy – Tamil Digital Library – Online Tamil Dictionaries – Sorkuvai Project.		
Contact Periods: **Lecture: 15Periods** **Tutorial:0 Periods** **Practical:0Periods** **Total: 15Periods**		

TEXT BOOK:

1	தமிழகவரலாறு – மக்களும்பண்பாடும் – கே.கே. பிள்ளை (வெளியீடு:தமிழ்நாடுபாடநூல்மற்றும்கல்வியியல்பணிகள்கழகம்).
2	கணினித்தமிழ் – முனைவர்இல.சுந்தரம் . (விகடன்பிரசுரம்).
3	கீழடி – வைகைநதிக்கரையில்சங்ககாலநகரநாகரிகம் (தொல்லியல்துறைவெளியீடு)
4	பொருநை – ஆற்றங்கரைநாகரிகம். (தொல்லியல்துறைவெளியீடு)

REFERENCES:

1	Social Life of Tamils (Dr.K.K.Pillay) A joint publication of TNTB & ESC and RMRL – (in print)
2	Social Life of the Tamils - The Classical Period (Dr.S.Singaravelu) (Published by:International Institute of Tamil Studies.
3	Historical Heritage of the Tamils (Dr.S.V.Subatamanian, Dr.K.D. Thirunavukkarasu)(Published by: International Institute of Tamil Studies).
4	The Contributions of the Tamils to Indian Culture (Dr.M.Valarmathi) (Published by:International Institute of Tamil Studies.)
5	Keeladi - 'Sangam City C ivilization on the banks of river Vaigai' (Jointly Published by:Department of Archaeology & Tamil Nadu Text Book and Educational Services Corporation,Tamil Nadu)
6	Studies in the History of India with Special Reference to Tamil Nadu (Dr.K.K.Pillay)(Published by: The Author)
7	Porunai Civilization (Jointly Published by: Department of Archaeology & Tamil Nadu Text Book and Educational Services Corporation, Tamil Nadu)
8	Journey of Civilization Indus to Vaigai (R.Balakrishnan) (Published by: RMRL) –Reference Book.

22BHS2Z4	**தமிழரும் தொழில் நுட்பமும்** **TAMILS AND TECHNOLOGY** *(Common to all Branches)*	**SEMESTER II**

PREREQUISITES	**CATEGORY**	**L**	**T**	**P**	**C**
NIL	**HSMC**	**1**	**0**	**0**	**1**

அலகு I	**நெசவு மற்றும் பானைத்தொழில்நுட்பம்**	**3 Periods**
சங்க காலத்தில் நெசவுத்தொழில் – பானைத்தொழில்நுட்பம் – கருப்பு சிவப்பு பாண்டங்கள்– பாண்டங்களில் கீறல் குறியீடுகள்.		
அலகு II	**வடிவமைப்புமற்றும்கட்டிடத்தொழில்நுட்பம்**	**3 Periods**
சங்க காலத்தில் வடிவமைப்பு மற்றும் கட்டுமானங்கள் & சங்க காலத்தில் வீட்டுப்பொருட்களில் வடிவமைப்பு-சங்ககாலத்தில் கட்டுமானபொருட்களும் நடுகல்லும்–சிலப்பதிகாரத்தில் மேடை அமைப்பு பற்றிய விவரங்கள்– மாமல்லபுரச் சிற்பங்களும், கோவில்களும்-சோழர் காலத்துப் பெருங்கோயில்கள் மற்றும் பிற வழிபாட்டுத்தலங்கள்– நாயக்கர் காலக் கோயில்கள்-மாதிரி கட்டமைப்புகள் பற்றி அறிதல், மதுரை மீனாட்சி அம்மன் ஆலயம் மற்றும் திருமலை நாயக்கர் மஹால் – செட்டிநாட்டு வீடுகள்– பிரிட்டிஷ்காலத்தில்சென்னையில்இந்தோ-சாரோசெனிக்கட்டிடக்கலை.		
அலகு III	**உற்பத்தித்தொழில்நுட்பம்**	**3 Periods**
கப்பல் கட்டும் கலை – உலோகவியல் – இரும்புத்தொழிற்சாலை – இரும்பை உருக்குதல், எஃகு – வரலாற்றுச்சான்றுகளாக செம்பு மற்றும் தங்கநாணயங்கள் –நாணயங்கள் அச்சடித்தல் – மணி உருவாக்கும் தொழிற்சாலைகள் – கல்மணிகள், கண்ணாடிமணிகள் – சுடுமண்மணிகள் – சங்குமணிகள் – எலும்புத்துண்டுகள்–தொல்லியல்சான்றுகள் சிலப்பதிகாரத்தில் மணிகளின் வகைககள்.		
அலகு IV	**வேளாண்மை மற்றும்நீர்ப்பாசனத்தொழில்நுட்பம்**	**3 Periods**
miz, ஏரி, குளங்கள், மதகு – சோழர்காலக்குமுழித்தூம்பின் முக்கியத்துவம் – கால்நடை பராமரிப்பு – கால்நடைகளுக்காக வடிவமைக்கப்பட்ட கிணறுகள் – வேளாண்மை மற்றும் வேளாண்மைச்சார்ந்த செயல்பாடுகள் – கடல்சார்அறிவு – மீன்வளம் – முத்து மற்றும் முத்துக்குளித்தல் – பெருங்கடல் குறித்த பண்டைய அறிவு –அறிவுசார் சமூகம்.		
அலகு V	**அறிவியல்தமிழ்மற்றும் கணினித்தமிழ்**	**3 Periods**
அறிவியல் தமிழின் வளர்ச்சி - கணினித்தமிழ்வளர்ச்சி- தமிழ் நூல்களை மின்பதிப்பு செய்தல் – தமிழ் மென் பொருட்கள் உருவாக்கம் – தமிழ் Iizயக்கல்விக்கழகம் – தமிழ்மின்நூலகம் – Iizயத்தில் தமிழ் அகராதிகள் –		

சொற்குவைத்திட்டம்.
Contact Periods: **Lecture: 15Periods** **Tutorial:0 Periods** **Practical:0Periods** **Total: 15Periods**

TEXT BOOK:

1	தமிழகவரலாறு – மக்களும்பண்பாடும் – கே.கே. பிள்ளை (வெளியீடு: தமிழ்நாடுபாடநூல்மற்றும்கல்வியியல்பணிகள்கழகம்).
2	கணினித்தமிழ் – முனைவர் இல.சுந்தரம் . (விகடன்பிரசுரம்).

3	கீழடி – வைகை நதிக்கரையில் சங்ககாலநகரநாகரிகம் (தொல்லியல்துறை வெளியீடு)
4	பொருநை – ஆற்றங்கரைநாகரிகம். (தொல்லியல்துறைவெளியீடு)

REFERENCES:

1	Social Life of Tamils (Dr.K.K.Pillay) A joint publication of TNTB & ESC and RMRL – (in print)
2	Social Life of the Tamils - The Classical Period (Dr.S.Singaravelu) (Published by:International Institute of Tamil Studies.
3	Historical Heritage of the Tamils (Dr.S.V.Subatamanian, Dr.K.D. Thirunavukkarasu)(Published by: International Institute of Tamil Studies).
4	The Contributions of the Tamils to Indian Culture (Dr.M.Valarmathi) (Published by:International Institute of Tamil Studies.)
5	Keeladi - 'Sangam City C ivilization on the banks of river Vaigai' (Jointly Published by:Department of Archaeology & Tamil Nadu Text Book and Educational Services Corporation,Tamil Nadu)
6	Studies in the History of India with Special Reference to Tamil Nadu (Dr.K.K.Pillay)(Published by: The Author)
7	Porunai Civilization (Jointly Published by: Department of Archaeology & Tamil Nadu Text Book and Educational Services Corporation, Tamil Nadu)
8	Journey of Civilization Indus to Vaigai (R.Balakrishnan) (Published by: RMRL) –Reference Book.

22BHS2Z5	**PROFESSIONAL ENGLISH** *(Common to all Branches)*	**SEMESTER II**

PREREQUISITES	**CATEGORY**	**L**	**T**	**P**	**C**
NIL	HSMC	2	1	0	3

Course Objectives	1. To engage learners in meaningful language activities to improve their LSRW skills 2. To enhance learners' awareness of general rules of writing for specific audiences 3. To help learners understand the purpose, audience, contexts of different types of writing 4. To develop analytical thinking skills for problem solving in communicative contexts 5. To demonstrate an understanding of job applications and interviews for internship and placements	
UNIT – I	**FUNDAMENTALS OF COMMUNICATION**	**9 Periods**
Listening–Listening to Personal Introduction and Filling a form Speaking - Self Introduction;Introducing someone in a formal context Reading -Reading Biographies/ Autobiographies and E-mails relevant to technical contexts. Writing - Writing Biographies/ Autobiographies; Drafting Professional E-mails. Grammar - Present Tense (Simple Present, Present Progressive, Present Perfect, Present Perfect Continuous); Parts of Speech Vocabulary - Word Formation with Prefixes; Antonyms; Portmanteau Words		
UNIT – II	**SUMMATION AND PROBLEM SOLVING**	**9 Periods**
Listening - Listening to Short-Stories / Personal Experiences/Watching Movies. Speaking-Narrating Personal Experiences / Events and Short Stories Reading - Reading Travelogues and Books. Writing - Report on an event (Field Trip, Industrial Visit, Educational Tours etc.), Review on Books and Movies. Grammar –Past Tense (Simple Past, Past Progressive, Past Perfect, Past Perfect Continuous); Impersonal Passive Vocabulary - Word Formation with suffixes; Synonyms; Phrasal Verbs.		
UNIT– III	**DESCRIPTION OF A PROCESS / PRODUCT**	**9 Periods**
Listening - Listening to Digital Marketing Advertisements for Product /Process Descriptions Speaking –Describing/Interpreting a Picture; Giving instructions to use the product. Reading – Reading Advertisements, Gadget Reviews; User Manuals. Writing - Writing Definitions; Product /Process Description; Transcoding; Content Writing Grammar -Future Tense(Simple Future, future continuous, Future Perfect, Future Perfect Continuous); If Clauses Vocabulary - Homonyms; Homophones, One Word Substitutes.		
UNIT– IV	**EXPRESSION**	**9 Periods**
Listening – Listening to/Watching Formal Job interviews or Celebrity Interviews Speaking – Participating in a Face to Face or Virtual Interview (Job/Celebrity Interview), virtual interviews Reading – Company profiles, Statement of Purpose, (SOP), Excerpts of interview with professionals from Newspaper, Magazine and other Resources Writing – Job / Internship Application – Cover letter & Resume Grammar – Question types: 'Wh' / Yes or No/ and Tags; Subject- Verb Agreement. Vocabulary – Idiomatic Expressions		
UNIT – V	**PUBLIC SPEAKING**	**9 Periods**
Listening – Listening to Ceremonious Speeches on You Tube and Jotting down phrases Speaking – Delivering Welcome Address; Introducing the Chief-Guest; Proposing Vote of Thank and Felicitation		

Reading – Excerpts of Speeches from Newspaper, Magazines and Motivational Books Writing – Drafting a Welcome Address, Introduction to the Chief-Guest, Vote of Thanks and Felicitation Grammar –Common Errors Vocabulary – Commonly Confused Words
Contact Periods: **Lecture: 30 Periods Tutorial: 15 Periods Practical: 0 Periods Total: 45 Periods**

TEXT BOOK

1	***English for Science & Technology*** *Cambridge University Press, 2021. Authored by Dr.VeenaSelvam, Dr. Sujatha Priyadarshini, Dr.Deepa Mary Francis, Dr. KN. Shoba, and Dr. Lourdes Joevani, Department of English, Anna University.*
2	***Communicative English,*** *Global Publishers, Chennai 2017 by Dr.J.Anbazhagan Vijay*

REFERENCES

1	*Raman.Meenakshi,Sharma.Sangeeta(2019).* ***Professional English.*** *Oxford University Press. New Delhi.*
2	***Learning to Communicate*** *– Dr. V. Chellammal, Allied Publishing House, New Delhi,2003*
3	***Using English****, Orient Blackswan, Chennai, 2017 by Board of Editors*
4	***OER****(Authentic Open Educational Resources)*

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Participate in a basic communicative task.	K3
CO2	Analyse problems in order to arrive at feasible solutions and communicate them orally and in the written format.	K3
CO3	Describe a product or process or mechanism.	K2
CO4	Present their opinions in a planned and logical manner, and draft effective resumes in context of job search.	K3
CO5	Deliver speeches at formal functions.	K3

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	-	-	1	-	-	2	-	-	3	3	-	-	-	1
CO2	-	1	1	-	-	2	-	-	1	3	-	1	-	1
CO3	-	-	-	1	-	-	-	-	-	3	-	-	-	1
CO4	-	-	1	-	-	-	-	-	2	3	-	-	-	1
CO5	-	-	-	-	-	-	-	-	2	2	-	-	-	1
22BHS2Z5	**-**	**1**	**1**	**1**	**-**	**1**	**-**	**-**	**2**	**3**	**-**	**1**	**-**	**1**

b) CO and Key Performance Indicators Mapping

CO1	3.3.2, 6.1.1, 9.2.1, 9.2.2, 9.2.3, 9.2.4, 9.3.1, 10.1.1, 10.1.2, 10.1.3, 10.2.1, 10.2.2
CO2	2.1.1, 2.2.3, 2.2.4, 3.1.2, 6.2.1, 9.2.1, 10.1.1, 10.1.2, 10.1.3, 10.2.1, 10.2.2, 12.3.1, 12.3.2
CO3	4.1.1, 10.1.1, 10.1.2, 10.1.3, 10.2.1, 10.2.2
CO4	3.3.2, 9.2.2, 9.2.3, 9.2.4, 9.3.1, 10.1.1, 10.1.2, 10.1.3, 10.2.1, 10.2.2
CO5	9.2.2, 9.2.3, 9.2.4, 10.1.1, 10.1.3, 10.2.1, 10.2.2

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	-	12	88	-	-	-	100
CAT2	-	18	82	-	-	-	100
Individual Assessment 1/ Case Study 1/ Seminar 1 / Project1	-	-	100	-	-	-	100
Individual Assessment 2/ Case Study 2/ Seminar 2 / Project 2	-	-	100	-	-	-	100
ESE	-	20	80	-	-	-	100

22BBS205	DIFFERENTIAL EQUATIONS AND NUMERICAL METHODS *(Common to all Branches except CSE & IT)*	SEMESTER II

PREREQUISITES	CATEGORY	L	T	P	C
NIL	BS	3	1	0	4

Course Objectives	1. To gain knowledge of methods to solve higher order differential equations with constant and variable coefficients. 2. To be familiar with forming partial differential equations and solving partial differential equations of standard types of first order and homogeneous linear differential equations. 3. To be familiar with numerical interpolation, numerical differentiation and numerical integration. 4. To acquire the knowledge of numerical solution to first order ordinary differential equations using single and multi step techniques. 5. To gain the knowledge of numerical solution to second order partial differential equations using explicit and implicit methods.	
UNIT – I	**ORDINARY DIFFERENTIAL EQUATIONS**	**9+3 Periods**
Higher order linear differential equations with constant coefficients -variable coefficients: Cauchy-Euler equation, Cauchy-Legendre equation-Method of variation of parameters-Simultaneous first order linear equations with constant coefficients.		
UNIT – II	**PARTIAL DIFFERENTIAL EQUATIONS**	**9+3 Periods**
Formation of partial differential equations – First order partial differential equations – Standard types and Lagrange's type – Homogeneous linear partial differential equation of second and higher order with constant coefficients.		
UNIT – III	**INTERPOLATION, NUMERICAL DIFFERENTIATION AND INTEGRATION**	**9+3 Periods**
Solution of polynomial and transcendental equations: Newton-Raphson method-Interpolation with equal interval: Newton's forward and backward difference formulae-Interpolation with unequal intervals: Lagrange's formulae-Numerical Differentiation: Newton's formulae-Numerical integration: Trapezoidal rule and Simpson's 1/3rd and 3/8 rules.		
UNIT – IV	**NUMERICAL SOLUTION OF ORDINARY DIFFERENTIAL EQUATIONS**	**9+3 Periods**
First order ordinary differential equations: Taylor's series method-Euler and modified Euler's methods-Runge- Kutta method of fourth order -Milne's and Adam's predicator-corrector methods.		
UNIT – V	**NUMERICAL SOLUTION OF PARTIAL DIFFERENTIAL EQUATIONS**	**9+3 Periods**
Partial differential equations: Finite difference method for two dimensional Laplace equation and Poisson equation- Implicit and explicit methods for one dimensional heat equation (Bender-Schmidt and Crank-Nicholson methods)-Finite difference explicit method for wave equation.		
Contact Periods: **Lecture: 45 Periods Tutorial: 15 Periods Practical: 0 Periods Total: 60 Periods**		

TEXT BOOK

1	*Veerarajan.T,* ***"Engineering Mathematics"****, Revised Edition 2018, McGraw Hill Education (India) Private Limited*
2	*P. Kandasamy, K. Thilagavathy, K. Gunavathi,* ***"Numerical Methods"****, S. Chand & Company, 3rd Edition, Reprint 2013.*

REFERENCES

1	*B.S.Grewal,* ***"Higher Engineering Mathematics"****, Khanna Publishers, New Delhi, 44th Edition, 2018.*
2	*SrimantaPal,* ***"Numerical Methods Principles, Analyses and Algorithms"****, Oxford University Press, New Delhi, 1st Edition 2009.*
3	*Raisinghania.M..D,* ***"Ordinary And Partial Differential Equations"****, 20th Edition, S. ChandPublishing,2020*
4	*S.S. Sastry,* ***"Introductory methods of numerical analysis"****, PHI, New Delhi, 5th Edition, 2015.*
5	*Ward Cheney, David Kincaid,* ***"Numerical Methods and Computing,*** *Cengage Learning, Delhi, 7th Edition 2013.*
6	*S. Larsson, V. Thomee,* ***"Partial Differential Equations with Numerical Methods"****, Springer, 2003.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Solve higher order linear differential equation with constant and variable coefficients and simultaneous differential equation.	K5
CO2	Form partial differential equations and find solutions of first and higher order partial differential equations.	K5
CO3	Obtain approximate solutions for transcendental equations and problems on interpolation, differentiation, integration.	K5
CO4	Find the numerical solutions of first order ordinary differential equations using single and multi step techniques.	K5
CO5	Solve second order partial differential equations using explicit and implicit methods.	K5

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**
CO1	3	3	-	1	-	-	-	-	-	-	-	1	3	-
CO2	3	3	-	1	-	-	-	-	-	-	-	1	3	-
CO3	3	3	-	1	-	-	-	-	-	-	-	1	3	-
CO4	3	3	-	1	-	-	-	-	-	-	-	1	3	-
CO5	3	3	-	1	-	-	-	-	-	-	-	1	3	-
22BBS205	**3**	**3**	**-**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**1**	**3**	**-**

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.1.1, 1.1.2, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3,2.2.4, 2.3.1, 2.3.2, 2.4.1, 2.4.3, 4.1.1,12.2.1
CO2	1.1.1, 1.1.2, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3,2.2.4, 2.3.1, 2.3.2, 2.4.1, 2.4.3, 4.1.1,12.2.1
CO3	1.1.1, 1.1.2, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3,2.2.4, 2.3.1, 2.3.2, 2.4.1, 2.4.3, 4.1.1,12.2.1
CO4	1.1.1, 1.1.2, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3,2.2.4, 2.3.1, 2.3.2, 2.4.1, 2.4.3, 4.1.1,12.2.1
CO5	1.1.1, 1.1.2, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3,2.2.4, 2.3.1, 2.3.2, 2.4.1, 2.4.3, 4.1.1,12.2.1

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	20	40	20	20	-	-	100
CAT2	20	40	20	20	-	-	100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	20	40	20	20	-	-	100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	20	40	20	20	-	-	100
ESE	20	40	20	20	-	-	100

22BES203	**PROGRAMMING IN C** *(Common to all Branches except MECH &PRODN)*	SEMESTERII

PREREQUISITES	CATEGORY	L	T	P	C
NIL	ES	3	0	0	3

Course Objectives	1. To study the basic concepts of computer and programming fundamentals. 2. To understand the data types in C , flow control statements, Arrays, Functions Pointers, Structures, Unions and File concepts in C.	
UNIT – I	**COMPUTER AND PROGRAMMING FUNDAMENTALS**	**(9 Periods)**
Computer fundamentals – Evolution, classification, Anatomy of a computer: CPU, Memory, I/O – Introduction to software –Classification of programming languages – Compiling –Linking and loading a program – Introduction to OS – Types of OS.		
UNIT – II	**DATATYPES AND FLOW OF CONTROL**	**(9 Periods)**
Structured programming – Algorithms – Structure of a C program – Variables – Data types – Operators and expressions – Input and Output statements – Tokens –Type Conversion – Control statements.		
UNIT – III	**ARRAYS AND FUNCTIONS**	**(9 Periods)**
1DArrays– 2D Arrays – Multidimensional Arrays – Strings – String handling functions – Functions – Recursion – Array as function arguments – Storage Classes – Enumerations.		
UNIT – IV	**POINTERS**	**(9 Periods)**
Introduction to pointers – Pointers arithmetic – call by reference – Relationship between Array and Pointers – Relationship between String and pointers – pointers to pointers – array of pointers – pointers to an array – Dynamic memory allocation – Arguments to main().		
UNIT – V	**STRUCTURES AND UNIONS, FILE OPERATIONS**	**(9 Periods)**
Preprocessor directives – Structures – Unions – Bit fields – Opening and closing a file – Working with file of records – Random access to file of records.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOK

1	*PradipDey, Manas Ghosh,* ***"Computer Fundamentals and Programming in C",*** *Second Edition, Oxford University Press, 2018.*

REFERENCES

1	*Al Kelley, Ira Pohl,**"A Book on C- Programming in C** ",Fourth Edition, Addison Wesley, 2001.*
2	*Herbert Schildt , "**C: The Complete Reference**", Fourth Edition, McGraw Hill Education, 2017.*
3	*YashavantP.Kanetkar,**" Let Us C",**15th edition,BPB Publications,2016.*
4	*Brian W. Kernighan and Dennis Ritchie, **"The C Programming Language",** Second Edition, Prentice Hall Software Series, 2015.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Articulate the basics of computer and evolution of programming languages.	K1
CO2	Write simple C programs using appropriate datatypes and control statements	K3
CO3	Write C programs using arrays , functions and enumerations	K3
CO4	Use pointers effectively to develop programs	K3
CO5	Create user defined datatypes using structures & union and effectively manipulate them in file operations.	K6

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO 2**
CO1	1	3	1	-	-	-	-	-	-	-	-	1	1	-
CO2	1	3	1	-	-	-	-	-	-	-	-	1	1	-
CO3	1	3	1	-	-	-	-	-	-	-	-	1	1	-
CO4	1	3	1	-	-	-	-	-	-	-	-	1	1	-
CO5	1	3	1	-	-	-	-	-	-	-	-	1	1	-
22BES203	**1**	**3**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**1**	**1**	**-**

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.3.1, 2.1.1, 2.1.2, 2.1.3, 2.2.3, 2.2.4, 2.3.1, 2.3.2, 2.4.1, 2.4.2, 2.4.3, 2.4.4, 3.1.3, 12.2.1
CO2	1.3.1, 2.1.1, 2.1.2, 2.1.3, 2.2.3, 2.3.2, 2.4.1, 2.4.2, 2.4.3, 2.4.4, 3.1.3, 3.2.3, 3.3.1, 12.1.2
CO3	1.3.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.3, 2.3.2, 2.4.1, 2.4.2, 2.4.3, 2.4.4, 3.1.3, 3.2.3, 3.3.1,12.1.2
CO4	1.3.1, 2.1.1, 2.1.2, 2.1.3, 2.2.3, 2.3.2, 2.4.1, 2.4.2, 2.4.3, 2.4.4, 3.1.3, 3.2.3, 3.3.1, 12.1.2,
CO5	1.3.1, 2.1.1, 2.1.2, 2.1.3, 2.2.3, 2.3.2, 2.4.1, 2.4.2, 2.4.3, 2.4.4, 3.1.3, 3.2.3, 3.3.1, 12.1.2

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1)%**	**Understanding (K2)%**	**Applying (K3)%**	**Analyzing (K4)**	**Evaluating (K5)%**	**Creating (K6)%**	**Total %**
CAT1	50	20	30	-	-	-	100
CAT2	20	30	50	-	-	-	100
Individual Assessment 1 / Case Study 1 / Seminar 1 / Project 1	50	-	50	-	-	-	100
Individual Assessment 2 / Case Study 2 / Seminar 2 / Project 2	-	-	100	-	-	-	100
ESE	20	30	50	-	-	-	100

22BPC201	BIOMOLECULES	SEMESTER II

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PC	3	0	0	3

Course Objectives	1. To identify the different classes of polymeric biomolecules and their monomeric building blocks. 2. To comprehend the properties of carbohydrates proteins, lipids, and nucleic acids 3. To understand the functional properties of carbohydrates proteins, lipids, and nucleic acids in the biological system 4. To know the basic information on structural and cytoskeletal biomolecules 5. To determine the levels of protein structures and their stability	
UNIT – I	**INTRODUCTION**	**9 periods**
Covalent and non-covalent interactions in biological molecules, Water – properties of water, hydrophobic effect, Water as a reactant, pH buffers, Acid-base reactions in biochemical processes, Maintenance of blood pH, Versatility of carbon bonding, Some common functional groups of biomolecules.		
UNIT – II	**CARBOHYDRATES**	**9 periods**
Carbohydrates- Classification, Structure and Properties of Carbohydrates (Mono, Di, Oligo & Starch, glycogen and cellulose) - Mutarotation, Hexose derivatives, Reducing sugars, Glycosidic Bond, Conjugated carbohydrates; Proteoglycans - glycosaminoglycans and lipopolysaccharides -Bacterial lipopolysaccharides.		
UNIT – III	**LIPIDS**	**9 periods**
Structure and properties of lipids – Classification, (Fatty acids, Glycerolipids, Phospholipids, Glycolipids, Sphingolipids, Steroids), Structure of vitamins and non-peptide hormones.		
UNIT – IV	**NUCLEIC ACIDS**	**9 periods**
Nucleic Acids – Structure of Purines, Pyrimidines, Nucleosides, Nucleotides, Ribonucleic acids – Structure and Classification, Deoxyribonucleic acids – Structure of DNA, Nucleoprotein complexes.		
UNIT – V	**PROTEINS**	**9 periods**
Classification of Amino acids, Structure and Properties of Amino acids-peptide bond, Classification of Proteins-Primary- Secondary structures-alpha helix, beta-sheet and turns, Tertiary and Quaternary structure of proteins, Fibrous and globular proteins, Ramachandran plot.		
Contact Periods: **Lecture:45 Periods** **Tutorial: 0 Periods** **Practical: 0 Periods** **Total: 45 Periods**		

TEXT BOOKS

1	*APA. Nelson, D. L., & Cox, M. M., "**Lehninger's —Principles of Biochemistry**", 7th Edition, Macmillan, 2017.*
2	*Voet, Donald, Judith G. Voet, and Charlotte W. Pratt., **Fundamentals of Biochemistry: Life at the Molecular Level**", 5th Edition, Wiley., 2016.*

REFERENCES

1	*Victor W. Rodwell; David Bender; Kathleen M. Botham; Peter J. Kennelly; P. Anthony Weil., "**Harper's Illustrated Biochemistry**", 31st Edition, McGraw-Hill Education, 2018.*
2	*Berg, J.M., Tymoczko, J.L., Stryer, L., "**Biochemistry**", 9th Edition, WH Freeman, 2019.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Comprehend the role of chemistry in a biological system	K1
CO2	Classify bio-molecules based on their chemical properties	K1
CO3	Infer the structure and properties of macromolecules	K2
CO4	Interpret the levels of macromolecular organization	K2
CO5	Realize the significance of complex biomolecules	K2

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**
CO1	1	1	-	-	-	-	-	-	-	-	-	-	3	1
CO2	1	1	-	-	-	-	-	-	-	-	-	-	3	1
CO3	1	1	1	-	-	-	-	-	-	-	-	-	3	1
CO4	1	1	-	-	-	-	-	-	-	-	-	-	3	1
CO5	1	1	-	-	-	-	-	-	-	-	-	-	3	1
22BPC201	**1**	**1**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**3**	**1**

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.4.1, 2.1.3
CO2	1.4.1, 2.1.3
CO3	1.4.1, 2.1.3, 3.2.1
CO4	1.4.1, 2.1.3
CO5	1.4.1, 2.1.3

ASSESSMENT PATTERN – THEORY

Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	60	40	-	-	-	-	100
CAT2	50	50	-	-	-	-	100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	50	50	-	-	-	-	100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	40	60	-	-	-	-	100
ESE	50	50	-	-	-	-	50

22BMC2Z1	ENVIRONMENTAL SCIENCE AND ENGINEERING *(Common to all Branches)*	SEMESTER II

PREREQUISITES	CATEGORY	L	T	P	C
NIL	MC	3	0	0	0

Course Objectives	1. To study the modern agriculture related problems, natural resources and its harnessing methods. 2. To study the interrelationship between living organism and environment. 3. To educate the people about causes of pollutions and its controlling methods. 4. To impart the knowledge of various environmental threats and its consequences. 5. To study the various water conservation methods, Act, Population policy, Welfare programs.	
UNIT – I	**ENVIRONMENTAL ENERGY RESOURCES**	**9 Periods**
Food-effects of modern agriculture, fertilizers, pesticides, eutrophication &biomagnifications-Energy resources: renewable resources - Hydro Energy, Solar & Wind. Non-renewable resources – Coal and Petroleum - harnessing methods.		
UNIT – II	**ECO SYSTEM AND BIODIVERSITY**	**9 Periods**
Eco system and its components - biotic and abiotic components. Biodiversity: types and values of biodiversity, hot spots of biodiversity, endangered and endemic species, conservation of biodiversity: In situ and ex situ conservation. Threats to biodiversity-destruction of habitat, habit fragmentation, hunting, over exploitation and man-wildlife conflicts. The IUCN red list categories.		
UNIT – III	**ENVIRONMENTAL POLLUTION**	**9 Periods**
Air pollution, classification of air pollutants – sources, effects and control of gaseous pollutants SO_2, NO_2, H_2S, CO, CO_2 and particulates. Water pollution - classification of water pollutants, organic and inorganic pollutants, sources, effects and control of water pollution. Noise pollution - decibel scale, sources, effects and control.		
UNIT – IV	**ENVIRONMENTAL THREATS**	**9 Periods**
Global warming-measure to check global warming - impacts of enhanced Greenhouse effect, Acid rain-effects and control of acid rain, ozone layer depletion- effects of ozone depletion, disaster management - flood, drought, earthquake and tsunami.		
UNIT – V	**SOCIAL ISSUES AND ENVIRONMENT**	**9 Periods**
Water conservation, rain water harvesting, e-waste management, Pollution Control Act, Wild life Protection Act. Population growth- exponential and logistic growth, variation in population among nations, population policy. Women and Child welfare programs. Role of information technology in human and health, COVID-19 - effects and preventive measures.		
Contact Periods: **Lecture:45 Periods** **Tutorial: 0 Periods** **Practical: 0 Periods** **Total:45 Periods**		

TEXT BOOK:

1	*Sharma J.P., **“Environmental Studies”**, 4th Edition, University Science Press, New Delhi 2016.*
2	*Anubha Kaushik and C.P.Kaushik, **“Environmental Science and Engineering”**, 7th Edition, New Age International Publishers, New Delhi, 2021.*

REFERENCES:

1	*A K De, **"Environmental Chemistry"**, 8^{th} Edition, New Age International Publishers, 2017.*
2	*G. Tyler Miller and Scott E. Spoolman, **"Environmental Science"**, Cengage Learning India Pvt, Ltd, Delhi, 2014.*
3	*ErachBharucha, **"Textbook of Environmental Studies"**, Universities Press(I) Pvt, Ltd, Hyderabad, 2015.*
4	*Gilbert M.Masters, **"Introduction to Environmental Engineering and Science"**, 3^{rd} Edition, Pearson Education, 2015.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Recognize and understand about the various environmental energy resources and the effective utility of modern agriculture.	K2
CO2	Acquire knowledge about the interaction of biosphere with environment and conservation methods of bio diversity.	K2
CO3	Be aware of the sources of various types of pollution, their ill effects and preventive methods.	K2
CO4	Identify and take the preventive measures to control the environmental threats and effects of Global warming, Ozone depletion, Acid rain, and natural disasters.	K2
CO5	Demonstrate an idea to save water and other issues like COVID -19.	K2

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	2	1	1	1	-	-	3	-	-	-	-	-	1	-	-
CO2	-	-	1	-	-	-	3	-	-	-	-	-	1	-	-
CO3	2	1	1	1	-	-	3	-	-	-	-	-	2	-	-
CO4	2	1	1	1	-	-	3	-	-	-	-	-	1	-	-
CO5	-	1	1	1	-	2	3	-	-	-	-	-	2	-	-
22BMC2Z1	**2**	**1**	**1**	**1**	**-**	**1**	**3**	**-**	**-**	**-**	**-**	**-**	**2**	**-**	**-**

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.2.1,1.4.1,2.1.2,2.3.1,3.1.5,3.2.1,4.3.1,7.1.1,7.1.2,7.2.1
CO2	3.1.5,7.1.1,7.1.2,7.2.1
CO3	1.2.1,1.3.1,1.4.1,2.1.2,2.3.1,3.1.5,3.2.1,4.1.3,4.3.1,7.1.1,7.1.2,7.2.1
CO4	1.2.1,1.4.1,2.1.2,2.3.1,3.1.5,4.1.3,4.3.1,7.1.1,7.1.2,7.2.1,7.2.2
CO5	2.1.2,2.2.2,3.1.5,4.1.3,4.3.1,6.2.1,7.1.1,7.1.2,7.2.1,7.2.2

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	20	40	20	20	-	-	100
CAT2	20	40	20	20	-	-	100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	20	40	20	20	-	-	100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	20	40	20	20	-	-	100
ESE	20	40	20	20	-	-	100

22BBS2Z6	**PHYSICS LABORATORY** *(Common to all Branches)*	**SEMESTER II**

PREREQUISITES	CATEGORY	L	T	P	C
NIL	BS	0	0	3	1.5

Course Objectives	1. To impart practical knowledge on the concept of properties of matter and utilize the experimental techniques to measure the properties 2. To impart practical knowledge on the modulii of elasticity 3. To analyze the properties of semiconductors 4. To learn practically the basic electronic concepts of transistor and logic gates 5. To realize the principle, concepts and working of a solar cell and study the properties of ferromagnetic material 6. To understand the concept of quantum physics

S. No.	LABORATORY EXPERIMENTS
1.	Determination of refractive index of the glass and given liquid – Spectrometer diffraction method.
2.	Determination of Planck's constant.
3.	Determination of Young's Modulus of the material in the form of bar – Cantilever Bending -Koenig's Method.
4.	a) Particle size determination using diode laser. b) Determination of numerical aperture and acceptance angle in an optical fiber.
5.	Hall effect - Determination of semiconductor parameters.
6.	Determination of band gap of semiconductor material.
7.	Determination of velocity of sound and compressibility of the given liquid-Ultrasonic Interferometer.
8.	Determination of moment of inertia of disc and rigidity modulus of a wire-Torsional pendulum.
9.	Transistor characteristics.
10.	Solar cell characteristics.
11.	Determination of Hysteresis losses in a Ferromagnetic material-B-H curve unit.
12.	Logic Gates – Verification and Construction.
Contact Periods: **Lecture: 0 Periods Tutorial: 0 Periods Practical: 45 Periods Total: 45 Periods**	

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Determine refractive index and compressibility of liquids, micro size of particles and numerical aperture of an optical fibre	K5
CO2	Measure the Young's and rigidity modulii of the given material	K5
CO3	Determine the bandgap of a given semiconductor material and identify the type of semiconductor and its carrier concentration through Hall measurement	K5
CO4	Analyze the characteristics of transistor and verify the truth table of logic gates	K4
CO5	Measure the efficiency of a solar cell and energy loss associated with the ferromagnetic material by plotting B-H curve	K5
CO6	Determine the Planck's constant and work function	K5

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	3	2	-	-	-	-	-	-	-	-	-	-	1	-
CO2	3	2	-	-	-	-	-	-	-	-	-	-	1	-
CO3	3	2	-	-	-	-	-	-	-	-	-	-	1	-
CO4	3	2	-	-	-	-	-	-	-	-	-	-	1	-
CO5	3	2	-	-	-	-	-	-	-	-	-	-	1	-
CO6	3	2	-	-	-	-	-	-	-	-	-	-	1	-
22BBS2Z6	**3**	**2**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**1**	**-**

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.1.1, 1.1.2, 1.2.1, 1.3.1, 2.1.1, 2.1.3, 2.4.1, 2.4.2, 2.4.3, 2.4.4
CO2	1.1.1,1.1.2, 1.2.1, 1.3.1, 2.1.1, 2.1.3, 2.4.1, 2.4.2, 2.4.3, 2.4.4
CO3	1.1.1,1.1.2, 1.2.1, 1.3.1, 2.1.1, 2.1.3, 2.4.1, 2.4.2, 2.4.3, 2.4.4
CO4	1.1.1,1.1.2, 1.2.1, 1.3.1, 2.1.1, 2.1.3, 2.4.1, 2.4.2, 2.4.3, 2.4.4
CO5	1.1.1, 1.1.2, 1.2.1, 1.3.1, 2.1.1, 2.1.3, 2.4.1, 2.4.2, 2.4.3, 2.4.4
CO6	1.1.1, 1.1.2, 1.2.1, 1.3.1, 2.1.1, 2.1.3, 2.4.1, 2.4.2, 2.4.3, 2.4.4

22BES2Z4	**WORKSHOP PRACTICE** *(Common to all Branches)*	**SEMESTER II**

PREREQUISTES	CATEGORY	L	T	P	C
NIL	ES	0	0	3	1.5

Course Objectives	
	1. To make various basic prototypes in the carpentry trade such as Half Lap joint, Lap Tee joint, Dovetail joint, Mortise & Tenon joint. 2. To make various welding joints such as Lap joint, Lap Tee joint, Edge joint, Butt joint and Corner joint. 3. To make various moulds in foundry such as Cube, Straight pipe, V pulley, and Conical bush. 4. To make various components using sheet metal such as Tray, Frustum of cone and Square box. 5. To understand the working and identify the various components of CNC Machines.

LIST OF EXPERIMENTS			
1. Introduction to use of tools and equipment's in Carpentry, Welding, Foundry and Sheet metal. 2. Safety aspects in Welding, Carpentry, Foundry and sheet metal. 3. Half Lap joint and Dovetail joint in Carpentry. 4. Welding of Lap joint and Butt joint and T-joint. 5. Preparation of Sand mould for Cube, Conical bush, Pipes and V pulley. 6. Fabrication of parts like Tray, Frustum of cone and Square box in sheet metal. 7.CNC Machines demonstration and lecture on working principle. 8. Electrical wiring and simple house wiring.			
Contact periods:			
Lecture: 0 Periods	**Tutorial: 0 Periods**	**Practical: 45 Periods**	**Total: 45 Periods**

COURSEOUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Safely Use tools and equipment's used in Carpentry, Welding, Foundry and Sheet metal to create basic joints.	K2
CO2	Prepare sand mould for various basic pattern shapes.	K3
CO3	Fabricate parts like Tray, Frustum of cone and Square box in sheet metal.	K3
CO4	Practice on the Welding and Carpentry	K3
CO5	Demonstrate the working of CNC Machines.	K2

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/ POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	2	2	3	2	1	3	1	2	3	3	2	3	-	2
CO2	2	2	3	2	1	3	3	2	3	3	2	3	-	2
CO3	2	2	3	2	1	3	3	2	3	3	2	3	-	2
CO4	2	2	3	2	1	3	3	2	3	3	2	3	-	2
CO5	2	2	3	2	3	-	-	2	3	3	2	2	-	2
22BES2Z4	**2**	**2**	**3**	**2**	**2**	**3**	**2**	**2**	**3**	**3**	**2**	**3**	**-**	**2**

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping	
CO1	1.2.1, 1.3.1, 2.1.1, 2.1.2, 2.1.3, 2.2.3, 2.2.4, 2.4.2, 2.4.3, 2.4.4, 3.1.1, 3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.2, 3.2.3, 3.3.1,3.3.2, 3.4.1, 4.1.1, 4.1.4, 4.2.1, 4.3.1, 5.2.2, 5.3.2, 6.1.1,6.2.1,7.1.2, 8.2.1, 8.2.2, 9.1.1, 9.1.2, 9.2.1, 9.2.2, 9.2.3, 9.2.4,9.3.1,10.1.1, 10.1.2, 10.1.3, 10.2.1, 10.2.2, 10.3.1, 10.3.2, 11.1.1, 11.3.1, 12.1.1, 12.2.2, 12.3.1, 12.3.2
CO2	1.2.1, 1.3.1, 2.1.1, 2.1.2, 2.1.3, 2.2.3, 2.2.4, 2.4.2, 2.4.3, 2.4.4, 3.1.1, 3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.2, 3.2.3, 3.3.1,3.3.2, 3.4.1, 4.1.1, 4.1.4, 4.2.1, 4.3.1, 5.2.2, 5.3.2, 6.1.1,6.2.1,7.1.1, 7.1.2, 7.2.2, 8.2.1, 8.2.2, 9.1.1, 9.1.2, 9.2.1, 9.2.2, 9.2.3, 9.2.4, 9.3.1, 10.1.1, 10.1.2, 10.1.3, 10.2.1, 10.2.2, 10.3.1, 10.3.2, 11.1.1, 11.3.1, 12.1.1, 12.2.2, 12.3.1, 12.3.2
CO3	1.2.1, 1.3.1, 2.1.1, 2.1.2, 2.1.3, 2.2.3, 2.2.4, 2.4.2, 2.4.3, 2.4.4, 3.1.1, 3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.2, 3.2.3, 3.3.1,3.3.2, 3.4.1, 4.1.1, 4.1.4, 4.2.1, 4.3.1, 5.2.2, 5.3.2, 6.1.1,6.2.1,7.1.1, 7.1.2, 7.2.2, 8.2.1, 8.2.2, 9.1.1, 9.1.2, 9.2.1, 9.2.2, 9.2.3, 9.2.4, 9.3.1, 10.1.1, 10.1.2, 10.1.3, 10.2.1, 10.2.2, 10.3.1, 10.3.2, 11.1.1, 11.3.1, 12.1.1, 12.2.2, 12.3.1, 12.3.2
CO4	1.2.1, 1.3.1, 2.1.1, 2.1.2, 2.1.3, 2.2.3, 2.2.4, 2.4.2, 2.4.3, 2.4.4, 3.1.1, 3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.2, 3.2.3, 3.3.1,3.3.2, 3.4.1, 4.1.1, 4.1.4, 4.2.1, 4.3.1, 5.2.2, 5.3.2, 6.1.1,6.2.1,7.1.1, 7.1.2, 7.2.2, 8.2.1, 8.2.2, 9.1.1, 9.1.2, 9.2.1, 9.2.2, 9.2.3, 9.2.4, 9.3.1, 10.1.1, 10.1.2, 10.1.3, 10.2.1, 10.2.2, 10.3.1, 10.3.2, 11.1.1, 11.3.1, 12.1.1, 12.2.2, 12.3.1, 12.3.2
CO5	1.2.1, 1.3.1, 2.1.1, 2.1.2, 2.1.3, 2.2.3, 2.2.4, 2.4.2, 2.4.3, 2.4.4, 3.1.1, 3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.2, 3.2.3, 3.3.1,3.3.2, 3.4.1, 4.1.1, 4.1.4, 4.2.1, 4.3.1,5.1.1, 5.1.2, 5.2.1, 5.2.2, 5.3.2, 7.1.1, 7.2.2, 8.2.1, 8.2.2, 9.1.1, 9.1.2, 9.2.1, 9.2.2, 9.2.3, 9.2.4, 9.3.1, 10.1.1, 10.1.2, 10.1.3, 10.2.1, 10.2.2, 10.3.1, 10.3.2, 11.1.1, 11.3.1, 12.2.2, 12.3.1, 12.3.2

22BES205	**PROGRAMMING IN C LABORATORY** *(Common to all Branches except Mech & Prodn)*	**SEMESTER II**

PREREQUISITES	CATEGORY	L	T	P	C
NIL	ES	0	0	3	1.5

COURSE OBJECTIVES:

To understand the concepts like Data types, Flow control statements, Functions, Arrays, command line arguments, Pointer, Dynamic memory allocation, Preprocessor Directives, Structures,Unions and Files in C

EXERCISES ILLUSTRATING THE FOLLOWING CONCEPTS:

1	Operators, Expressions and IO formatting
2	Decision Making and Looping
3	Arrays and Strings
4	Functions and Recursion
5	Pointers
6	Dynamic Memory Allocation
7	Command line arguments
8	Preprocessor Directives
9	Structures
10	Unions
11	Files
12	Mini Project

Contact periods:

Lecture: 0 Periods	Tutorial: 0 Periods	Practical: 45 Periods	Total: 45 Periods

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Use appropriate data types and flow control statements to write C programs	K6
CO2	Write C programs using arrays , functions and command line arguments	K6
CO3	Write C programs using pointers, dynamic memory allocation and preprocess or directives	K6
CO4	Implement user defined data types using structures & union and effectively manipulate them in file operations.	K6
CO5	Develop simple applications using C	K6

COURSE ARTICULATION MATRIX

a) CO and PO Mapping													
COs/POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**
CO1	2	3	1	1	-	-	-	-	-	-	-	-	1	-
CO2	2	3	1	1	-	-	-	-	-	-	-	-	1	-
CO3	2	3	1	1	-	-	-	-	-	-	-	-	1	-
CO4	2	3	1	1	-	-	-	-	-	-	-	-	1	-
CO5	2	3	2	1	-	-	-	-	3	3	-	-	1	-
22BES205	**2**	**3**	**2**	**1**	**-**	**-**	**-**	**-**	**1**	**1**	**-**	**-**	**1**	**-**
1 – Slight, 2 – Moderate, 3 – Substantial														

b) CO and Key Performance Indicators Mapping	
CO1	1.1.1, 1.3.1, 2.1.1,2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.3.1, 2.3.2, 2.4.1, 2.4.3, 2.4.4, 3.2.3, 3.3.1, 4.1.1, 4.1.2, 4.2.1
CO2	1.1.1, 1.3.1, 2.1.1,2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.3.1, 2.3.2, 2.4.1, 2.4.3, 2.4.4, 3.2.3, 3.3.1, 4.1.1, 4.1.2, 4.2.1
CO3	1.1.1, 1.2.1, 1.3.1, 2.1.1,2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.3.1, 2.3.2, 2.4.1, 2.4.3, 2.4.4, 3.2.3, 3.3.1, 4.1.1, 4.1.2, 4.2.1
CO4	1.1.1, 1.3.1, 2.1.1,2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.3.2, 2.4.1, 2.4.3, 2.4.4, 3.2.3, 3.3.1, 4.1.1, 4.1.2, 4.2.1
CO5	1.1.1, 1.2.1, 1.3.1, 2.1.1,2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.3.2, 2.4.1, 2.4.3, 2.4.4, 3.1.1, 3.1.5, 3.1.6, 3.2.3, 3.3.1

22BBS307	**TRANSFORM CALCULUS AND PARTIAL DIFFERENTIAL EQUATIONS** *(CommontoCiviland IBTBranches)*	**SEMESTER III**

PREREQUISITES	**CATEGORY**	**L**	**T**	**P**	**C**
NIL	**BS**	**3**	**1**	**0**	**4**

Course Objectives	To be familiar with Fourier Series. To gain the knowledge of solving Boundary value problems. To be familiar with Laplace and Inverse Laplace transforms to solve ordinary differential equations.To acquire knowledge on Fourier transforms.To be familiar with Z-transform to solve difference equations.	
UNIT – I	**FOURIER SERIES**	**9 Periods**
Dirichlet's Conditions – General Fourier series – Odd and even functions- Half range Sine and Cosine series – Root Mean Square Value- Parseval's Identity on Fourier series–Harmonic Analysis		
UNIT – II	**BOUNDARY VALUE PROBLEMS**	**9 Periods**
Classification of PDE – Method of separation of variables - Fourier series solutions of onedimensional wave equation – One dimensional equation of heat conduction – Steady state solutionof twodimensional equation of heat conduction (Infinite Stripes in cartesian coordinates only).		
UNIT – III	**LAPLACE TRANSFORMS**	**9 Periods**
Laplace transform –Sufficient condition for existence –Transform of elementary functions –Basic properties – Transforms of derivatives and integrals of functions -Derivatives and integrals of transforms -Transforms of unit step function and impulse functions –Transform of periodic functions. Inverse Laplace transform - Statement of Convolution theorem –Initial and final value theorems–Solution of linear ordinary differential equation of second order with constant coefficients using Laplace transformation techniques.		
UNIT – IV	**FOURIER TRANSFORMS**	**9 Periods**
StatementofFourierintegralTheorem–Fouriertransformpair–FourierSineandCosineTransforms–properties – Transforms of Simple functions – Convolution Theorem – Parseval's Identity.		
UNIT – V	**Z TRANSFORMS**	**9 Periods**
Z-transforms - Elementary properties –Convergence of Z-transforms - Initial and Final value theorems - Inverse Z-transform using partial fraction and convolution theorem– Formation of difference equations - Solution to difference equations of second order with constant coefficients using Z- transform.		
Contact Periods: **Lecture: 45 Periods Tutorial: 15 Periods Practical: 0 Periods Total: 60 Periods**		

TEXT BOOK:

1	*Veerarajan. T.* ***"Transforms and partial Differential equations"****, Tata Mc GrawHill Publishing Co., New Delhi. 2015.*
2	*B.S.Grewal.,* ***"HigherEngineeringMathematics"****,KhannaPublishers,NewDelhi,44th Edition,2018.*

REFERENCES

1	*Kandasamy,ThilagavathyandGunavathy.,* ***"EngineeringMathematics"****forIIISemester,S.Chand&Co, Ramnagar, New Delhi.*
2	*N.P.Bali andManish Goyal ,* ***"Transformsand partial Differentialequations"****,University Science Press, New Delhi, 2010.*
3	*VeerarajanT.,* ***"EngineeringMathematics"****forSemesterI&II,TataMcGrawHillEducation (India) Pvt Ltd., New Delhi, Third Edition 2012.*
4	*Erwinkreyszig,* ***"AdvancedEngineeringMathematics"****,9th Edition,JohnWiley&Sons,2006.*

COURSE OUTCOMES: On completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Express the periodic functions arising in the study of engineering problems as sine and cosine series.	K3
CO2	Solve the Partial Differential Equations arising in engineering problems like Wave, Heat flow and Laplace equation in steady state (Cartesian coordinates) using Fourier series.	K3
CO3	Apply Laplace transform technique to solve the given integral equations and ordinary differential equations.	K3
CO4	Find Fourier Transforms, infinite Fourier Sine &Cosine transforms.	K3
CO5	Apply Z - transform technique to solve difference equations	K3

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/POs	PO1	PO2	PO3	PO4	PO 5	PO6	PO7	PO8	PO9	PO1 0	PO1 1	PO1 2	PSO1	PSO2
CO1	3	2	-	-	-	-	-	-	-	-	-	-	1	-
CO2	3	2	-	-	-	-	-	-	-	-	-	-	1	1
CO3	3	2	-	-	-	-	-	-	-	-	-	-	1	1
CO4	3	2	-	-	-	-	-	-	-	-	-	-	-	1
CO5	3	2	-	-	-	-	-	-	-	-	-	-	-	-
22BBS307	3	2	-	-	-	-	-	-	-	-	-	-	1	1

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.1.1, 1.1.2,1.3.1,1.4.1,2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.4.1
CO2	1.1.1, 1.1.2,1.2.1, 1.3.1, 1.4.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.3.1, 2.3.2, 2.4.1
CO3	1.1.1, 1.1.2, 1.3.1, 1.4.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.4.1
CO4	1.1.1, 1.1.2, 1.3.1, 1.4.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.4.1
CO5	1.1.1, 1.1.2, 1.3.1, 1.4.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.2.4, 2.4.1

ASSESSMENT PATTERN – THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	20	30	50	-	-	-	100
CAT2	20	30	50	-	-	-	100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	20	30	50	-	-	-	100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	20	30	50	-	-	-	100
ESE	20	30	50	-	-	-	100

22BBS308	**CELL BIOLOGY**	**SEMESTER III**

PREREQUISITES	CATEGORY	L	T	P	C
BIOMOLECULES	**BS**	**3**	**0**	**0**	**3**

Course Objectives	To Gain the insights of cell structure and cell division ,understand the composition of extracellular matrix, cell junction and cell adhesion.Get familiarized with the various transport mechanisms and understand the different types of receptor and signal transduction and familiarized with the techniques to study cell line	
UNIT – I	**CELL STRUCTURE AND FUNCTION OF THE ORGANELLES**	**9 Periods**
Structure of Prokaryotic and Eukaryotic cells their organelles, principles of membrane organization, membrane proteins, types of cell division, mitosis & meiosis, cell cycle and molecules that control cell cycle. Cell cycle check points.		
UNIT – II	**EXTRACELLULAR MATRIX AND CELL JUNCTIONS**	**9 Periods**
Extra cellular matrix- composition, cytoskeletal proteins-Microfilaments, Microtubules, Intermediate filaments, actin-myosin interaction and its role. types of cell junctions and cell adhesion molecules(CAMs)		
UNIT – III	**TRANSPORT ACROSS BIOMEMBRANES**	**9 Periods**
Passive & active transport, permeases, Co- transport - symport, antiport, .types of ATPase pumps-Na K pump, V type, P type pumps, voltage and ligand gated channels, endocytosis and exocytosis. Mode of entry of virus and toxins into cells.		
UNIT – IV	**RECEPTORS AND SIGNAL TRANSDUCTION**	**9 Periods**
Cytosolic, nuclear and membrane bound receptors with examples, autocrine, paracrine and endocrine modes of action Signal amplification, role of secondary messengers- cyclic AMP, inositol tri phosphates and cyclic GMP; G proteins - role in signal transduction, calcium ion flux and its role in cell signaling, Tyrosine kinases and Serine Threonine kinases –examples and mechanism.		
UNIT – V	**TECHNIQUES USED TO STUDY CELLS AND CELL LINES**	**9 Periods**
Cell fractionation - Preparation of Nuclear, Mitochondrial & cytoplasmic fractions, Cell viability,flow cytometry, Morphology and identification of cells using microscopic studies like SEM, TEM, Confocal Microscopy. Localization of proteins in cells – Immunostaining.		
Contact Periods: **Lecture: 45 Periods** **Tutorial:0 Periods** **Practical: 0 Periods** **Total: 45 Periods**		

TEXT BOOK

1	Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, Keith; Walter, P., (eds) c2002: *“**Molecular Biology of the Cell**”,* Garland Science, New York and London.
2	Darnell J, Lodish H, Baltimore D, *“**Molecular Cell Biology**”,* W.H.Freeman; 8th edition,2016
3	Brai De Robertis& De Robertis, *“**Cell Biology**”,* Fourth edition,2007
4	Geoffrey M. Cooper and Robert E. Hausman,***“The Cell: A Molecular Approach”***, ASM Press and Sinauer Associates, Fifth Edition, 2009.

REFERENCES:

1	James D.Watson,***“Molecular Biology of the Cell”***,Third edition,2004.
2	Channarayappa,***“Cell biology”***,Universities Press,2010
3	Rastogi.S.C, *“**Cell biology**”,* New Age International publishers, 2005
4	https://www.ncbi.nlm.nih.gov/books
5	http://www.di.uq.edu.au/sparqglossary#b
6	https://cellbiology.med.unsw.edu.au
7	https://micro.magnet.fsu.edu

COURSE OUTCOMES: On completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Understand the structural organization of the cell and cell division.	K2
CO2	Familiarize with extracellular matrix, cell junction, cell adhesion.	K1
CO3	Understand the various transport mechanism in the cell.	K2
CO4	Get familiarized with the type of receptors and signal transduction pathways.	K2
CO5	Familiarize with the techniques for cytometry analysis.	K3

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs / POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	1	1	-	-	-	-	-	-	-	-	-	-	1	-
CO2	1	1	-	-	-	-	-	-	-	-	-	-	1	-
CO3	1	1	-	-	-	-	-	-	-	-	-	-	1	-
CO4	1	1	-	-	-	-	-	-	-	-	-	-	1	-
CO5	1	1	-	1	1	1	-	-	-	-	-	-	1	1
22BBS308	1	1	-	1	1	1	-	-	-	-	-	-	1	1

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.2.1,2.2.2
CO2	1.2.1,2.2.2
CO3	1.2.1,2.2.2
CO4	1.2.1,2.2.2
CO5	1.2.1,4.1.2,4.1.3,5.1.2

ASSESSMENT PATTERN

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	70	30	-	-	-	-	100
CAT2	60	40					100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	50	50	-	-	-	-	100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	40	60	-	-	-	-	100
ESE	50	50	-	-	-	-	100

22BES306	PROCESS CALCULATIONS AND HEAT TRANSFER	SEMESTER III

PREREQUISITES	CATEGORY	L	T	P	C
NIL	ES	3	1	0	4

Course Objectives	The primary aim of this course is to train the students in the fundamental principles of material balance, energy balances and various heat transfer methods to develop solutions for the problems encountered in chemical engineering.	
UNIT – I	**BASICS OF BIOCHEMICAL CALCULATIONS**	**9+3 periods**
Dimensions and Units: Dimensions and Systems of units - fundamental and derived quantities, Dimensional equation. Different ways of expression of units of quantities and unit conversion. Composition conversion-atomic weight, molecular weight, equivalent weight, molar concept, mole percent, weight percent, volume percent, molarity, molality, normality, etc., Basics of unit operations and unit processes involved in biotechnology industries and its applications.		
UNIT – II	**MATERIAL BALANCE**	**9+3 periods**
Process flow sheet, degrees of freedom, Overall and component balances; material balances without and with chemical reactions; recycle, by pass and purge streams; Unsteady state material balance.		
UNIT – III	**ENERGY BALANCE**	**9+3 periods**
Fundamentals of energy balance calculations–Concepts of heat capacity, latent heat, sensible heat, enthalpy change, Standard heat of reaction, the heat of mixing and dissolution of solids, Hess's law, and Humidity calculations. Energy balance with and without chemical reactions.		
UNIT – IV	**CONDUCTION AND CONVECTION**	**9+3 periods**
Introduction – Mode of heat transfer; Conduction – Basic concepts of conduction in solids, liquids and gases – One dimensional heat conduction – Critical and optimum insulation thickness. Principles of convection – Equations of forced and free convection. Combined heat transfer coefficients by convection and conduction. Unsteady state heat transfer fundamentals.		
UNIT – V	**RADIATION AND HEAT EXCHANGERS**	**9+3 periods**
Basic laws of heat transfer by radiation – black body and gray body concepts – solar radiations – combined heat transfer coefficients by convection and radiation. Principle and working of Heat Transfer equipment – Double pipe, Shell & tube and Plate type heat exchanger, Overall & Individual heat transfer co-efficient, LMTD.		
Contact Periods: **Lecture: 45 Periods Tutorial: 15 Periods Practical: 0 Periods Total: 60Periods**		

TEXT BOOK

1	K.V. Narayanan, B.Lakshmikutty, ***"Stoichiometry and Process calculations",*** Prentice hall of India, 2nd edition. 2017.
2	YunusCengel, "***Heat and Mass Transfer – Fundamentals & Applications***", McGraw-Hill, 2019.

REFERENCES

1	Bhatt B.I and VoraS.M.***"Stoichiometry"***, *Tata McGraw-Hill, New Delhi, 4th Edition.2010.*
2	O.A.Hougen, K.M.Watson, R.A.Ragatz, "***Chemical Process Principles Part-I: Material andEnergy Balances***", CBS Publishers, 2018
3	C. J. Geankoplis, "***Transport Processes and separation process principles (includes unitOperations)***", Pearson Education Limited, 2013.
4	Theodore L. Bergman, Adrienne S. Lavine, Frank P. Incropera, David P. DeWitt***"Principle of Heat and Mass Transfer",*** John Wiley,2019.

COURSE OUTCOMES: On completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Develop a fundamental understanding of the engineering unit conversions and Stoichiometry for doing balance calculations.	K1
CO2	Have a comprehensive understanding and be able to perform engineering calculations basedon material balances.	K2
CO3	Establish mathematical methodologies for the computation of energy balances.	K2
CO4	Understand the basic laws of heat transfer & to develop solutions for the problem involving steady state & transient heat conduction in simple geometries.	K1
CO5	Calculate heat transfer by conduction, convection & thermal radiation realistic cases.	K2

COURSE ARTICULATION MATRIX

a)CO and PO Mapping

COs/POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2
CO1	2	1	1	-	-	-	-	-	-	-	-	-	3	1
CO2	3	1	1	-	-	-	-	-	-	-	-	-	3	1
CO3	3	1	1	-	-	-	-	-	-	-	-	-	3	1
CO4	2	1	1	-	-	-	-	-	-	-	-	-	3	1
CO5	3	1	1	-	-	-	-	-	-	-	-	-	3	1
22BES306	3	1	1	-	-	-	-	-	-	-	-	-	3	1

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.1.1, 1.2.1, 1.4.1, 2.1.2, 2.1.3, 3.2.1
CO2	1.1.1, 1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 3.2.1
CO3	1.1.1, 1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 3.2.1
CO4	1.1.1, 1.2.1, 1.4.1, 2.1.2, 2.1.3, 3.2.1
CO5	1.1.1, 1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 3.2.1

ASSESSMENT PATTERN – THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	30	70	-	-	-	-	100
CAT2	30	70	-	-	-	-	100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	50	50	-	-	-	-	100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	50	50	-	-	-	-	100
ESE	30	70	-	-	-	-	100

22BPC302	INDUSTRIAL MICROBIOLOGY	SEMESTER III

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PC	3	0	0	3

Course Objectives	To Understand the classification, microscopic examination, staining methods of microorganisms, nutritional media types, growth, control of micro organisms and to developknowledge about the industrial fermentation process and production of modern biotechnology products.	
UNIT – I	**BASIC MICROBIOLOGY**	**9 Periods**
History of microbiology, Classification and nomenclature of microorganism, microscopic examination of microorganisms- light and electron microscopy; Staining techniques – simple, differential & special staining; Colony morphology and arrangement of bacterial cells.		
UNIT – II	**GROWTH AND CONTROL OF MICROORGANISMS**	**9 Periods**
Nutritional requirements of bacteria and different media used for bacterial culture; Isolation of pure culture (Spread Plate, Streak Plate, Pour Plate); Growth curve and different methods to quantify the bacterial growth; Physical control of microorganisms (dry and moist heat sterilization,filtration, radiation)-Chemical control of microorganisms (Phenolics, alcohol, aldehydes, halogens,heavy metals, quaternary ammonium salts, sterilizing gases)-evaluation of antimicrobial agent effectiveness; Host-microbe interactions, anti-bacterial, anti-fungal and anti-viral agents, mode of action of antibiotics and its resistance.		
UNIT – III	**INDUSTRIAL FERMENTATION PROCESS**	**9 Periods**
Historical overview of industrial fermentation process -traditional and modern Biotechnology. Commercial potential of Biotechnology products in India. Industrial Fermentation- microorganisms, mode of operation, fermentation processes-pictorial representation.		
UNIT – IV	**PRODUCTION OF PRIMARY & SECONDARY METABOLITES**	**9 Periods**
Production of primary metabolites- Organic acids (citric acid & acetic acid); amino acids (glutamic acid & tryptophan) and alcohols (ethanol &butanol), Production of secondary metabolites- antibiotics: (penicillin & streptomycin), vitamins (Vit B_{12} and Vit B_2), enzymes (proteases & amylases).		
UNIT – V	**PRODUCTION OF MODERN BIOTECHNOLOGY PRODUCTS**	**9 Periods**
Production of recombinant proteins having therapeutic and diagnostic applications (insulin, human growth hormone), Production of recombinant vaccines (Hepatitis B vaccine, cholera vaccine), production of monoclonal antibodies.		
Contact Periods: **Lecture: 45 Periods** **Tutorial: 0 Periods** **Practical: 0 Periods** **Total: 45 Periods**		

TEXT BOOK:

1	*Prescott LM, Harley JP, Klein DA,* ***"Microbiology",*** *4th Edition, Wm. C. Brown Publishers, 2010.*
2	*Waites, M.J., Morgan,N.L.,Rockey,J.S.,Higton, G.,"****Industrial Microbiology: An Introduction****", Blackwell, 2001.*

REFERENCES:

1	*Pelczar MJ, Chan ECS and Krein NR,* ***"Microbiology",*** *McGraw Hill Education, 5th Edition, 2001.*
2	*Lee, S.Y., Nielsen, J. and Stephanopoulos, G., "****Industrial Biotechnology: Products and Processes****", John Wiley & Sons, 2016.*
3	*Cruger, W.,Cruger, A ., "****A Textbook of Industrial Microbiology****", Panima Publishing Corporation, 2nd Edition, 2005.*
4	*Pandey, A., Negi, S.,Soccol, C.R., "****Current Developments in Biotechnology and Bioengineering: Production, isolation and purification of industrial products****". Elsevier, 2016.*
5	*Okafor, N., "Modern Industrial Microbiology and Biotechnology", CRC Press, 2007.*

COURSE OUTCOMES: On completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Understand the classification, microscopic examination and staining methods of microorganisms	K1
CO2	Differentiate the types of nutritional media, growth pattern and control of micro organisms	K2
CO3	Develop knowledge about the industrial fermentation process.	K2
CO4	Identify the importance of microbes and their role in production of primary and secondary metabolites.	K3
CO5	Explore the microbial process for production of modern biotechnology products.	K3

COURSE ARTICULATION MATRIX

a)CO and PO Mapping

COs/POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO1 2	PSO 1	PSO 2
CO1	1	2	-	-	-	-	-	-	-	-	-	-	2	1
CO2	1	2	-	-	-	-	-	-	-	-	-	-	2	1
CO3	1	2	-	-	-	-	-	-	-	-	-	-	2	1
CO4	1	2	-	-	-	-	-	-	-	-	-	-	2	1
CO5	1	2	-	-	-	-	-	-	-	-	-	-	2	1
22BPC302	1	2	-	-	-	-	-	-	-	-	-	-	2	1

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.2.1,2.2.2
CO2	1.2.1,2.2.2
CO3	1.2.1,2.2.2, 2.2.3,2.2.4
CO4	1.2.1,2.2.2, 2.2.3,2.2.4
CO5	1.2.1,2.2.2, 2.2.3,2.2.4

ASSESSMENT PATTERN – THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	50	50	-	-	-	-	100
CAT2	20	30	50	-	-	-	100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	50	50	-	-	-	-	100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	-	50	50	-	-	-	100
ESE	40	30	30	-	-	-	100

22BPC303	BIOCHEMISTRY	SEMESTER III

PREREQUISITES	CATEGORY	L	T	P	C
Chemistry for Biotechnology Biomolecules	PC	3	0	0	3

Course Objectives	To provide an insight into catabolic and anabolic metabolism of biomolecules and the mechanisms of protein folding and transportation	
UNIT – I	**CARBOHYDRATE METABOLISM**	**9 Periods**
Metabolism concepts-Glycolysis, TCA cycle, pentose phosphate &glyoxalate shunt, Respiratory chain-Oxidative Phosphorylation and Photophosphorylation. Metabolic disorders associated with carbohydrates.		
UNIT – II	**LIPID METABOLISM**	**9 Periods**
Fatty acid synthesis and oxidative degradation, Triacylglycerol, phospholipid biosynthesis and degradation; Cholesterol biosynthesis. Metabolic disorders associated with lipids.		
UNIT – III	**NUCLEIC ACID METABOLISM**	**9 Periods**
Biosynthesis of nucleotides, denovo and salvage pathways for purines, denovo and salvage pathways for pyrimidines, Regulation of purine and pyrimidine synthesis, Degradation of nucleotides, Metabolic disorders associated with nucleic acids.		
UNIT – IV	**AMINO ACID METABOLISM**	**9 Periods**
Nitrogen metabolism, Biosynthesis of six essential amino acids (Met, Thr, Lys, Ile, Val, Leu) and aromatic amino acids. Urea cycle, Metabolic disorders associated with chain and aromatic amino acid degradation.		
UNIT – V	**PROTEIN FOLDING & TARGETING**	**9 Periods**
Protein folding: Levinthal paradox, Anfinsen's experiment, cooperativity in protein folding, free energy landscape of protein folding and pathways of protein folding, molten globule state, chaperons, Protein targeting, signal sequence, secretion; targeting of organelle proteins, Protein degradation, receptor-mediated endocytosis, turnover.		
Contact Periods: **Lecture:45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOKS

1	APA. Nelson, D. L., & Cox, M. M., "***Lehninger's —Principles of Biochemistry***", 7h Edition, Macmillan, 2017.
2	Voet, Donald, Judith G. Voet, and Charlotte W. Pratt, "***Fundamentals of Biochemistry: Life at the Molecular Level***", 5th Edition, Wiley., 2016.

REFERENCES:

1	Shawn O. Farrell and Mary K. Campbell, "***Biochemistry***", 8th Edition, Brooks/Cole, 2013
2	Satyanarayana, U. and U. Chakerapani, "***Biochemistry***" 3rd Rev. Edition, Books & Allied (P) Ltd., 2006.
3	Victor W. Rodwell; David Bender; Kathleen M. Botham; Peter J. Kennelly; P. Anthony Weil., "***Harper's Illustrated Biochemistry***", 31st Edition, McGraw-Hill Education, 2018.
4	Berg, J.M., Tymoczko, J.L., Stryer, L., "***Biochemistry***", 9th Edition, WH Freeman, 2019.

COURSE OUTCOMES: On completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	derstand the metabolic pathways of Carbohydrates, amino acids, nucleic acids and lipids.	K1
CO2	thom the complex relationship between biochemical pathways within living cells	K1
CO3	ow the metabolic disorders associated with biochemical metabolisms	K2
CO4	Understand the mechanism of protein targeting and transport	K2
CO5	Grasp the protein folding mechanism	K2

COURSE ARTICULATION MATRIX

a) CO and PO Mapping														
COs/POs	**PO1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**
CO1	1	1	-	-	-	-	-	-	-	-	-	-	3	1
CO2	1	1	-	-	-	-	-	-	-	-	-	-	3	1
CO3	1	1	-	-	-	-	-	-	-	-	-	-	3	1
CO4	1	1	-	-	-	-	-	-	-	-	-	-	3	1
CO5	1	1	-	-	-	-	-	-	-	-	-	-	3	1
22BPC303	1	1	-	-	-	-	-	-	-	-	-	-	3	1
1 – Slight, 2 – Moderate, 3 – Substantial														

b) CO and Key Performance Indicators Mapping	
CO1	1.4.1, 2.1.3
CO2	1.4.1, 2.1.3
CO3	1.4.1, 2.1.3,
CO4	1.4.1, 2.1.3
CO5	1.4.1, 2.1.3,

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	70	30	-	-	-	-	100
CAT2	40	60	-	-	-	-	100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	50	50	-	-	-	-	100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	30	70	-	-	-	-	100
ESE	60	40	-	-	-	-	100

22BPC304	GENETICS	SEMESTER III

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PC	3	0	0	3

Course Objectives	To give an understanding on the fundamentals of conventional genetics and its relevance in disease and therapy. To describe various genetic laws, learn the chromosome structure function and understand methodologies for cytogenetic applications. To apply the Hardy-Weinberg Law in analyzing population genetics for gene frequency, sex linkage, equilibrium, and heterozygote frequency.	
UNIT – I	**BACTERIAL GENETICS**	**9 Periods**
Fine structure in merozygotes- plasmids and episomes, Recombination in bacteria, Transformation, Transduction, Conjugation – mapping.		
UNIT – II	**CLASSICAL GENETICS**	**9 Periods**
Mendel's Principles and experiments, segregation, multiple alleles – independent assortments, genotypic interactions, epistasis and sex chromosomes, sex determination, dosage compensation, sex linkage and pedigree analysis.		
UNIT – III	**APPLIED GENETICS**	**9 Periods**
Chromosome organization, structure and variation in prokaryotes and eukaryotes, Giant chromosomes – polytene and lampbrush, deletion, inversion, translocation, duplication. variation in chromosomal numbers – aneuploidy, euploidy, polyploidy, Ames test, karyotyping, Linkage-complete and incomplete, Crossing over – cytological basis of crossing over, chromosome mapping – two and three factor cross – interference, somatic cell hybridization.		
UNIT – IV	**POPULATION GENETICS**	**9 Periods**
Hardy-Weinberg equilibrium, Extensions of Hardy- Weinberg equilibrium, Random mating and non-random mating, Population analysis, Models for population genetics. Mutation and Migration size, Genetic variation and Sociobiology, Eugenics.		
UNIT – V	**GENETIC DISEASES**	**9 Periods**
Inborn errors of metabolism, Sickle cell anemia, Hemochromatosis, Cystic fibrosis, Hypogonadotropic hypogonadism, Gaucher's disease, Achondroplasia, Phenylketonuria, Huntington's Disease, Cystic fibrosis, Hemoglobinopathies, Age-related macular degeneration, Obesity, Type 2 diabetes,Psychiatric disease, Including missing heritability, Autism.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOK

1	Gardner, E.J, Simmons, M.J, and Snustad, D.P.,***"Principles of Genetics"***, 8 Edition, JohnWiley& Sons, Singapore,2015.
2	Strickberger, M.W.,***"Genetics"***, 3rd Edition, Prentice Hall of India, New Delhi,2015.
3	Klug, W.S. and Cummings, M.R.,***"Concepts of Genetics"***, Pearson Education, New Delhi, 2019

REFERENCES

1	Tamarin, R.H.,***"Principles of Genetics"***, Tata McGraw Hill, New Delhi,2002.
2	De Robertis, E. D. P. and De Robertis, E. M. F.,***"Cell and Molecular Biology"***, 8th Edition, Lippincott Williams & Wilkins, New York, USA,2010.

COURSE OUTCOMES: On completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Understand the fundamentals of bacterial genetics.	K1
CO2	Understand classical mendelian genetics in inheritance of genes.	K1
CO3	Apply concepts of genetics in chromosomal mapping	K2
CO4	Know population based on concepts of population genetics.	K2
CO5	Understand various genetic disorders and their genetic basis.	K2

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2
CO1	1	1	-	-	-	-	-	-	-	-	-	-	3	1
CO2	1	1	-	-	-	-	-	-	-	-	-	-	3	1
CO3	1	1	-	-	-	-	-	-	-	-	-	-	3	1
CO4	1	1	-	-	-	-	-	-	-	-	-	-	3	1
CO5	1	1	-	-	-	-	-	-	-	-	-	-	3	1
22BPC304	1	1	-	-	-	-	-	-	-	-	-	-	3	1

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.4.1, 2.1.3
CO2	1.4.1, 2.1.3
CO3	1.4.1, 2.1.3
CO4	1.4.1, 2.1.3
CO5	1.4.1, 2.1.3

ASSESSMENT PATTERN – THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	50	50	-	-	-	-	100
CAT2	40	60	-	-	-	-	100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	60	40	-	-	-	-	100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	30	70	-	-	-	-	100
ESE	50	50	-	-	-	-	100

22BBS309	CELL BIOLOGY LABORATORY	SEMESTER III

PREREQUISITES	CATEGORY	L	T	P	C
NIL	BS	0	0	3	1.5

Course Objectives	Students are able to handle and operate light microscope and familiarize with slide preparation and staining techniques. Students are able to study the different cell division stages.

LIST OF EXPERIMENTS

1.	Principles of microscopy, phase contrast and fluorescent microscopy
2.	Identification of given plant, animal and bacterial cells and their components by microscopy
3.	Identification of cells in a blood smear using Leishman stain.
4.	Identification of cells in a blood smear using Giemsa staining.
5.	Identification of cells in a blood smear Haemotoxylin Eosin Staining.
6.	Counting of RBCs and WBCs using Haemocytometer
7.	Study of Osmosis and Tonicity of blood cells.
8.	Study of Cell viability using Tryphan Blue Assay
9.	Separation and identification of peripheral blood mononuclear cells from blood.
10.	Identification of meiosis cell division in grasshopper testis.
11.	Staining of different stages of mitosis in *Alliumcepa*(Onion) root tip.
12.	Immunostaining of cells

Contact Periods:
Lecture: 0 Periods Tutorial: 0 Periods Practical: 45 Periods Total: 45 Periods

REFERENCES:

1 De Robertis& De Robertis,***Cell biology,*** W B Saunders Co publications, 4th edition, 2007.

COURSE OUTCOMES:
On completion of the course, the students will be able to:

		Bloom's Taxonomy Mapped
CO1	Operate and identify the parts and function of microscope.	K3
CO2	Prepare the slides for microscopic examinations.	K3
CO3	Perform different staining techniques to identify blood cells	K3
CO4	Interpret the different stages of cell division using microscope.	K3
CO5	Work as a team to interpret practical data.	K3

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO1 2	PSO 1	PSO 2
CO1	-	-	-	2	-	-	-	-	-	-	-	-	3	1
CO2	-	-	-	1	-	-	-	-	-	-	-	-	3	1
CO3	-	-	-	3	-	-	-	-	-	-	-	-	3	1
CO4	-	-	-	2	-	-	-	-	-	-	-	-	3	1
CO5	-	-	-	-	-	-	-	-	2	-	-	-	3	1
22BBS309	-	-	-	2	-	-	-	-	2	-	-	-	3	1

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	4.1.1, 4.1.2,4.2.1
CO2	4.2.1
CO3	4.1.1, 4.1.2, 4.2.1, 4.3.1
CO4	4.2.1, 4.3.1
CO5	9.2.1,9,2.2,9.2.3

22BPC305	MICROBIOLOGY LABORATORY	SEMESTER III

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PC	0	0	3	1.5

Course Objectives	To demonstrate the proper safety procedures, parts & functions of microscope, staining techniques for microorganism identification, culture media preparation and growth pattern of bacteria.
LISTOF EXPERIMENTS	
1.	Laboratorysafetyandsterilizationtechniques.
2.	Microscopic Methods-IdentificationofMicroorganisms.
3.	Stainingtechniques–simple and differential staining (Gram staining), lacto phenol and acid fast staining
4.	Identification of fungal morphology by lactophenol cotton blue staining
5.	Preparationofculture media–nutrientbroth, nutrientagar-slant preparation
6.	Culturingofmicroorganismsinbrothandinplates (pourplates, streakplatesand spread plate techniques)
7.	Preparation of selective media using MacConkey agar.
8.	Serial Dilutionmethod
9.	Biochemical Tests for bacterial identification
10.	Motility Test-Hangingdroptechnique
11.	Antibiotic sensitivityassay-DiscDiffusionmethod
12.	Preservationofbacterialcultures-lyophilization& glycerol stock
13.	Study of bacterial growth curve.
Contact Periods: **Lecture: 0 Periods Tutorial: 0 Periods Practical: 45Periods Total: 45 Periods**	

TEXT BOOK:

1	*James G. Cappuccino & Natalie, "**Microbiology, A Laboratory manual**", Pearson Education Publishers, 6th edition, 2004.*
2	*Waites, M.J., Morgan,N.L.,Rockey,J.S.,Higton, G.,"**Industrial Microbiology: An Introduction**", Blackwell, 2001.*

REFERENCES:

1	*Harsha S,* **"Biotechnology Procedures andExperiments Handbook",** *Infinity Science Press, 2007.*

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Identify and demonstrate the proper safety procedures concerning lab safety.	K3
CO2	Identify the parts & functions of microscope.	K3
CO3	Perform different staining techniques to identify microorganisms.	K3
CO4	Identify the purpose & principle associated with different media types used in lab.	K3
CO5	Demonstrate the preservation methods and growth pattern of bacteria.	K3

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	1	-	-	2	-	-	-	-	-	-	-	-	2	1
CO2	1	-	-	2	-	-	-	-	-	-	-	-	2	1
CO3	1	-	-	2	-	-	-	-	-	-	-	-	2	1
CO4	1	-	-	2	-	-	-	-	-	-	-	-	2	1
CO5	1	-	-	2	-	-	-	-	-	-	-	-	2	1
22BPC305	1	-	-	2	-	-	-	-	-	-	-	-	2	1

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.2.1, 4.1.1,4.1.2
CO2	1.2.1, 4.1.1,4.1.2,4.2.1
CO3	1.2.1, 4.1.1,4.1.2,4.2.1,4.3.1
CO4	1.2.1, 4.1.1,4.1.2, 4.2.1,4.3.1
CO5	1.2.1, 4.1.1,4.1.2, 4.2.1,4.3.1

22BPC306	BIOCHEMISTY LABORATORY	SEMESTER III

PREREQUISITES	CATEGORY	L	T	P	C
Chemistry for Biotechnology **Chemistry Laboratory**	**PC**	**0**	**0**	**3**	**1.5**

Course Objectives	Train the students on qualitative and quantitative analysis of basic biomolecules.
Experiment No.	**EXPERIMENTS**
1.	Units, Volume/Weight measurements, concentrations, Sensitivity, Specificity, Precision and Accuracy.
2.	Preparation of buffers and Titration curves of amino acids.
3.	Qualitative tests for carbohydrates.
4.	Quantitative tests for reducing sugars.
5.	Qualitative tests for Amino Acids.
6.	Quantitative tests for Protein.
7.	Estimation of Nucleic acids : Test for ribose and deoxyribose.
8.	Estimation of glucose by GOD-POD method.
9.	Quantitative tests for Cholesterol.
10.	Determination of isoelectric point of casein.
Contact Periods: **Lecture:0 Periods** **Tutorial: 0 Periods** **Practical: 45 Periods** **Total: 45 Periods**	

REFERENCES

1	David. T. Plummer, "***An Introduction to Practical Biochemistry***", McGraw – Hill, 3rd edition., 2017
2	Benjamin F. Lasseter, "***Biochemistry in the Lab A Manual for Undergraduates***", 1st Edition, CRC Press, 2019.
3	Andreas Hofmann, Samuel Clokie, "***Wilson And Walker's Principles And Techniques Of Biochemistry And Molecular Biology***", 8th Edition, Wiley, 2018.

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	pare reagents accurately and reproducibly for experiments	K3
CO2	erate pH meter, weighing balance, colorimeter and spectrophotometer	K3
CO3	the experiments for isolation and extraction of any bioactive compounds	K3
CO4	Identify and quantify the bio molecules (Carbohydrate, Protein, Nucleic acid, Lipids) in any	K3
CO5	Understand the practical accession behind preparation and separation of various biomolecules	K3

COURSE ARTICULATION MATRIX

a) CO and PO Mapping														
COs/POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO1 1**	**PO 12**	**PSO 1**	**PSO 2**
CO1	-	-	-	2	-	-	-	-	-	-	-	-	3	1
CO2	-	-	-	1	-	-	-	-	-	-	-	-	3	1
CO3	-	-	-	4	-	-	-	-	-	-	-	-	3	1
CO4	-	-	-	2	-	-	-	-	-	-	-	-	3	1
CO5	-	-	-	1	-	-	-	-	-	-	-	-	3	1
22BPC306	-	-	-	2	-	-	-	-	-	-	-	-	3	1
1 – Slight, 2 – Moderate, 3 – Substantial														
b) CO and Key Performance Indicators Mapping														
CO1	4.2.1, 4.3.1													
CO2	4.2.1													
CO3	4.1.1, 4.1.2, 4.2.1, 4.3.1													
CO4	4.2.1, 4.3.1													
CO5	4.1.4,													

22BES407	FLUID MECHANICS	SEMESTER IV

PREREQUISITES	CATEGORY	L	T	P	C
Differential Equations and Numerical Methods	**ES**	**3**	**0**	**0**	**3**

Course Objectives	Understand dynamics and properties of fluid flow, learn strong foundation of fluid mechanics (flow measurements) and develop dynamic characteristics of fluid flow through pipes and porous medium.	
UNIT – I	**INTRODUCTION**	**9 periods**
Properties of fluids, fluid statics, concept of shear stress, Newton's law of viscosity – Fluid behavior under shear, Newtonian and non-Newtonian fluids, Types of flow – laminar, turbulent, steady,unsteady, non uniform and uniform flows – compressible and incompressible fluids, Similitude -relationship between dimensional analysis and similitude		
UNIT – II	**FLUID DYNAMICS**	**9 periods**
Continuity equation, Bernoulli's equation, boundary layer condition, form drag, skin drag, drag coefficient – laminar and turbulent flow through closed conduit velocity profiles, pipes, tubes, fittings, valves, friction factor for smooth and rough pipes, head losses due to friction in pipes and fittings.		
UNIT – III	**FLUID FLOW MEASURMENT AND PUMPING EQUIPMENTS**	**9 periods**
Orifice meter, Venturimeter, Pitot tube, Rota meter, weirs and notches, hot wire anemometer, displacement meter, current meter, magnetic flow meter, pressure measurement bymanometers, U-tube, differential and inclined manometers. Pumps – types, selection and specifications, positive displacement pumps, reciprocating pump, rotary pumps, centrifugal pumps - characteristics curve of pumps – fans and compressors		
UNIT – IV	**FLUIDIZATION AND PACKED BEDS**	**9 periods**
Mechanisms, types – fluidized beds, properties of fluidized beds, continuous fluidization and application, packed beds – pressure drop, flooding and loading. Mixing & agitation		
UNIT – V	**MECHANICAL OPERATIONS**	**9 periods**
Size reduction equipments – operations and their classification, Energy and power requirements, Laws of crushing, open and closed circuit operations - techniques of size analysis – different methods for storage of solids, conveyors and elevators.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOK:

1	*McCabe Smith and Harriott, **"Unit Operations of Chemical Engineering"**, 7th Edition, Tata McGraw-Hill company, 2022.*
2	*Geankoplis C.J, **"Transport Processes and Unit Operations",** 3rd Edition, Prentice Hall of India, 2003.*

REFERENCES :

1	*Frank M. White, **"Fluid Mechanics"**, 8th Edition, Tata McGraw-Hill company, 2017.*
2	*J. M. Coulson, J. F. Richardson and R. K. Sinnott, **"Chemical Engineering. Vol I & II"**, 6th Edition, Butterworth-Heinemann Ltd, 1999.*
3	*Bansal R K, **"Fluid mechanics and Hydraulic machines"**, 10th Edition, Lakshmi publications (P) Ltd, New Delhi, 2019.*

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	derstand stress – strain relationship in fluids and analyse fluid flow problems.	K1
CO2	To apply Bernoulli principle and measure pressure drop in flow systems	K3
CO3	Describe the function and performance of flow metering devices.	K5
CO4	Determine minimum fluidization velocity in fluidized bed.	K4
CO5	Present characteristics of particulate solids, Principles of size reduction and screening, crushing and grinding equipment.	K2

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/POs	**PO1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO1 0**	**PO1 1**	**PO1 2**	**PSO 1**	**PSO 2**
CO1	-	1	1	1	1	-	-	-	-	-	-	1	3	2
CO2	1	1	-	1	-	2	1	-	1	-	1	1	3	2
CO3	-	1	1	-	1	2	-	-	-	-	-	-	2	3
CO4	1	1	1	1	-	-	-	-	1	-	-	1	3	2
CO5	-	1	1	1	-	-	1	-	-	1	1	1	3	2
22BES407	1	1	1	1	1	1	1	-	1	1	1	1	3	2

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	2.2.3, 2.2.4,2.3.2,3.1.6, 4.1.4, 5.1.1,
CO2	1.2.1, 2.1.3, 4.3.1, 6.2.1, 7.2.2,
CO3	2.2.2, 2.4.1, 3.1.1, 3.2.2, 5.3.2, 6.2.1
CO4	1.2.1, 2.1.3, 2.3.2, 3.2.3, 4.3.3
CO5	2.1.2, 2.4.2, 3.2.1, 4.2.2, 7.2.2

ASSESSMENT PATTERN – THEORY

Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	20	20	20	20	20	-	100
CAT2	20	20	20	20	20	-	100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	30	30	20	-	20	-	100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	30	30	20	-	20	-	100
ESE	40	30	20	-	10	-	100

22BPC407	MOLECULAR BIOLOGY	SEMESTER IV

PREREQUISITES	CATEGORY	L	T	P	C
Microbiology **Cell Biology**	**PC**	**3**	**0**	**0**	**3**

Course Objectives	To learn the fundamental aspects of nucleic acids, the principle and process of DNA replication, transcription and translation and to study the basics of regulation of gene expression, mutation and DNA repair.	
UNIT – I	**CHEMISTRY OF NUCLEIC ACIDS**	**9 Periods**
Nucleic acids as genetic material;Structure and physico chemical properties of elements in DNA and RNA, Primary structure of DNA: Chemical and structural qualities of 3',5'-Phosphodiester bond. Secondary Structure of DNA: Watson & Crick model, Chargaff's rule, X–ray diffraction analysis of DNA, Forces stabilizes DNA structure, Conformational variants of double helical DNA, Hogsteen base pairing, Triple helix, Quadruple helix, Reversible denaturation and hyperchromic effect. Tertiary structure of DNA: DNA supercoiling, Conformation of DNA and RNA; classes of RNA; Organization of eukaryotic chromosome – c0t value**.**		
UNIT – II	**DNA REPLICATION**	**9 Periods**
- Overview of differences in prokaryotic and eukaryotic DNA replication, Rules of replication in all nucleic acid; enzymology; DNA replication: Meselson& Stahl experiment, bi–directional DNA replication, Okazaki fragments; Replication in prokaryotes - D-loop and rolling circle mode of replication; replication of linear viral DNA. Replication of telomeres in eukaryotes. Inhibitors of DNA replication.		
UNIT – III	**TRANSCRIPTION**	**9 Periods**
RNA polymerase- RNA replicase (Virus), Transcription in prokaryotes and eukaryotes; Inhibitors; features of promoters and enhancers; transcription factors; nuclear RNA splicing mechanisms – tRNA- rRNA- mRNA; ribozymes; RNA **-** editing.		
UNIT – IV	**TRANSLATION**	**9 Periods**
Elucidation of genetic code; Salient features of genetic code - Wobble hypothesis; ribosomes – prokaryotic & eukaryotic; protein synthesis; post translational processing; Protein targeting.		
UNIT – V	**MUTATION – REPAIR AND REGULATION OF GENE EXPRESSION**	**9 Periods**
Regulation of genes – replication- transcription & translation factors; Lac and trp operon; Mutation– transition- transversion- artificial & natural mutation; suppressor mutation; Repair of DNA.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOK

1	David Friefelder, ***"Molecular Biology"***, Narosa Publ. House.2^{nd} edition, 1999.
2.	Harvey Lodish, Arnold Berk, S.L Zipursky, Paul Matsudaira, David Baltimore and James Danell ***"Molecular Cell Biology"***,4^{th} Edition, New York: W.H Freeman and company, 2016.

REFERENCES

1	Malacinski, G.M., Freifelder's ***"Essentials of Molecular Biology"***, 4^{th} edition, Nasora Publishing House, New Delhi, 2015.
2	Watson J.D., Hopkins W.H., Roberts J.W., Steitz J.A., Weiner A.M., ***"Molecular Biology of the Gene"***, McGraw Hill,2^{nd} Edition, 1986.
3	Waston, B.B, & Gann, L.L, ***"Watson Molecular Biology of the Gene"***, 7^{th} Edition, Pearson Education, 2014.
4	Weaver, R.., ***"Molecular Biology"***, 3^{rd} Edition, McGraw Hill, 2011
5.	Benjamin L., ***"Genes IX"***, 9^{th} Edition, Jones & Bartlett Publishers Inc. 2013.

COURSE OUTCOMES: On completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	derstand the basic structure and biochemistry of nucleic acids	K1
CO2	Comprehend the principle of DNA replication	K1
CO3	Get familiarize with the process of transcription and RNA processing.	K2
CO4	Become aware of the process of protein synthesis.	K2
CO5	Understand the regulatory mechanism of molecular biology.	K1

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	-	-	-	-	-	-	-	-	-	-	-	3	1
CO2	3	-	-	-	-	-	-	-	-	-	-	-	3	2
CO3	1	2	3	-	-	-	-	-	-	-	-	-	3	2
CO4	-	3	2	-	2	-	-	-	-	-	-	-	2	3
CO5	-	1	3	-	2	-	-	-	-	-	-	2	2	3
22BPC407	3	3	3	-	2	-	-	-	-	-	-	2	3	3

b) CO and Key Performance Indicators Mapping

CO1	1.2.1, 2.4.3
CO2	3.1.5
CO3	3.1.4,3.1.5,
CO4	5.1.2.
CO5	12.1.1,12.1.2

ASSESSMENT PATTERN – THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	70	30	-	-	-	-	100
CAT2	40	60	-	-	-	-	100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	50	50	-	-	-	-	100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	30	70	-	-	-	-	100
ESE	60	40	-	-	-	-	100

22BPC408	BIOCHEMICAL THERMODYNAMICS	SEMESTER IV

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PC	3	0	0	3

Course Objectives	To expound theory and fundamentals behind the thermodynamics implications in the biological processes. The students will be able to design & solve physical and chemical problems encountered in chemical and biochemical industries by applying fundamental thermodynamics laws.	
UNIT – I	**THERMODYNAMIC LAW AND PROPERTIES OF FLUIDS**	**9 Periods**
First Law of thermodynamics; a generalized balance equation and conserved quantities; Volumetric properties of fluids exhibiting non ideal behavior; estimation of thermodynamic properties using equations of state; calculations involving actual property exchanges; Maxwell's relations and applications.		
UNIT – II	**SOLUTION THERMODYNAMICS**	**9 Periods**
Partial molar properties; Chemical potential, Fugacity and fugacity coefficient in solutions; Henrys law and dilute solutions; Activity in solutions and activity coefficient;Gibbs-Duhem equation ; Excess properties and residual properties of mixtures.		
UNIT – III	**PHASE EQUILIBRIA**	**9 Periods**
Criteria for phase equilibria; VLE calculations for binary and multi component systems; liquid-liquid equilibria and solid-solid equilibria.		
UNIT – IV	**CHEMICAL REACTION EQUILIBRIA**	**9 Periods**
Equilibrium criteria for homogeneous chemical reactions; evaluation of equilibrium constant; effect of temperature and pressure on equilibrium constant; calculation of equilibrium conversion and yields for single and multiple reactions.		
UNIT – V	**THERMODYNAMIC DESCRIPTION OF MICROBIAL GROWTH AND PRODUCT FORMATION**	**9 Periods**
Thermodynamics of microbial growth stoichiometry thermodynamics of maintenance, Calculation of the Operational Stoichiometry of a growth process at Different growth rates, Including Heat using the Herbert –Pirt Relation for Electron Donor, thermodynamics and stoichiometry of Product Formation		
Contact Periods: **Lecture:45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOKS:

1	Smith J.M., Van Ness H.C., Abbott M.M.,***'Introduction to Chemical Engineering Thermodynamics'***, McGraw-Hill, 8th edition, 2018.
2	Narayanan K.V,***'A Text Book of Chemical Engineering Thermodynamics'***, Prentice Hall of India, 2nd edition, 2013.
3	Christiana D Smolke,***'The Metabolic Pathway Engineering Handbook Fundamentals'***, CRC Press Taylor & Francis, 1st edition, 2010.

REFERENCES:

1	Hougen O.A., Watson K.M., and Ragatz R.A., ***'Chemical Process Principles Part II'***, John Wiley & Sons, 2nd edition. 2004.
2	Stanley I. Sandler ***'Chemical, Biochemical, and Engineering Thermodynamics'***, John Wiley Sons, 5th edition, 2017.

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	ıstrate the application of thermodynamics in design & operation of process industries.	K1
CO2	sign & solve problem in realistic cases by applying thermodynamics concepts.	K1
CO3	Estimate thermodynamic properties of substances in gas and liquid states	K2
CO4	Interpret the phase equilibria concepts in multi-component systems	K2
CO5	Understand about biochemical equilibrium and able to calculate the kinetics of biological systems.	K2

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	2	2	-	2	-	-	-	-	-	-	-	-	1	1
CO2	2	1	-	2	-	-	-	-	-	-	-	-	1	1
CO3	2	2	-	2	1	2	-	-	-	-	-	-	1	1
CO4	2	2	-	2	-	-	-	-	-	-	-	-	1	1
CO5	2	2	-	2	-	2	-	-	-	-	-	-	1	1
22BPC 408	2	2	-	2	1	2	-	-	-	-	-	-	1	1

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.2.1, 1.3.1,1.4.1,2.1.2,2.1.3, 2.1.3,2.2.2,2.3.2,2.4.4,4.1.1,4.1.4,4.3.3
CO2	1.2.1, 1.3.1,1.4.1,2.1.2,2.1.3, 2.1.3,2.2.2,2.2.3,4.1.1,4.1.2,4.3.2
CO3	1.2.1, 1.3.1,1.4.1,2.1.2,2.1.3, 2.1.3,2.2.2,2.3.2,2.4.4,4.1.1,4.1.2,4.1.4,4.2.1,4.3.1,5.3.1,6.1.1
CO4	1.2.1, 1.3.1,1.4.1,2.1.2,2.1.3, 2.1.3,2.2.2,2.3.2,2.4.4,4.1.1,4.1.2,4.1.4,4.2.1,4.3.1.
CO5	1.2.1, 1.3.1,1.4.1,2.1.2,2.1.3, 2.1.3,2.2.2,2.3.2,2.4.4,4.1.1,4.1.2,4.1.4,4.2.1,4.3.1,6.2.1

ASSESSMENT PATTERN – THEORY

Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
Unit test - 1	20	20	-	20	40	-	100
Unit test - 2	20	20	-	20	40	-	100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	50	50	-	-	-	-	100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	30	70	-	-	-	-	100
ESE	20	20	-	30	30	-	100

22BPC409	ENZYME ENGINEERING AND TECHNOLOGY	SEMESTER IV

PREREQUISITES	CATEGORY	L	T	P	C
BIOMOLECULES BIOCHEMISTRY	PC	3	0	0	3

Course Objectives	Students are able to understand the basic enzyme catalysis and kinetics. Get to know about different immobilization methods. Students able to familiarize with different enzyme assay and also about enzyme applications	
UNIT – I	**INTRODUCTION TO ENZYMES**	**9 Periods**
Enzymes-Introduction-active site, concept of active site, co factors, co enzymes-examples, Lock and Key Hypothesis, Induced fit hypothesis, Classification of enzymes, Mechanism of catalysis-acid base catalysis, electrostatic catalysis, covalent catalysis, Enzyme catalysis, Theory of catalysis-collision state theory, transition state theory, Enzyme activity and specific activity, role of entropy in catalysis		
UNIT – II	**ENZYME KINETICS**	**9 Periods**
Kinetics of enzyme catalyzed reaction-MichaelisMenten equation, Briggs Haldane modification, Significance of Km kcat,Vmax. Linear plots-Line weaver burk plot, Eadiehofstee plot. Mechanism of Bimolecular reaction, Inhibition-types of enzyme inhibition-competitive, uncompetitive, non-competitive, mixed, allosteric inhibition. Allosteric enzymes-Monod Wyman Changeux Model		
UNIT – III	**ENZYME IMMOBILISATION**	**9 Periods**
Enzyme immobilization- Physical and Chemical methods Physical methods-Adsorption, entrapment, encapsulation. Chemical methods-covalent bonding, cross linking. Application of immobilized enzymes in industries. case studies		
UNIT – IV	**ENZYME CHARACTERIZATION AND PURIFICATION**	**9 Periods**
Extraction and purification of enzymes from microbial, plant and animal sources, methods of precipitation, dialysis, filtration, chromatography – methods-ion-exchange, size exclusion, hydrophobic interaction, Affinity chromatography, HPLC, Molecular weight determination-SDS PAGE, Native PAGE		
UNIT – V	**ENZYME ASSAYS AND APPLICATIONS**	**9 Periods**
Types of Enzyme assays- End point methods, kinetic methods, coupled kinetic assay, Immuno assay methods, artificial enzymes. Application of enzymes as Biosensors, Application in food industries, textile industries, food industries, Biopharmaceutical industries, tanning industries		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOK

1	Trevor Palmer, *"Enzymes"*, Affiliated East West Press Pvt Ltd, New Delhi, 2004.
2	Harvey W. Blanch, Douglas S. Clark, "***Biochemical Engineering***", Marcel Dekker Inc, 2002
3	B. Sivasankar, ***"Bioseparations: Principles and Technique"***, Prentice-Hall of India Pvt.Ltd, 2007

REFERENCES

1	James M Lee, ***Biochemical Engineering***, Prentice Hall of India, USA, 2009.
2	James. E. David F. Bailey & Ollis,***Biochemical Engineering Fundamentals***, McGraw Hill, 2011.
3	Rufus O. Okotore,***Essentials of Enzymology***,Xlibris Corporation,2015

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	derstand the basics of enzymes and mechanism of enzyme catalysis	K1
CO2	Familiarize with the enzyme kinetics and apply to solve problems in enzyme kinetics	K3
CO3	Familiarize with the different types of enzyme immobilisation and its applications	K1
CO4	Analyze the different methods for enzyme extraction and purification.	K4
CO5	Understand the different assay procedures for enzymes and get familiarize with the different enzyme applications	K1

a) CO and PO Mapping

COs/POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	2	1	-	1	-	-	1	-	1	-	-	-	1	-
CO2	1	-	2	-	2	-	1	1	1	-	2	-	-	2
CO3	1	-	1	2	-	-	-	3	1	-	1	-	-	3
CO4	1	2	2	-	-	1	-	2	-	-	-	-	1	-
CO5	1	-	-	-	-	-	-	2	1	1	2	-	-	3
22BPC409	1	1	2	2	2	1	1	2	1	1	2	-	1	3

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance indicators mapping

CO1	1.2.1, 1.3.1, 2.3.1, 4.1.1
CO2	1.1.1, 3.1.1, 5.1.1
CO3	1.2.1, 4.2.1, 1.1.2
CO4	1.2.1, 2.2.1, 3.1.1, 5.1.2
CO5	1.3.1, 2.1.1

COURSE ARTICULATION MATRIX

ASSESSMENT PATTERN – THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	60	30	10	-	-	-	100
CAT2	40	30	30	-	-	-	100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	50	50	-	-	-	-	100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	30	40	30	-	-	-	100
ESE	40	30	30	-	-	-	100

22BPC410	ANALYTICAL TECHNIQUES IN BIOTECHNOLOGY	SEMESTER IV

PREREQUISITES	CATEGORY	L	T	P	C
Engineering Physics **Chemistry for Biotechnology**	PC	3	0	2	4

Course objectives	ᴑ enable the students to understand and to get familiarized with principles of analytical instruments to solve researchproblems and to enable them tointerpret the analytical data and research findings based on the knowledge obtained from thiscourse.	
UNIT – I	**BASICS OF MEASUREMENT**	**9+6 Periods**
Classification of analytical methods – calibration of instrumental methods – electrical components and circuits -signal to noise ratio; Properties of electromagnetic radiations and their interaction withmatter.		
UNIT – II	**MOLECULAR SPECTROSCOPY**	**9+6 Periods**
UV and visible light spectroscopy-Qualitative and Quantitative absorption Measurement, Beer- Lambert law, IR spectroscopy, Raman spectroscopy, NMR spectroscopy, X- ray crystallography– principle, instrumentation and applications; Atomic Absorption spectroscopy, Mass Spectroscopy.		
UNIT – III	**ELECTROPHORESIS**	**9+6 Periods**
General principle of electrophoresis, support media (Agarose and Polyacrylamide gels, Electrophoresis of proteins by SDS-PAGE gradient gels, Isoelectric Focusing, Two Dimensional PAGE, Electrophoresis of nucleic acids using agarose gel, PFGE, Capillary Electrophoresis.		
UNIT – IV	**CHROMATOGRAPHY**	**9+6 Periods**
Basic Principles of chromatography, TLC and Column chromatography, matrix materials, HPLC, Affinity chromatography, Ion Exchange Chromatography, Gel Exclusion Chromatography and Gas chromatography.		
UNIT – V	**THERMAL METHODS**	**9+6 Periods**
Differential Thermal Analysis techniques - instrumentation & application, DTA curve. Differential Scanning Calorimetry - Instrumentation & Application, Instrumentation, Thermogravimetry – Instrumentation & Application, TGcurve. Biosensors – Components, Types		
Contact Periods: **Lecture: 45 Periods** **Tutorial: 0 Periods** **Practical: 30 Periods** **Total: 75 Periods**		

LIST OF EXPERIMENTS

- Precision and Validity in an instrument.
- Validation of Lambert-Beer's law using $KMnO_4$.
- Determination of concentration of the Iron content present in the tablet using atomic absorption spectrometry.
- Raman spectroscopy – Identification of functional groups
- Data interpretation of FTIR spectra
- Demonstration on the working of XRD
- Determination of the concentration of Na and Ca using flame photometer.
- Separation of amino acids by TLC.
- Column chromatographic analysis of chlorophyll
- Separation of compounds using High Performance Liquid chromatography
- Gel filtration – Size based separation of proteins

TEXT BOOK:

1	lard H.W., Merritt L.L., Dean J.A. & Settle F.A***"Instrumental Methods of Analysis"***, East West Publishers, 7th Edition.2004
2	oog, D.A., F. James Holler and Stanky, R. Crouch***"Instrumental Methods of Analysis"***. Cengage LearningIndia Pvt. Ltd., 7th edition, 2020.

REFERENCES:

1	rrison, R.G., Todd, P., Rudge, S.R. and Petrides, B.B.***"Bioseparations: Science and Engineering"***, Oxford University Press,2015.
2	lson K. and Walker J.***"Principles and Techniques of Biochemistry and Molecular Biology"***, Cambridge University Press,8th Edition, 2018.
3	ayaraman.***"Laboratory Manual in Biochemistry",***1st Edition., New Age International Publications, 2007
4	R. F. Boye,***Modern experimental Biochemistry***, Pearson India, 2002

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	To understand the basic principles of measurement and calibration in analytical methods.	K2
CO2	To impart knowledge on the working principles of spectroscopic instruments.	K1
CO3	instill knowledge on the separation of biomolecules such as nucleic acids and proteins by electrophoresis and chromatography methods.	K3
CO4	To describe the thermal behavior of thebioproducts and components of a biosensor.	K3
CO5	To develop a protocol to identify and determine the concentration of a analyze by analytical instruments.	K6

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO2**
CO 1	2	1	1	1	-	-	-	-	-	-	2	1	1	1
CO 2	2	1	1	1	-	-	-	-	-	-	-	1	1	-
CO 3	2	1	-	1	-	-	-	-	-	-	-	-	-	-
CO 4	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	-	-	-	-	1	2	-	-	-	-	-	-	-	-
22BPC410	2	1	1	1	1	2	-	-	-	-	2	1	1	1

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.1,1.2,1.3,1.4,2.1,2.2,2.3,2.4,3.1, 3.2,4.1,4.2,11.2,11.3,12.3
CO2	1.1,1.2,1.3,1.4,2.1,2.2, 2.3,2.4, 3.2,4.1,4.2,12.2,12.3
CO3	1.1,1.3,1.4,2.1, 2.2,2.4,4.1
CO4	1.1
CO5	1.2

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	14	10	2	10	12	2	100
CAT2	10	12	4	10	10	4	100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	-	30	5	5	-	-	100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	30	5	5	-	-	-	100
ESE	40	30	30	-	-	-	100

22BES408	**ENGINEERING EXPLORATION FOR INDUSTRIAL BIOTECHNOLOGY**	**SEMESTER IV**

PREREQUISITES	CATEGORY	L	T	P	C
NIL	ES	0	0	3	1.5

COURSE OBJECTIVE	The objective of the course is to provide an introduction to the engineering field. It is designed to help the student to learn about engineering and how it is useful in our everyday life.	
UNIT-1	**INTRODUCTION**	**15 Periods**
Introduction to Engineering and Engineering study: Difference between science and engineering, scientist and engineer needs and wants, various disciplines of engineering, some misconceptions of engineering, expectation for the 21st century engineer and Graduate Attributes.		
UNIT-II	**ENGINEERING DESIGN**	**15 Periods**
Engineering Requirement, Knowledge within Engineering disciplines, Engineering advancements, Problem definition, Idea generation through brain storming and researching, solution creation through evaluating and communicating, text/analysis, final solution and design improvement.		
UNIT-III	**ENGINEERING DISCIPLINES**	**15 Periods**
INDUSTRIAL BIOTECHNOLOGY: Defining the problem, Data gathering through literature, Specify requirements, Brainstorm, Evaluate, Choose solution, Design, Implementation of the design, Develop Prototype/Model. **GUIDELINES** • Practical based learning carrying credits. • Multi-disciplinary/ Multi-focus group of 3-4 students. • Groups can select to work on specific tasks, or projects related to real world problems. • Each group has a faculty coordinator/Instructor who will guide/evaluate the overall group as well as individual students. • The students have to display their project/model/product at the end of the semester. • The progress of the course is evaluated based on class performance and final demonstration.		
Contact Periods: **Lecture: 0 Periods** **Tutorial: 0 Periods** **Practical: 45 Periods** **Total: 45 Periods**		

REFERENCES:

1	*Ryan A Brown, Joshua W. Brown and Michael Berkihiser: "**Engineering Fundamentals: Design, Principles, and Careers**", Goodheart-Willcox Publisher, Second edition, 2014.*
2	*Saeed Moaveni, "**Engineering Fundamentals: An Introduction to Engineering**", Cengage learning, Fourth Edition, 2011.*

COURSE OUTCOMES On Completion of the course, the students will be able to		**Bloom's Taxonomy Mapped**
CO1	Explain technological and engineering development, change and impacts of engineering	K2
CO2	Complete initial steps (Define a problem list criteria and constraints, Brainstorm potential solutions and document ideas) in engineering designs	K3
CO3	Communicate possible solutions through drawings and prepare project reports.	K3
CO4	Draw sketches to a Design problem.	K3
CO5	Apply the concept of engineering fundamentals in Industrial Biotechnology	K3

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	1	1	1	2	2	2	3	3	1	2	1	3
CO2	3	3	1	2	1	2	2	2	3	3	1	2	1	3
CO3	3	3	3	3	1	2	2	2	3	3	1	2	1	3
CO4	3	2	3	3	1	2	2	2	3	3	1	2	1	3
CO5	3	2	3	3	1	2	2	2	3	3	1	2	1	3
22BES408	3	3	3	3	1	2	2	2	3	3	1	2	1	3

b) CO and Key Performance Indicators mapping

CO1	1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.2.1, 2.2.2, 2.2.3, 2.2.4, 2.4.4, 3.1.1, 3.1.4, 3.1.6, 4.1.1, 4.1.3, 4.1.4, 4.3.1, 4.3.2, 4.3.3, 4.3.4, 5.1.1, 6.2.1, 7.1.1, 7.1.2, 8.1.1, 9.1.1, 9.2.2, 9.2.3, 9.3.1, 10.1.2, 10.1.3, 11.3.1, 12.1.2, 12.3.1
CO2	1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.2.1, 2.2.2, 2.2.3, 2.2.4, 2.4.4, 3.1.1, 3.1.4, 3.1.6, 4.1.1, 4.1.3, 4.1.4, 4.3.1, 4.3.2, 4.3.3, 4.3.4, 5.1.1, 6.2.1, 7.1.1, 7.1.2, 8.1.1, 9.1.1, 9.2.2, 9.2.3, 9.3.1, 10.1.2, 10.1.3, 11.3.1, 12.1.2, 12.3.1
CO3	1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.2.1, 2.2.2, 2.2.3, 2.2.4, 2.4.4, 3.1.1, 3.1.4, 3.1.6, 4.1.1, 4.1.3, 4.1.4, 4.3.1, 4.3.2, 4.3.3, 4.3.4, 5.1.1, 6.2.1, 7.1.1, 7.1.2, 8.1.1, 9.1.1, 9.2.2, 9.2.3, 9.3.1, 10.1.2, 10.1.3, 11.3.1, 12.1.2, 12.3.1
CO4	1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.2.1, 2.2.2, 2.2.3, 2.2.4, 2.4.4, 3.1.1, 3.1.4, 3.1.6, 4.1.1, 4.1.3, 4.1.4, 4.3.1, 4.3.2, 4.3.3, 4.3.4, 5.1.1, 6.2.1, 7.1.1, 7.1.2, 8.1.1, 9.1.1, 9.2.2, 9.2.3, 9.3.1, 10.1.2, 10.1.3, 11.3.1, 12.1.2, 12.3.1
CO5	1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.2.1, 2.2.2, 2.2.3, 2.2.4, 2.4.4, 3.1.1, 3.1.4, 3.1.6, 4.1.1, 4.1.3, 4.1.4, 4.3.1, 4.3.2, 4.3.3, 4.3.4, 5.1.1, 6.2.1, 7.1.1, 7.1.2, 8.1.1, 9.1.1, 9.2.2, 9.2.3, 9.3.1, 10.1.2, 10.1.3, 11.3.1, 12.1.2, 12.3.1

22BES409	CHEMICAL ENGINEERING LABORATORY	SEMESTER IV

PREREQUISITES	CATEGORY	L	T	P	C
Fluid Mechanics **Process calculations and Heat transfer**	ES	0	0	3	1.5

Course Objectives	To learn chemical engineering principles and their practical applications in the areas of fluid mechanics, Heat transfer, mass transfer and particle mechanics.
LISTOF EXPERIMENTS	
1.	Flow measurement using Venturimeter, Orificemeter for liquids
2.	Studies on flow behavior and friction loss in Fluidized bed.
3.	Product size distribution analysis using Roll Crusher
4.	Product size distribution analysis using Ball Mill
5.	Studies on Simple Distillation.
6.	Calculations of filter and medium resistances in Leaf filter apparatus
7.	Adsorption Equilibria
8.	Leaching
9.	Liquid-Liquid Equilibria
10	Batch drying
11	Batch sedimentation
12	Double Pipe Heat exchanger
13	Determination of effect of temperature on reaction rate content
Contact Periods **Lecture: 0 Periods Tutorial: 0 Periods Practical: 45 Periods Total: 45 Periods**	

TEXT BOOKS

1	*YunusCengel*, "***Heat and Mass Transfer – Fundamentals & Applications***", *McGraw-Hill, 5th edition. 2015.*
2	*Geankoplis C.J*, "**Transport Processes and Unit Operations**", *Prentice Hall of India, 4th edition. 2003.*

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Able to calculate pressure and flow rate of liquid	K3
CO2	Find out the efficiencies of filtration and distillation range.	K3
CO3	Calculate the heat exchange limitation.	K3
CO4	Separate soluble components by using liquid equilibria.	K3
CO5	Knowledge on the basic principles of chemical engineering.	K3

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**
CO1	1	-	-	2	-	-	-	-	-	-	-	-	2	1
CO2	1	-	-	2	-	-	-	-	-	-	-	-	2	1
CO3	1	-	-	2	-	-	-	-	-	-	-	-	2	1
CO4	1	-	-	2	-	-	-	-	-	-	-	-	2	1
CO5	1	-	-	2	-	-	-	-	-	-	-	-	2	1
22BES409	1	-	-	2	-	-	-	-	-	-	-	-	2	1

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.2.1, 4.1.1,4.1.2
CO2	1.2.1, 4.1.1,4.1.2,4.2.1
CO3	1.2.1, 4.1.1,4.1.2,4.2.1,4.3.1
CO4	1.2.1, 4.1.1,4.1.2, 4.2.1,4.3.1
CO5	1.2.1, 4.1.1,4.1.2, 4.2.1,4.3.1

22BPC411	MOLECULAR BIOLOGY LABORATORY	SEMESTER IV

PREREQUISITES	CATEGORY	L	T	P	C
Microbiology Lab Cell biology Lab	PC	0	0	3	1.5

Course Objectives	To provide hands on experience in performing basic and advanced molecular biology techniques and to introduce students to the theory behind in each technique and to describe common applications of each methodology in biological research.

LIST OF EXPERIMENTS

1. DNA Extraction from plant cells.
2. DNA Extraction from animal cells.
3. DNA Extraction from Human blood.
4. DNA Extraction from bacterial cell.
5. Qualitative Analysis of Genomic DNA
6. Quantitative Analysis of DNA.
7. Isolation of total RNA from bacteria.
8. Qualitative analysis of RNA.
9. Quantitative analysis of RNA.
10. Plasmid Extraction from bacterial cell.
11. Elution of DNA from Agarose gel.

Contact Periods:
Lecture: 0 Periods Tutorial: 0 Periods Practical: 45 Periods Total: 45 Periods

REFERENCE BOOK

1	Sambrook J and Russell DM, ***"Molecular Cloning: A Laboratory Manual",***2014.

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	derstand the principles underlying in the techniques of molecular biology .	K3
CO2	Analyze the applications of these techniques.	K3
CO3	Carry out lab experiments and interpret the results.	K3
CO4	Take safety precautions on usage of hazardous chemicals in case of emergency.	K3

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	2	-	-	-	-	-	-	-	-	-	-	-	3	1
CO2	3	-	-	-	-	-	-	-	-	-	-	-	3	2
CO3	1	3	2	-	2	-	-	-	-	-	-	-	3	2
CO4	-	3	3	-	3	-	-	-	-	-	-	3	2	3
22BPC411	3	3	3	-	3	-	-	-	-	-	-	3	3	3

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.2.1, 1.4.1,
CO2	2.4.3,3.1.5
CO3	3.1.4,3.1.5,4.3.2
CO4	5.1.2,8.2.1,8.2.2

22BES510	MASS TRANSFER OPERATIONS	SEMESTER V

PREREQUISITES	CATEGORY	L	T	P	C
NIL	ES	3	1	0	4

Course Objectives	To understand the basic laws of diffusion & to develop solutions for the problem involving solid, liquids and gas systems. To design the absorption column for the separation processes in single and multistage modes and the process of distillation and to design the types of distillation columns. To know the principle and design features of extraction / leaching equipment used in process industries and learn technological methods in design and troubleshooting of solid-fluid operations in process industries.	
UNIT – I	**DIFFUSION AND MASS TRANSFER**	**9+3 Periods**
Molecular diffusion in solids, liquids and gases; Inter-phase mass transfer; theories to determine mass transfer coefficients; Analogies in Transport phenomenon		
UNIT – II	**GAS - LIQUID OPERATIONS**	**9+3 Periods**
Principles of gas absorption; Single and Multistage absorption; Absorption with chemical reaction; Design principles of absorbers; Industrial absorption equipment; HTU, NTU concepts.		
UNIT – III	**VAPOUR - LIQUID OPERATIONS**	**9+3 Periods**
Vapour-Liquid equilibria; Simple, Steam and Flash Distillation; Continuous distillation; McCabe - Thiele & enthalpy concentration method; Industrial distillation equipment, HETP, HTU and NTU concepts.		
UNIT – IV	**EXTRACTION OPERATIONS**	**9+3 Periods**
Liquid-Liquid equilibria, Staged and continuous extraction, Solid-liquid equilibria, Leaching principles, Equipment for extraction and leaching		
UNIT-V	**SOLID - FLUID OPERATIONS**	**9+3 Periods**
Adsorption equilibria – Types - Batch and fixed bed adsorption; Drying – Mechanism - Drying curves - Time of drying; Equipment for drying - Batch and continuous dryers		
Contact Periods: **Lecture: 45 Periods Tutorial: 15 Periods Practical: 0 Periods Total: 60 Periods**		

TEXT BOOK

1	Yunus Cengel, ***"Heat and Mass Transfer – Fundamentals & Applications",*** McGraw-Hill, 5th edition 2015.
2	Geankoplis C.J, ***"Transport Processes and Unit Operations",*** Prentice Hall of India, 4th edition 2003.

REFERENCES

1	Incropera F.P., ***"Fundamentals of Heat and Mass Transfer"***, John Wiley, 7th edition. 2011.
2	McCabe W.L., Smith J.C, ***"Unit Operations in Chemical Engineering"***, McGraw-Hill, 7th edition. 2014.
3	Treybal R.E, ***"Mass Transfer Operations"***, McGraw-Hill, 3rd edition. 1981.
4	nciples of Mass transfer Operations , 6th edition, Nirali Prakashan publisher,2017.

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Understand the basic laws of diffusion & to develop solutions for the problem involving solid, liquids and gas systems	K1
CO2	Design the absorption column for any complex separation processes	K1
CO3	Design and operate the various classes of distillation columns for V-L operations	K2
CO4	Design the extraction / leaching equipment for L-L & S-L operations.	K3
CO5	Design the drying and adsorption equipment for S-F operations.	K3

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/POs	PO1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2
CO1	3	2	1	-	-	-	-	-	3	1	-	1	3	3
CO2	3	-	3	2	2	-	-	-	3	2	-	2	3	3
CO3	1	1	2	2	2	-	-	-	2	1	-	1	1	2
CO4	2	2	2	2	2	-	2	1	2	2	-	2	1	2
CO5	2	1	2	1	1	-	-	2	2	2	2	2	2	3
22BES510	3	2	2	2	2	-	2	1	3	2	2	2	1	3

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.2.1, 1.3.1,1.4.1,2.1.2,2.1.3, 2.1.3,2.2.2,2.3.2,2.4.4,4.1.1,4.3.3
CO2	1.2.1, 1.3.1,1.4.1,2.1.2,2.1.3,4.1.1,4.1.2,4.3.2
CO3	1.2.1,1.3.1,1.4.1,2.1.2,2.1.3,2.3.2,2.4.4,4.1.1,4.1.4,4.2.1,4.3.1,5.3.1,6.1.1
CO4	1.2.1, 1.3.1,1.4.1,2.1.2,2.1.3, 2.1.3,2.4.4,4.1.1,4.1.2,4.1.4,4.2.1,4.3.1.
CO5	1.2.1, 1.3.1,1.4.1, 2.1.3,2.2.2,2.3.2,2.4.4, 4.1.4,4.2.1,4.3.1,6.2.1

ASSESSMENT PATTERN – THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	50	10	10	10	10	10	100
CAT2	50	10	10	10	10	10	100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	20	20	20	20	10	10	100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	20	20	20	20	10	10	100
ESE	20	20	20	20	20	-	100

22BPC512	BIOPROCESS PRINCIPLES	SEMESTER V

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PC	3	0	0	3

Course Objectives	To learn the basic principles of fermentation process and basic configuration and parts of a fermenter. To gain the knowledge about the sterilization kinetics, metabolic stoichiometry and energetics. To understand microbial kinetics in batch, fed-batch and continuous mode of operation.	
UNIT – I	**FERMENTATION PROCESSES AND BASIC CONFIGURATION OFFERMETER**	**9 Periods**
General requirements of fermentation processes, Different types of fermentations and fermenters, Process flow sheeting, pictorial representation of fermenter, Basic configuration of fermenter and ancillaries, main physical and chemical parameters to be monitored and controlled in fermentation processes.		
UNIT – II	**RAW MATERIALS AND MEDIA DESIGN FOR FERMENTATION PROCESS**	**9 Periods**
Criteria for good medium, medium requirements for fermentation processes, carbon, nitrogen, minerals, vitamins and other complex nutrients, oxygen requirements, medium formulation of optimal growth and product formation, types of culture media, design of various commercial media for industrial fermentations – medium optimization methods- OFAT (One Factor at a Time), PB (Plackett and Burman), RSM (Response Surface Methodology).		
UNIT – III	**STERILIZATION KINETICS**	**9 Periods**
Thermal death kinetics of microorganisms, batch and continuous heat sterilization of liquid media, filter sterilization of liquid media, sterilization of air, design of sterilization equipment for batch and continuous process.		
UNIT – IV	**METABOLIC STICHIOMETRY AND ENERGITICS**	**9 Periods**
Stoichiometry of cell growth and product formation – Elemental balances, degrees of reduction of substrate and biomass and available electron balances, Yield coefficients of biomass and product formation, Maintenance coefficients, energetic analysis of microbial growth and product formation, Oxygen consumption and heat evolution in aerobic cultures, Thermodynamic efficiency of growth.		
UNIT – V	**KINETICS OF MICROBIAL GROWTH AND PRODUCT FORMATION**	**9 Periods**
Modes of operation – batch, fed-batch and continuous cultivation, Biomass estimation – Direct and Indirect methods. Simple unstructured kinetic models for microbial growth – Monod model, Growth of filamentous organisms and yeast, Product formation kinetics – Leudeking - Piret models, substrate and product inhibition on cell growth and product formation.		
Contact Periods: **Lecture: 45 Periods** **Tutorial: 0 Periods** **Practical: 0 Periods** **Total: 45 Periods**		

TEXT BOOK

1	Peter F. Stanbury, Stephen. J, Hall. A. Whitaker, ***"Principles of Fermentation Technology",*** Science & Technology Books, 2007.
2.	Shuler Michael. L, Fikret Kargi, "***Bioprocess Engineering",*** Prentice Hall,2008.
3	Doran M Pauline***, "Bioprocess Engineering Principles",*** Elsevier, 2 nd Edition,2012.

REFERENCES

1	Bailey, James E, David F.Olli, ***"Biochemical Engineering Fundamentals",*** 2nd Edition. McGraw Hill,1986.
2	Blanch H. W, Clark D. S, ***"Biochemical Engineering",*** 2nd Edition, CRC Press, 2007.
3	Rajiv Dutt, ***"Fundamentals of Biochemical Engineering",*** Springer, 2008.
4	Ghasem D. Najaf pour, ***"Biochemical Engineering and Biotechnology",*** Elsevier, 2007.
5.	Himmelbla.D.M, ***"Basic principles and calculations in chemical Engineering",*** 6th edition, Pearson education,2006.

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Understand the general requirements of a fermentation process.	K2
CO2	Understand the basic configuration of a fermenter and its ancillaries.	K2
CO3	Demonstrate an ability to design good media.	K3
CO4	Explain the sterilization kinetics and design the sterilization equipment for batch and continuous process.	K3
CO5	Able to model microbial growth, substrate utilization and product formation.	K3

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs / POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**
CO1	3	-	-	-	-	-	-	-	-	-	-	-	3	1
CO2	3	-	-	-	-	-	-	-	-	-	-	-	3	2
CO3	1	2	3	-	-	-	-	-	-	-	-	-	3	2
CO4	-	3	2	-	2	-	-	-	-	-	-	-	2	3
CO5	-	1	3	-	2	-	-	-	-	-	-	2	2	3
22BPC512	3	3	3	-	2	-	-	-	-	-	-	2	3	3

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.2.1,2.2.2
CO2	1.2.1,2.2.2
CO3	1.2.1,2.2.2
CO4	1.2.1,2.2.2
CO5	1.2.1,4.1.2,4.1.3,5.1.2

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	70	30	-	-	-	-	100
CAT2	60	40	-	-	-	-	100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	50	50	-	-	-	-	100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	40	60	-	-	-	-	100
ESE	60	40	-	-	-	-	100

22BPC513	GENETIC ENGINEERING	SEMESTER V

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PC	3	0	0	3

Course Objectives	To impart the knowledge on various components and techniques used in DNA manipulation. To introduce basic knowledge to construct various recombinant proteins. To describe techniques to analyze clones. To introduce Transgenic Technology for animals.	
UNIT – I	**INTRODUCTION TO RECOMBINANT DNA TECHNOLOGY**	**9 Periods**
Role of genes within cells; Genetic elements that control gene expression in Prokaryotes and Eukaryotes; Repressors and Promoters; Methods of creating recombinant molecules ; Restriction and modifying enzymes- DNA polymerase, DNA ligase, Alkaline phosphatase – Inter and intra molecular ligation, Polynucleotide kinase, Terminal transferase and Exonuclease; Restriction mapping; Design of Linkers and Adaptors;Safety guidelines of recombinant DNA research.		
UNIT – II	**CLONING AND EXPRESSION VECTORS**	**9 Periods**
Plasmid vector: pBR322 and pUC, Host range – shuttle vectors, Plasmid compatibility, copy number regulation and TA cloning. Bacteriophage vector: λDNA vectors – Insertional and replacement vectors. Single strand DNA vectors: M13 phage vector and its applications. Combinatorial vectors: Cosmid and Phagemid. Artificial chromosomes: Bacterial and yeast artificial chromosomes. Insect and Mammalian vectors. Prokaryotic and Eukaryotic expression vectors.		
UNIT – III	**CONSTRUCTION OF LIBRARIES**	**9 Periods**
Construction of genomic and cDNA library: Methods, Limitations in cDNA library construction and full-length cDNA library construction. Screening of DNA libraries: Nucleic acid hybridization and PCR , Southwestern and Northwestern strategies, Immunochemical, protein-protein/ligand interaction, functional complementation/gain of function approaches. Differential cDNA library: Differential expression analysis and screening, Subtracted cDNA library, PCR based differential display analysis and difference cloning.		
UNIT – IV	**POLYMERASE CHAIN REACTION**	**9 Periods**
DNA amplification; primer synthesis; Taq polymerase; Types of PCR –Inverse PCR, Nested PCR, RACE PCR, RAPD-Taqman assay, Molecular beacons; site directed mutagenesis (Kunkel's Method) - Methods of nucleic acid sequencing: Sangers method. Pyrosequencing, Nanopore DNA sequencing, Next generation sequencing.		
UNIT – V	**APPLICATIONS OF RECOMBINANT DNA TECHNOLOGY**	**9 Periods**
Applications of recombinant technology in Agriculture, Pharmaceutical industry and Medicine; Knockout animals, Production of novel products, Antisense technology; Transgenic animals; Nuclear transfer eg. Dolly.; CRISPR-Cas9 editing.		
Contact Periods: **Lecture: 45 Periods** **Tutorial: 0 Periods** **Practical: 0 Periods** **Total: 45 Periods**		

TEXT BOOK

1	Old RW, Primrose SB – "Principles of Gene Manipulation, An Introduction To Genetic Engineering", Blackwell Science Publications, 2013.
2.	Brown T.A., (2017), Genomes 4, Bios Scientific Publishers Ltd, Oxford, 3rd edition

REFERENCES

1	Primrose S.B., Twyman RM., (2006), Principles of Gene Manipulation and Genomics, 7th Edition, Blackwell Science.
2	Glick B.R.,and Pasternick J.J., (2017), Molecular Biotechnology: Principles and Applications of Recombinant DNA, 5th Edition, ASM press, Eashington.
3	Sathyanarayana U (2008) Biotechnology, Books & Allied (p) ltd.-Kolkata
4	Sambrook (Joseph) and Russell(David W), (2001), Molecular Cloning :A manual, Cold Spring Harbour Laboratory Press.

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Understand the various tools and techniques used in creating rDNA technology.	K1
CO2	Analyze the features of various types of cloning and expression vectors.	K3
CO3	Understand the various methods to construct and screen DNA libraries.	K2
CO4	Apply suitable modern molecular techniques to amplify and sequence the gene.	K3
CO5	Apply Genetic Engineering principles for the production of transgenics.	K3

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/POs	**PO 1**	**PO 2**	**PO 3**	**PO4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**
CO1	3	-	2	-	-	2	-	-	-	-	-	-	3	1
CO2	3	1	2	-	-	-	-	2	-	-	-	-	3	1
CO3	2	2	1	-	-	-	-	-	-	-	-	-	1	3
CO4	1	3	-	-	2	-	-	-	-	-	-	-	1	3
CO5	1	1	-	-	1	2	2	-	-	-	-	1	1	3
22BPC513	3	3	2	-	2	2	2	2	-	-	-	1	1	3

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.4.1, 3.1.5, 6.2.1
CO2	1.4.1, 2.1.3,3.1.5,8.2.2
CO3	1.4.1, 2.1.3,3.1.5,
CO4	1.4.1, 2.1.3, 5.2.2
CO5	1.4.1, 2.1.3,5.2.2,6.1.1,7.1.1,7.1.2

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	70	30	-	-	-	-	100
CAT2	20	20	60	-	-	-	100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	50	50	-	-	-	-	100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	30	70	-	-	-	-	100
ESE	40	60	-	-	-	-	100

22BPC514	PROTEIN ENGINEERING	SEMESTER V

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PC	3	0	0	3

Course Objectives	To acquire knowledge on different bonds in protein and structure elucidation methods. To learn the various topologies of secondary, super secondary, tertiary and quaternary structures. To understand the relationship between protein structure and function using some models. To learn the fundamentals of protein engineering and design	
UNIT – I	**BONDS IN PROTEIN & STRUCTURE ELUCIDATION**	**9 Periods**
Covalent, Ionic, hydrogen, hydrophobic and vanderwaals interactions in protein structure. Elucidation of secondary structure- circular di-chroism; Elucidation of tertiary structure protein structure using X-ray diffraction and Nuclear Magnetic Resonance (NMR).		
UNIT – II	**POST TRANSLATIONAL MODIFICATION AND PEPTIDE ANALYSIS**	**9 Periods**
Amino acids - molecular properties (size, solubility, charge, pKa), Post translational modification-modification at N-terminus and C-terminus, Glycosylation; Determination of amino acid composition, peptide sequencing - automated Edman method & mass-spectrometry, peptide synthesis, peptide mapping.		
UNIT – III	**PROTEIN ARCHITECTURE**	**9 Periods**
Primary structure, Secondary structures-alpha helix, beta sheet and turns. Super-secondary structure: Alpha-turn-alpha, beta-turn-beta (hairpin), beta-sheets, alpha-beta-alpha, topology diagrams, Tertiary structure – types of different domains (α, β and α / β); α domain – Coiled to coil structure and Four helix bundle; β domain – up and down, Greek key and jelly roll barrels; α / β domains – TIM barrel, Rossman fold and Horseshoe fold; Protein folding – role of molecular chaperones, protein disulphide isomerase and peptidyl prolyl cis-trans isomerase; Quaternary structure- importance-examples		
UNIT – IV	**STRUCTURE-FUNCTION RELATIONSHIP**	**9 Periods**
DNA-binding proteins: prokaryotic transcription factors, Helix-turn-Helix motif in DNA binding, trp repressor, Eucaryotic transcription factors, Zn fingers, helix-turn helix motifs in homeodomain, Leucine zippers, Membrane proteins and receptors:Bacteriorhodopsin and Photosynthetic reaction center, Immunoglobulins: IgG Light chain and heavy chain architecture, Enzymes: Serine proteases.		
UNIT – V	**CASE STUDIES IN PROTEIN ENGINEERING**	**9 Periods**
Advantages - protein data base analysis – methods to alter primary structure of proteins, examples of engineered proteins, thermal stability of T4-lysozyme, engineering proteins for post translational modification, Engineering oxygenases for environmental pollutant degradation, De novo protein design – principles and examples. Protein engineering for biomaterials- functionalization		
Contact Periods: **Lecture: 45 Periods** **Tutorial: 0 Periods** **Practical: 0 Periods** **Total: 45 Periods**		

TEXT BOOK

1	Branden C, Tooze, "***Introduction to Protein Structure***", Garland Publishing, NY, USA, Second Edition, 2012.
2	Creighton T.E., "***Proteins: Structure and Molecular Properties***", Second Edition, Freeman WH publishers, 1993

REFERENCES

1	Lilia Alberghina., "***Protein Engineering for Industrial Biotechnology***", Lilia Alberghina, CRC Press, 2003.
2	Stefan Lutz, Uwe Theo Bornscheuer., "***Protein Engineering Handbook"***, Volume1, Wiley Publications, 2012.
3	Khudyakov YE, "***Medicinal Protein Engineering***", CRC Press, First Edition, 2008.
4	Voet D and Voet G., "***Biochemistry***", John Wiley and Sons, Fourth edition,2012

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Acquire knowledge about the bonds and energies in protein and elucidation of protein structure.	K1
CO2	Understand the basics of post translational modification and peptide analysis.	K1
CO3	Understand the architecture of proteins	K1
CO4	Elucidate the structure function relationship of proteins	K2
CO5	Understand the basics and steps involved in protein engineering	K2

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**
CO1	2	1	-	1	-	-	-	-	-	-	-	-	3	1
CO2	1	1	-	-	-	-	-	-	-	-	-	-	3	1
CO3	1	1	-	-	-	-	-	-	-	-	-	-	3	1
CO4	1	1	-	-	-	-	-	-	-	-	-	-	3	1
CO5	-	1	2	1	2	-	-	-	-	-	-	-	3	1
22BPC514	1	1	1	1	1	-	-	-	-	-	-	-	3	1

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.2.1,1.3.1,1.4.1,2.2.1,4.1.2,4.1.3
CO2	1.2.1, 2.1.3
CO3	1.2.1, 1.3.1,2.1.3
CO4	1.2.1, 1.3.1,2.1.3
CO5	2.4.1, 3.2.1,4.2.1,5.2.1

ASSESSMENT PATTERN – THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	50	50	-	-	-	-	100
CAT2	30	40	20	10	-	-	100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	60	40	-	-	-	-	100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	30	50	10	10	-	--	100
ESE	30	40	20	10	-	-	100

22BMC5Z2	CONSTITUTION OF INDIA *(Common to all Branches)*	SEMESTER V

PREREQUISITES	CATEGORY	L	T	P	C
NIL	MC	3	0	0	0

Course Objectives	*The objective of the course is to familiarize the students on the role, powers and functions of Indian government. Also understand the recent acts in India.	
UNIT- I	**INTRODUCTION AND EMERGENCY PROVISIONS**	**(9 Periods)**
Historical Background: The Company rule, The Crown rule - Constituent Assembly: Composition, Objectives - Preamble and Salient features of the Indian Constitution - Fundamental Rights, Fundamental Duties, Directive Principles of state policy, Emergency Provisions - National Emergency, President Rule, Financial Emergency.		
UNIT- II	**SYSTEM OF GOVERNMENT**	**(9 Periods)**
Parliamentary system: merits, demerits, reasons for adopting parliamentary system – Federal system: Evaluation of federal features – Centre-State relations: Legislative, Administrative and Financial relations – Local Government: Panchayat Raj and urban local government.		
UNIT- III	**UNION AND STATE GOVERNMENT**	**(9 Periods)**
President of India: Election, Powers and functions - Prime Minister and Cabinet: Structure and functions – Governor: Powers and functions - Chief Minister and Council of Ministers: Functions.		
UNIT- IV	**ORGANS OF GOVERNANCE AND RECENT ACTS**	**(9 Periods)**
Parliament: Lok Sabha and Rajya Sabha, Composition and powers - State Legislative Assembly and Legislative Council: Composition and powers - Judicial System in India: Structure and features - Supreme Court and High Court: Composition, Jurisdiction, Recent acts in significance-RTI, Citizenship act, POCSO act.		
UNIT- V	**POLITICAL DYNAMICS**	**(9 Periods)**
Political parties: Party system, Recognition of National and State parties – Elections: Electoral system and reforms – Pressure groups – National Integration: Obstacles, National Integration Council – Foreign Policy: Principles and Objectives.		
Contact Periods: **Lecture: 45 Periods** **Tutorial: 0 Periods** **Practical: 0 Periods** **Total: 45 Periods**		

TEXT BOOK:

1	*National portal of India, "**The Constitution of India**" (Full Text), https://legislative.gov.in/constitution-of-india*
2	*Dr.B.R.Ambedkar, "**The Constitution of India**", SudhirPrakashan, 2020*

REFERENCES:

1	*Durga Das Basu, "**Introduction to the Constitution of India**, LexisNexis, 2022*
2	*P.M.Bakshi, "**The Constitution of India**", LexisNexis, 2020*
3	*Subash C Kashyap, "**Our Parliament**", National Book Trust, 2021*
4	*Subash C Kashyap, "**Our Political System**", National Book Trust, 2011*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Know the evolution of Indian Constitution and its basic premises	K1
CO2	Explain the system of governance in India.	K2
CO3	Describe the structure of Union and State Governments	K2
CO4	Obtain the knowledge of functions of Legislature and Judiciary	K1
CO5	Know the political system of India	K1

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO2	-	-	-	-	-	1	-	1	1	-	-	-	-	-
CO3	-	-	-	-	-	2	-	1	1	-	-	-	-	-
CO4	-	-	-	-	-	1	-	1	2	-	-	-	-	-
CO5	-	-	-	-	-	2	-	2	1	-	-	-	-	-
22BMC5Z2	-	-	-	-	-	2	-	1	1	-	-	-	-	-

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	6.1.1, 6.2.1, 8.1.1, 8.2.1, 8.2.2, 9.1.2
CO2	6.1.1, 6.2.1, 8.1.1, 8.2.1, 8.2.2, 9.1.2
CO3	6.1.1, 6.2.1, 8.1.1, 8.2.1, 8.2.2
CO4	6.1.1, 6.2.2, 9.1.2, 9.2.1
CO5	6.2.2, 8.1.1,8.2.2, 9.1.2, 9.2.1

ASSESSMENT PATTERN – THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	50	50	-	-	-	-	100
CAT2	50	50		-	-	-	100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	50	50	-	-	-	-	100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	50	50	-	-	-	-	100
ESE	50	50	-	-	-	-	100

22BPC515	BIOPROCESS LABORATORY I	SEMESTER V

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PC	0	0	3	1.5

Course Objectives	To train and familiarize the students on enzyme kinetics studies, medium optimization techniques, microbial growth kinetics and operation of fermenters.
List of Experiments	
1.	Enzyme kinetics – Determination of Michaelis Menten parameters
2.	Enzyme activity – Effect of Temperature
3.	Enzyme activity – Effect of pH
4.	Enzyme inhibition kinetics
5.	Enzyme immobilization – Gel entrapment/ Cross linking
6.	Medium optimization by Plackett - Burman design
7.	Growth of bacteria - calculation of μ and Yield coefficient
8.	Growth of yeast - calculation of μ and Yield coefficient.
9.	Sterilization Kinetics.
10.	Study of ancillaries and construction of bioreactor.

Contact Periods:
Lecture: 0 Periods Tutorial: 0 Periods Practical: 45 Periods Total: 45 Periods

REFERENCES

1	Peter F. Stanbury, Stephen. J, Hall. A. Whitaker, ***"Principles of Fermentation Technology",*** Science & Technology Books, 2007.
2	Shuler Michael. L, Fikret Kargi, "***Bioprocess Engineering",*** Prentice Hall,2008.
3	Doran M Pauline***, "Bioprocess Engineering Principles",*** Elsevier, 2 nd Edition,2012.
4	Bailey, James E, David F. Olli, ***"Biochemical Engineering Fundamentals",*** 2nd Edition. McGraw Hill,1986.
5.	Blanch H. W, Clark D. S, ***"Biochemical Engineering",*** 2nd Edition, CRC Press, 2007.
6	Ninfa. A.J, Ballou. D.P, ***"Fundamental Lab approachesfor Biochemistry and Biotechnology",*** 2nd Edition, Oxford University press, UK,1998.

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Understand enzyme kinetics and Estimate Michaelis Menten parameters.	K2
CO2	Learn the basic configuration of fermenter and its ancillaries.	K1
CO3	Analyze and estimate the growth kinetics of bacteria and yeast.	K4
CO4	Familiarize with medium optimization techniques.	K2
CO5	Understand sterilization kinetics	K2

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs / POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2
CO1	3	-	-	-	-	-	-	-	-	-	-	-	3	1
CO2	3	-	-	-	-	-	-	-	-	-	-	-	3	2
CO3	1	2	3	-	-	-	-	-	-	-	-	-	3	2
CO4	-	3	2	-	2	-	-	-	-	-	-	-	2	1
CO5	-	1	3	-	2	-	-	-	-	-	-	1	2	3
22BPC515	3	3	3	-	2	-	-	-	-	-	-	2	3	2

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.2.1,2.2.2
CO2	1.2.1,2.2.2
CO3	1.2.1,2.2.2
CO4	1.2.1,2.2.2
CO5	1.2.1,4.1.2,4.1.3

22BPC516	GENETIC ENGINEERING LABORATORY	SEMESTER V

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PC	0	0	3	1.5

Course Objectives	To make the students to understand the basic genetic engineering techniques and learn about the identification and characterization of gene and protein.

List of Experiments

1. Isolation of Total DNA
2. Preparation of Plasmid DNA from bacterial cell.
3. Restriction digestion of DNA (single and Double digestion)
4. Ligation of DNA into expression vectors
5. Competent cell preparation
6. Transformation
7. Selection of Recombinants – Blue white screening assay
8. Primer Designing using insilico approach.
9. PCR – Amplification of genes.
10. Protein Profiling by SDS-PAGE
11. Western blot
12. RT-PCR

Contact Periods:
Lecture: 0 Periods **Tutorial: 0 Periods** **Practical: 45 Periods** **Total: 45 Periods**

REFERENCES

1	Green MR and Sambrook J. *"**Molecular Cloning: A Laboratory Manual**"*. 4th Edition, CSHL press, 2012.
2	Sambrook, Joseph and David W. Russell, **'The Condensed Protocols: From Molecular Cloning: A Laboratory Manual',** Cold Spring Harbor, 2006.
3	Old RW, Primrose SB, "Principles Of Gene Manipulation, An Introduction To Genetic Engineering ", Blackwell Science Publications, 1993.
4	Ansubel FM, Brent R, Kingston RE, Moore DD, "Current Protocols In Molecular Biology ", Greene Publishing Associates, NY, 1988.

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Understand the principles underlying in the techniques of genetic engineering.	K1
CO2	Experience basic techniques of DNA isolation and manipulation	K2
CO3	Experience in selecting genetically transformed organisms for downstream analysis.	K3
CO4	Experience basic techniques involved in analysis of gene expression at nucleic acids and protein level	K2
CO5	Understand the recent advancements in genetic engineering and about transgenic plants and animals.	K4

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/POs	PO1	PO 2	PO 3	PO4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2
CO1	2	2	3	-	-	-	-	-	-	-	-	-	3	2
CO2	2	1	2	1	-	-	-	-	-	-	-	-	3	1
CO3	2	2	2	-	-	-	-	-	-	-	-	-	2	2
CO4	2	2	2	-	1	-	-	-	-	-	-	-	2	3
CO5	2	1	2	-	3	-	-	-	-		-	-	2	3
22BPC516	2	2	2	1	3	-	-	-	-	-	-	-	3	2

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.2.1, 1.4.1,2.4.3
CO2	2.4.3,3.1.5
CO3	3.1.4,3.1.5,4.3.2
CO4	5.1.2,8.2.1,8.2.2
CO5	4.3.1, 4.3.2, 4.3.3, 11.3.1, 12.1.1,12.1.2,

22BES611	CHEMICAL REACTION ENGINEERING	SEMESTER VI

PREREQUISITES	CATEGORY	L	T	P	C
NIL	ES	3	1	0	4

Course Objectives	To impart the basic concepts in reaction kinetics, and Design experiments involving chemical reactors, and analyzing and interpreting data. Also gives knowledge in design and sizing of industrial scale reactor on the basis of kinetic data obtained at lab scale.	
UNIT – I	**KINETICS OF HOMOGENOUS REACTIONS**	**9+3 periods**
Classification of reactions, Types of rate expressions, Elementary and Non elementary reactions, Types of intermediates and searching for a mechanism in non elementary reactions, Temperature dependency of the rate constant based on Arrhenius, Collision and Transition state theories.		
UNIT – II	**DATA ANALYSIS AND INTERPRETATION**	**9+3 periods**
Differential and integral methods of analysis of rate data, Interpretation of rate data in constant and variable volume systems, Kinetics of irreversible, Parallel and Series reactions in constant volume batch reactor.		
UNIT – III	**REACTOR DESIGN**	**9+3 periods**
Ideal batch reactors – steady state MFR & PFR – holding time for flow systems; Design for single reactions - performance equations for single reactors – size comparison of single reactors – MFR vs PFR. Concept of space time and velocity. Size comparison of single reactors - Plug flow reactors in series and parallel, Mixed flow reactors of equal and different sizes in series.		
UNIT – IV	**NON IDEAL FLOW**	**9+3 periods**
Residence time distribution Function. Relationship among E, F and C curves - conversion from tracer information. Non-ideal flow models – Dispersion model and Tanks in series Model.		
UNIT-V	**HETEROGENOUS REACTIONS**	**9+3 periods**
Non catalytic fluid-solid systems: Kinetic models for non catalytic fluid-solid systems - Progressive conversion and Unreacted core Models. Development of rate expressions for various controlling regimes. Heterogeneous Catalysis: Kinetics and rate expressions for fluid-solid catalytic reactions. Langmuir Hinshelwood and Eley Rideal mechanisms for surface Reactions. Reaction and diffusion within porous catalysts. Concept of effectiveness factor.		
Contact Periods: **Lecture: 45 Periods** **Tutorial: 15 Periods** **Practical: 0 Periods** **Total: 60 Periods**		

TEXT BOOK

1	Levenspiel O, ***'Chemical Reaction Engineering '***, John Wiley, 3rd Edition, 1999
2	Fogler H.S, ***'Elements of Chemical Reaction Engineering'***, Prentice Hall of India, 4th edition, 2002.

REFERENCES

1	Missen R.W., Mims C.A., Saville B.A., *“**Introduction to Chemical Reaction Engineering and Kinetics**”*. John Wiley & Sons, 1st Edition, 1999.
2	Froment. G.F., Bischoff K.B., *“**Chemical Reactor Analysis and Design**”*, John Wiley and Sons, 3rd Edition, 2010
3	James B.R., John G. E., *“**Chemical Reactor Analysis and Design Fundamentals**”*, Nob Hill Publishers, 1stEdition, 2002
4	emical Reaction Engineering I, Nirali Publications 23rd Edition,2016.

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom’s Taxonomy Mapped**
CO1	Solve the kinetics of Homogeneous reactions.	K1
CO2	Develop design aspects for different ideal reactors	K1
CO3	Familiarity with applications of multiple reactions in process industries	K2
CO4	Demonstrate non ideal flow in chemical reactors.	K3
CO5	Design reactor for catalyzed reaction by understanding the heterogeneous chemical reactor system	K3

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**
CO1	3	2	1	-	-	-	-	-	3	1	-	1	3	3
CO2	3	-	3	2	2	-	-	-	3	2	-	2	3	3
CO3	1	1	2	2	2	-	-	-	2	1	-	1	1	2
CO4	1	2	-	1	2	-	2	1	2	2	-	2	1	-
CO5	2	1	2	1	1	-	-	1	2	2	2	2	2	-
22BES611	3	2	2	2	2	-	2	1	3	2	2	2	1	3

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.2.1, 1.3.1,1.4.1,2.1.2,2.1.3, 2.1.3,2.2.2,2.3.2,2.4.4,4.1.1,4.1.4,4.3.3
CO2	1.2.1, 1.3.1,1.4.1,2.1.2,2.1.3, 2.2.2,2.2.3,4.1.1,4.1.2,4.3.2
CO3	1.2.1,1.3.1,1.4.1,2.1.2,2.1.3,2.1.3,2.2.2,2.3.2,2.4.4,4.1.1,4.1.4,4.2.1,4.3.1,5.3.1,6.1.1
CO4	1.2.1, 1.3.1,1.4.1,2.1.2,2.1.3, 2.1.3,2.4.4,4.1.1,4.1.2,4.1.4,4.2.1,4.3.1.
CO5	1.2.1, 1.3.1,1.4.1,2.1.2,2.1.3, 2.1.3,2.2.2,2.3.2,2.4.4, 4.1.4,4.2.1,4.3.1,6.2.1

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	50	10	10	10	10	10	100
CAT2	50	10	10	10	10	10	100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	20	20	20	20	10	10	100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	20	20	20	20	10	10	100
ESE	20	20	20	20	20	-	100

22BPC617	IMMUNOLOGY	SEMESTER VI

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PC	3	0	0	3

Course Objectives	To learn the general concepts of immune system, immune organs and cells. To know about antigens and antibodies. To get familiarize with the mechanisms related to cell and antibody mediated immunity MHC and complement system. To know about the types of hypersensitivity reaction and also immune responses to different infectious agents. To understand autoimmunity, immunology behind graft acceptance and rejection and immunodeficiency diseases/disorders.	
UNIT – I	**INTRODUCTION TO IMMUNE SYSTEM**	**9 Periods**
Historical perspective, classification of immune system,innate immunity – four type of defensive barriers; Adaptive immunity - four characteristic attributes, Cells and organs of the immune system – hematopoiesis, Cells of immune system, organs of immune system.		
UNIT – II	**ANTIGENS AND ANTIBODIES**	**9 Periods**
Immunogenicity versus antigenicity, factors that influence immunogenicity, adjuvants, epitopes, haptens, pattern- recognition receptors. Basic structure of antibodies, immunoglobulin fine structure, and antibody mediated effector functions, antibody classes and biological activities, antigenic determinants on immunoglobulins. B-cell and T cell receptor. Immunoglobulin super family. Monoclonal antibodies. Antigen- antibody interaction: cross-reactivity, precipitation and agglutination.		
UNIT – III	**HUMORAL AND CELLULAR IMMUNITY**	**9 Periods**
Classification of T and B cells, T-cell maturation and thymus, T_H-cell activation, T-cell differentiation, cell death and T-cell populations, peripheral γδ T cells. B-Cell maturation, activation and proliferation, humoral response, regulation of B-cell development. Cytokines, major histocompatibility complex, complements.		
UNIT – IV	**HYPERSENSITIVE REACTIONS AND IMMUNE RESPONSE TO INFECTIOUS DISEASES**	**9 Periods**
Gell and Coombs classification of hypersensitivity. Protective immune response to viral infections, bacterial infections, fungal infections, protozoan diseases, diseases caused by parasitic worms (Helminths) and emerging infectious disease.		
UNIT-V	**AUTOIMMUNITY,TRANSPLANTATION IMMUNOLOGY AND IMMUNO DEFICIENCY**	**9 Periods**
Organ specific and systemic auto immune diseases. Immunologic basis of graft rejection, clinical manifestation of graft rejection, general and specific immunosuppressive therapy, immune tolerance to allografts and clinical transplantation. Primary immunodeficiency, AIDS and other secondary immunodeficiencies.		
Contact Periods: **Lecture:45Periods** **Tutorial: 0 Periods** **Practical: 0 Periods** **Total: 45 Periods**		

TEXT BOOK

1	Delves PJ, Martin SJ, Burtn DR and Roitt IM, ***"Roitt's Essential Immunology"***, 13th Edition, Wiley–Blackwell,2016.
2	OwenJA, Punt J and Stranford SA, ***"Kuby Immunology***", Macmillan International,8thEdition, 2019.

REFERENCES

1	*Coico, Richard "**Immunology: A Short Course**" VIth Edition. John Wiley, 2008.*
2	*Robert R Rich, Thomas A Fleisher, William T Shearer, Harry Schroeder, Anthony J Frew, and Cornelia M Wey, " **Clinical Immunology – Principles and Practive**," Elsevier, 4th Edition, 2013*
3	*Maurice R, G O`Gorman, and Albert D Donnnenberg, **"Handbook of human Immunology"**, Second edition, CRC Press, 2008*
4.	Chakravarthy AK,**"*Immunology*",**TataMcGraw-Hill,2006.

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Apply the general concepts of immune system and describe the cells and organs of the immune system	K1
CO2	Apply the properties of antigens and antibodies, demonstrate various antigen-antibody interactions	K1
CO3	Apply the concept of cell and antibody mediated immunity and outline the mechanism of complement system	K2
CO4	Apply the mechanism behind hypersensitivity and molecular mechanisms involved in pathogenesis of diseases caused by various pathogenic organisms	K3
CO5	Outline the mechanism behind transplantation immunology, concept of autoimmunity and immunodeficiencies.	K3

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/POs	**PO1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**
CO1	-	1	-	-	-	2	2	2	-	-	1	2	2	2
CO2	1	-	-	1	1	-	-	2	3	3	2	2	1	3
CO3	1	1	-	-	-	-	-	1	1	-	-	-	1	3
CO4	-	-	-	-	1	-	-	2	3	3	1	1	1	3
CO5	-	2	-	1	3	-	-	-	-	-	-	-	2	2
22BPC617	1	1	-	1	2	2	2	2	3	3	2	2	2	3

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.2.1, 2.1.1, 2.1.2, 2.1.3, 3.1.1, 3.1.2, 6.2.1, 7.1.2, 8.1.1, 9.1.1, 12.1.2
CO2	1.2.1, 2.1.1, 3.1.2, 3.1.3, 4.1.1, 6.1.1, 6.2.1, 10.1.1, 10.1.2, 10.3.1, 11.1.2, 11.2.1
CO3	1.2.1, 9.1.1, 9.2.1, 9.2.2, 10.1.2, 10.2.2
CO4	9.1.1, 9.1.2, 9.2.1, 10.1.2, 10.2.2
CO5	6.1.1, 6.2.1, 10.1.2, 10.3.1, 10.3.2

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	50	10	10	10	10	10	100
CAT2	50	10	10	10	10	10	100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	20	20	20	20	10	10	100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	20	20	20	20	10	10	100
ESE	50	10	10	10	10	10	100

22BPC618	BIOPROCESS ENGINEERING	SEMESTER VI

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PC	3	0	0	3

Course Objectives	To acquire the knowledge on design, performance stability analysis, scale up, monitoring and control of bioprocess.	
UNIT – I	**DESIGN AND ANALYSIS OF BIOREACTORS**	**9 Periods**
Bioreactors- Types- Design considerations; Design and operation of novel bioreactors-airlift- bubble column- packed bed and fluidized bed reactors; Bioreactors for animal and plant cell culture; Stability analysis of bioreactors; Design of continuous sterilizer.		
UNIT – II	**BIOREACTOR SCALE – UP**	**9 Periods**
Oxygen transfer in bioreactors - microbial oxygen demands; Mass transfer coefficients (k_La)-determination methods; mass transfer correlations; Regime analysis of bioreactor processes; Scale up-geometric and dynamic similarities- criteria for bioreactors based on oxygen transfer- power consumption and impeller tip speed.		
UNIT – III	**MONITORING & CONTROL OF BIOPROCESSES**	**9 Periods**
Bioprocess monitoring- modes- On-line measurement of physio-chemical and biochemical parameters; Methods of on-line and off-line biomass estimation; microbial calorimetry; Flow injection analysis; Computer based data acquisition- LabVIEW; Bioprocess control system- Feedback & Feedforward control – Types of controllers – proportional, derivative, integral and PID, tuning of controllers.		
UNIT – IV	**MODELLING AND SIMULATION OF BIOPROCESSES**	**9 Periods**
Overview of bioprocess modeling and simulation, Structured models for analysis of various bioprocess – compartmental models, models of cellular energetics and metabolism, single cell models, plasmid replication and plasmid stability model; Introduction to bioprocess simulation software-Dynamic simulation of batch - continuous and fed-batch system.		
UNIT – V	**BIOREACTOR CONSIDERATION IN ENZYME SYSTEMS**	**9 Periods**
Analysis of film and pore diffusion effects on kinetics of immobilized enzyme reactions; formulation of dimensionless groups (Damkohler number, Thiele modulus) and calculation of effectiveness factors; Kinetics of immobilized enzyme reactors – packed bed and fluidized bed.		
Contact Periods: **Lecture: 45 Periods** **Tutorial: 0 Periods** **Practical : 0 Periods** **Total: 45 Periods**		

TEXT BOOK:

1	*Shuler, M.L., Kargi, F., DeLisa, M.,"**Bioprocess Engineering: Basic Concepts**", 2nd Edition , Prentice Hall, 2017.*
2	*Doran, P.M.,"**Bioprocess Engineering Principles**", 2ndEdition, Elsevier, 2013.*

REFERENCES

1	*Blanch, H.W., Clark,D.S., "**Biochemical Engineering**", 2nd Edition , CRC Press, 1997.*
2	*Bailey, J.E., Ollis, D.F.," **Biochemical Engineering Fundamentals**", 2nd Edition , McGraw Hill, 1986.*
3	*Dunn, I.J., Heinzle, E., Ingham, J., Přenosil, J.E.,"**Biological Reaction Engineering: Dynamic Modelling Fundamentals with Simulation Examples**", 2nd Edition, Wiley, 2005.*
4	*Katoh, S., Horiuchi, J.I., Yoshida, F., "**Biochemical Engineering: A Textbook for Engineers, Chemists and Biologists**", John Wiley & Sons, 2015.*
5	*Liu, S.,"**Bioprocess Engineering-Kinetics, Biosystems, Sustainability and Reactor Design**", Elsevier, 2013.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Design and analyze the performance of bioreactors.	K2
CO2	Scale up the bioreactors based on various criteria.	K2
CO3	Clearly understand the monitoring and control of bioprocess.	K2
CO4	Perform modeling and simulations of bioprocess using software	K3
CO5	Understand the immobilized enzyme kinetics and apply for enzyme bioreactor design	K3

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/POs	**PO1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**
CO1	1	2	3	2	2	-	-	-	-	-	-	-	3	2
CO2	2	2	2	2	2	-	-	-	-	-	-	-	3	2
CO3	2	-	-	3	3	-	-	-	-	-	-	-	2	3
CO4	2	2	-	3	2	-	-	-	-	-	-	-	2	3
CO5	2	1	-	2	-	1	-	-	-		-	-	1	3
22BPC618	2	2	3	3	2	-	-	-	-	-	-	2	2	3

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.2.1,2.2.2,3.1.1,3.2.2, 4.1.2,5.1.1
CO2	1.2.1,2.2.2,3.1.1,3.2.2, 4.1.2,5.1.1
CO3	1.2.1,4.1.2,5.1.1,5.2.1
CO4	1.2.1,2.2.2, 4.1.4,5.1.1,6.1.1
CO5	1.2.1,2.2.2,3.2.2,3.4.1,4.1.2,5.1.1

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	50	50	-	-	-	-	100
CAT2	-	50	50	-	-	-	100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	50	50	-	-	-	-	100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	-	50	50	-	-	-	100
ESE	40	40	20	-	-	-	100

22BPC619	BIOINFORMATICS	SEMESTER VI

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PC	3	0	2	4

Course Objectives	To learn the basics of Unix commands and Perl programming and to understand the string alignment methods also to learn the methods to construct phylogenetic trees and structure prediction.	
UNIT – I	**UNIX AND PERL PROGRAMMING**	**9+6 periods**
Operating system - Components- Linux OS-working Environment -Basic UNIX commands - file, directory related commands –pipes and Filter; Perl – Introduction, Data types, variables, operators, Array operations, Hashes, Lists, control structures and file handling.		
UNIT – II	**BIOLOGICAL DATABASES**	**9+6 periods**
Databases – Introduction, Biological Databases – Primary databases – Nucleic acids – NCBI, EMBL, DDBJ. Proteins – PIR, Swissprot; Secondary databases – Prosite, prints, profile, Pfam; Structure databases-PDB, Structure classification databases – SCOP, CATH. Model organism databases, Metabolic pathway databases-KEGG.		
UNIT – III	**PATTERN MATCHING & MACHINE LEARNING**	**9+6 periods**
Alignment -pair wise sequence alignment - local and global alignment, Substitution matrices-PAM, BLOSUM; dynamic programming, dotplot analysis; database search tools - BLAST, FASTA; Multiple sequence alignment –Progressive alignment, Iterative method; Machine learning methods - Neural Networks, Hidden Markov models.		
UNIT – IV	**PHYLOGENY**	**9+6 periods**
Introduction to phylogeny terms; Molecular Clock theory -Jukes-Cantor and Kimura's model; phylogeny tree reconstruction methods- distance based-UPGMA, Neighbour Joining, Character based-Maximum Parsimony, Maximum Likelihood methods; Boot strapping technique		
UNIT – V	**STRUCTURE PREDICTION AND DRUG DESIGN**	**9+6 periods**
3D Structure prediction methods– Homology modeling, Threading, Ab-initio prediction; Micro array analysis –Principle and methods; Introduction to Computer Aided Drug Design (CADD).		
PRACTICALS		
Contact Periods: **Lecture: 45 Periods** **Tutorial: 0 Periods** **Practical: 30 Periods** **Total: 75 Periods**		

List of Experiments

- Perl Programming
- Biological Databases- Sequence Databases, Structure Databases, Specialized Databases; Data Retrieval tools and methods; Database file formats.
- Molecular visualization tools - Rasmol, Cn3D and Swiss PDB Viewer.
- Pairwise alignment-dynamic programming – NEEDLE and Water; Dotplot analysis
- Database similarity searching using Heuristic methods- BLAST, FASTA
- Multiple sequence alignment- CLUSTAL
- Protein sequence analysis -ExPASy proteomics tools
- Construction of Phylogenetic tree - Maximum Parsimony & Maximum Likelihood method - NJ, UPGMA method - PHYLIP program
- Homology Modeling - Homology modeling using SPDBV
- Model validation using Ramachandran plot, ProSA, Pro Check.
- Prediction of binding affinity of Ligand and Receptor using Docking studies

TEXT BOOK :

1	*David. W. Mount. **"Bioinformatics genome and sequence analysis"**, Cold Spring House Laboratory publications, 2nd Edition. 2004*
2	*Rastogi,S.C., Mendiratta.N and Rastogi.P, **"Bioinformatics – Methods & Applications: Genomics,Proteomics and Drug Discovery"**, Prentice Hall of India Learning Pvt (Ltd), India , 4th Edition, 2013*

REFERENCES:

1	*Andreas D. Baxevanis, **"Bioinformatics, A Practical Guide to the Analysis of Genes and Proteins"**, Wiley-Interscience, 3rd Edition.2004*
2	*Teresa Attwood, **"Introduction to Bioinformatics"**,Pearson Education India, 1st Edition. 2007*
3	*James Tisdall, **"Beginning PERL for Bioinformatics"**, O'Reilly publishers, 2001.*
4	*Harshawardhan P Bal, **"PERL programming for Bioinformatics"**, Tata Mc Graw Hill publications, 2003.*
5	*Arthur Lesk, **"Introduction to Bioinformatics",** Oxford University Press, 2nd Edition, 2002.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Gain expertise on UNIX operating system commands and Perl programming.	K2
CO2	Acquire knowledge on different biological databases and retrieve sequences	K1
CO3	Demonstrate an ability to align the macromolecular string by dynamic programming and heuristic methods	K4
CO4	Construct and interpret the phylogenetic trees.	K4
CO5	Understand the methods for structure prediction of proteins and computer aided drug design and able to validate 3D structure	K5

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	1	2	-	3	2	-	-	-	2	-	-	1	2	1
CO2	1	2	-	2	2	-	-	-	-	-	-	1	1	1
CO3	1	1	1	2	3	-	1	-	-	-	-	1	1	
CO4	2	2	-	3	2	-	-	-	1	-	-	1	2	2
CO5	1	2	-	3	2	-	-	-	2	-	-	1	2	3
22BPC619	1	2	1	3	2	-	1	-	2	-	-	2	2	2

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	3.2.1, 2.2.4, 2.4.2, 3.2.3
CO2	1.2.1, 2.1.1, 2.2.4, 2.4.3, 2.4.4, 3.1.1, 3.4.2, 4.3.1, 4.3.3
CO3	1.1.2, 2.2.1, 2.4.3, 4.1.3
CO4	4.1.2, 4.3.3, 5.3.1
CO5	1.3.1, 2.4.2, 2.4.4, 4.3.1, 5.3.1, 5.3.2

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	25	25	-	25	25	-	100
CAT2	25	25	-	25	25	-	100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	25	25	-	25	25	-	100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	25	25	-	25	25	-	100
ESE	25	25	-	25	25	-	100

22BPC620	BIOPROCESS ENGINEERING LABORATORY	SEMESTER VI

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PC	0	0	3	1.5

Course Objectives	To possess hands on experience to understand the basic concepts involved in the bioprocess engineering such as sterilization, growth kinetics, RTD and rheology, mass transfer rate in fermentation process.

List of Experiments

1. Thermal death kinetics
2. Batch reactor kinetics – estimation of reaction rate constant
3. Estimation of mass transfer coefficient for starch hydrolysis by immobilized amylase enzyme in packed bed reactor
4. Estimation of k_La – dynamic gassing method in batch fermenter
5. Estimation of k_La – sulphite oxidation method
6. Estimation of k_La – power correlation method
7. Study of rheological property of fermentation broth.
8. Residence time distribution in CSTR
9. Residence time distribution in PFR
10. Production of primary metabolites in fermenter
11. Production of secondary metabolites in fermenter
12. Dynamic Simulation of Batch, Continuous and Fed batch reactor using Berkeley Madonna software

Contact Periods:
Lecture : 0 Periods   Tutorial : 0 Periods   Practical: 45 periods   Total: 45 periods

REFERENCES

1	*Shuler, M.L., Kargi, F., DeLisa, M.,"**Bioprocess Engineering: Basic Concepts**", 2nd Edition , Prentice Hall, 2017.*
2	*Doran, P.M., "**Bioprocess Engineering Principles**", 2nd Edition , Elsevier, 2013.*
3	*Cutlip, M.B., and Shacham, M. "Problem solving in Chemical and Biochemical Engineering with Polymath, Excel, and Matlab", Prentice Hall, 2008.*
4	*Dunn, I.J., Heinzle, E., Ingham, J., Přenosil, J.E., "**Biological Reaction Engineering: Dynamic Modelling Fundamentals with Simulation Examples**", 2nd Edition, Wiley, 2005.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Design, analyze the growth kinetics in bioreactor and interpret the data meaningfully.	K3
CO2	Understand sterilization kinetics and its data interpretation	K3
CO3	Estimate the residence time distribution in CSTR and PFR to demonstrate the non-ideality existence in reactors.	K3
CO4	Determine mass transfer coefficients and rheology in fermentation process	K3
CO5	Solve and simulate the bioreactor data using Berkeley Madonna software	K3

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/POs	PO1	PO 2	PO3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2
CO1	2	2	3	-	-	-	-	-	-	-	-	-	3	2
CO2	2	1	2	1	-	-	-	-	-	-	-	-	3	1
CO3	2	2	2	-	-	-	-	-	-	-	-	-	2	2
CO4	2	2	2	-	1	-	-	-	-	-	-	-	2	3
CO5	2	1	2	-	3	-	-	-	-		-	-	2	3
22BPC620	2	2	2	1	3	-	-	-	-	-	-	-	3	2

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.2.1,1.2.2, 2.2.2,3.1.1
CO2	1.2.1,2.2.2,3.2.2,3.4.1,4.1.2
CO3	1.2.1,2.2.2,3.2.2,3.4.1
CO4	1.2.1,2.2.2, 3.2.2,5.1.1
CO5	1.2.1,2.2.2,3.2.2,3.4.1,4.1.2,5.1.1

22BPC621	IMMUNOLOGY LABORATORY	SEMESTER VI

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PC	0	0	3	1.5

Course Objectives	To perform different staining techniques to identify blood cells and cell division using microscope. To perform qualitative and quantitative analyses of antigens and antibodies and interpret the data based on pathological processes. To work as a team to perform and analyze practical methods.
List of Experiments	
1.	Identification of Immune cells in a blood smear.
2.	Isolation of peripheral blood mononuclear cells.
3.	Separation and preservation of serum from blood
4.	Agglutination reaction to determine blood group
5.	Testing of typhoid antigens by widal test.
6.	Immunodiffusion - Ouchterlony method
7.	Immunodiffusion - radial immunodiffusion
8.	Rocket Immunoelectrophoresis
9.	Countercurrent immunoelectrophoresis
10.	Enzyme Linked Immuno Sorbent Assay (ELISA)

Contact Periods:
Lecture: 0 Period **Tutorial: 0 Periods** **Practical: 45 Periods** **Total: 45 Periods**

TEXT BOOK :

1	De Robertis & De Robertis, **"Cell Biology"**, 4th edition, Lippincott, 2007.
2	Roitt I., **"Essential Immunology"**, 13 th edition, Blackwell Scientific,2017.

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Identify the different specimens using microscope	K1
CO2	Perform different staining techniques for the study of blood cells and cell division	K1
CO3	Demonstrate various strategies of antigen-antibody interactions	K2
CO4	Perform experiments to quantify immune molecules	K2
CO5	Interpret the data obtained based on pathological processes	K2

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	-	-	3	-	-	-	2	-	-	-	-	3	1
CO2	1	-	-	3	-	-	-	2	-	-	-	-	3	1
CO3	1	-	-	3	-	-	-	2	-	-	-	-	3	1
CO4	1	-	-	3	-	-	-	2	-	-	-	-	3	1
CO5	1	-	-	3	-	-	-	2	-	-	-	-	3	1
22BPC621	1	-	-	3	-	-	-	2	-	-	-	-	3	1

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.3.1, 2.1.3
CO2	1.4.1, 2.3.3
CO3	1.1.3, 2.1.3
CO4	1.4.1, 2.1.3,3.4.2
CO5	1.4.1,1.2.4

22BES612	DESIGN THINKING FOR INDUSTRIAL BIOTECHNOLOGY					SEMESTER VI
PREREQUISITES		**CATEGORY**	**L**	**T**	**P**	**C**
NIL		**ES**	**0**	**0**	**3**	**1.5**

Course Objectives	To provide the technologist with a standardized innovation process to develop creative and viable solutions to problems—design related.

LIST OF EXPERIMENTS	**45 periods**

DESIGN THINKING PROCESS AND PRACTICE:

Definition and need for design thinking, objective and concepts of design thinking and brainstorming. Stages of design thinking process (with examples) - empathize, define, ideate, prototype, evaluate.

Understanding creative thinking process, understanding problem solving, creative problem solving. Process of engineering design product, design thinking approach, stages of product design, examples of best product designs and functions, Assignment-Engineering product design.

Students should identify a real world problem. Define the problem related to community, ideate a possible and potential solutions, create a prototype and test the solution

Contact Periods:
Lecture: 0 Periods **Tutorial: 0 Periods** **Practical: 45 Periods** **Total: 45 Periods**

COURSE OUTCOMES Upon completion of the course, the students will be able to		**Bloom's Taxonomy mapped**
SCO1	Apply biotechnology knowledge to solve the real world problems	K3
CO2	Redefining the problem, or creating a different solution	K4
CO3	Apply the learnt process and skills to a Capstone project, with opportunity to present and transfer to the workplace.	K4
CO4	Apply the outcome to develop visual literacy and articulacy to explain design decisions.	K4
CO5	Develop critical skills to enable the process - communication, collaborative working, lateral thinking, decision making.	K4

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	2	-	3	2	2	2	-	-	3	3	2
CO2	2	3	3	2	2	2	-	-	-	2	2	-	3	2
CO3	1	-	-	-	-	-	-	-	2	3	-	-	2	2
CO4	-	-	-	-	-	-	-	-	2	3	-	-	2	2
CO5	-	-	-	-	-	1	-	-	-	3	2	-	2	3
22BES612	2	3	3	2	2	2	2	2	2	3	2	3	3	2

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.2.1, 2.1.1, 2.1.2, 2.1.3, 3.1.1, 3.1.2, 3.1.3, 4.1.1, 6.1.1, 6.2.1, 7.1.2, 8.1.1, 9.1.1, 12.1.2
CO2	1.2.1, 2.1.1, 2.1.2, 2.1.3, 3.1.1, 3.1.2, 3.1.3, 4.1.1, 6.1.1, 6.2.1, 10.1.1, 10.1.2, 10.3.1, 11.1.2, 11.2.1
CO3	1.2.1, 9.1.1, 9.1.2, 9.2.1, 9.2.2, 10.1.2, 10.2.2
CO4	9.1.1, 9.1.2, 9.2.1, 9.2.2, 10.1.2, 10.2.2
CO5	6.1.1, 6.2.1, 10.1.2, 10.2.2, 10.3.1, 10.3.2

22BHS704	SAFETY AND QUALITY MANAGEMENT IN BIOTECHNOLOGY	SEMESTER VII

PREREQUISITES	CATEGORY	L	T	P	C
NIL	HS	3	0	0	3

Course Objectives	To introduce the concepts of food safety and to reveal the significance of risk analysis. To learn the art of drafting SOPs and to give an overview on laboratory accreditation processes. To expose the students to hazard analysis and to prepare HACCP based SOPs. To build capability of preparing Quality management documents to get certifications. To practice the various classes of quality management tools.	
UNIT – I	**SAFETY AND RISK ANALYSIS**	**9 periods**
Introduction to Food Safety, Food Safety System, Total Quality Management, Project Management, An Introduction to Risk Analysis- Risk Management, Risk Assessment, Risk Communication.		
UNIT – II	**STANDARD OPERATING PROCEDURES**	**9 periods**
Preparing scope, quality policy and quality objectives of food processing company, Defining Standard operating procedure – purpose- Format - developing and implementing, effective writing. SOP for purchasing raw materials, receiving raw materials, storage, cleaning, holding, cooling, freezing, thawing, reheating, personal hygiene, facility and equipments. Systems in laboratory accreditation		
UNIT – III	**HACCP PRINCIPLE**	**9 periods**
Conduct a hazard analysis, CCP identification, establish critical limits for each CCP, establish CCP monitoring procedures, establish corrective actions procedures, establish procedures for HACCP verification and validation, documenting the HACCP Program.		
UNIT – IV	**INTRODUCTION TO QUALITY MANAGEMENT**	**9 periods**
Evolution of Quality Management, Concepts of Product and Service Quality, Dimensions of Quality, Deming's, Juran's, Crosby's Quality Philosophy, Quality Cos, An Overview and Requirements of ISO 17025, Requirements Specific to Food Testing Laboratories – Physical, Chemical and Biological Parameters		
UNIT-V	**QUALITY MANAGEMENT TOOLS**	**9 periods**
Seven old and new Quality management tools, Statistical process control – Mean & range chart, P chart and C chart, Seven deadly wastages, PDCA cycle, Quality circle, Quality audit, Internal audit, Continuous improvement of productivity- proficiency testing for product quality- Six Sigma Concept.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOK

1	Andres Vasconcellos J. 2005. ***Quality Assurance for the Food industry - A practical approach. CRC press.***
2	J Evans and W Linsay, ***The Management and Control of Quality***, 6'th Edition, Thomson, 2005

REFERENCES

1	Inteaz Alli. 2004. ***Food quality assurance - Principles & practices***. CRC Press. New York
2	Sara Mortimore and Carol Wallace. 2013. ***HACCP - A practical approach***. Third edition. Chapman and Hall, London
3	Roday, S. 1998. ***Food Hygiene and Sanitation***, Tata McGraw-Hill Education
4	Mitra A., ***Fundamentals of Quality Control and Improvement***, PHI, 2nd Ed., 1998.

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Understand the concepts of food safety and the importance of risk analysis	K1
CO2	Draft SOPs and prepared with the various laboratory accreditation processes	K1
CO3	Learn the hazard analysis and prepare HACCP based SOPs	K2
CO4	Know policies and how to prepare quality management documents	K3
CO5	Use and exploit the various classes of quality management tools.	K3

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**
CO1	-	1	-	-	-	2	2	2	-	-	1	2	2	2
CO2	1	-	-	1	1	-	-	2	3	3	2	2	1	3
CO3	1	1	-	-	-	-	-	1	1	-	-	-	1	3
CO4	-	-	-	-	1	-	-	2	3	3	1	1	1	3
CO5	-	2	-	1	3	-	-	-	-	-	-	-	2	2
22BHS704	1	1	-	1	2	2	2	2	3	3	2	2	2	3

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.2.1, 1.4.1,2.4.3
CO2	2.4.3,3.1.5
CO3	3.1.4,3.1.5,4.3.2
CO4	5.1.2,8.2.1,8.2.2
CO5	4.3.1, 4.3.2, 4.3.3, 11.3.1, 12.1.1,12.1.2,

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	50	10	10	10	10	10	100
CAT2	50	10	10	10	10	10	100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	20	20	20	20	10	10	100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	20	20	20	20	10	10	100
ESE	50	10	10	10	10	10	100

22BES713	BIOPROCESS ECONOMICS AND PLANT DESIGN	SEMESTER VII

PREREQUISITES	CATEGORY	L	T	P	C
NIL	ES	3	0	0	3

Course Objectives	To understand the engineering fundamentals that include process selection, flow sheet preparation, design constraints, plant location selection, layout and to calculate capital,operating costs for process plants.	
UNIT – I	**INTRODUCTION TO DESIGN PROJECT**	**9 Periods**
Introduction to Design – nature of design – Technical feasibility survey - Organization of project-process development – data acquisition – design data information of project – Project documentation – codes and standards.		
UNIT – II	**PROCESS DESIGN DEVELOPMENT**	**9 Periods**
Equipment selection and specifications; materials of construction; flow sheeting; piping and instrumentation; process safety and loss prevention- types of hazards-HAZOP analysis.		
UNIT – III	**GENERAL SITE CONSIDERATIONS**	**9 Periods**
Introduction – plant location and site selection; site layout- plant layout utilities; environmental considerations – waste management – visual impact; government regulations and other legal restrictions; community factors and human resources.		
UNIT – IV	**COSTING AND PROJECT EVALUATION**	**9 Periods**
Introduction – Accuracy and purpose of capital cost estimates; fixed and working capital operating costs – estimation of equipment purchased costs- cost indexes - rapid and factorial method of cost estimation, Lang factors; Operating costs- fixed and variable operating costs-estimation of operating costs- Factors affecting investment and production costs.		
UNIT – V	**ECONOMIC EVALUATION OF PROJECTS**	**9 Periods**
Cash flow diagrams –discounted cash flow – rate of return – payback time - sensitivity analysis; Alternate investments; Depreciation-types, methods to determine depreciation – Alternate investments-computer methods for costing and project evaluation; accounting for uncertainty and variations for future development; Optimization techniques.		
Contact Periods: **Lecture: 45 Periods** **Tutorial: 0 Periods** **Practical: 0 Periods** **Total: 45 Periods**		

TEXT BOOK :

1	*Moran, S., "**An Applied Guide to Process and Plant Design**", Elsevier, 2015.*
2	*Towler, G., Sinnot, R.K., "**Chemical Engineering Design Principles, Practice and Economics of Plant and Process Design**", 2nd Edition, Butterworth Heinemann, 2013.*

REFERENCES

1	*Backhurst, J.R., Harker, J.H.,"**Process Plant Design**", Butterworth-Heinemann, 2013.*
2	*Sinnott.R.K., "**Coulson & Richardson's Chemical Engineering, Series Vol-6**", 2nd Edition, Butterworth Heinemann, 2005.*
3	*Peters, M., Timmerhaus,K., West,R., "**Plant Design and Economics for Chemical Engineers**", 5th Edition , McGraw Hill, 2003.*
4	*Baasal, W.D., "**Preliminary Chemical Engineering Plant Design**", Springer, 1989.*

COURSE OUTCOMES: On completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Understand the basics engineering fundamentals for project development and process design	K1
CO2	Design process equipment and consider safety, operability and other design constraints in bioprocess plant design.	K2
CO3	Develop knowledge to select plant location, layout and utilities for new process plants	K2
CO4	Calculate capital investment and operating costs for process plants.	K3
CO5	Understand the basic concepts of cost estimation and profitability analysis.	K3

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	1	1	-	-	1	-	-	-	-	-	-	1	2
CO2	1	1	2	1	1	-	-	-	-	-	-	-	1	2
CO3	1	1	2	1	2	-	-	-	-	-	-	-	2	2
CO4	1	1	1	-	-	-	-	-	-	-	-	-	1	1
CO5	1	1	1	-	-	-	-	-	-	-	-	-	1	2
22BES713	2	1	2	1	1	1	-	-	-	-	-	-	2	2

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.2.1,2.2.2,3.1.1,6.2.1
CO2	1.2.1,2.2.2,3.2.2,3.4.1,4.1.2,5.1.1
CO3	1.2.1,2.2.2,3.2.2,3.4.1,4.1.2,5.1.1,5.2.1
CO4	1.2.1,2.2.2, 3.2.2
CO5	1.2.1,2.2.2,3.2.2,3.4.1,4.1.2,5.1.1,6.1.1

ASSESSMENT PATTERN – THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	50	50	-	-	-	-	100
CAT2	20	30	50	-	-	-	100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	50	50	-	-	-	-	100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	-	50	50	-	-	-	100
ESE	40	40	20	-	-	-	100

22BPC722	DOWNSTREAM PROCESSING	SEMESTER VII

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PC	3	0	0	3

Course Objectives	To impart knowledge on the basics of the bioseparation process with an insightful view of different unit operations in downstream processing and to provide an idea about the basics of scale-up operations of downstream techniques.	
UNIT – I	**FUNDAMENTALS OF DOWNSTREAM PROCESSING**	**9 Periods**
Broad categories of bioproducts; properties of biological materials relevant in separation; Scope, Need for and Importance of downstream processing; Stages of downstream processing; Basic principles of engineering analysis in bioseparation; Selection criteria for separation; Economic importance of DSP; Pretreatment and stabilization of bioproducts; Cell disruption – elements of cell structure, intracellular vs extracellular products, Methods of cell disruptions– mechanical and non-mechanical methods.		
UNIT – II	**METHODS OF SOLID-LIQUID SEPARATION**	**9 Periods**
Sedimentation – principles, methods, and coefficients; Centrifugation – principles, settling velocity, sigma analysis, flow rate analysis in a tubular bowl and disk type centrifuges – scale-up of centrifugation; Ultracentrifugation – Determination of molecular weight; Flocculation- principles – electrical double layer, Schulze Hardy Rule – flocculation rate – flocculants; Filtration– principles, conventional and cross-flow filtration, filter aid, filter media and equipment, Darcy's law, filtration rates with incompressible and compressible cakes for batch and continuous filters, scale-up parameter estimations.		
UNIT – III	**PRODUCT ISOLATION**	**9 Periods**
Extraction- phase separation and partitioning equilibria, batch, and counter-current stage calculations, scale-up and design of extractors, Aqueous two-phase and Reverse micelle extraction; Adsorption - Common adsorbents, Adsorption isotherm, Types of adsorptions, process calculations in batch, continuous stirred tank, and fixed-bed adsorption; Membrane-based separation: classification of membrane separation process - micro, ultra-filtration, reverse osmosis, dialysis,Theoretical model for membrane process, estimation of flux and concentration polarization, membrane fouling, membrane filtration equipment.		
UNIT – IV	**PRODUCT PURIFICATION**	**9 Periods**
Precipitation of proteins - protein solubility, methods of precipitation, Precipitate formation phenomenon; Chromatography - principles, types - ion-exchange, size exclusion, hydrophobic interaction, Affinity chromatography, HPLC, Column chromatography -Description, estimation of separation parameters and column efficiency.		
UNIT – V	**FINISHING OPERATIONS**	**9 Periods**
Crystallization – principle, analysis of batch crystallization, crystallization scale-up, and design, Recrystallization; Drying - principles – heat and mass transfer – dryers' description and operations of vacuum shelf dryers, batch vacuum rotary dryers, freeze dryers and spray dryers, Scale-up and design of drying systems.		
Contact Periods: **Lecture: 45 Periods** **Tutorial: 0 Periods** **Practical: 0 Periods** **Total: 45 Periods**		

TEXT BOOK

1	Belter P.A., Cussler E.L., Houhu W., "***Bioseparations: Downstream Processing for Biotechnology***", Wiley India Pvt. Ltd., 1st Edition, 2011.
2	Roger G.Harrison, Paul W. Todd, Scott R.Rudge and Demetri P.Petrides, **"*Biosepartions Science and Engineering*"**, Oxford University Press, 2015.
3	B. Sivasankar, **"*Bioseparations: Principles and Technique*"**, Prentice-Hall of India Pvt.Ltd, 1st edition, 2007.

REFERENCES

1	Ghosh R, **"*Principles of Bioseparation Engineering*"**, World Scientific Co. Ltd, 1st Edition,2006
2	Michael R. Ladisch, **"*Bioseparations Engineering: Principles, Practice, and Economics*",** Wiley, 2002.
3	R.O. Jenkins, **"*Product Recovery in Bioprocess Technology – Biotechnology By Open Learning Series*"**, Butterworth-Heinemann, 2ndEdition, 1992.
4	Mukesh Doble, **"*Principles of Downstream Techniques in Biological and Chemical Processes*",** Taylor & Francis Group, 2021.
5	Mccabe W., Smith J., Harriott W., "***Unit Operations in Chemical Engineering***", McGraw Hill, 7th Edition, 2017.

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Understand the need for bio separations and impart the skills in various cell disruption techniques	K2
CO2	Analyze the techniques for solid-liquid separation and predict the parameters for large scale.	K3
CO3	Explore the principles and working of different unit operations for the isolation of bio-products.	K3
CO4	Discriminate the various techniques of high-resolution purification	K3
CO5	Classify the different methods and equipment used for the final polishing of bio-products at the industrial level.	K3

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO 2**
CO1	2	1	-	1	-	-	1	-	1	-	-	-	1	-
CO2	1	-	2	-	2	-	1	1	1	-	2	-	-	2
CO3	1	-	1	2	-	-	-	3	1	-	1	-	-	3
CO4	1	2	2	-	-	1	-	2	-	-	-	-	1	-
CO5	1	-	-	-	-	-	-	2	1	1	2	-	-	3
22BPC722	1	1	2	2	-	1	1	2	1	1	2	-	1	3

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.3.1, 1.4.1, 2.1.2, 4.2.1, 7.2.2, 9.2.4
CO2	1.3.1, 2.1.2, 2.2.4, 5.2.2, 7.2.2, 9.2.4,11.2.1
CO3	1.3.1, 3.1.1, 4.2.1, 8.1.1, 8.1.2, 9.2.4
CO4	1.3.1, 2.1.2, 2.2.4, 3.1.1,6.1.1, 8.1.1, 8.1.2
CO5	1.3.1, 8.1.1, 8.1.2, 9.2.4, 10.1.1, 10.1.2, 11.2.1

ASSESSMENT PATTERN

Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	30	70	-	-	-	-	100
CAT2	40	60	-	-	-	-	100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	50	50	-	-	-	-	100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	60	40	-	-	-	-	100
ESE	40	60	-	-	-	-	100

22BPC723	DOWNSTREAM PROCESSING LABORATORY	SEMESTER VII			
PREREQUISITES	**CATEGORY**	**L**	**T**	**P**	**C**
NIL	**PC**	**0**	**0**	**3**	**1.5**

Course Objectives	To implement the various product separation techniques. To perform different product isolation techniques. To create deeper understanding of final product purification.

LIST OF EXPERIMENTS

1. Solid liquid separation – Sedimentation.
2. Solid liquid separation – Centrifugation.
3. Solid liquid separation – Filtration.
4. Cell disruption techniques – Physical, Chemical, and Mechanical method.
5. Isolation of products – Aqueous two-phase extraction.
6. Isolation of products – Adsorption
7. Purification - Ammonium sulphate precipitation and Dialysis
8. High resolution Purification – Ion-exchange chromatography.
9. High resolution Purification – Gel filtration chromatography.
10. Product polishing - Crystallization and freeze drying (Lyophilization)

Contact Periods:
Lecture: 0 Periods Tutorial: 0 Periods Practical: 45 Periods Total: 60 Periods

TEXT BOOK:

1	Roger G.Harrison, Paul Todd, Scott R.Rudge and Demetri P.Pterides , ***"Biosepartions Science and Engineering",*** Oxford University Press,2nd Edition,2015.
2	R.O. Jenkins, (Ed.), "***Product Recovery In Bioprocess Technology – Biotechnology By Open Learning Series"***, Butterworth-Heinemann,1st Edition,1992

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Apply techniques for the recovery of products from fermentation broth.	K1
CO2	Decide and Perform experiments for isolating bio products.	K2
CO3	Concentrate and purify the products through various techniques.	K2
CO4	Able to formulate and finish the bioproducts.	K3

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	-	-	-	-	1	2	1	1	1	1	1	3	2
CO2	2	2	3	-	-	-	-	-	2	2	-	2	3	2
CO3	2	2	2	1	-	-	-	-	1	1	-	1	1	2
CO4	2	2	-	3	-	-	1	1	2	1	2	3	3	1
22BPC723	2	2	2	2	3	-	1	2	1	1	-	2	3	3

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.2.1,2.2.2
CO2	1.2.1,2.2.2
CO3	1.2.1,2.2.2
CO4	1.2.1,2.2.2
CO5	1.2.1,4.1.2,4.1.3

22BEE702	ENGINEERING PROJECTS IN COMMUNITY SERVICE	SEMESTER VII

PREREQUISITES	CATEGORY	L	T	P	C
NIL	EEC	0	0	4	2

Course Objectives	To provide an environment where teams of students can exercise their engineering skills by being exposed to realistic systems and customers and at the same time helping their community.

Problem identification – Identifying the issues within the community -Preliminary survey - Preparing a questionnaire, formats and survey forms. - A preliminary survey including the socio-economic conditions of the allotted habitation - Different types of surveys, tools and techniques for collecting the information. - Analysis of collected data and mapping of issues with the solutions available. - Based on the survey and the specific requirements of the habitation, Community Awareness Campaigns – Identifying the factors – Normalization of factors and finding the path way for problem solution – Selection of problem from the community and mapping of issues - Planning for working: Aim, objective and scope, time line - Application of engineering knowledge and tools for solutions Validation of the solution by supervising the execution of solution - Measuring the attainment of the solution: Feedback from community

Contact Periods:
Lecture: 0 Periods Tutorial : 0 Periods Practical : 60 Periods Total : 60 Periods

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Identify engineering related problems in the community.	K2
CO2	Analyze and Design different solutions to solve the problems of community.	K4
CO3	Apply economical solution to those problems in the field.	K4
CO4	To understand complexity and ambiguity	K1
CO5	Connections with professionals and community members for learning and career opportunities	K2

Course Articulation Matrix

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	-	2	2	-	1	2	1	-	2	-	1	-	1	1
CO2	-	2	2	-	1	2	1	-	2	-	1	-	1	1
CO3	-	2	2	-	1	2	1	-	2	-	1	-	1	1
CO4	-	2	2	-	1	2	1	-	2	2	1	-	1	1
CO5	-	2	2	-	1	2	1	-	2	2	1	-	1	1
22BEE702	-	2	2	-	1	2	1	-	2	-	1	-	1	1

1 – Slight, 2 – Moderate, 3 – Substantial

22BEE803	CAPSTONE PROJECT	SEMESTER VIII

PREREQUISITES	CATEGORY	L	T	P	C
NIL	EEC	0	0	16	8

Course Objectives	To carry out the literature review. To identify the problem statement. To design the research work. To analyze and interpret results using advanced analytical tools. To develop writing and presentation skills

DESCRIPTION

The students should perform a project with the following criteria:

- Background of the study
- Hypothesis and rationale.
- Plan of the study.
- Designing of the experiment.
- Validation.
- Results and interpretation.
- Discussion.
- Conclusion and Significance of the study.
- Outcomes and Summary.
- Report preparation and Presentation (PPT)

Students are encouraged to publish their original results in journals.

Contact Periods:
Lecture: 0 Periods Tutorial: 0 Periods Practical: 240 Periods Total: 240 Periods

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Acquire practical knowledge on the selected area of biotechnology project	K4
CO2	Identify, design and analyze the experiments in the systematic and ethical approach.	K5
CO3	Develop a project as an individual or in a team.	K6
CO4	Develop the communication skills for project presentation.	K6
CO5	Develop the writing skills for drafting the project report.	K6

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	3	-	2	-	-	1	2	1	-	-	-	2	3	2
CO2	-	3	2	3	3	-	-	2	2	-	2	1	3	2
CO3	-	-	-	-	-	-	-	-	3	2	-	-	2	3
CO4	-	-	-	-	2	-	-	-	-	3	2	-	2	3
CO5	-	-	-	-	-	-	-	-	-	3	2	-	2	3
22BEE 803	3	3	2	3	3	1	2	2	2	3	2	2	2	3

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.2.1, 3.1.1, 3.1.2, 3.1.3, 6.1.1, 6.2.1, 7.1.2, 8.1.1, 12.1.2
CO2	2.1.1, 2.1.2, 2.1.3, 3.1.1, 3.1.2, 3.1.3, 4.1.1, 5.1.1, 5.2.2, 8.1.1, 9.1.1, 9.1.2, 9.2.1, 9.2.2, 9.2.3, 11.1.2, 11.2.1, 12.1.1, 12.3.1, 12.3.2
CO3	9.1.1, 9.1.2, 9.2.1, 9.2.2, 10.1.2, 10.2.2
CO4	5.1.1, 5.2.2, 10.1.2, 10.2.2, 11.1.2, 11.2.1
CO5	10.1.2, 10.2.2, 10.3.1, 10.3.2, 11.1.2, 11.2.1

22BVA$03	RESEARCH PUBLICATIONS

PREREQUISITES	CATEGORY	L	T	P	C
NIL	EEC	1	0	0	1

Course Objectives	To understand the philosophy of science and ethics, research integrity and publication ethics. To identify research misconduct and predatory publications. To understand indexing and citation databases, open access publications, research metrics (citations, h-index, impact Factor, etc.). To understand the usage of plagiarism tools.	
UNIT – I	**INTRODUCTION TO RESEARCH**	**3 Periods**
Definition and Objectives of Research, Scientific Methods, Various Steps in Scientific Research, Research planning , Selection of a Problem for Research , Formulation of the Selected Problems, Purpose of the Research, Formulation of research objectives, Formulation of research questions, Hypotheses Generation and Evaluation, Values Underlying Research Integrity; Framework for Good Academic Research Practices.		
UNIT – II	**LITERATURE SURVEY AND TECHNICAL PAPER WRITING**	**3 Periods**
Planning; Research Questions and Documentation; Literature Review; Overview of Literature survey, Literature survey using web of science, Scopus. Data, Precision, Accuracy & errors, Experimentation, Design of Experiments, Research Execution. Documentation & Manuscript writing. Tutorial on BibTex with LaTex to add references to a document. Tutorial on using Microsoft word with bibliographic sources.		
UNIT – III	**SCIENTIFIC CONDUCT**	**3 Periods**
Ethics with respect to science and research - Intellectual honesty and research integrity - Scientific misconducts: Falsification, Fabrication and Plagiarism (FFP) - Redundant Publications: duplicate and overlapping publications, salami slicing - Selective reporting and misrepresentation of data		
UNIT – IV	**PUBLICATION ETHICS**	**3 Periods**
Publication ethics: definition, introduction and importance - Best practices / standards setting initiatives and guidelines: COPE, WAME, etc. - Conflicts of interest - Publication misconduct: definition, concept, problems that lead to unethical behaviour and vice versa, types - Violation of publication ethics, authorship and contributor ship - Identification of publication misconduct, complaints and appeals - Predatory publisher and journals.		
UNIT – V	**OPEN ACCESS PUBLISHING**	**3 Periods**
Open access publications and initiatives - SHERPA/RoMEO online resource to check publisher copyright & self-archiving policies - Software tool to identify predatory publications developed by SPPU - Journal finger / journal suggestion tools viz. JANE, Elsevier Journal Finder, Springer, Journal Suggester, etc.		
Contact Periods: **Lecture: 15 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 15 Periods**		

TEXT BOOK

1	Chaddah, P. (2018). Ethics in competitive research: Do not get scooped; do not 1. Get plagiarized Pothy. com.
2.	Krause, S. D. (2007). The process of research writing. Steven D. Krause.

REFERENCES

1	Beall, J. (2012). Predatory publishers are corrupting open access. Nature News, 489(7415), 179
2	Muralidhar, K. (2019). Ethics in science education, research and governance
3	Griffiths, P. A. (1995). On being a scientist: Responsible conduct in research. Washington (DC): National Academy Press.
4	Lowry, C. (Ed.). (2016). Choosing & Using Sources: A Guide to Academic Research. Ohio State University Libraries..
5.	NPTEL course Introduction to Research.

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Acquire the knowledge on ethical research.	K1
CO2	Understand how to perform literature survey and design research plan.	K2
CO3	Get Familiarized with technical paper writing using software tools.	K1
CO4	Awareness on Publication ethics.	K1
CO5	Apply the knowledge to select right medium of research Publication.	K3

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**
CO1	3	2	-	2	-	-	-	-	-	-	-	1	3	2
CO2	3	3	-	2	-	-	-	-	-	-	-	2	3	1
CO3	-	-	3	-	-	-	-	-	-	-	-	-	1	3
CO4	-	-	-	-	-	2	-	-	-	-	-	1	1	3
CO5	-	-	-	-	-	-	-	-	-	3	-	1	1	3
22BVA$03	3	3	-	-	-	2	-	-	-	-	-	1	2	3

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.4.1, 2.1.3, 2.2.2, 2.2.3,2.2.4, 2.3.2, 2.4.1,4.1.1
CO2	1.4.1, 2.1.3, 2.2.2, 2.2.3,2.2.4, 2.3.2, 2.4.1, 2.4.4,4.1.2
CO3	3.1.2, 3.1.3
CO4	6.1.2,12.2.2
CO5	10.1.1,10.1.2,10.1.3,10.3.1, 10.3.2, 12.2.2

22BVA$04	NEXT GENERATION SEQUENCE ANALYSIS

PREREQUISITES	CATEGORY	L	T	P	C
Nil	EEC	1	0	0	1

Course Objectives	To understand the different platforms for NGS sequencing, To familiarize with the steps and alignment tools. To apply the NGS analysis for differential gene expression analysis and other applications	
UNIT – I	**DIFFERENT PLATFORMS FOR NEXT GENERATION SEQUENCING**	**3 Periods**
Different platforms for NGS sequencing-Overview of 454 pyro sequencing system, Illumina sequencing, SOLiD sequencing, Ion Torrent, Nano-pore technology, Pacific Biosciences Single Molecule Real time Sequencing -advantages and disadvantages		
UNIT – II	**STEPS IN NGS DATA ANALYSIS**	**3 Periods**
Base calling, FASTQ format, Base quality score. NGS data quality control and pre-processing, Steps in NGS data analysis, Visualization tools		
UNIT – III	**ALIGNMENT TOOLS**	**3 Periods**
Burrows–Wheeler transformation, ELAND (Efficient Large-scale Alignment of Nucleotide Databases)		
UNIT – IV	**DIFFERENTIAL GENE EXPRESSION ANALYSIS**	**3 Periods**
Principles of RNAseq, BW aligner, SHRiMP, BFAST, The TopHat/Cufflinks software package, HTSeq, RNA Seq data analysis		
UNIT – V	**APPLICATIONS OF NGS ANALYSIS**	**3 Periods**
Case study-differential expression, RNA Seq (transcriptomics), Chip Seq , Metagenomics		
Contact Periods: **Lecture: 15 Periods** **Tutorial: 0 Periods** **Practical: 0 Periods** **Total: 15 Periods**		

TEXT BOOK

1	Xinkun Wang., "***Next Generation Sequencing Data analysis***", CRC Press, New York,2016
2	Stuart M. Brown, "***Next-generation DNA Sequencing Informatics***", Cold Spring Harbor Laboratory Press,2015
3	Lloyd Low., Martti Tammi., "***Bioinformatics A Practical Handbook of Next Generation Sequencing and Its Applications***", World Scientific Publishing Co. Singapore,2017

REFERENCES

1	Ali Masoudi Nejad, Zahra Narimani, Nazanin Hosseinkhan., "***Next Generation Sequencing and Sequence Assembly: Methodologies and Algorithms***", Series: Springer Briefs in Systems Biology, Springer New York NY ,First edition,2013

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Understand the basics of various platforms for NGS sequencing	K1
CO2	Familiarize with the steps involved in NGS analysis	K1
CO3	Familiarize with the alignment tools in NGS analysis	K1
CO4	Apply the different NGS tools for differential gene expression analysis	K3
CO5	Apply the NGS technique for various applications	K3

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**
CO1	1	1	-	1	2	-	-	-	-	-	-	-	1	3
CO2	1	1	-	1	2	-	-	-	-	-	-	-	1	3
CO3	1	1	1	1	2	-	-	-	-	-	-	-	1	3
CO4	-	-	-	1	2	2	-	-	-	-	-	-	1	3
CO5	-	1	-	1	2	1	-	-	-	-	-	-	1	3
22BVA$04	1	1	1	1	2	1	-	-	-	-	-	-	1	3

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.4.1,2.4.1,4.2.1,5.2.1,5.2.2
CO2	1.3.1,2.4.1,4.1.2,5.2.2
CO3	1.3.1,2.4.1,4.1.2,5.2.2
CO4	2.2.3,4.1.2,5.2.1,5.2.2,6.1.1
CO5	2.2.3,4.1.2,5.2.1,6.1.1

22BVA$05	PATENTS AND COPYRIGHTS

PREREQUISITES	CATEGORY	L	T	P	C
NIL	EEC	1	0	0	1

Course Objectives	Create an understanding on Intellectual Properties and the importance of it. To understand Trademarks and Trade secrets. To create awareness of unfair completion and methods of it. Create awareness on the protection copyrights and patents. Understand the Ownership rights and transfer. Create awareness of Cyber laws, Cyber Crime and get understanding of Privacy of Data. To create awareness international aspects of IPR and the Emerging Trends in IPR	
UNIT – I	**INTRODUCTION**	**3 Periods**
Introduction to Intellectual property, types of intellectual property, importance of intellectual property rights, agencies Responsible for Intellectual property Registration, Regulatory – Compliance and Liability Issues.		
UNIT – II	**PATENT RIGHTS**	**3 Periods**
Origin, Meaning of Patent, Types, Inventions which are not patentable, Registration Procedure, Rights and Duties of Patentee, Assignment and licence , Restoration of lapsed Patents, Surrender and Revocation of Patents, Infringement, Remedies & Penalties.		
UNIT – III	**COPY RIGHT**	**3 Periods**
Origin, Definition &Types of Copy Right, Registration procedure, Assignment & licence, Terms of Copy Right, Piracy, Infringement, Remedies, Copy rights with special reference to software.		
UNIT – IV	**CYBER LAW**	**3 Periods**
Information Technology Act – Cyber Crime and E-commerce – Data Security – Confidentiality – Privacy – International aspects of Computer and Online Crime.		
UNIT – V	**ROLE OF PATENTS IN PRODUCT DEVELOPMENT & COMMERCIALIZATION**	**3 Periods**
Recent changes in IPR laws impacting patents and copy rights, intellectual cooperation in the science and allied industry. Patentable and non-patentable research. Case studies.		
Contact Periods: **Lecture: 15 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 15 Periods**		

TEXT BOOK

1	Deborah E. Bouchoux, "Intellectual Property: The Law of Trademarks, Copyrights, Patents and Trade Secrets", Cengage Learning, Third Edition, 2012.
2.	Prabuddha Ganguli,"Intellectual Property Rights: Unleashing the Knowledge Economy", McGraw Hill Education, 2011.

REFERENCES

1	R. Radha Krishnan, S. Balasubramanian: “Intellectual Property Rights”, Excel Books. New Delh.
2	A short course in International Intellectual Property Rights – Karla C. Shippey, World Trade Press – 2 nd Edition.
3	Intellectual Property Rights – Heritage, Science, & Society under international treaties – A. Subbian, - Deep & Deep Publications – New Delhi.
4	Singh. K, (2010), Intellectual Property Rights in Biotechnology, BCLI, New Delhi.

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom’s Taxonomy Mapped**
CO1	Acquire the knowledge on IPR.	K1
CO2	Understand how to prepare and protect the Inventions , start up ideas and rights of patents and copy rights.	K2
CO3	Get Familiarized with exposure to licensing and transfer of Copyrights and Patents.	K1
CO4	Awareness of Cyber laws and Cyber Crime, to protect the data from Cybercrime.	K1
CO5	Apply the knowledge of patents in product development and commercialization.	K3

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	-	-	-	-	-	-	-	-	-	-	1	3	2
CO2	3	-	-	-	-	-	-	-	-	-	-	2	3	1
CO3	1	-	-	-	-	-	-	-	-	-	-	-	1	3
CO4	-	-	-	-	-	2	-	-	-	-	-	1	1	3
CO5	2	2	-	-	-	-	-	-	-	-	-	1	1	3
22BVA$05	3	2	-	-	-	2	-	-	-	-	-	1	2	3

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.4.1, 12.2.2
CO2	1.4.1, 12.2.2
CO3	1.4.1, 6.1.1
CO4	12.2.2, 12.3.1
CO5	1.4.1, 2.1.3, 12.2.2

22BVA$06	VERMICOMPOSTING

PREREQUISITES	CATEGORY	L	T	P	C
NIL	EEC	1	0	0	1

Course Objectives	To understand the importance of vermicompost application to the soil. To learn the art of Vermicomposting. To know the scopes and opportunities for vermicompost production. To assess the need for vermicomposting organic farming in India. To practice vermicomposting techniques in appropriate site/location
	15 periods

1. Concept of Vermitechnology - Definition and justification
2. Importance of Vermicompost in Agri-horticultural practices.
3. Vermicomposting for Organic Farming - an Eco-Friendly Approach Vermicomposting for Rural Development
4. Waste materials: Classification, disposal techniques & their impact on environment
5. Earthworms: Type, identification & usefulness
6. Anaerobic (Pit) & Aerobic (Heap) composting: techniques & their comparison
7. Vermiculturing: Techniques & importance
8. Vermicomposting techniques, standard composition of vermicompost
9. Vermi-wash production techniques, standard composition of vermiwash
10. Economics on Vermiculture and Vermicomposting

Contact Periods: **15**
Lecture: 15 Periods **Tutorial: 15 Periods** **Practical: 0 Periods** **Total: 15 Periods**

REFERENCES

1	Dr Keshav Singh, Dr Gorakh Nath, Dr Rabish Chandra Shukla and Dr Deepak Kumar Bhartiya, Textbook of Vermicompost: Vermiwash and Biopesticides, 1st edition, 2022, Om publications, India.
2	Rhonda Sheman, The Worm Farmer’s Handbook, Mid- to Large-Scale Vermicomposting for Farms, Businesses, Municipalities, Schools, and Institutions, 2018, Chelsea Green Publishing, UK.

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom’s Taxonomy Mapped**
CO1	Basic facts, process and principle applied	K1
CO2	Develop skills on harvesting and management of vermicompost	K2
CO3	Techniques of composting in a limited space	K3
CO4	Recall and demonstrate practical skill	K3
CO5	Understand the scope of vermicomposting as entrepreneurship	K5

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/POs	PO1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2
CO1	1	-	-	-	-	3	-	2	-	-	-	-	1	3
CO2	1	-	-	-	-	3	-	2	-	-	-	-	1	3
CO3	1	-	-	-	-	3	-	2	-	-	-	-	1	3
CO4	1	-	-	-	-	3	-	2	-	-	-	-	1	3
CO5	1	-	-	-	-	3	-	2	-	-	-	-	1	3
22BVA$06	1	-	-	-	-	3	-	2	-	-	-	-	1	3

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.3.1, 2.1.3
CO2	1.2.1, 2.1.3
CO3	1.4.1, 2.2.3
CO4	1.4.1, 2.1.3,3.4.2
CO5	1.4.1,3.2.1,3.3.2

22BVA$07	MUSHROOM CULTIVATION

PREREQUISITES	CATEGORY	L	T	P	C
NIL	EEC	1	0	0	1

Course Objectives	Enable the students to identify edible and poisonous mushrooms. Provide hands on training for the preparation of bed for mushroom cultivation and spawn production. Help the students to learn a means of self-employment and income generation	
UNIT – I	**INTRODUCTION TO MUSHROOMS**	**3 Periods**
Mushrooms -Taxonomical rank -History and Scope of mushroom cultivation - Vegetative characters of edible and poisonous mushrooms.		
UNIT – II	**COMMON EDIBLE MUSHROOMS**	**3 Periods**
Button Mushroom (Agaricus bisporous), Oyster mushroom (Pleurotus sajorcaju), paddy straw mushroom (Volvariella volvacea), Milky Mushroom (Calocybe indica); Other economically important and medicinal mushroom- Shiitake Mushroom (Lentinula edodes), Kabul Dhingri (King Oyster) Mushroom.		
UNIT – III	**PRINCIPLES OF MUSHROOM CULTIVATION**	**3 Periods**
Structure and construction of mushroom house. Sterilization of substrates. Spawn production - culture media preparation- production of pure culture, mother spawn, and multiplication of spawn. Composting technology, mushroom bed preparation. Spawning, spawn running, harvesting. Cultivation of oyster and paddy straw mushroom. Problems in cultivation - diseases, pests and nematodes, weed moulds and their management strategies.		
UNIT – IV	**HEALTH BENEFITS OF MUSHROOMS**	**3 Periods**
Nutritional and medicinal values of mushrooms. Therapeutic aspects- antitumor effect		
UNIT – V	**POST HARVEST TECHNOLOGY**	**3 Periods**
Preservation of mushrooms - freezing, dry freezing, drying, canning, quality assurance and entrepreneurship.Value added products of mushrooms.		
Contact Periods: **Lecture: 15 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 15 Periods**		

TEXT BOOK

1	Pandey, R.K. and Ghosh, S.K. (1996). ***A handbook of Mushroom Cultivation***. Emkey Publication.
2	Pathak, V.N. and Yadav, N. (1998). ***Mushroom Production and Processing Technology***. Agrobios, Jodhpur.
3	Nita, B. (2000). ***Handbook of Mushrooms***. Vol 1 & 2. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.

REFERENCES

1	Tripathi, D.P. (2005) ***Mushroom Cultivation***, Oxford & IBH Publishing Co. PVT.LTD, New Delhi.

COURSE OUTCOMES: On completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Identify edible types of mushroom	K1
CO2	Gain the knowledge of cultivation of different types of edible mushrooms and spawn production	K1
CO3	Manage the diseases and pests of mushrooms	K2
CO4	Know the medicinal values of mushroom	K2
CO5	Learn a means of self-employment and income generation	K2

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs / POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	1	-	-	-	-	3	-	2	-	-	-	-	1	3
CO2	1	-	-	-	-	3	-	2	-	-	-	-	1	3
CO3	1	-	-	-	-	3	-	2	-	-	-	-	1	3
CO4	1	-	-	-	-	3	-	2	-	-	-	-	1	3
CO5	1	-	-	-	-	3	-	2	-	-	-	-	1	3
22BVA$07	1	-	-	-	-	3	-	2	-	-	-	-	1	3

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.3.1, 2.1.3
CO2	1.2.1, 2.1.3
CO3	1.4.1, 2.2.3
CO4	1.4.1, 2.1.3,3.4.2
CO5	1.4.1,3.2.1,3.3.2

22BVA$08	PHARMACOVIGILANCE

PREREQUISITES	CATEGORY	L	T	P	C
NIL	EEC	1	0	0	1

Course Objectives	To understand the Adverse Drug Reactions. To understand the Reporting Database. To eligible to understand the role of clinical pharmacist in Pharmacovigilance.	
UNIT – I	**INTRODUCTION TO PHARMACOVIGILANCE**	**3 Periods**
Overview of Pharmacovigilance. Brief History of Pharmacovigilance. Thalidomide's Impact on Regulations. Scope, definition and aims of Pharmacovigilance		
UNIT – II	**ADVERSE DRUG REACTIONS**	**3 Periods**
Adverse Drug Reactions (ADRs) - Classification, mechanism, predisposing factors, causality assessment for ADRs. ICH Definition of Adverse Drug Reaction. Medical Evaluation of Adverse Events in Pharmacovigilance. Diagnosis and Managements of ADRs.		
UNIT – III	**INDICATORS OF PHARMACOVIGILANCE**	**3 Periods**
Reporting Database, Role of clinical pharmacist in Pharmacovigilance. Pharmacovigilance indicators. Rationale and objectives and Classification of pharmacovigilance indicators.		
UNIT – IV	**GUIDELINES FOR PHARMACOVIGILANCE**	**3 Periods**
Signal Detection, Managements and Risk Assessments & Evaluation in Pharmacovigilance. Regulator Guideline & laws in Pharmacovigilance. Regulatory Aspects in Pharmacovigilance.		
UNIT – V	**DRUG REGULATORY ACTIVITES**	**3 Periods**
Standard Terms and Terminology used in Pharmacovigilance. Medical Dictionary for Drug Regulatory Activities MedDRA		
Contact Periods: **Lecture: 15 Periods** **Tutorial: 0 Periods** **Practical: 0 Periods** **Total: 15 Periods**		

TEXT BOOK

1	*SK Gupta ,**Textbook of Pharmacovigilance** .2nd Edition , Jaypee Brothers, Medical Publishers Pvt. Limited.,2019.*
2	*John Talbot, Patrick Waller ,**Stephens' Detection of New Adverse Drug Reactions**.5th Edition, John Wiley & Sons,2003*

REFERENCES

1	*Barton Cobert ,**Cobert's Manual of Drug Safety and Pharmacovigilance**,2nd Edition,. ISBN-13: 9780763791599,2012*
2	***n Introduction Pharmacovigilance** ,2nd Edition , Wiley-Blackwell,2017.*
3	*s for Biomedical Research on Human Subjects 2000. ICMR, New Delhi.*

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	learn about development of pharmacovigilance	K1
CO2	establish pharmacovigilance programme in an organization	K1
CO3	various methods that can be used to generate safety data and signal detection	K2
CO4	develop the skills of classifying drugs, diseases and adverse drug reactions.	K2
CO5	Understand global scenario of Pharmacovigilance	K2

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	1	-	-	-	-	3	-	2	-	-	-	-	1	3
CO2	1	-	-	-	-	3	-	2	-	-	-	-	1	3
CO3	1	-	-	-	-	3	-	2	-	-	-	-	1	3
CO4	1	-	-	-	-	3	-	2	-	-	-	-	1	3
CO5	1	-	-	-	-	3	-	2	-	-	-	-	1	3
22BVA$08	1	-	-	-	-	3	-	2	-	-	-	-	1	3

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.3.1, 2.1.3
CO2	1.2.1, 2.1.3
CO3	1.4.1, 2.2.3
CO4	1.4.1, 2.1.3,3.4.2
CO5	1.4.1,3.2.1,3.3.2

22BVA$09	BASICS OF YOGA FOR YOUTH EMPOWERMENT

PREREQUISITES	CATEGORY	L	T	P	C
NIL	EEC	1	0	0	1

Course Objectives	To understand the importance of physical and mental health and refresh life energy and retard ageing process also purify the minds and understand the values of moral virtues	
UNIT – I	**PHYSICAL HEALTH**	**3 periods**
Manavalakalal (SKY) Yoga: Introduction - Education as a means for youth empowerment - Greatness of Education - Yoga for youth Empowerment. Simplified Physical Exercises: Hand, Leg, Breathing, Eye exercises - Kapalabathi, Makarasana Part I, Makarasana Part II, Body Massage, Acu pressure, Relaxation exercises - Benefits. ;Yogasanas 1: Pranamasana - Hastha Uttanasana - Pada Hasthasana - Aswa Sanjalana Asana - Thuvipatha asva Sanjalana asana – Astanga Namaskara - Bhujangasana - Atha Muktha Savasana - Aswa Sanjalana Asana - Hastha Uttanasana - Pranamasana. ; Pranayama: Naddi suddi-Clearance Practice - Benefits. ; Simplified Physical Exercise - Kayakalpa Practices - Meditation Practices.		
UNIT – II	**LIFE FORCE**	**3 periods**
Reasons for Diseases: Natural reasons (Genetic / imprints, Planetary Position, Natural calamities and climatic changes) - Unnatural reasons (Food habits, Thoughts, Deeds). ; Philosophy of Kaya kalpa: Physical body - Sexual vital fluid - Life force - Bio-Magnetism - Mind. ; Maintaining youthfulness: Postponing old age Transformation of food into seven components Importance of sexual vital fluid - Measure and method in five aspects of life - Controlling undue Passion. ; Kayakalpa practice: Aswini Mudra - Ojas breath - Benefits of Kaya Kalpa.		
UNIT – III	**MENTAL HEALTH**	**3 periods**
Mental Frequencies: Beta, Apha, Theta and Delta wave - Agna Meditation explanation - benefits. ; Shanti meditation: Shanti meditation explanation – benefits. ; Thuriya Meditation: Thuriya Meditation explanation – benefits. ; Benefits of Blessing: Self blessing (Auto suggestion) - Family blessing- Blessing the others - World blessing - Divine protection.		
UNIT – IV	**VALUES**	**3 periods**
Human Values: Self-control - Self-confidence - Honesty Contentment - Humility- Modesty Tolerance - Adjustment-Sacrifice – Forgiveness.; Purity (Body, Dress, Environment) - Physical purity - Mental purity-Spiritual purity. ; Social Values: Non-violence – Service - Patriotism – Equality - Respect for parents and elders - care and protection - Respect for teacher ; Punctuality-Time Management		
UNIT – V	**MORALITY (VIRTUES)**	**3 periods**
Importance of Introspection: I-Mine (Ego, Possessiveness); Six Evil Temperaments - Greed – Anger - Miserliness - Immoral sexual passion - Inferiority and superiority Complex – Vengeance ; Maneuvering of Six Temperaments: Contentment – Tolerance - Charity - Chastity Equality - Pardon (Forgiveness) ; Five essential Qualities acquired through Meditation: Perspicacity – Magnanimity – Receptivity –Adaptability - Creativity (Improved Memory Power)		
Contact Periods: **Lecture: 15 Periods** **Tutorial: 0 Periods** **Practical: 0 Periods** **Total: 15 Periods**		

TEXT BOOK:

1	B.K.S Iyengar, ***"Light on yoga (yoga dipika***)", 2008, Harper Collins publishers Daryaganj, New Delhi, India.
2	B.K.S Iyengar, ***"Light on pranayama",*** 2008, Harper Collins publishers Daryaganj, New Delhi, India.

REFERENCES:

1	M.D. Gharote and S.K. Ganguly: ***"Teaching methods for yogic practice, Kaivalyadhama"***, 1998, SMYM Samiti, Lonavla, Pune Dist, Maharashtra.
2	Nagendra H.R.: ***"New perspective in stress Mangement",*** 2000, Pub.Vivekanandha Kendra Yoga Prakashana, Bangalore, India.

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	To train the students to develop their body for leading a healthy life.	K1
CO2	To rejuvenate life energy and achieve spiritual development.	K3
CO3	To strengthen mind, will power and concentration.	K2
CO4	To introspect and purify mind.	K5
CO5	To understand the values of peace, harmony and non-violence in revitalizing human society.	K4

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**
CO1	-	3	3	2	1	-	-	-	-	-	-	3	3	2
CO2	2	2	-	3	-	-	1	1	2	1	2	3	3	2
CO3	2	2	3	1	2	2	-	-	-	-	-	2	2	3
CO4	1	3	3	2	1	-	1	1	-	-	-	3	3	2
CO5	1	3	-	-	1	-	-	-	1	1	1	3	3	2
22BVA$09	1	3	3	2	1	2	1	1	2	1	2	3	3	2

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.1,1.2,1.3,1.4,2.1,2.2,2.3,2.4,3.1, 3.2,4.
CO2	1.1,1.2,1.3,1.4,2.1,2.2, 2.3,2.4, 3.2,4.1,4.2,12.2,12.3
CO3	1.1,1.3,1.4,2.1, 2.2,2.4,4.1
CO4	4.1.2, 4.3.3, 5.3.1
CO5	1.3.1, 2.4.2, 2.4.4, 4.3.1, 5.3.1, 5.3.2

22BVA$10	BIOINDUSTRIES TRADE AND POLICY REGULATIONS					SEMESTER
PREREQUISITES		**CATEGORY**	**L**	**T**	**P**	**C**
Nil		**EEC**	**1**	**0**	**0**	**1**

Course Objectives	To understand the multinational dimensions in management of a biotech company and the business operations in more than one country	
UNIT – I	AN OVERVIEW OF INTERNATIONAL BUSINESS	**3 periods**
Definition and drivers of International Business- Changing Environment of International Business Country attractiveness- Trends in Globalization- Effect and Benefit of Globalization-International Institution: UNCTAD Basic Principles and Major Achievements, Role of IMF, Features of IBRD, Role and Advantage of WTO.		
UNIT – II	THEORIES OF INTERNATIONAL TRADE AND INVESTMENT	**3 periods**
Theories of International Trade: Mercantilism, Absolute Advantage Theory, Comparative Cost Theory, Hecksher-Ohlin Theory-Theories of Foreign Direct Investment : Product Life Cycle, Eclectic, Market Power, Internationalisation-Instruments of Trade Policy : Voluntary Export Restraints, Administrative Policy, Anti-dumping Policy, Balance of Payment.		
UNIT – III	GLOBAL ENTRY	**3 periods**
Strategic compulsions-– Strategic options – Global portfolio management- Global entry strategy, different forms of international business, advantages - Organizational issues of international business – Organizational structures – Controlling of international business, approaches to control – Performance of global business, performance evaluation system.		
UNIT – IV	PRODUCTION, MARKETING, FINANCIALS OF GLOBAL BUSINESS	**3 periods**
Global production: Location, scale of operations- cost of production- Standardization Vs DifferentiationMake or Buy decisions- global supply chain issues- Quality considerations. Globalization of markets: Marketing strategy- Challenges in product development- pricing-production and channel management. Foreign Exchange Determination Systems: Basic Concepts-types of Exchange Rate Regimes- Factors Affecting Exchange Rates.		
UNIT – V	CASE STUDY	**3 periods**
Bioproducts – enzymes-biomolecules – trade and policy regulations implemented in biotech industries – case study		
Contact Periods: **Lecture: 15 Periods** **Tutorial: 0 Periods** **Practical: 0 Periods** **Total: 15 Periods**		

TEXT BOOK

1	Charles W.I. Hill and Arun Kumar Jain, ***"International Business"***, 6th edition, Tata McGraw Hill, New Delhi, 2010.
2	Michael R. Czinkota, Ilkka A. Ronkainen and Michael H. Moffet, ***"International Business",*** 7 th Edition, Cengage Learning, New Delhi, 2010
3	K. Aswathappa, ***"International Business"*** , 5th Edition, Tata Mc Graw Hill, New Delhi, 2012.

REFERENCES

1	John D. Daniels and Lee H. Radebaugh, ***"International Business "***, Pearson Education Asia, New Delhi,12 th edition.
2	Vyuptakesh Sharan, ***"International Business "***, 3rd Edition, Pearson Education in South Asia, New Delhi, 2011
3	Rakesh Mohan Joshi, ***"International Business",*** Oxford University Press, New Delhi, 2009

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	In Depth knowledge of driving factors of international Business	K1
CO2	Understanding of theories of trade and investment practiced in the global world	K1
CO3	Deep Insights in to various market entry strategies followed by Global Organizations	K2
CO4	Ability to identify the various global production and supply chain issues and have an understanding of foreign exchange determination system	K2
CO5	To understand the trade and policy regulations implemented in biotech industry with case study	K2

COURSE ARTICULATION MATRIX

a) CO and PO Mapping														
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**
CO1	1	1	-	-	-	-	-	-	-	-	-	-	3	1
CO2	1	1	-	-	-	-	-	-	-	-	-	-	3	1
CO3	1	1	-	-	-	-	-	-	-	-	-	-	3	1
CO4	1	1	-	-	-	-	-	-	-	-	-	-	3	1
CO5	1	1	-	-	-	-	-	-	-	-	-	-	3	1
22BVA$10	1	1	-	-	-	-	-	-	-	-	-	-	3	1
1 – Slight, 2 – Moderate, 3 – Substantial														
b) CO and Key Performance Indicators Mapping														
CO1	1.4.1, 2.1.3													
CO2	1.4.1, 2.1.3													
CO3	1.4.1, 2.1.3,													
CO4	1.4.1, 2.1.3													
CO5	1.4.1, 2.1.3,													

22BVA$11	**Professional Skills and Career Readiness**	**SEMESTER**

PREREQUISITES	**CATEGORY**	**L**	**T**	**P**	**C**
	EEC	0	0	2	1

Course Objectives	• To develop students' technical communication and presentation skills. • To build confidence in public speaking, group discussions, and interviews. • To improve English communication (verbal and written) for placement scenarios.

S.No	Topics / Activities	Hours
1	**Ice-breaker & Self-introductions** – Students introduce themselves, Elevator pitch	2
2	**Technical Presentations** – Students prepare a short (3-4 min) presentation on a simple technical topic	4
3	**PowerPoint / Slide Design** – Best practices, visual aids, readability	3
4	**Email Etiquette & Writing** – Structure, tone, salutations, follow-up emails	2
5	**Report Writing** – Format, structure, executive summary, technical vs business report	4
6	**Group Discussion & Debates** – Practice GD on technical/non-technical issues, role-playing, feedback	4
7	**Mock Interviews** – One-on-one and panel interviews, feedback	4
8	**Resume / CV Building** – Format, content, tailoring to job descriptions, highlighting projects	3
9	**Non-verbal Communication Skills** – Body language, posture, eye contact, voice modulation	2
10	**Reflection & Feedback -** Peer feedback, self-reflection, goal-setting for communication improvement.	2

Contact Periods:
Lecture: 00 Periods **Tutorial: 00 Periods** **Practical: 30 Periods** **Total: 30 Periods**

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Prepare and deliver technical presentations.	K3
CO2	Write professional emails, reports, and resumes.	K3
CO3	Participate in group discussions and role-plays.	K3
CO4	Demonstrate interview skills in mock scenarios.	K3
CO5	Use non-verbal communication effectively (body language, eye contact).	K3

ASSESSMENT PATTERN:
No End Semester Examination
Only Continuous Assessment

Continuous Assessment Marks distribution

1.	Presentation Assessment	25
2.	Written Assessment (Emails/report/resume)	20
3.	Mock Interview	25
4.	Participation (GDs, role-plays, and non-verbal communication)	30
	Total	**100**

22BVA$12	**Placement Training**	**SEMESTER**

PREREQUISITES	**CATEGORY**	**L**	**T**	**P**	**C**
	EEC	0	0	2	1

Course Objectives	• To refine communication skills targeted at placement interviews (technical and HR). • To enhance confidence in problem-solving, aptitude, and group tasks. • To instill professional behaviour and soft skills required for workplace success.

S. No	Topics / Activities	Hours
1	**Aptitude & Reasoning Training** – Logical puzzles, quantitative reasoning	4
2	**Group Discussion** – Real-world engineering case studies, brainstorming	4
3	**Leadership & Teamwork Workshop** – Role plays, team tasks, problem solving, decision making	
4	**Behavioural Interviews** – Common HR questions, STAR method, mock HR interview	4
5	**Technical Interviews** – Mock technical questions, peer feedback, clarity of answer.	4
6	**Personal Branding** – Crafting LinkedIn profile, writing cover letters, personal elevator pitch	4
7	**Group Exercise / Presentation** – Group presentation on a hypothetical project	4
8	**Feedback & Reflection Session** – Students reflect on their performance, set professional goals	2

Contact Periods:
Lecture: 00 Periods **Tutorial: 00 Periods** **Practical: 30 Periods** **Total: 30 Periods**

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Solve common aptitude and reasoning problems for placement tests.	K3
CO2	Perform well in group discussions and case-study discussions.	K3
CO3	Demonstrate leadership and teamwork in simulated workplace situations.	K3
CO4	Participate confidently in technical and HR interviews.	K3
CO5	Develop a professional portfolio (resume, LinkedIn, cover letter).	K6

ASSESSMENT PATTERN:
No End Semester Examination
Only Continuous Assessment

Continuous Assessment Marks distribution

1.	Aptitude Test	20
2.	Group Case Presentation	20
3.	Mock Interviews	25
4.	Portfolio Evaluation	25
5.	Participation & Reflection	10
	Total	**100**

22BEE$IX	INTERNSHIP/INDUSTRIAL TRAINING

PREREQUISITES	CATEGORY	L	T	P	C
NIL		0	0	0	4

Course Objectives	To understand the functioning and mission of the institute or the industry, to get hands on training in handling the equipments or instruments, to conduct experimental or production process, to analyze and interpret outcomes to check for the quality using advanced analytical tools and to develop writing and presentation skills.

DESCRIPTION

Internship or Industrial training can be carried out at any type of Biotechnology based industry/institute as follows:

1. Food Processing industry
2. Bioprocess Engineering and Fermentation industry
3. Forensic Science Research Institute
4. Animal Cell Culture Laboratory
5. Plant Tissue Culture Laboratory
6. Genetics and Plant Breeding Institute
7. Waste Management Industry
8. Pharmaceutical Company
9. Enzyme Production Unit
10. Microbiological testing Laboratory

Day wise curriculum for internship shall be provided by common consensus of Industry HR, Department Heads of Industry, Head of The Department of Institution, Placement and Training Officer and Faculty Supervisor.

Syllabus shall be approved by the Principal before internship training The

modules include the following

1. Overview and history of the industry
2. Visit to various divisions in the industry
3. Choosing one or two different departments for training
4. Study and training -operation of major equipments
5. Manufacturing processes
6. Process planning
7. Process control
8. Quality assessment

9. Study of TQM concepts implementation
10. ISO and other quality systems implementation
11. Knowledge management system
12. Completion of specific projects assigned
13. Case study

Contact Periods:
1 week to 4 weeks

COURSE OUTCOMES: On completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Acquire practical knowledge on the selected area of biotechnology research and development	K1
CO2	Identify, design and analyze the experiments in the systematic and ethical approach.	K3
CO3	Develop a production process or an experimental prototype as an individual or in a team.	K2
CO4	Develop the communication skills for technical presentation.	K2
CO5	Develop the writing skills for drafting the internship report.	K3

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs / POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2
CO1	3	-	2	-	-	1	2	1	-	-	-	2	3	2
CO2	-	3	2	3	3	-	-	2	2	-	2	1	3	2
CO3	-	-	-	-	-	-	-	-	3	2	-	-	2	3
CO4	-	-	-	-	2	-	-	-	-	3	2	-	2	3
CO5	-	-	-	-	-	-	-	-	-	3	2	-	2	3
18BEE$IX	3	3	2	3	3	1	2	2	2	3	2	2	2	3

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	7.1.2, 9.1.1
CO2	7.2.1,11.1.2, 12.1.2
CO3	6.1.1, 7.1.1,11.2.1
CO4	6.2.1, 7.1.2,11.3.1, 12.1.2
CO5	7.1.2, 8.1.1,12.2.2

22BPE$01	IMMUNOTECHNOLOGY

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	To understand the principles of microbial pathogenesis, clinical importance of specific pathogens and inculcate knowledge on recent outbreaks and their disease transmission and understand the recent techniques to study the pathogens.	
UNIT – I	**ANTIGENS**	**9 Periods**
Types of antigens, preparation of antigens for raising antibodies, handling of animals, adjuvants and their mode of action.		
UNIT – II	**ANTIBODIES &IMMUNODIAGNOSIS**	**9 Periods**
Monoclonal and polyclonal antibodies – production, Western blot analysis, immunoelectrophoresis, SDS-PAGE - purification and synthesis of antigens, ELISA- principle and applications, radio immuno assay (RIA) – principles and applications, non isotopic methods of detection of antigens-enhanced chemiluminescence assay		
UNIT – III	**ASSESSSMENT OF CELL MEDIATED IMMUNITY**	**9 Periods**
Identification of lymphocytes and their subsets in blood using flow cytometry. Estimation of cytokines, macrophage activation, macrophage microbicidal assay, in-vitro experimentation to understand the pathogenesis and defense mechanisms.		
UNIT – IV	**IMMUNOPATHOLOGY**	**9 Periods**
Preparation and storage of tissues, identification of various cell types and antigens in tissues, isolation and characterization of cell types from inflammatory sites and infected tissues, immunocytochemistry – immunofluoresecence, immunoenzymatic technique, immuno electron microscopy.		
UNIT – V	**MOLECULAR IMMUNOLOGY**	**9 Periods**
Preparation of vaccines, application of recombinant DNA technology for the study of the immune system, production of anti idiotypic antibodies, catalytic antibodies, application of PCR technology to produce antibodies and other immune molecules, immunotherapy with genetically engineered antibodies – Tetramer.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOK

1	Judith A Owen, Jenni Punt, Sharon A Stranford, Patricia P Jones, Janis Kuby, Kuby Immunology 8th Edition,New York : W.H. Freeman, 2019.
2	Peter Williams, Julian Ketley & George Salmond, **“Methods in Microbiology: Bacterial Pathogenesis”**, Vol. 27, Academic Press, 1998.
3	Iglewski B.H and Clark V.L **“Molecular basis of Bacterial Pathogenesis”**, Academic Press, 1990.

REFERENCES

1	Recent reviews in Infect. Immun., Mol. Microbiol., Biochem. J., EMBO,Life sciences etc.
2	Nester, Anderson, Roberts, Pearsall, Nester, **“Microbiology: A Human Perspective”**, Mc Graw Hill, 3rd Edition, 2001.
3	Eduardo A. Groisman, **“Principles of Bacterial Pathogenesis”**, Academic Press, 2001.
4	Sunil K. Lal,”**Molecular Biology of the SARS-Coronavirus”**, springer, 2010

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom’s Taxonomy Mapped**
CO1	To understand the basics of microbiology and the discovery.	K1
CO2	To know how to analyze pathological condition in molecular level.	K1
CO3	To acquire knowledge on the pathogenesis of recent outbreaks.	K2
CO4	To learn basic molecular biology and experimental skills.	K2
CO5	To Study the modern approaches to control pathogens.	K2

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/POs	**PO1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO1 0**	**PO1 1**	**PO1 2**	**PSO 1**	**PSO 2**
CO1	1	1	-	-	-	-	-	-	-	-	-	-	3	1
CO2	1	1	-	-	-	-	-	-	-	-	-	-	3	1
CO3	1	1	-	-	-	-	-	-	-	-	-	-	3	1
CO4	1	1	2	-	-	-	-	-	-	-	-	-	3	1
CO5	1	1	-	-	-	-	-	-	-	-	-	-	3	1
18BPE$01	1	1	2	-	-	-	-	-	-	-	-	-	3	1

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.4.1, 2.1.3
CO2	1.4.1, 2.1.3
CO3	1.4.1, 2.1.3
CO4	1.4.1, 2.1.3,3.4.2
CO5	1.4.1, 2.1.3

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category *	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	70	30	-	-	-	-	100
CAT2	60	40	-	-	-	-	100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	50	50	-	-	-	-	100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	60	40	-	-	-	-	100
ESE	60	40	-	-	-	-	100

22BPE$02	NEUROBIOLOGY AND COGNITIVE SCIENCES

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	To provide an understanding on the fundamentals on neuronal systems, neuronal drugs and on how the brain responds and adapts to changing environments and outline of their mechanism of action. To learn the fundamental relationships among neural activity, drug therapy, cognition and behavior.	
UNIT – I	**NEUROANATOMY**	**9 Periods**
Classification of central and peripheral nervous system; Structure and function of neurons; type of Neurons; Synapses; Glial cells; Myelination; Brief anatomy of Brain and Spinal cord Blood Brain barrier; Meninges and Cerebrospinal fluid; Spinal Cord; Neural Development.		
UNIT – II	**NEUROPHYSIOLOGY**	**9 Periods**
Resting and action potentials; Mechanism of action potential conduction; Voltage dependent channels - sodium and potassium channels; nodes of Ranvier; Chemical and electrical synaptic transmission; information representation and coding by neurons.		
UNIT – III	**NEUROPHARMACOLOGY**	**9 Periods**
Classification of neurotransmitters and their mechanism of action: acetyl choline, serotonin, dopamine and -amino butyric acid (GABA); Peptide transmitters: mechanism of action; Nicotinic and muscarinic acetyl choline receptors; hormones and their effect on neuronal function.		
UNIT – IV	**APPLIED NEUROBIOLOGY**	**9 Periods**
Basic mechanisms of sensations like touch, pain, smell and taste; neurological mechanisms of vision and audition; skeletal muscle contraction.		
UNIT – V	**BEHAVIOUR AND COGNITIVE SCIENCE**	**9 Periods**
Basic mechanisms associated with motivation; control of feeding, sleep, hearing and memory; Disorders associated with the nervous system - Parkinson's disease, Alzheimer's disease, schizophrenia, Epilepsy; Anxiety and mood disorders - Depression, Agrophobia.		
Contact Periods: **Lecture: 45 Periods** **Tutorial: 0 Periods** **Practical: 0 Periods** **Total: 45 Periods**		

TEXT BOOK

1	Dale Purves, George J. Augustine, David Fitzpatrick, William C. Hall, "*Neuroscienc"e*, Oxford university press, sixth edition, 2018.
2	Striedter, G. F, "***Neurobiology: a functional approach***", Oxford University press, 2016

REFERENCES

1	Gondon M.Shepherd "***Neurobiology***", Oxford University Press, Third edition, 1994
2	Mark F. Bear, Barry W. Connors, Michael A. Paradiso, "***Neuroscience: Exploring the Brain***", Lippincott Williams and Wilkins, Fourth Edition, 2015..
3	Squire, L., Berg, D., Bloom, F.E., du Lac, S., Ghosh, A., Spitzer, N.C, "***Fundamental Neuroscience***", UK: Academic Press, Fourth edition, 2012.
4	Eric R. Kandel, James H. Schwartz, Thomas M. Jessell, Steven A. Siegelbaum, A. J. Hudspeth, "***Principles of Neural Science***", McGraw Hill / Medical, Fifth Edition, 2012.

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Comprehend the central and peripheral nervous system, and describe the structure and functions of neurons and supporting cells	K1
CO2	Analyze the functioning of voltage-dependent channels and conduction mechanism	K2
CO3	Understand the concept of synaptic transmission and the working details of various neurotransmitters.	K2
CO4	Evaluate the mechanism of sensations and skeletal muscle contraction	K2
CO5	Fathom the fundamental concepts behind behavioural science and associated disorders.	K2

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	1	-	-	-	-	-	-	-	-	-	-	1	1
CO2	2	1	-	-	-	-	-	-	-	-	-	-	1	1
CO3	2	1	-	-	-	-	-	-	-	-	-	-	1	1
CO4	2	1	-	-	-	-	-	-	-	-	-	-	1	1
CO5	2	1	-	-	-	-	-	-	-	-	-	-	1	1
22BPE$02	2	1	-	-	-	-	-	-	-	-	-	-	1	1

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.2.1, 2.1.2
CO2	1.2.1, 2.1.2
CO3	1.2.1, 2.1.2
CO4	1.2.1, 2.1.2
CO5	1.2.1, 2.1.2

ASSESSMENT PATTERN

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	40	60	-	-	-	-	100
CAT2	30	70	-	-	-	-	100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	60	40	-	-	-	-	100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	30	70	-	-	-	-	100
ESE	40	60	-	-	-	-	100

22BPE$03	MOLECULAR PATHOGENESIS

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	To understand the principles of microbial pathogenesis, clinical importance of specific pathogens and inculcate knowledge on recent outbreaks and their disease transmission and understand the recent techniques to study the pathogens.	
UNIT – I	**BASICS OF MICROBIOLOGY AND IMMUNOLOGY**	**9 Periods**
Louis Pasteur's contributions - Robert Koch's postulates - early discoveries of microbial toxins, Vaccines and Antibiotics - Attributes & components of microbial pathogenesis, Host natural defense mechanism - humoral and cellular defense mechanisms – complements - inflammation process - general disease symptoms – Pathogen resistance to the defense mechanisms.		
UNIT – II	**PATHOGENESIS OF DISEASES**	**9 Periods**
Virulence factors - gene regulation in virulence of pathogens - labile & stable toxins; Vibrio Cholera - Cholera toxin - E.coli pathogens: - ETEC – EPEC - EHEC - EIEC Hemolytic Uremic Syndrome - Shigella toxin - Plasmodium Life cycle - Antimalarials based on transport processes - Influenza virus - action of amantidine.		
UNIT – III	**RECENT DISEASE OUTBREAKS**	**9 Periods**
Clinical features and molecular mechanism of pathogenesis- Superficial mycoses- Dermatophytes- Intracellular stage-H1N1; HIV- Disease transmission of Chickengunya – Dengue, SARS-CoV-2.		
UNIT – IV	**EXPERIMENTAL STUDIES ON HOST PATHOGEN INTERACTIONS**	**9 Periods**
Virulence assays; cytopathic - cytotoxic effects. Criteria and tests in identifying virulence factors - attenuated mutants - signal transduction and host responses.		
UNIT – V	**MODERN APPROACHES TO CONTROL PATHOGENS**	**9 Periods**
Serotyping - Immuno and DNA based techniques - New therapeutic strategies based on life threatening pathogens - Vaccines - DNA, subunit and cocktail vaccines. Modern diagnosis based on highly conserved virulence factors.		
Contact Periods: **Lecture: 45 Periods** **Tutorial: 0 Periods** **Practical: 0 Periods** **Total: 45 Periods**		

TEXT BOOK

1	*Judith A Owen, Jenni Punt, Sharon A Stranford, Patricia P Jones, Janis Kuby,* ***Kuby Immunology*** *8th Edition,New York : W.H. Freeman, 2019.*
2	*Iglewski B.H and Clark V.L* ***"Molecular basis of Bacterial Pathogenesis"****, Academic Press, 1990.*

REFERENCES

1	*Nester, Anderson, Roberts, Pearsall, Nester,* ***"Microbiology: A Human Perspective"****, Mc Graw Hill, 3rd Edition, 2001.*
2	*Eduardo A. Groisman,* ***"Principles of Bacterial Pathogenesis"****, Academic Press, 2001.*
3	*Sunil K. Lal,"* ***Molecular Biology of the SARS-Coronavirus*** *", springer, 2010.*
4	*Peter Williams, Julian Ketley & George Salmond,* ***"Methods in Microbiology: Bacterial Pathogenesis"****, Vol. 27, Academic Press, 1998.*

COURSE OUTCOMES: On completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	To understand the basics of microbiology and the discovery.	K1
CO2	To know how to analyze pathological condition in molecular level.	K1
CO3	To acquire knowledge on the pathogenesis of recent outbreaks.	K2
CO4	To learn basic molecular biology and experimental skills.	K2
CO5	To Study the modern approaches to control pathogens.	K2

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	1	-	-	-	-	-	-	-	-	-	-	3	1
CO2	1	1	-	-	-	-	-	-	-	-	-	-	3	1
CO3	1	1	-	-	-	-	-	-	-	-	-	-	3	1
CO4	1	1	2	-	-	-	-	-	-	-	-	-	3	1
CO5	1	1	-	-	-	-	-	-	-	-	-	-	3	1
22BPE$03	1	1	2	-	-	-	-	-	-	-	-	-	3	1

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.4.1, 2.1.3
CO2	1.4.1, 2.1.3
CO3	1.4.1, 2.1.3
CO4	1.4.1, 2.1.3,3.4.2
CO5	1.4.1

ASSESSMENT PATTERN – THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	50	50	-	-	-	-	100
CAT2	60	40	-	-	-	-	100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	70	30	-	-	-	-	100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	60	40	-	-	-	-	100
ESE	50	50	-	-	-	-	100

22BPE$04	CANCER BIOLOGY

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	To describe the epidemiological factors and molecular switches of cancer development at cellular and molecular level and to familiarize with the current strategies of cancer diagnosis, prevention and therapy.	
UNIT – I	**FUNDAMENTALS OF CANCER BIOLOGY**	**9 periods**
Epidemiology of cancer: Environmental factors, Viruses, Life style habits, Mutations. Regulation of cell cycle, Modulation of cell cycle in cancer: pRb, p53. Classification of cancer forms and hallmarks of cancers.		
UNIT – II	**PRINCIPLES OF CARCINOGENESIS**	**9 periods**
Theory of carcinogenesis, Chemical carcinogenesis, Physical carcinogenesis; X-ray radiation: mechanisms of radiation carcinogenesis. Mutations that cause changes in signal molecules. Genetic basis of cancer: DNA repair.		
UNIT – III	**PRINCIPLES OF MOLECULAR CELL BIOLOGY OF CANCER**	**9 periods**
Cyclin dependent kinases, Tumor suppressor genes, Oncogenes, Virus and cancers: DNA viruses, Retroviruses. Signaling Pathways: GPCR, RAS, JAK-STAT, Wnt-β-Catenin, Notch, Hedgehog, Myc, NF-κb. Growth factors related to transformation, Telomerases, p53 mediated Apoptosis.		
UNIT – IV	**PRINCIPLES OF CANCER METASTASIS**	**9 periods**
Clinical significances of invasion, Three step theory of invasion, Proteinases and tumor cell invasion. Angiogenesis: VEGF signaling.		
UNIT-V	**CANCER DETECTION AND THERAPY**	**9 periods**
Cancer screening and early detection, Detection using biochemical assays, Tumor markers. Advances in cancer detection invasive and non-invasive methods. Different forms of therapy-Chemotherapy, Radiation therapy, Immunotherapy, Molecular therapy, Nanoparticle mediated drug delivery. Use of signal targets towards therapy of cancer; Gene therapy.		
Contact Periods: **45** **Lecture: 45 Periods** **Tutorial: 0 Periods** **Practical: 0 Periods** **Total: 45 Periods**		

TEXT BOOK

1	Stella Pelengaris, Michael Khan, ***'The Molecular Biology of Cancer'***, Wiley Blackwell Publishing, 2nd edition, 2013
2	Robert A. Weinberg, ***'The Biology of Cancer'***, Garland Science, 2nd edition, 2014

REFERENCES

1	Ruddon R. W., ***'Cancer Biology'***, 4th edition, Oxford University Press, 2007
2	Athena Aktipis C., Randolph M Nesse, ***'Evolutionary foundations for Cancer Biology'***, Evol Appl.,January; 6(1): 144-15, 2013
3	King Roger J.B., Mike Robbins, ***'Cancer Biology'***, Prentice Hall, 3rd edition, 1996
4	Pezzella, F., Tavassoli, M., & Kerr, D. J. (Eds.). (2019). Oxford textbook of cancer biology. Oxford University Press.

COURSE OUTCOMES: On completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Understand the epidemiology of carcinogenesis.	K2
CO2	Describe the complex molecular pathways and regulatory switches involved in the transformation of a normal cell to a cancer cell.	K2
CO3	Describe the stages of cancer leading to the movement of cancer cells across the body.	K2
CO4	Develop knowledge on the current strategies in cancer diagnosis and therapy.	K3
CO5	Summarize the novel methods in the diagnosis and treatment of cancer.	K3

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/ POs	PO 1	PO 2	PO3	PO4	PO5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2
CO1	-	-	1	-	-	-	-	-	-	-	-	-	-	-
CO2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO4	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO5	-	-	-	-	-	2	-	3	-	-	-	-	-	-
22BPE $04	1	1	2	1	1	3	1	2	1	1	1	1	0	0

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	6.1.1, 6.1.2
CO2	6.1.1, 6.1.2
CO3	2.2.1, 10.1.3
CO4	10.1.3
CO5	4.1.3, 4.2.1, 4.3.1,8.1.1

ASSESSMENT PATTERN – THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT - 1	50	10	10	10	10	10	100
CAT - 2	50	10	10	10	10	10	100
Individual Assignment 1/Case study 1/ Seminar 1/ Project 1	20	20	20	20	10	10	100
Individual Assignment 2/Case study 2/ Seminar 2/ Project 2	20	20	20	20	10	10	100
ESE	20	20	20	20	20	-	100

22BPE$05	BIOPHARMACEUTICAL TECHNOLOGY

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	To provide foundation and inform biopharmaceutical aspects in drug development. To gain knowledge in physiochemical properties, pharmacology and formulation of biopharmaceuticals. To learn the procedures in drug manufacturing and delivery systems

UNIT – I : INTRODUCTION	**9 Periods**
Pharmaceutical industry & development of drugs, Historical perspective of Biopharmaceutics, types of therapeutic agents, Generics and its advantages, Drugs and cosmetic act and regulatory aspects. Routes of drug administration.	
UNIT – II : PHARMACOKINETICS AND PHARMACODYNAMICS	**9 Periods**
Mechanism of drug action, Pharmacokinetics – Mechanism and factors governing - Absorption, Distribution, Metabolism and Excretion; Zero, First, Second-order reactions kinetics; compartment modeling, kinetics of protein – drug binding, bioavailability and bioequivalence, Prodrugs.	
UNIT – III : DOSAGE FORMS	**9 Periods**
Classification of dosage forms: solid unit dosages – Tablets- types, manufacture and coating, capsules – preparation and coating; liquids – solutions, suspension; semi-solid – ointments, pastes, suppositories - laxatives; Analytical methods in drug product analysis, packing techniques, Radiopharmaceuticals.	
UNIT – IV : BIOPHARMACEUTICAL PRODUCT DEVELOPMENT	**9 Periods**
Reaction process for bulk drug manufacture - Penicillin, Streptomycin, Vitamins A, B12, cancer vaccines, antibodies, Insulin, Interferons, recombinant proteins – streptokinase, Asparginase and growth hormones-Gonadotrophins, Erythropoietin.	
UNIT – V : DRUG DELIVERY	**9 Periods**
Design and pharmacokinetic principles of controlled drug delivery systems, Oral, Parenteral controlled release systems, Transdermal, Ophthalmic drug delivery systems.	
Contact Periods: **Lecture: 45 Periods** **Tutorial:0 Periods** **Practical: 0 Periods** **Total: 45 Periods**	

TEXT BOOKS:

1	Gary Walsh, **"*Pharmaceutical Biotechnology: Concepts and Applications*",** John Wiley and Sons, Fourth edition, 2007.
2	Leon Lachman et al, **"*Theory and Practice of Industrial Pharmacy*",** Lea and Febiger, 3rd Edition, 1986.

REFERENCES

1	Remington's, **"*The science and practice of Pharmacy*"**, Elsevier, Twenty third edition, 2021
2	Brahmankar D M, Jaiswal S B, ***"Biopharmaceutics and Pharmacokinetics A Treatise",*** Vallabh Publisher, 2008.
3	Anya M. Hillery and Kinam Park,**"*Drug Delivery: Fundamentals and Applications*"**, 2nd Edition, CRC Press, 2016
4.	S.P. Vyas and Dixit, Pharmaceutical Biotechnology CBS Publishers and Distributors, New Delhi, 2003.

COURSE OUTCOMES: On completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Perceive the pharmacological terms and drug development and its regulation	K1
CO2	Interpret the basic concepts of pharmacokinetics and drug metabolism	K3
CO3	Understand the forms of dosage, packing and contaminant analysis	K2
CO4	Enlighten the process involved in bulk drug manufacturing	K2
CO5	Discuss novel methods for production and delivery of biopharmaceuticals	K3

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs / POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	-	-	-	-	-	-	2	1	2	3	2	1	-	3
CO2	-	-	-	-	-	-	3	1	1	2	2	1	-	3
CO3	-	-	-	-	-	2	2	-	-	1	3	2	-	3
CO4	-	-	-	-	-	3	3	3	-	1	2	2	-	3
CO5	-	1	-	1	-	-	3	3	-	-	-	3	3	3
22BPE$05	-	1	-	1	-	3	3	3	-	-	2	2	-	3

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	7.1.2, 9.1.1
CO2	7.2.1,11.1.2, 12.1.2
CO3	6.1.1, 7.1.1,11.2.1
CO4	6.2.1, 7.1.2,11.3.1, 12.1.2
CO5	7.1.2, 8.1.1,12.2.2

ASSESSMENT PATTERN

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	70	30	-	-	-	-	100
CAT2	60	40	-	-	-	-	100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	50	50	-	-	-	-	100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	40	60	-	-	-	-	100
ESE	60	40	-	-	-	-	100

22BPE$06	TISSUE ENGINEERING

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	To learn the fundamentals of tissue engineering and tissue repairing. To acquire knowledge on clinical applications of tissue engineering. To understand the basic concept behind tissue engineering focusing on the stem cells, Bio materials and its applications.	
UNIT – I	**INTRODUCTION**	**9 periods**
Introduction to tissue engineering: Basic definition; current scope of development; use in therapeutics, cells as therapeutic agents, cell numbers and growth rates, measurement of cell characteristics morphology, number viability, motility and functions. Measurement of tissue characteristics, appearance, cellular component, ECM component, mechanical measurements and physical properties		
UNIT – II	**TISSUE ARCHITECTURE**	**9 periods**
Tissue types and Tissue components, Tissue repair, Engineering wound healing and sequence of events. Basic wound healing Applications of growth factors: VEGF/angiogenesis, Basic properties, Cell-Matrix& Cell-Cell Interactions, telomeres and Self-renewal, Control of cell migration in tissue engineering.		
UNIT – III	**BIO-MATERIALS**	**9 periods**
Biomaterials: Properties of biomaterials, Surface, bulk, mechanical and biological properties. Scaffolds & tissue engineering, Types of biomaterials, biological and synthetic materials, Biopolymers, Applications of biomaterials, Modifications of Biomaterials, Role of Nanotechnology.		
UNIT – IV	**BASIC BIOLOGY OF STEM CELLS**	**9 periods**
Stem Cells: Introduction, hematopoietic differentiation pathway Potency and plasticity of stem cells, sources, embryonic stem cells, hematopoietic and mesenchymal stem cells, Stem Cell markers, FACS analysis, Differentiation, Stem cell systems- Liver, neuronal stem cells, Types & sources of stem cell with characteristics: embryonic, adult, haematopoetic, fetal, cord blood, placenta, bone marrow, primordial germ cells, cancer stem cells induced pleuripotent stem cells.		
UNIT-V	**CLINICAL APPLICATIONS**	**9 periods**
Stem cell therapy, Molecular therapy, In vitro organogenesis, Neurodegenrative diseases, spinal cord injury, heart disease, diabetes, burns and skin ulcers, muscular dystrophy, orthopedic applications, Stem cells and Gene therapy Physiological models, issue engineered therapies, product characterization, components, safety, efficacy. Preservation –freezing and drying. Patent protection and regulation of tissue-engineered products, ethical issues.		
Contact Periods: **Lecture: 45 Periods** **Tutorial: 0 Periods** **Practical: 0 Periods** **Total: 45 Periods**		

TEXT BOOK

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

REFERENCES

1	*Bernard N. Kennedy (editor)., "**Stem cell transplantation, tissue engineering, and cancer applications**", Nova Science Publishers, 2008.*
2	*Raphael Gorodetsky, Richard Schäfer., "**Stem cell-based tissue repair**", RSC Publishing, 2011.*
3	*R. Lanza, I. Weissman, J. Thomson, and R. Pedersen, "**Handbook of Stem Cells**", Two Volume, Volume 1-2: Volume 1-Embryonic Stem Cells; Volume 2-Adult & Fetal Stem Cells, Academic Press, 2004.*
4	*R. Lanza, J. Gearhart etal (Eds), "**Essential of Stem Cell Biolo**gy", Elsevier Academic press, 2006.*
5	*J. J. Mao, G. Vunjak-Novakovic et al (Eds), "**Translational Approaches In Tissue Engineering & Regenrative Medicine**", Artech House, INC Publications, 2008.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Ability to understand the components of the tissue architecture.	K1
CO2	Opportunity to get familiarized with the stem cell characteristics and their relevance in medicine.	K1
CO3	Awareness about the properties and broad applications of biomaterials.	K2
CO4	Overall exposure to the role of tissue engineering and stem cell therapy in Organogenesis.	K3
CO5	Understand the role of tissue engineering and materials in clinical applications	K3

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**
CO1	-	1	-	-	-	2	2	2	-	-	1	2	2	2
CO2	1	-	-	1	1	-	-	2	3	3	2	2	1	3
CO3	1	1	-	-	-	-	-	1	1	-	-	-	1	3
CO4	-	-	-	-	1	-	-	2	3	3	1	1	1	3
CO5	-	2	-	1	3	-	-	-	-	-	-	-	2	2
22BPE$06	1	1	-	1	2	2	2	2	3	3	2	2	2	3

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	2.2.2, 6.1.1, 7.1.2, 8.1.1, 11.1.1, 12.1.2
CO2	1.1.1, 4.2.1, 5.2.1, 8.1.1, 9.1.1,9.2.1,10.1.1, 10.1.2, 11.1.1, 12.1.2
CO3	1.1.1, 2.1.1, 8.1.1, 9.1.1
CO4	5.2.1, 8.1.1, 9.1.1,9.2.1,10.1.1, 10.1.2, 11.1.1, 12.1.2
CO5	1.1.1,2.2.2, 4.2.1, 5.2.1, 6.1.1,7.1.2, 8.1.1, 9.1.1,9.2.1,10.1.1, 10.1.2, 11.1.1, 12.1.2

ASSESSMENT PATTERN							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	50	10	10	10	10	10	100
CAT2	50	10	10	10	10	10	100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	20	20	20	20	10	10	100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	20	20	20	20	10	10	100
ESE	50	10	10	10	10	10	100

2BPE$07	MOLECULAR FORENSICS

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	Create an understanding on laws and Principles of forensic science. To be aware of tools and techniques of Forensic science. Create awareness on genetics of forensic. To be familiar of DNA profiling and its limitation. To create awareness on the recent trends in forensics.	
UNIT – I	**INTRODUCTION TO FORENSIC SCIENCE**	**9 Periods**
Forensic Science: Definition of Forensic Science, The Role of the Forensic Laboratory, History and Development of Forensic Science in India & Abroad, Pioneers in Forensic Science, Multidisciplinary nature, Forensic Technology solving crimes with advanced technology, Forensic intelligence and Interviews. Forensic Evidences: Concise of Forensic Physical, Biological, Chemical and Psychological evidences, Medico-Legal Cases. Laws and Principles of Forensic Science: Law of Exchange (Locard), Law of Individuality, Law of Comparison, Law of Progressive Changes and Law of Probability, Branches of Forensic Science..		
UNIT – II	**GENERAL FORENSIC TOOLS AND TECHNIQUES**	**9 Periods**
Definition, Need of Instrumentation in Forensic Science, Qualitative and quantitative methods of analysis, Destructive and Non-Destructive Methods, Separatory techniques, Hyphenated techniques, Accuracy, Precision, Signal to noise ratio, Sensitivity and detection limit, sources of noise, Instrument calibration. Microscopy: Theory and basic principles, setup and Forensic applications of Compound, Comparison, Fluorescence, Polarized, Stereo-zoom microscope. Structure and Forensic applications of Scanning Electron microscope (SEM), Transmission Electron Microscope (TEM). Thin Layer Chromatography: Basic Principle, Setup, visualization and Forensic applications etc.		
UNIT – III	**FORENSIC GENETICS**	**9 Periods**
Human Genetics, Heredity, Alleles, Mutations and Population Genetics, The concept of Genetics polymorphism, Hardy-Weinberg Law. DNA Statistics: frequency estimate calculations, interpretations, allele frequency determination, Paternity/Maternity index, Sibling index, Probability of match. Human Genome Project: Introduction, History, Goals, Benefits, Social, Ethical and Legal Issues. DNA Forensic Databases, Ethical, Legal, and Social Issues Associated with DNA Databanking, Potential Benefits of DNA Databanking Quality control, certification and accreditation.		
UNIT – IV	**ADVANCED DNA FORENSICS**	**9 Periods**
DNA Profiling: Introduction, History of DNA Typing, molecular biology of DNA, variations, polymorphism, DNA Extraction-Organic and Inorganic extraction, Comparison of Extraction methods, Commercial kits DNA typing systems- RFLP analysis, PCR amplifications, sequence polymorphism. Analysis of SNP, YSTR, Mitochondrial DNA, Ancient DNA typing, Evaluation of results. Forensic Significance of DNA profiling: Applications in disputed paternity cases, child swapping, missing person's identity- civil immigration, veterinary, wildlife and agriculture cases, legal perspectives- legal standards for admissibility of DNA profiling, procedural and ethical concerns, status of development of DNA profiling in India and abroad. New and future technologies: DNA chips, SNPs and limitations of DNA profiling.		
UNIT – V	**RECENT TRENDS IN FORENSIC SCIENCE**	**9 Periods**
Environmental Forensics: Definition, Legal processes involving environmental forensic science. Geo-forensics Global Positioning System; Basic principles and applications. Biometrics in Personal Identification: Introduction, Concepts of Biometric Authentication, Role in person Identification, Techniques and Technologies (Finger Print Technology, Face Recognition, IRIS, Retina Geometry, Hand Geometry, Speaker Recognition, Signature Verification and other forensic related techniques). Bioterrorism: Definition, Concepts of Biosecurity and microbial forensics, Weapons of mass destruction (WMD), mass-casualty weapons (MCW), NBC and CBRNE, Dirty Bombs.		
Contact Periods: **Lecture: 45 Periods** **Tutorial: 0 Periods** **Practical: 0 Periods** **Total: 45 Periods**		

TEXT BOOK

1	James, S.H and Nordby, J.J. (2003) Forensic Science: An introduction to scientific and investigative techniques CRC Press,
2.	J A Siegel, P.J Saukko (2000) Encyclopedia of Forensic Sciences Vol. I, II and III, Acad. Press.

REFERENCES

1	Willdard, H. H (1974) Instrumental Methods of Analysis.
2	Settle,F.A.(1997) Handbook of Instrumental Techniques for Analytical Chemistry, Prentice Hall.
3	John M. Butler (2005) Forensic DNA Typing: Biology, Technology, and Genetics of STR Markers Academic Press.
4	Forensic DNA Profiling Protocols (1998) Patrick J. Lincoln and Jim Thomson; Humana Press, Inc.

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Acquire the knowledge of forensic science.	K1
CO2	Understand the Instrumentation in Forensic Science	K2
CO3	Awareness of forensic genetics and its significance	K1
CO4	Get familiarize with DNA profiling and its applications in forensic.	K3
CO5	Apply the knowledge of forensic science in various fields.	K3

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**
CO1	1	-	-	-	-	-	-	-	-	-	-	1	3	2
CO2	1	-	-	-	3	-	-	-	-	-	-	2	3	1
CO3	1	-	-	-	-	-	-	-	-	-	-	-	1	3
CO4	-	-	-	-	-	-	-	-	-	-	-	1	1	3
CO5	2	2	-	-	-	-	-	-	-	-	-	1	1	3
22BPE$07	2	2	-	-	-	-	-	-	-	-	-	1	2	3

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.4.1, 12.2.2
CO2	1.4.1, 5.2.2, 12.2.2
CO3	1.4.1
CO4	12.2.2, 12.3.1
CO5	1.4.1, 2.1.3, 12.2.2

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	70	30	-	-	-	-	100
CAT2	20	20	60	-	-	-	100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	50	50	-	-	-	-	100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	30	70	-	-	-	-	100
ESE	40	60	-	-	-	-	100

22BPE$08	MEDICINAL CHEMISTRY

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	To impart comprehensive understanding of the chemical basis of drug action including physicochemical and steric properties of drug. To study the classification, chemical nomenclature, generic names and synthesis of various medicinal agents. To understand the structure activity relationship, biochemical/molecular basis of mechanism of action and uses of drug.	
UNIT – I	**PRINCIPLES OF MEDICINAL CHEMISTRY**	**9 Periods**
Physicochemical properties in relation to biological action: Ionization, Drug distribution and pKa values and their relation to drug transport, hydrogen bonding, redox potential, surface activity and chelation. Steric properties of drugs: optical and geometrical isomerism. Functional group and their effects of on drug action: steric effect, concept of isosterism, bioisosterism, homologs and analogs.		
UNIT – II	**DRUGS ACTING ON SYNAPTIC AND NEURO-EFFECTOR JUNCTION SITES**	**9 Periods**
Classification, biochemical/molecular basis of mechanism of action, structure activity relationship including stereo chemical aspects, physiochemical properties and synthesis of selected drugs belonging to the class of Cholinergics, Anticholinergics, Anticholinesterases and Adrenergics.		
UNIT – III	**DRUGS ACTING ON THE CENTRAL NERVOUS SYSTEM**	**9 Periods**
Classification, molecular basis of mechanism of action, structure activity relationship and synthesis of Hypnotics and Sedatives, Opioid analgesics, Anticonvulsants and Psychopharmacological agents (neuroleptics, antidepressants, anxiolytics).		
UNIT – IV	**DRUGS ACTING ON CARDIOVASCULAR SYSTEM**	**9 Periods**
Structural basis of mechanism of action, structure activity relationship including physiochemical properties, and synthesis of selected drugs belonging to the class of anti-anginal, vasodilators, calcium channel blockers and cardiac glycosides.		
UNIT-V	**AUTOCOIDS**	**9 Periods**
Synthetic procedures, uses, structure activity relationship including physicochemical properties of the following classes of drugs Antihistamines, Eicosanoids, Analgesic-antipyretics, Anti - inflammatory (non-steroidal) agents.		
Contact Periods: **45** **Lecture:45Periods** **Tutorial: 0Periods** **Practical: 0 Periods** **Total: 45 Periods**		

TEXT BOOK

1	*AshutoshKar*, ***"Medicinal Chemistry",*** *6th Edition, New Age International (P) Ltd. Publishers, New Delhi 2015.*
2	*Graham L. Patrick,* ***"An introduction to Medicinal Chemistry",*** *6th Edition, Oxford University Press, 2017*

REFERENCES

1	*Donald J. Abraham*, ***"Burger's Medicinal Chemistry and Drug Discovery",*** *Vol V, 6th Edition, John Wiley and Sons, Inc., 2003.*
2	*William O Foye,* ***"Thomas L Lemke, David A Williams Foye's Principles of Medicinal Chemistry",*** *7th Edition, Wolters Kluwer Health Adis (ESP) Publisher, 2012.*
3	*"Indian Pharmacopoeia", Vol-I,7th Edition, Published by Indian Pharmacopoeia Commission*
	India, 2014
4	*Ilango, K. and Valentina, P.,* ***"Text book of MedicinalChemistry",*** *Vol.1, 1st edition, Keerthi Publishers,2007.*

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Helps in correlating between pharmacology of a disease and its mitigation	K1
CO2	To understand the drug metabolic pathways, adverse effect and therapeutic value of drugs	K1
CO3	To know the structural activity relationship of different class of drugs.	K2
CO4	Well acquainted with the synthesis of some important class of drugs.	K3
CO5	To understand the chemistry of drugs with respect to their pharmacological activity.	K3

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**
CO1	3	2	1	-	-	-	-	-	3	1	-	1	3	3
CO2	3	-	3	2	2	-	-	-	3	2	-	2	3	3
CO3	1	1	2	2	2	-	-	-	2	1	-	1	1	2
CO4	2	2	2	2	2	-	2	1	2	2	-	2	1	2
CO5	2	1	2	1	1	-	-	2	2	2	2	2	2	3
22BPE$08	3	2	2	2	2	-	2	1	3	2	2	2	1	3

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.1.2, 10.3.1
CO2	2.1.2,9.1.1
CO3	1.1.2, 2.1.2,2.2.1,9.1.1.,10.1.1
CO4	1.3.1,2.1.1, 6.2.2,8.2.2
CO5	1.3.1,2.1.1, 3.1.6,6.2.2,7.2.2,8.2.2,

ASSESSMENT PATTERN – THEORY

Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	50	10	10	10	10	10	100
CAT2	50	10	10	10	10	10	100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	20	20	20	20	10	10	100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	20	20	20	20	10	10	100
ESE	50	10	10	10	10	10	100

22BPE$09	GENOMICS AND PROTEOMICS

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	To provide foundational knowledge about genomes and proteomes with relevant tools for genome analysis, including DNA sequencing techniques and bioinformatics software. Additionally, students will learn about methodologies used in proteomics, such as mass spectrometry and protein microarrays.	
UNIT – I	**OVERVIEW OF GENOMES OF BACTERIA, ARCHAEA AND EUKARYOTA**	**9 periods**
Genome organization of prokaryotes and eukaryotes, Gene structure of Bacteria, Archaea and Eukaryotes, Minimal cell Genome, Human genome project, Introduction to functional and comparative genomics.		
UNIT – II	**MAPPING TECHNIQUES**	**9 periods**
Cytogenetic mapping, Radiation hybrid mapping, Fish-STS mapping, SNP mapping, Optical mapping. Linking and jumping of clones, Gap closure, Pooling strategies, Electronic PCR, Automation in Genome sequencing-Next Generation Sequencing.		
UNIT – III	**FUNCTIONAL GENOMICS**	**9 periods**
Gene finding, Annotation of genome – experimental and computational approach. ORF and functional prediction, Transcriptomics (RNA sequencing) & analysis of transcriptomic data, high-throughput analysis of gene expression, DNA microarrays and expression profiling		
UNIT – IV	**PROTEOMICS TECHNIQUES**	**9 periods**
Protein level estimation-Edman protein microsequencing, Protein cleavage, 2D gel electrophoresis, metabolic labelling. Detection of proteins on SDS gels. Mass spectrometry principles of MALDI-TOF, Fourier Transform Ion Cyclotron Resonance Mass Spectrometer, Orbitrap Mass Analyzer, Tandem MS, Peptide mass fingerprinting.		
UNIT-V	**PROTEIN PROFILING**	**9 periods**
Large-scale protein profiling using proteomics, Protein-protein interactions, Functional Proteomics Protein microarrays, proteome database. Bioinformatics-based tools for analysis of proteomics data.		
Contact Periods: **Lecture: 45 Periods** **Tutorial: 0 Periods** **Practical: 0 Periods** **Total: 45 Periods**		

TEXT BOOK

1	Arthur Lesk., "***Introduction to Genomics***", 3rd Edition, Oxford University Press, 2017.
2	Richard Twyman, Ph.D Cfe, George A, "***Principles of Proteomics***", 2nd Edition, Garland Science, 2013.
3	Nawin C. Mishra, Günter Blobel, "***Introduction to Proteomics: Principles and Applications***", 1st Edition, Wiley, 2010.

REFERENCES

1	Conard, Edward. "***Genomics***". Apple Academics, 2010
2	Liebler, "***Introduction to Proteomics***", Humana Press, 2002
3	T.A Brown, "***Introduction to Genetic: A molecular Approach***", Garland Science, Taylor and Francis, 2012
4	R.M.Twyman, S.B. Primrose, "***Principle of Genome Analysis and Genomics***", Wiley Blackwell Publications, 2007.

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Understand the basic structure and organization of genomes of Prokaryotes	K1
CO2	Understand the basic structure and organization of genomes of Eukaryotes	K1
CO3	Have insight on basic organization of proteomes.	K2
CO4	Analyze proteomes and genomes using the relevant tools.	K3
CO5	Get familiarize with the principles of the methodologies of genomic and proteomic	K3

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**
CO1	1	1	-	-	-	-	-	-	-	-	-	-	3	1
CO2	1	1	-	-	-	-	-	-	-	-	-	-	3	1
CO3	1	1	1	-	-	-	-	-	-	-	-	-	3	1
CO4	1	1	-	-	-	-	-	-	-	-	-	-	3	1
CO5	1	1	-	-	-	-	-	-	-	-	-	-	3	1
22BPE$09	1	1	1	-	-	-	-	-	-	-	-	-	3	1

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.4.1, 12.2.2
CO2	1.4.1, 5.2.2, 12.2.2
CO3	1.4.1
CO4	12.2.2, 12.3.1
CO5	1.4.1, 2.1.3, 12.2.2

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT - 1	50	30	20	-	-	-	100
CAT - 2	50	20	30	-	-	-	100
Individual Assignment 1/Case study 1/ Seminar 1/ Project 1	20	60	20	-	-	-	100
Individual Assignment 2/Case study 2/ Seminar 2/ Project 2	20	20	60	-	-	-	100
ESE	20	40	40	-	-	-	100

22BPE$10	METABOLIC ENGINEERING

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	To understand the basics of metabolic pathways to enhance product yield, to determine the stoichiometry of cellular reactions and reaction rates, to perform metabolic flux analysis and demonstrate experimental determination of fluxes, to understand the basics of metabolic control analysis and to analyze the flux control coefficients for metabolic pathways and to demonstrate consistency and validation tests for flux distribution in metabolic networks.	
UNIT – I	**INTRODUCTION TO METABOLIC ENGINEERING**	**9 Periods**
Overview of cellular metabolism, Comprehensive models for cellular reactions, Coordination of metabolic reactions- Feedback inhibition, Energy charge, Examples of metabolic pathway manipulations for the enhancement of product yield.		
UNIT – II	**STOICHIOMETRY OF CELLULAR REACTIONS**	**9 Periods**
Stoichiometry of cellular reactions, metabolite balancing, determination of reaction rates and yield coefficients, thermodynamics of cellular reactions.		
UNIT – III	**METABOLIC FLUX ANALYSIS**	**9 Periods**
Metabolic flux analysis and its applications, methods for the experimental determination of metabolic fluxes by isotope labeling- MS and NMR in labeling measurement.		
UNIT – IV	**METABOLIC CONTROL ANALYSIS**	**9 Periods**
Analysis of metabolic control analysis, determination of flux control coefficients, MCA of linear and branched pathways- Determination of flux control coefficients.		
UNIT – V	**APPLICATIONS OF METABOLIC DESIGN**	**9 Periods**
Multigene networks, metabolic regulation network at enzyme level and whole cell level, Examples of metabolic pathway manipulations, new concepts for quantitative bioprocess research and development.		
Contact Periods: **Lecture: 45 Periods** **Tutorial:0 Periods** **Practical: 0 Periods** **Total: 45 Periods**		

TEXT BOOK

1	Gregory N. Stephanopoulos, Aristos A. Aristidou, Jens Nielsen, "***Metabolic Engineering: Principles and Methodologies***" ,Academic Press 1998.
2	Sang Yup Lee E. Terry Papoutsakis Marcel Dekker, "***Metabolic Engineering***".inc 1998

REFERENCES:

1	Eberhard O. Voit "***Computational Analysis of Biochemical Systems: A Practical Guide for Biochemists and Molecular Biologists***" by Cambridge University Press 2000
2	R. Verpoorte, A. W. Alfermann and T. S. Johnson (eds). "***Applications of Plant Metabolic Engineering***".Springer, P.O. Box 17, 3300 AA Dordrecht, The Netherlands. 2007.
3	"***Systems Modeling in Cellular Biology: From Concepts to Nuts and Bolts***" Edited by Zoltan Szallasi, JorgStelling and VipulPeriwal MIT Press Cambridge 2006
4	Nielsen J and Villadsen J. (1994) "***Bioreaction Engineering Principles***". New york: Plenum Press

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	To learn stoichiometry and energetics of metabolism.	K1
CO2	To apply practical applications of metabolic engineering in chemical, energy, medical and environmental fields.	K3
CO3	To integrate modern biology with engineering principles.	K2
CO4	To design a system, component, or process to meet desired needs.	K2
CO5	To validate engineering processes and evaluate the consistency of metabolic engineering processes .	K3

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs / POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	1	-	-	-	-	1	2	2	2	2	-	2	3	1
CO2	1	2	-	-	-	1	2	2	2	2	-	2	3	1
CO3	3	1	-	-	-	2	3	2	2	2	-	2	3	2
CO4	2	1	-	-	-	-	3	2	2	2	-	2	3	1
CO5	2	-	3	2	2	3	3	3	3	2	-	2	3	3
22BPE$10	2	-	2	-	-	3	2	2	1	2	-	2	3	1

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.1.2, 10.3.1
CO2	2.1.2,9.1.1
CO3	1.1.2, 2.1.2,2.2.1,9.1.1.,10.1.1
CO4	1.3.1,2.1.1, 6.2.2,8.2.2
CO5	1.3.1,2.1.1, 3.1.6,6.2.2,7.2.2,8.2.2,

ASSESSMENT PATTERN

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT - 1	70	30	-	-	-	-	100
CAT - 2	60	40	-	-	-	-	100
Individual Assignment 1/Case study 1/ Seminar 1/ Project 1	50	50	-	-	-	-	100
Individual Assignment 2/Case study 2/ Seminar 2/ Project 2	40	60	-	-	-	-	100
ESE	60	40	-	-	-	-	100

22BPE$11	PLANT BIOTECHNOLOGY

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	To Gain the insights of the basics of genes, genomes and breeding principles, analyzing techniques in tissue culture and genetic engineering.	
UNIT – I	**PLANT BIOTECHNOLOGY CONCEPTS**	**9 Periods**
Basic concepts and history of biotechnology, Different branches of biotechnology, Tools of Genetic Engineering: Cloning vehicles, Restriction enzymes, Modifying enzymes, DNA ligase, Polymerase etc. Cloning Vectors, Recombinant DNA technology		
UNIT – II	**PLANT BREEDING TECHNIQUES**	**9 Periods**
Significance of plant breeding in crop development. Methods of plant breeding in self- and cross-pollinated crops. Clonal selection, population improvement programme. Heterosis, Genetical and physiological basis. Interspecific/ Intergeneric hybridization, Heterosis inbreeding depression. Polyploidy its types. Mutation breeding Gene actions, heritability, genotype and environmental interactions.		
UNIT – III	**PLANT CELL AND TISSUE CULTURE**	**9 Periods**
Scope and importance of tissue culture in crop improvement, totipotency and morphogenesis, Organogenesis, Rhizogenesis, Embryogenesis, Nutritional requirement of in vitro cultures, Different techniques of in-vitro culture. Protoplast isolation, culture Manipulation and fusion. Cybrids, Products of somatic hybridization, Cryopreservation of germplasm. Secondary metabolites production		
UNIT – IV	**AGROBACTERIUM & VIRAL VECTORS**	**9 Periods**
Pathogenesis, crown gall disease, genes involved in the pathogenesis, Ti plasmid – t-DNA, importance in genetic engineering. Viral Vectors: Gemini virus, cauliflower mosaic virus, viral vectors and its benefits.		
UNIT – V	**APPLICATION OF PLANT BIOTECHNOLOGY**	**9 Periods**
Outline of plant tissue culture, transgenic plants, herbicide and pest resistant plants, molecular pharming , theraputic products.		
Contact Periods: **Lecture: 45 Periods** **Tutorial:0 Periods** **Practical: 0 Periods** **Total: 45 Periods**		

TEXT BOOK

1	Slater, A., Scott, N. and Fowler, M., "***Plant biotechnology: the genetic manipulation of plants***" OUP Oxford, 2008.
2	Ignacimuthu .S., *"**Plant Biotechnology**"*, Oxford and IBH Publishing Co Pvt. Ltd. New Delhi, 2003.

REFERENCES:

1	Swaminathan, M. S., "***Biotechnology in Agriculture – A dialogue",*** MacMillan India, New Delhi, 1991
2	Bhojwani S.S., Razdan M.K. *"**Plant tissue culture: Theory and Practice**"*, A revised edition, Elsevier science, 1996.
3.	Stewart, C.N. Jr., "***Plant Biotechnology & Genetics: Principles, Techniques and Applications***", John Wiley & Sons Inc. U.S.A, 2008
4.	Singh B.D., *"**Text Book of Plant Biotechnology**",* Kalyani Publishers, 1998.

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Apply the basic concepts of genetic engineering to establish plant tissue culture.	K1
CO2	Gain knowledge about the significance of different breeding techniques.	K1
CO3	Understand the importance of tissue culture towards the crop improvement	K2
CO4	Demonstrate plant-pathogen interactions and various approaches for resistances.	K2
CO5	Emphasis the development of transgenic plants, herbicide and pest resistant plants	K2

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2
CO1	1	1	-	-	-	-	-	-	-	-	-	-	3	1
CO2	1	1	-	-	-	-	-	-	-	-	-	-	3	1
CO3	1	1	-	-	-	-	-	-	-	-	-	-	3	1
CO4	1	1	-	-	-	-	-	-	-	-	-	-	3	1
CO5	1	1	-	-	-	-	-	-	-	-	-	-	3	1
22BPE$11	1	1	-	-	-	-	-	-	-	-	-	-	3	1

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.4.1, 2.1.3
CO2	1.4.1, 2.1.3
CO3	1.4.1, 2.1.3,
CO4	1.4.1, 2.1.3
CO5	1.4.1, 2.1.3,

ASSESSMENT PATTERN – THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT - 1	50	50	-	-	-	-	100
CAT - 2	50	50	-	-	-	-	100
Individual Assignment 1/Case study 1/ Seminar 1/ Project 1	50	50	-	-	-	-	100
Individual Assignment 2/Case study 2/ Seminar 2/ Project 2	30	70	-	-	-	-	100
ESE	50	50	-	-	-	-	100

22BPE$12	ANIMAL BIOTECHNOLOGY

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	To understand the basics and applications of animal cell culture, to develop strategies to detect animal diseases based on molecular diagnosis, to evaluate therapeutic properties of various biomolecules, to demonstrate the breeding of farm animals based on micromanipulation technology and to understand the role of stem cells in developing transgenic animal models.	
UNIT – I	**ANIMALCELL CULTURE**	**12 Periods**
Introduction to basic tissue culture techniques, Equipment and instruments in ATC – Media for animal cell culture-natural and artificial media, Animal cell cultures – Growth kinetics of animal cells in culture, Maintenance and preservation - Various types of cultures-cultures of cells, tissues and organs.		
UNIT – II	**SCALE-UP OF ANIMAL CELL CULTURE**	**9 Periods**
Scale-up of suspension and anchorage-dependent animal cells, Bioreactors for animal cell culture: Static monolayer culture, roller bottle culture, micro carrier culture, fixed bed and fluidized bed reactor, stirred tank culture, airlift culture, continuous flow culture.		
UNIT – III	**THERAPY OF ANIMAL DISEASES**	**10 Periods**
Recombinant cytokines and cytokine therapy – Therapeutic applications of monoclonal antibody, Vaccines - DNA, sub unit, cocktail vaccines - Gene therapy for animal diseases.		
UNIT – IV	**MICROMANIPULATION OF EMBRYO**	**7 Periods**
Micromanipulation technology - Equipments - Enrichment of x and y bearing sperms from semen samples – Artificial insemination - *In vitro* fertilization -Embryo transfer – Application of micromanipulation technology in breeding of farm animals		
UNIT – V	**TRANSGENIC ANIMALS**	**7 Periods**
Concepts of transgenic animal technology; Strategies for the production of transgenic animals-knock in technology and knock out technology-Stem cell cultures in the production of transgenic animals- Engineered Embryonic stem cell culture method, pro-nuclei transfer, Applications of transgenic animal technology-case studies		
Contact Periods: **Lecture: 45 Periods** **Tutorial:0 Periods** **Practical: 0 Periods** **Total: 45 Periods**		

TEXT BOOK

1	Ranga M.M, "***Animal Biotechnology***", 3rd Edition, Agrobios India Limited 2010.
2	Ramadass. P and Meera Rani. S, "***Text Book of Animal Biotechnology"***, Agrobios India Limited 2002.

REFERENCES:

1	Ashish S.Varma and Anchal singh, "***Animal biotechnology-Models in Discovery and Translation***", Elsevier publication, 2014.
2	Freshney R.I., "***Culture of animal cells- a manual of basic techniques and specialized applications***", Wiley-Blackwell, 7^{th} edition, 2016.
3	Masters J.R., "***Animal cell culture. Practical Approach***", IRL Press, 2^{nd} edition, 2002
4.	Sasidhara.R, "***Animal Biotechnology***", MJP Publishers, 2009.

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Exploit the biomolecular techniques for the study and diagnosis of infective and parasitic animal diseases, as well as for the formulation of innovative biotechnological vaccines to be implemented in field of veterinary science.	K3
CO2	Perceive and deduce the contemplative ethical problems subjective to testing protocols involving animals.	K1
CO3	Demonstrate various diagnostic and therapeutic techniques for the identification and curing of animal diseases.	K1
CO4	Reckon and utilize the concept of gamete and embryo manipulation technology for the production of transgenic animals and cloning.	K2
CO5	Acquire knowledge about the concept of transgenic animal production and its significance in biotechnology.	K1

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs / POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	1	3	-	-	-	-	-	-	-	-	-	-	3	1
CO2	-	-	-	-	-	2	-	3	-	-	-	-	1	3
CO3	2	3	2	-	-	-	-	-	-	-	-	-	2	2
CO4	2	2	2	-	-	1	-	2	-	-	-	-	3	2
CO5	3	2	2	-	-	1	2	2	-	-	-	-	3	1
18BPE$12	2	3	2	-	-	1	2	2	-	-	-	-	3	2

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.3.1,2.1.1
CO2	6.2.2,8.2.2
CO3	1.3.1,2.1.3,2.2.3
CO4	1.3.1,2.1.1, 6.2.2,8.2.2
CO5	1.3.1,2.1.1, 6.2.2,8.2.2,3.1.6

ASSESSMENT PATTERN							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT - 1	70	30	-	-	-	-	100
CAT - 2	60	40	-	-	-	-	100
Individual Assignment 1/Case study 1/ Seminar 1/ Project 1	50	50	-	-	-	-	100
Individual Assignmen t 2/Case study 2/ Seminar 2/ Project 2	40	60	-	-	-	-	100
ESE	60	40	-	-	-	-	100

22BPE$13	STEM CELL TECHNOLOGY

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	To familiarize the students with the concept of the stem cells and its different types, to categorize the stem cells and to learn its developmental biology, to provide insights on the stem cells differentiation, to give a broad view of mammalian stem cells, reviewing where they are found in the body, the different types and how they are cultured to learn the basic biology of these stem cells as well as bioengineering and application of these stem cells to potential treatments of human diseases.	
UNIT – I	**STEM CELLS AND TYPES**	**9 periods**
Stem cells: Definition, Classification, Sources and Properties –Types of stem cells: methods of isolation, study of stem cells and their viability IPSC, embryonic stem cells, cancer stem cells. – Preservations of Stem cell. Embryonic stem cell: Isolation, Culturing, Differentiation, Properties – Adult stem cell: Isolation, Culturing, Differentiation, Trans-differentiation, Plasticity, and Properties		
UNIT – II	**STEM CELLS IN PLANTS AND ANIMALS**	**9 periods**
Stem cell and founder zones in plants –particulary their roots – stem cells of shoot meristems of higher plants. Skeletal muscle stem cell – Mammary stem cells – intestinal stem cells – keratinocyte stem cells of cornea – skin and hair follicles –tumour stem cells.		
UNIT – III	**STEM CELLS DIFFERENTIATION**	**9 periods**
Factors influencing proliferation, physical, chemical and molecular methods for differentiation of stem cells – hormonal role in differentiation.		
UNIT – IV	**REGENERATION AND EXPERIMENTAL METHODS**	**9 periods**
Germ cells, hematopoietic organs, and kidney, cord blood transplantation, donor selection, HLA matching, patient selection, peripheral blood and bone marrow transplantation, - Stem cell Techniques: fluorescence activated cell sorting (FACS), time lapse video, green fluorescent protein tagging		
UNIT – V	**APPLICATION AND ETHICAL ISSUES**	**9 periods**
Stem cell Therapy for neurodegenerative diseases, spinal cord injury, heart disease, diabetes, burns, skin ulcers, muscular dystrophy and orthopaedic applications. Stem cell policy and ethics, stem cell research: Hype, hope and controversy.		
Contact Periods: **Lecture: 45 Periods Tutorial: 15 Periods Practical: 0 Periods Total: 15 Periods**		

TEXT BOOKS

1	Stem cells by C.S Potten., Elsevier, 2006.
2	Essentials of Stem Cell Biology by Robert Lanza., fourth edition. Elsevier 2014.

REFERENCES

1	Stem cell biology and Gene Therapy by Peter Quesenberry., First Edition, Wiley-Liss, 1998.
2	Embryonic Stem cells – Protocols by KursadTurksen., Second Edition Humana Press,
	2002
3	Stem Cells: From Bench to Bedside by AriffBongso, EngHinLee., World Scientific Publishing Company, 2005
4	Stem cells in clinic and Research by Ali Gholamrezanezhad., Intech, 2013

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Understand the concept of the stem cells and its different types	K1
CO2	Categorize the stem cells and understand their developmental biology	K2
CO3	Reveal the factors influencing the stem cells differentiation and to optimize them.	K3
CO4	Culture the mammalian stem cell cultures with the varied SOPs.	K4
CO5	Apply the concepts of these stem cells to potential treatments of human diseases	K5

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**
CO1	-	-	-	-	1	3	-	3	1	-	-	1	3	1
CO2	-	-	-	-	2	3	-	3	2	-	-	1	1	2
CO3	1	-	1	1	2	3	1	3	2	1	1	1	3	1
CO4	1	-	2	2	2	3	1	3	2	1	1	1	3	1
CO5	-	-	2	2	2	3	1	3	2	1	1	1	3	1
22BPE$13	1	-	2	2	2	3	1	3	2	1	1	1	3	1

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	5.1.1, 6.1.1, 6.2.1, 8.1.1, 8.2.2, 9.1.1, 12.1.1
CO2	5.1.1, 6.1.1, 6.2.1, 8.1.1, 8.2.2, 9.1.1, 12.1.1
CO3	1.1.1, 3.1.1, 4.1.2, 5.1.1, 6.1.1, 6.2.1, 7.1.2, 8.1.1, 8.2.2, 9.1.1, 10.1.1, 11.2.1, 12.1.1
CO4	1.1.1, 3.1.1, 4.1.2, 5.1.1, 6.1.1, 6.2.1, 7.1.2, 8.1.1, 8.2.2, 9.1.1, 10.1.1, 11.2.1, 12.1.1
CO5	3.1.1, 4.1.2, 5.1.1, 6.1.1, 6.2.1, 7.1.2, 8.1.1, 8.2.2, 9.1.1, 10.1.1, 11.2.1, 12.1.1

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT - 1	50	50	-	-	-	-	100
CAT - 2	50	50	-	-	-	-	100
Individual Assignment 1/Case study 1/ Seminar 1/ Project 1	50	50	-	-	-	-	100
Individual Assignment 2/Case study 2/ Seminar 2/ Project 2	50	50	-	-	-	-	100
ESE	50	50	-	-	-	-	100

22BPE$14	MARINE BIOTECHNOLOGY					
PREREQUISITES		**CATEGORY**	**L**	**T**	**P**	**C**
NIL		**PE**	**3**	**0**	**0**	**3**

Course Objectives	To learn the basis of marine environment and various applications of marine organisms and to equip the students in understanding of how biotechnology could be applied in finding solutions to marine problems.	
UNIT – I	**INTRODUCTION TO MARINE ENVIRONMENT**	**9 periods**
Marine ecosystem and its functioning: intertidal, estuarine, open ocean, deep sea; Biology of marine organisms- feeding and reproduction - Marine flora-Phytoplankton, seaweeds, sea grasses and mangroves; Marine fauna–Zooplankton; marine invertebrates -crustaceans & molluscs; Vertebrates and marine mammals - dolphins and whales.		
UNIT – II	**BIOACTIVE COMPONENTS AND BIOMATERIALS FROM MARINE ENVIRONMENT**	**9 periods**
Marine toxins – tetrodotoxins, conotoxins and ciguateratoxins; Marine enzymes-protease, lipase, chitinase, glucanase, Marine Biominerals, Biopolymers-polysaccharides, chitin, marine collagens, GFP, Probiotics, antiviral and antimicrobial agents.		
UNIT – III	**MARINE ENVIRONMENTAL BIOTECHNOLOGY**	**9 periods**
Marine pollution – biology indicators (marine micro, algae) – biodegradation & bioremediation – marine fouling and corrosion.		
UNIT – IV	**AQUACULTURE TECHNOLOGY**	**9 periods**
Important of coastal aquaculture – marine fishery resources – common fishing crafts and gears – aqua farm design and construction.		
UNIT – V	**MANIPULATION TECHNIQUES**	**9 periods**
Chromosome manipulation in aquaculture – hybridization; Ploidy induction; Gynogenesis, Androgenesis and sex reversal in commercially important fishes.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOK :

1	Fingerman M, Nagabhushanam R, Thompson M.F, ***"Recent advances in marine biotechnology",*** Volume 2, Science Pub Inc, 1999.
2	Fingerman M, Nagabhushanam R, Thompson M.F, ***"Recent advances in marine biotechnology",*** Volume 3, Science Pub Inc, 1999.

REFERENCES :

1	Joanne M. W, Sherwood L, Woolverton C.J, ***"Prescott's Microbiology"***, McGraw-Hill, 8th edition., 2011.
2	Kaiser M.J and Attrill M.J, ***"Marine Ecology: Process, Systems and Impacts***", Oxford, 2nd edition., 2011.
3	Recent advances in marine biotechnology volume 3 – M.Fingerman , R . Nagabhushanam Mary – Frances Thomson. Science Publishers Inc, USA 1999
4	Recent advances marine biotechnology volume 7 – M.Fingerman , R .Nagabhushanam Mary – Frances Thomson Science Publishers Inc, USA 2002.

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Learn the basic of ocean structure and characteristics	K1
CO2	Explain the marine eco system	K3
CO3	Describe the important microorganism in marine system	K5
CO4	Understand importance of biotechnological solution for marine problems	K4
CO5	Elaborate on various active compounds extract from marine organisms	K2

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	-	-	-	-	1	1	-	-	-	-	1	3	3
CO2	1	-	-	-	-	-	1	-	-	-	-	1	2	1
CO3	-	2	-	-	2	1	1	-	-	-	-	1	3	2
CO4	1	-	-	-	-	-	-	-	-	-	-	1	1	1
CO5	1	-	1	-	-	-	-	-	-	-	-	1	1	2
22BPE$14	1	2	-	-	1	-	1	-	1	-	-	2	3	-

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.1,1.2,1.3,1.4,2.1,2.2,2.3,2.4,3.1, 3.2,4.1,4.2,11.2,11.3,12.3
CO2	1.1,1.2,1.3,1.4,2.1,2.2, 2.3,2.4, 3.2,4.1,4.2,12.2,12.3
CO3	1.1,1.3,1.4,2.1, 2.2,2.4,4.1
CO4	4.1.2, 4.3.3, 5.3.1
CO5	1.3.1, 2.4.2, 2.4.4, 4.3.1, 5.3.1, 5.3.2

ASSESSMENT PATTERN – THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT - 1	50	50	-	-	-	-	100
CAT - 2	50	50	-	-	-	-	100
Individual Assignment 1/Case study 1/ Seminar 1/ Project 1	50	50	-	-	-	-	100
Individual Assignment 2/Case study 2/ Seminar 2/ Project 2	50	50	-	-	-	-	100
ESE	50	50	-	-	-	-	100

22BPE$15	PHARMACOGENOMICS

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	To understand the genetic basis for variation in drug response and explore genome-based applications for drug design in personalized medicine.	
UNIT – I	**INTRODUCTIONTO PHARMACOGENOMICS**	**9 periods**
Pharmacogenetics-the roots of pharmacogenomics; Pharmacogenomics - It is not just pharmacogenetics, Genetic drug response profiles, the effect of drugs on Gene expression, pharmacogenomics in drug discovery and drug development.		
UNIT – II	**HUMAN GENOME**	**9 periods**
Expressed sequence Tags (EST) and computational biology; Microbial genomics - computational analysis of whole genomes, comparative genome analysis; Genomic differences that affect the outcome of host pathogen interactions: A template for the future of whole genome-based pharmacological science; Protein coding genes, repeat elements, genome duplication, analysis of proteome, DNA variation; Biological complexity; Single nucleotide polymorphisms (SNP's) in Pharmacogenomics - approaches, number and types of SNPs, Study design for analysis, Analytical issues, Development of markers.		
UNIT – III	**ASSOCIATION STUDIES IN PHARMACOGENOMICS**	**9 periods**
Viability and Adverse Drug Reaction in drug response - contribution of genetic factor; Multiple inherited genetic factors influence the outcome of drug treatments – Liver metabolism enzymes, Transporters, Plasma binding proteins, Drug targets.		
UNIT – IV	**GENOMICS APPLICATIONS FOR DRUG ACTION AND TOXICITY**	**9 periods**
Platform technologies - Genomics, Proteomics, Bioinformatics; The pharmaceutical process and applications of pharmaceutical industry - Understanding biology and diseases, Target identification and validation, Drug candidate identification and optimization, safety and toxicology studies.		
UNIT-V	**PHARMACOGENOMICS AND DRUG DESIGN**	**9 periods**
The need of protein structure information, protein structure and variation in drug targets the scale of problem, Mutation of drug targets leading to change in the ligand binding pocket.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOK

1	Licinio, J and Wong, Ma-Li. ***"Pharmacogenomics: The Search for the Individualized Therapies"***, Wiley-Blackwell, 2009.
2	Chiranjib Chakraborty and Atana Bhattacharyya, ***"Pharmacogenomics: An Approachto New Drugs Development"***, 2004.

REFERENCES

1	Martin M. Zdanowicz, M.M. ***"Concepts in Pharmacogenomics"***, American Society of Health-System Pharmacists, Second Edition , 2017.
2	Russ B. Altman, David Flockhart, David B. Goldstein, ***"Principles of Pharmacogenetics and Pharmacogenomics"***, UK: John Wiley, 2012.
3	Rothstein, Mark, A. ***"Pharmacogenomics: Social, Ethical and Clinical Dimensions"***, Wiley- Liss, 2003.
4	Sandosh Padmanabhan, ***"Handbook of Pharmacogenomics and Stratified Medicine"***, Elsevier Science, 2014.
5	Martin M. Zdanowicz, M.M. ***"Concepts in Pharmacogenomics"***, American Society of Health-System Pharmacists, Second Edition , 2017.

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Learn about the human genome, gene expression and their relation to drug development.	K1
CO2	Distinguish the effect of genetic differences between individuals in the outcome of drug	K1
CO3	Describe the role of single nucleotide polymorphism as a biomarker for predicting risk and	K2
CO4	Utilize and manage a new genomics-based tools for assessing drug action and toxicity.	K3
CO5	Have a complete understanding of protein targets to learn ligand binding to develop new	K3

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**
CO1	1	1	-	-	-	-	-	-	-	-	-	-	1	1
CO2	1	1	-	-	-	-	-	-	-	-	-	-	1	1
CO3	1	1	-	-	-	-	-	-	-	-	-	-	1	1
CO4	1	1	-	-	-	-	-	-	-	-	-	-	1	1
CO5	1	1	-	-	-	-	-	-	-	-	-	-	1	1
22BPE$15	1	1	-	-	-	-	-	-	-	-	-	-	1	1

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.4.1, 12.2.2
CO2	1.4.1, 5.2.2, 12.2.2
CO3	1.4.1
CO4	12.2.2, 12.3.1
CO5	1.4.1, 2.1.3, 12.2.2

ASSESSMENT PATTERN – THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT - 1	50	30	20	-	-	-	100
CAT - 2	50	20	30	-	-	-	100
Individual Assignment 1/Case study 1/ Seminar 1/ Project 1	20	60	20	-	-	-	100
Individual Assignment 2/Case study 2/ Seminar 2/ Project 2	20	20	60	-	-	-	100
ESE	20	40	40	-	-	-	100

22BPE$16	GENOME EDITING

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	To give an understanding on the fundamentals of conventional genome editing its relevance in disease. To describe various techniques, genome editing and its applications.	
UNIT – I	**INTRODUCTION**	**9 periods**
Introduction to genetics and genetic engineering, Genes and Genome Organization, History and basics of genetic Engineering, Advantages and limitations of genetic Engineering.		
UNIT – II	**GENOME ENGINEERING**	**9 periods**
Pharmacogenetics-the roots of pharmacogenomics; Pharmacogenomics - It is not just pharmacogenetics, Genetic drug response profiles, the effect of drugs on Gene expression, pharmacogenomics in drug discovery and drug development.		
UNIT – III	**HUMAN GENOME AND ZFN TECHNOLOGY**	**9 periods**
Breakage of Genomic DNA, Repair of genomic DNA, Homologous and non-homologous recombination, site specific recombination, Targeted gene modification. Basics of Zing finger nucleases, design of zinc finger nucleases for genome editing, Applications of Zinc finger nucleases.		
UNIT – IV	**GENOME EDITING**	**9 periods**
Basics of TALEN (Transcription activator-like effector nuclease), Design of TALEN for genome editing, Applications of TALEN		
UNIT – V	**APPLICATION IN TREATING DISEASES**	**9 periods**
CRISPR system in bacteria, Cas9 in genome editing, Human cell engineering-Thalassemia, SCID, Hemophilia, etc; Disease modeling-Cancer, iPSc and animal models; Engineered immune cells for cancer therapy; Personalized therapy; Challenges: safety and specificity; Ethical concerns: Germ line gene editing.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOK

1	Harber , J. E., Genome Stability: ***DNA Repair and Recombination*** , Garland Science, 2013.
2	Yamamoto, T. ***Targeted Genome Editing Using Site-Specific Nucleases***, Springer, 2015.

REFERENCES

1	Barrangou , R. and Oost, J. van der, ***CRISPR-Cas Systems: RNA-mediated Adaptive Immunity in Bacteria and Archaea*** , Springer, 2013.
2	Addgene, ***CRISPR 101:A Desktop Resource*** , January 2016
3	Zlatanova, J. and Holde, K. van, ***Molecular Biology: Structure and Dynamics of Genomes and Proteomes***. Garland Science, 2015
4	R.M.Twyman, S.B. Primrose, "***Principle of Genome Analysis and Genomics***", Wiley Blackwell Publications, 2007.

COURSE OUTCOMES: On completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	New technique development in genome engineering.	K1
CO2	Application of already developed techniques for biomedical use.	K1
CO3	Development of high-throughput genome engineering techniques.	K2
CO4	Application of already developed techniques in understanding fundamental mechanism of interesting biological problems.	K2
CO5	Understand various applications in treating human diseases.	K2

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2
CO1	1	-	-	1	-	-	-	-	2	3	-	-	1	3
CO2	1	-	-	-	-	-	-	-	-	3	-	-	1	3
CO3	1	-	-	2	-	2	-	-	-	3	-	-	1	3
CO4	1	-	1	-	-	-	-	-	-	3	-	-	1	3
CO5	1	-	2	-	-	-	-	-	-	3	-	-	1	3
22BP E$16	1	-	1	1	-	2	-	-	2	3	-	-	1	3

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.4.2, 2.1.3
CO2	1.4.1, 3.1.3
CO3	1.4.4, 2.1.4
CO4	1.4.1, 2.1.3,3.4.2
CO5	1.4.1,2.2.1

ASSESSMENT PATTERN – THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT - 1	50	50	-	-	-	-	100
CAT - 2	60	40	-	-	-	-	100
Individual Assignment 1/Case study 1/ Seminar 1/ Project 1	50	50	-	-	-	-	100
Individual Assignment 2/Case study 2/ Seminar 2/ Project 2	50	50	-	-	-	-	100
ESE	50	50	-	-	-	-	100

22BPE$17	ASPECTS OF BIOCHEMICAL ENGINEERING

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	To understand the basic concepts of biochemical processes, stoichiometric analysis, thermodynamics, kinetic aspects of chemical and enzymatic reactions.	
UNIT – I	**INTRODUCTION**	**9 Periods**
Introduction-applications of biochemical processes- differences between chemical engineering and biochemical engineering -advantages of biochemical products-characteristics of the living organisms-classifications of the living organisms-taxonomy of the microorganisms- classifications of the microorganisms - applications of microorganisms -microbial culture and composition of the medium-strain development and improvement scale-up of inoculums development- difference between peptides and proteins, anabolism and catabolism of living systems, major metabolic pathways-bioproducts and their availability, classification of bioproducts, industrial fermentation process-industrial bioproducts and their market values.		
UNIT – II	**STOICHIOMETRY AND THERMODYNAMICS OF BIOCHEMICAL REACTIONS**	**9 Periods**
Stoichiometry of biochemical processes: law of conservation of mass- degree of reduction, energetic growth yield, energetic product yield and weight fraction of carbon- thermodynamic efficiency of aerobic and anaerobic processes- development of the complete stoichiometric equation of a biochemical process: calculation of O_2 requirement and heat evolved in aerobic fermentation process- validity of the experimental data of a biochemical process- calculation of theoretical yield of biomass in aerobic fermentation process- stoichiometric analysis of anaerobic fermentation process: calculation of theoretical yield of methane from the anaerobic digestion of organic waste- determination of stoichiometric formula of the 'ash free' biomass- calculation of heat evolved for the formation of biomass- definition of thermodynamics: system and surrounding, thermodynamic state, properties of a system- first law of thermodynamics- change of entropy in exothermic and endothermic reactions- Gibb's free energy of chemical reaction- "thermodynamics of biomethanation process- enthalpy of formation and Hess' law-characteristics of chemical equilibrium- factors affecting chemical equilibrium constant.		
UNIT – III	**BIOREACTOR TYPES, DESIGN AND ANALYSIS**	**9 Periods**
Different types of reactor- reactor analysis- analysis of CSTR and PFR- -design and analysis of activated sludge process- design and analysis of anaerobic digestion process- scale up of bioreactor- transport phenomenon in bioprocess- air and medium sterilization.		
UNIT – IV	**KINETIC ASPECTS OF CHEMICAL AND ENZYMATIC REACTIONS**	**9 Periods**
Kinetics of homogenous chemical reactions-kinetics of enzyme catalyzed reactions using free and immobilized enzymes-kinetics of substrate utilization, product formation and biomass production of microbial cells.		
UNIT – V	**OPERATION AND PROCESS CONTROL**	**9 Periods**
Operation of industrial fermenter and material analysis: schematic diagram of fermenter accessories of a fermenter-flow diagram of the citric acid fermentation process- materials analysis of citric acid fermentation process-process control: process control of bioprocesses- different parameters involve in bioprocesses- monitoring and control of physical parameters- monitoring and control of chemical parameters- automated process control system- overview of downstream processing- economic analysis of biochemical processes.		

Contact Periods:			
Lecture: 45 Periods	**Tutorial: 0 Periods**	**Practical: 0 Periods**	**Total: 45 Periods**

TEXT BOOK:

1	*Kargi. F., Shuler. M.L., **"Bioprocess Engineering: Basic Concepts",** 3rd Edition. Prentice Hall, 2017.*
2	*Doran. P. M., **"Bioprocess Engineering Principles",** Academic Press, 2012*

REFERENCES:

1	*Najafpour G., **"Biochemical Engineering and Biotechnology**", 2nd Edition, Elsevier, 2015*
2	*Scott F.H., **"Elements of Chemical Reaction Engineering**", 5th Edition, Pearson Education, Inc., 2015*
3	*Schügerl K., Bellgardt K.-H., Bioreaction Engineering: Modeling and Control, Springer, 2000*
4	*Bailey, J.E., Ollis, D.F.," **Biochemical Engineering Fundamentals**", 2^{nd} Edition , McGraw Hill, 1986.*

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Understand the basic aspects of biochemical processes and industrial bioproducts.	K1
CO2	Acquire knowledge about the stoichiometric analysis and thermodynamics of biochemical processes.	K2
CO3	Familiarize about the various types, design and analysis of bioreactors	K2
CO4	Inculcate the kinetic aspects of chemical and enzymatic reactions	K3
CO5	Impart knowledge about the operation and process control of industrial fermenter.	K3

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	2	1	1										1	2
CO2	1	1	2	1	1								1	2
CO3	1	1	2	1	2								2	2
CO4	1	1	1	2									1	1
CO5	1	1	1										1	2
22BPE$17	2	1	2	1	1								2	2

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.2.1,2.2.2,3.1.1
CO2	1.2.1,2.2.2,3.2.2,3.4.1,4.1.2,5.1.1
CO3	1.2.1,2.2.2,3.2.2,3.4.1,4.1.2,5.1.1,5.2.1
CO4	1.2.1,2.2.2, 3.2.2,4.2.2,4.3.2
CO5	1.2.1,2.2.2,3.2.2,3.4.1,4.1.2,5.1.2

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT - 1	50	50	-	-	-	-	100
CAT - 2	20	30	50	-	-	-	100
Individual Assignment 1/Case study 1/ Seminar 1/ Project 1	50	50	-	-	-	-	100
Individual Assignment 2/Case study 2/ Seminar 2/ Project 2	-	50	50	-	-	-	100
ESE	50	50	-	-	-	-	100

22BPE$18	FERMENTATION TECHNOLOGY				
PREREQUISITES	**CATEGORY**	**L**	**T**	**P**	**C**
NIL	**PE**	**3**	**0**	**0**	**3**

Course Objectives	To gain the knowledge about basics of fermentation process and to familiarize about beer, wine , fermented foods production.	
UNIT – I	**INTRODUCTION**	**9 Periods**
Fermentation processes-basic requirements of fermentation processes – An overview of aerobic and anaerobic fermentation processes and their application in industry -Medium requirements for fermentation processes - Design and usage of commercial media for industrial fermentation-Fundamentals of material and energy balance for fermentation processes.		
UNIT – II	**BEER FERMENTATION**	**9 Periods**
Barley Beer-types, bottom and top fermented beers; Raw materials for beer fermentation-Barley malt, adjuncts, hops, water, yeast; Brewing process- malting, milling, mashing, wort boiling, fermentation, lagering and packaging; Beer defects; Continuous brewing process.		
UNIT – III	**WINE FERMENTATION**	**9 Periods**
Grape wine-types; Wine making process-crushing of grapes, fermentation, ageing, storage,clarification, packaging; Wine defects		
UNIT – IV	**FOOD FERMENTATION**	**9 Periods**
Introduction to fermented foods, microbial cultures used in food industry, fermented dairy products, fermented meat products, fermented vegetable products, fermented oriental food products, fermentation for flavor production, fermented, dried and smoked fish products- microorganisms as food-single cell protein, mycoprotein production.		
UNIT – V	**ADVANCED FERMENTATION PROCESSES**	**9 Periods**
Recombinant protein expression with *E.coli* and fermentation. Expression in yeast *Pichia pastoris*, production of recombinant vaccines, purification of recombinant proteins. Animal cell culture, Plant cell culture; Cell culture practices, nutritional requirement of cultured cell, cell growth and propagation, prevention and eradication of contamination, Cell synchronization; Cell cloning. Scaling-up of animal and plant cell culture.		
Contact Periods: **45** **Lecture: 45 Periods** **Tutorial: 0 Periods** **Practical: 0 Periods** **Total: 45 Periods**		

TEXT BOOK:

1	*Okeke, Benedict C., and Okafor, Nduka. "**Modern Industrial Microbiology and Biotechnology",** CRC Press, Taylor & Francis Group, 2018.*
2	*Waites, Michael J., et al. "**Industrial Microbiology: An Introduction**", Wiley, 2009.*

REFERENCES:

1	*Whitaker, Allan., Stanbury, Peter F., Hall, Stephen J.. **"Principles of Fermentation Technology"** Elsevier, 2016.*
2	*Charles W. Bamforth, David J. Cook, **"Food, Fermentation, and Micro-organisms",** John Wiley & Sons, 2019.*
3	*Gopal Kumar Sharma, "**Advances In Fermented Foods And Beverages",** New India Publishers, 2021*

COURSE OUTCOMES: On completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Gain the knowledge about basics of fermentation process.	K1
CO2	Familiarize about the beer fermentation process.	K2
CO3	Understand about the processing steps in wine production .	K2
CO4	Explore about the various fermented food products.	K3
CO5	Inculcate the knowledge about the advances in fermentation process.	K3

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	1											1	1
CO2	1	1											1	1
CO3	1	1	2	2									1	2
CO4	1	1	2	2									1	2
CO5	1	1	2	2									1	2
18BPE$18	1	1	2	2									1	2

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.2.1,2.2.2
CO2	1.2.1,2.2.2
CO3	1.2.1,2.2.2,3.2.2,3.4.1,4.1.2
CO4	1.2.1,2.2.2,3.2.2,3.4.1,4.1.2
CO5	1.2.1,2.2.2,3.2.2,3.4.1,4.1.2

ASSESSMENT PATTERN – THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT - 1	50	50	-	-	-	-	100
CAT - 2	20	30	50	-	-	-	100
Individual Assignment 1/Case study 1/ Seminar 1/ Project 1	50	50	-	-	-	-	100
Individual Assignment 2/Case study 2/ Seminar 2/ Project 2	-	50	50	-	-	-	100
ESE	50	50	-	-	-	-	100

22BPE$19	FOOD PROCESS ENGINEERING					
PREREQUISITES		**CATEGORY**	**L**	**T**	**P**	**C**
NIL		**PE**	**3**	**0**	**0**	**3**

Course Objectives	To understand the basic constituents of foods, various food preservation techniques, unit operations and packaging methods involved in food processing.	
UNIT – I	**BASICS OF FOOD CHEMISTRY AND MICROBIOLOGY**	**9 Periods**
Constituents of food- water – bound and unbound water activity, carbohydrate, lipids, proteins- organoleptic and textural characteristics; Bacteria, yeasts and molds – sources, types and species of importance in food processing and preservation; Fermented foods; Single cell protein.		
UNIT – II	**FOOD PRESERVATION**	**9 Periods**
High Temperature - blanching, pasteurization, sterilization, evaporation, dehydration, distillation, baking, roasting, frying; Thermal death time relationships (D, Z and F values); Low Temperature - microbial activity at low temperature and methods – chilling, freezing; Irradiation; Chemicals preservation; Hurdle technology.		
UNIT – III	**UNIT OPERATIONS IN FOOD PROCESSING**	**9 Periods**
Raw material preparation- cleaning, sorting, grading and peeling; Size reduction; Pumping; Mixing and forming; Separation and concentration – centrifugation, filtration, extraction, crystallization;Heat transfer–conduction, convection, radiation, extruders (Theory and equipment only); Large scale processing – meat, beverage, confectionary, dairy, fresh fruits and vegetables.		
UNIT – IV	**FOOD PACKAGING**	**9 Periods**
Types of packaging material and containers; Interactions between packaging and foods; Controlling packaging atmosphere, Modified atmosphere packaging, Aseptic packaging, Active and intelligent packaging; Packing - meat, dairy, fresh fruits and vegetables, beverages and confectionaries; Food packaging closure and sealing system; Nutrition labelling and legislative requirements.		
UNIT – V	**FOOD SAFETY AND QUALITY CONTROL**	**9 Periods**
Objectives, importance and functions of quality control; Food safety- definition, food laws and regulations - FSSAI, FDA; Grades and standards; Concept of codex almentarious/HACCP/ /ISO 9000 series etc; Food recalls.		
Contact Periods: **Lecture: 45 Periods** **Tutorial: 0 Periods** **Practical: 0 Periods** **Total: 45 Periods**		

TEXT BOOK:

1	*Fellows P.J, "**Food Processing Technology: Principles and Practices",** Woodhead Publishing 4th edition,2016.*
2	*Robertoson G.L, **"Food Packaging: Principles and Practice",** CRC Press, 3rd edition,2016.*

REFERENCES:

1	*Frazier W.C and Westoff D.C., **"Food Microbiology",** McGraw Hill, 5th edition, 2013.*
2	*Smith P.G., "**Introduction to Food Process Engineering**", Springer, 2nd edition, 2011.*
3	*Toledo.R.T, "**Fundamentals of Food Process Engineering**", Springer, 3rd edition, 2007..*
4	*Berk.Z, **"Food Process Engineering and Technology".** Elsevier, 2009.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Understand the basic constituents of foods and the relationship between food and microorganism in fermentation process.	K1
CO2	Develop knowledge about various preservation techniques for food product.	K2
CO3	Gain the knowledge about the different unit operations involved in food processing.	K2
CO4	Explore the types of packaging methods for food products.	K3
CO5	Understand the food safety and control concepts.	K3

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	1											1	1
CO2	1	1											1	1
CO3	1	1	2	2									1	2
CO4	1	1	2	2									1	2
CO5	1	1	2	2									1	2
18BPE$18	1	1	2	2									1	2

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.2.1,2.2.2
CO2	1.2.1,2.2.2
CO3	1.2.1,2.2.2,3.2.2,3.4.1,4.1.2
CO4	1.2.1,2.2.2,3.2.2,3.4.1,4.1.2
CO5	1.2.1,2.2.2,3.2.2,3.4.1,4.1.2

ASSESSMENT PATTERN

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT - 1	50	50	-	-	-	-	100
CAT - 2	20	30	50	-	-	-	100
Individual Assignment 1/Case study 1/ Seminar 1/ Project 1	50	50	-	-	-	-	100
Individual Assignment 2/Case study 2/ Seminar 2/ Project 2	-	50	50	-	-	-	100
ESE	50	50	-	-	-	-	100

<table>
<tr><td>22BPE$20</td><td colspan="6">BIOREACTOR DESIGN AND SCALE UP PROCESS</td></tr>
<tr><td colspan="2">PREREQUISITES</td><td>CATEGORY</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td colspan="2">NIL</td><td>PE</td><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td>Course Objectives</td><td colspan="6">To understand the operation modes of bioreactor, mass transfer process in bioreactor and to familiarize about the design and analysis of bioreactors.</td></tr>
<tr><td>UNIT – I</td><td colspan="4">BASIC BIOREACTOR CONCEPTS</td><td colspan="2">9 Periods</td></tr>
<tr><td colspan="7">Bioreactor Operation – Batch operation, semi-continuous and fed-batch operation, Continuous Operation – Chemostat, turbidostat – Microbiological reactors, enzyme reactors – Tank-type, Column-type biological reactors – Case studies – Continuous Fermentation with Biomass Recycle, Tanks-in-series, Tubular plug flow bioreactors.</td></tr>
<tr><td>UNIT – II</td><td colspan="4">AERATION AND AGITATION IN BIOPROCESS SYSTEMS</td><td colspan="2">9 Periods</td></tr>
<tr><td colspan="7">Mass transfer in agitated tanks – Effect of agitation on dissolved oxygen - Correlations with kLa in Newtonian and non Newtonian liquid – Power number, Power requirement for mixing in aerated and non aerated tanks for Newtonian and non Newtonian liquids – Agitation rate studies - Mixing time in agitated reactor, residence time distribution – Shear damage, bubble damage, Methods of minimizing cell damage – Laminar and Turbulent flow in stirred tank bioreactors.</td></tr>
<tr><td>UNIT – III</td><td colspan="4">SELECTION AND DESIGN OF BIOPROCESS EQUIPMENT</td><td colspan="2">9 Periods</td></tr>
<tr><td colspan="7">Materials of construction for bioprocess plants – Design considerations for maintaining sterility of process streams processing equipments, selection, specification – Design of heat and mass transfer equipment used in bioprocess industries – Requirements, design and operation of bioreactor for microbial, plant cell and animal cell.</td></tr>
<tr><td>UNIT – IV</td><td colspan="4">SCALE UP AND SCALE DOWN ISSUES</td><td colspan="2">9 Periods</td></tr>
<tr><td colspan="7">Effect of scale on oxygenation, mixing, sterilization, pH, temperature, inoculum development, nutrient availability and supply – Bioreactor scale-up based on constant power consumption per volume,mixing time, impeller tip speed (shear), mass transfer co-efficients – Scale up of downstream processes – Adsorption (LUB method), Chromatography (constant resolution etc.), Filtration (constant resistance etc.), Centrifugation (equivalent times etc.), Extractors (geometry based rules) –Scale–down related aspects.</td></tr>
<tr><td>UNIT – V</td><td colspan="4">BIOREACTOR INSTRUMENTATION AND CONTROL</td><td colspan="2">9 Periods</td></tr>
<tr><td colspan="7">Sensor Design and Operating Principle: Temperature, flow measurement and control, Pressure measurement and control, shaft power, rate of stirring, detection and prevention of foam, measurement of cells, measurement and control of dissolved oxygen, inlet and outlet gas analysis, pH measurement and control, SCADA systems for Bioreactors: SCADA architecture, SCADA communication, SCADA functions; Case Studies in Bioreactor Instrumentation and Control.</td></tr>
<tr><td colspan="7">Contact Periods:
Lecture: 45 Periods   Tutorial: 0 Periods   Practical: 0 Periods   Total: 45 Periods</td></tr>
</table>

TEXT BOOK:

1	*Impre, J.F.M.V., Vanrolleghem, P.A. and Iserentant, D.M., "**Advanced Instrumentation, Data Interpretation and Control of Biotechnological Processes**", Kluwer Academic Publishers, 2010..*
2	*Mansi, E.M.T.EL., Bryce, C.F.A., Demain, A.L. and Allman, A.R., **"Fermentation Microbiology and Biotechnology**", Taylor and Francis, 2012*

REFERENCES :

1	*Towler, G. and Sinnott, R., "**Chemical Engineering Design: Principles, Practice, Economics of Plant and Process Design**", Butterworth – Heinemann ltd., Elsevier, 2012.*
2	*Mann, U., "**Principles of Chemical Reactors Analysis & Design: New tools for Industrial Chemical Reactor Operations**", Willey–VCH, 2009.*
3	*Carl-Fredrik Mandenius., **"Bioreactors:Design, Operation and Novel Applications**",Wiley, 2016*
4	*Klass van't Riet and Johannes Tramper., **"Basic Bioreactor Design**",CRC Press, 1991.*

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Understand the operation modes of bioreactor.	K1
CO2	Gain knowledge about the mass transfer process in bioreactor system.	K2
CO3	Familiarize about the design and analysis of bioreactors.	K2
CO4	Understand about bioreactor scale up and scale down issues .	K3
CO5	Gain knowledge about bioreactor instrumentation and process control.	K3

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	1	1										2	1
CO2	1	1	2	1	1								2	1
CO3	1	1	2	1	2								2	1
CO4	1	1	1	2									2	1
CO5	1	1	1	2									2	1
22BPE$20	2	1	2	2	1								2	1

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.2.1,2.2.2,3.1.1
CO2	1.2.1,2.2.2,3.2.2,3.4.1,4.1.2,5.1.1
CO3	1.2.1,2.2.2,3.2.2,3.4.1,4.1.2,5.2.1
CO4	1.2.1,2.2.2, 3.2.2,4.1.2
CO5	1.2.1,2.2.2,3.2.2,3.4.1,4.1.2,5.1.1

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT - 1	50	50	-	-	-	-	100
CAT - 2	20	30	50	-	-	-	100
Individual Assignment 1/Case study 1/ Seminar 1/ Project 1	50	50	-	-	-	-	100
Individual Assignment 2/Case study 2/ Seminar 2/ Project 2	-	50	50	-	-	-	100
ESE	40	40	20	-	-	-	100

22BPE$21	BIOREACTOR CONSIDERATIONS FOR RECOMBINANT PRODUCTS				
PREREQUISITES		**CATEGORY**	**L**	**T**	**P**	**C**
NIL		**PE**	**3**	**0**	**0**	**3**

Course Objectives	To acquire skills on techniques of isolation of gene of interest, construction of recombinant DNA and to apply techniques for production of pharmaceuticals, growth hormones, vaccines, gene therapy in expression system.	
UNIT – I	**GENETICALLY ENGINEERED ORGANISMS**	**9 Periods**
Different host vector systems, Guidelines for choosing Host Vector systems, Process constraints - Genetic instability, considerations in plasmid design, Regulatory constraints, principles and implementation of containment, good industrial large-scale practice (GILSP).		
UNIT – II	**CONSIDERATIONS FOR ANIMAL CELL CULTURES**	**9 Periods**
Structure and biochemistry of animal cells - Methods Used for the cultivation of animal cells - Bioreactor considerations for animal cell culture - Products of animal cell cultures, economics of animal cell tissue cultures.		
UNIT – III	**CONSIDERATIONS FOR PLANT CELL CULTURES**	**9 Periods**
Overview of plant cell cultures - Plant cells in culture compared to microbes - Bioreactor considerations for plant cell culture - Bioreactors for suspension cultures - Reactors using cell immobilization - Bioreactors for organized tissues, economics of plant cell tissue cultures.		
UNIT – IV	**DOWNSTREAM PROCESSING CONSIDERATIONS**	**9 Periods**
Release of protein from Biological Host, genetic approaches to facilitate protein purification, Solid-Liquid separation, extraction of Recombinant protein, Avoidance of proteolysis from extracts, membranes for protein isolation and purification, Chromatographic techniques, Removal of detergent from protein fractions, precipitation of proteins, protein crystallization for large scale bio separation.		
UNIT – V	**SAFETY CONSIDERATIONS ASSOCIATED WITH AGRICULTURAL AND ENVIRONMENTAL APPLICATIONS**	**9 Periods**
Risk assessment methods, safety considerations, Application of rDNA organism in the environment, Survival, multiplication and/or dissemination in the environment, Interactions with species or biological systems, effects on the environment, evaluating environmental risks of rDNA organisms released from industrial applications.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOK :

1	*Michael L. Shuler, Fikret Kargi, Matthew De Lisa,. **"Bioprocess Engineering"**, 3rd Edition,Prentice Hal, 2017.*
2	*Bailey J.A and Ollis D.F., **"Biochemical Engineering Fundamentals"**, McGraw Hill (New York), 2nd Edition, 2010.*

REFERENCES

1	*Pörtner, R. and Barradas, O.B.J.P., 2007. Animal cell biotechnology. Methods and Protocols, 2nd. Edition. Humana.*
2	*Slater, A., Scott, N. and Fowler, M., 2008. Plant biotechnology: the genetic manipulation of plants. OUP Oxford.*
3	*Cutler, P. ed., 2004. Protein purification protocols (Vol. 244). Springer Science & Business Media.*
4	*Perry R H ,"Perry's Chemical Engineers' Handbook", McGraw-Hill, 8th Edition, 2008.*

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Acquire skills on techniques of isolation of gene of interest and construction of recombinant DNA.	K1
CO2	Apply techniques for production of pharmaceuticals, growth hormones, vaccines, gene therapy in expression system.	K2
CO3	Apply rDNA technology in evolving plants for resistance to pest and disease, tolerance to herbicides and abiotic factors.	K2
CO4	Identify problems associated with production of recombinant proteins and protein purification and devising strategies to overcome problem..	K3
CO5	Acquire knowledge on environmental applications of genetic engineering through bioremediation.	K3

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**
CO1	2	1	1	-	-	1	-	-	-	-	-	-	1	2
CO2	1	1	2	1	1	-	-	-	-	-	-	-	1	2
CO3	1	1	2	1	2	-	-	-	-	-	-	-	2	2
CO4	1	1	1	-	-	-	-	-	-	-	-	-	1	1
CO5	1	1	1	-	-	-	-	-	-	-	-	-	1	2
22BPE$21	2	1	2	1	1	1	-	-	-	-	-	-	2	2

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.2.1,2.2.2,3.1.1,6.2.1
CO2	1.2.1,2.2.2,3.2.2,3.4.1,4.1.2,5.1.1
CO3	1.2.1,2.2.2,3.2.2,3.4.1,4.1.2,5.1.1,5.2.1
CO4	1.2.1,2.2.2, 3.2.2
CO5	1.2.1,2.2.2,3.2.2,3.4.1,4.1.2,5.1.1,6.1.1

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT - 1	50	50	-	-	-	-	100
CAT - 2	20	30	50	-	-	-	100
Individual Assignment 1/Case study 1/ Seminar 1/ Project 1	50	50	-	-	-	-	100
Individual Assignment 2/Case study 2/ Seminar 2/ Project 2	-	50	50	-	-	-	100
ESE	50	50	-	-	-	-	100

22BPE$22	BIOPROCESS CONTROL AND INSTRUMENTATION					
PREREQUISITES		**CATEGORY**	**L**	**T**	**P**	**C**
NIL		**PE**	**3**	**0**	**0**	**3**
Course Objectives	To categorize bioprocess instrumentation for the measurement of various parameters and to understand the components of control system in bioprocesses					
UNIT – I	**BIOPROCESS INSTRUMENTATION**					**9 Periods**
Temperature, pH, Level, Flow, Pressure, DO sensors. Response of First order systems: Transfer Function, Transient Response, Forcing Functions and Responses. Physical examples of First and second order systems: Examples of First order systems, Linearization, Transportation Lag.						
UNIT – II	**COMPONENTS OF CONTROL SYSTEM**					**9 Periods**
Block Diagram, Development of Block Diagram, Controllers and Final Control Elements. Closed loop Transfer functions: Standard Block-Diagram Symbols,Transfer Functions for Single-Loop Systems and Multi-loop Systems.						
UNIT – III	**TRANSIENT RESPONSE OF SIMPLE CONTROL SYSTEMS**					**9 Periods**
Servo Problem, Regulatory Problem, Controllers: Proportional, Proportional-Integral, PID Controllers.Ziegler-Nichols Controller Settings. Stability: Routh Test for Stability, Root Locus.						
UNIT – IV	**INTRODUCTION TO FREQUENCY RESPONSE**					**9 Periods**
Substitution Rule, Bode Diagrams. Control system design based on frequency response: Bode and Nyquist Stability Criterion, Gain and Phase Margins.						
UNIT – V	**ADVANCED CONTROLS IN BIOREACTORS**					**9 Periods**
Introduction to dead time compensation, pH measurement and control, Oxygen measurement and control, Adaptive control and online estimation, Cascade control for jacketed bioreactors						
Contact Periods: **Lecture: 45 Periods** **Tutorial: 0 Periods** **Practical: 0 Periods** **Total: 45 Periods**						

TEXT BOOK:

1	*Impre, J.F.M.V., Vanrolleghem, P.A. and Iserentant, D.M., "**Advanced Instrumentation, Data Interpretation and Control of Biotechnological Processes**", Kluwer Academic Publishers, 2010..*
2	*Stephanopoulose G, "**Chemical Process Control: An Introduction to Theory and Practice",** Prentice Hall of India, New Delhi, 1993.*

REFERENCES :

1	*Seborg D E, Edgar TF, Mellichamp D A, Doyle FJ,* **"Process Dynamics and Control",** *3/e, John Wiley & Sons, 2010.*
2	*Tapobrata Panda, "**Bioreactor Analysis and Design**", Tata McGraw Hill, 2011.*
3	*LeBlanc, SE., Coughanowr, DR.. "**Process Systems Analysis and Control**". McGraw-Hill Higher Education, 2009.*
4	*James B. Riggs, M. Nazmul Karim.,* **"Chemical and Bio-process Control",** *Pearson, 2007*

COURSE OUTCOMES: On completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Categorize Bioprocess instrumentation for the measurement of various parameters	K1
CO2	Understand the components of control system in bioprocesses .	K2
CO3	Develop the closed loop control system using P/PI/PID controller	K2
CO4	Analyze the stability of feedback control system	K3
CO5	Gain knowledge about the advanced control system in bioreactors.	K3

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	1	1	-	-	-	-	-	-	-	-	-	2	1
CO2	1	1	2	1	1	-	-	-	-	-	-	-	2	1
CO3	1	1	2	2	2	-	-	-	-	-	-	-	2	1
CO4	1	1	2	2	2	-	-	-	-	-	-	-	2	1
CO5	1	1	2	2	2	-	-	-	-	-	-	-	2	1
22BPE$22	2	1	2	2	2	-	-	-	-	-	-	-	2	1

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.2.1,2.2.2,3.1.1
CO2	1.2.1,2.2.2,3.2.2,3.4.1,4.1.2,5.1.1
CO3	1.2.1,2.2.2,3.2.2,3.4.1,4.1.2,,5.2.1
CO4	1.2.1,2.2.2,3.2.2,3.4.1,4.1.2,,5.2.1
CO5	1.2.1,2.2.2,3.2.2,3.4.1,4.1.2,5.1.1

ASSESSMENT PATTERN – THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT - 1	50	50	-	-	-	-	100
CAT - 2	20	30	50	-	-	-	100
Individual Assignment 1/Case study 1/ Seminar 1/ Project 1	50	50	-	-	-	-	100
Individual Assignment 2/Case study 2/ Seminar 2/ Project 2	-	50	50	-	-	-	100
ESE	40	40	20	-	-	-	100

22BPE$23	BIOPROCES MODELLING AND SIMULATION					
PREREQUISITES		**CATEGORY**	**L**	**T**	**P**	**C**
NIL		**PE**	**3**	**0**	**0**	**3**

Course Objectives	To introduce the fundamental aspects of modeling of various biological systems. To address the various modeling paradigms, based on the level of detail. To outline the applications of such modeling techniques.	
UNIT – I	**MODELING OF BIOLOGICALSYSTEMS**	**9 Periods**
Modeling Principles, model development from first principles. Modeling approaches for biological systems – structured and unstructured systems; Compartment models; Deterministic and stochastic approaches for modeling structured systems.		
UNIT – II	**MODELLING OF DIFFUSION SYSTEMS (BIOFILM AND IMMOBILIZED ENZYME SYSTEMS**	**9 Periods**
External mass transfer, Internal diffusion and reaction within biocatalysts, derivation of finite model for diffusion-reaction systems, dimensionless parameters from diffusion-reaction models, the effectiveness factor concept, case studies; oxygen diffusion effects in a biofilm, biofilm nitrification		
UNIT – III	**MODELING BIOREACTOR**	**9 Periods**
Bioreactor modelling: Ideal and non-ideal bioreactors; Stirred tank models; characterization of mass and energy transfer distributions in stirred tanks, Tower Reactor Model; Flow modeling, bubble column flow models, mass transfer modeling, structured models for mass transfer in tower reactors, process models in tower reactors, airlift models,		
UNIT – IV	**LINEAR SYSTEM ANALYSIS**	**9 Periods**
Study of linear systems, linearization of non-linear systems; Simulation of linear models using software; Parameter estimation and sensitivity analysis; Steady state and unsteady state systems; stability analysis; Case study of recombinant protein production.		
UNIT – V	**HYBRID AND OTHER MODELING TECHNIQUES**	**9 Periods**
Advanced modeling techniques such as fuzzy logic, neural network, hybrid systems and fuzzy logic systems; case studies.		
Contact Periods: **Lecture: 45 Periods** **Tutorial:0 Periods** **Practical: 0 Periods** **Total: 45 Periods**		

TEXT BOOK

1	Moser, Anton, ***"Bioprocess technology: kinetics and reactors",*** Springer Science & Business Media, 2012.
2	Wayne Bequette. B, ***"Process Control: Modeling, Design, and Simulation",*** Prentice-Hall, 2023.

REFERENCES:

1	Said Elnashaie S.E.H., Parag Gharyan, "***Conservation Equations and Modeling of Chemical and Biochemical Processes",*** Marcel Dekker, 2003.
2	Elmar Heinzle, Dunn.I. J, ***"Biological Reaction Engineering: Dynamic Modeling Fundamentals with 80 Interactive Simulation Examples",*** Wiley-VCH., 2021.
3	Najaf pour, G.D., ***"Biochemical Engineering & Biotechnology"***, 2nd Edition, Elsevier, 2015.
4	William L. Luyben ., ***"Process Modeling, Simulation, and Control for Chemical Engineers",*** McGraw Hill, 1990.

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Understand the modelling of biological systems and bioreactors.	K2
CO2	Design new models for biological systems, biofilm and immobilized enzyme systems, and bioreactors.	K3
CO3	Carry out simulation of models using software.	K2
CO4	Analyze the simulation studies and stability and sensitivity of the system.	K4
CO5	Understand advanced modelling techniques.	K2

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs / POs	**PO 1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	1	1	-	-	-	-	-	-	-	-	-	-	1	-
CO2	1	1	-	-	-	-	-	-	-	-	-	-	1	-
CO3	1	1	-	-	-	-	-	-	-	-	-	-	1	-
CO4	1	1	-	-	-	-	-	-	-	-	-	-	1	-
CO5	1	1	-	1	1	1	-	-	-	-	-	-	1	1
22BPE$23	3	3	-	1	1	1	-	-	-	-	-	-	3	1

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.2.1,2.2.2
CO2	1.2.1,2.2.2
CO3	1.2.1,2.2.2
CO4	1.2.1,2.2.2
CO5	1.2.1,4.1.2,4.1.3,4.1.2

ASSESSMENT PATTERN

Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT - 1	70	30	-	-	-	-	100
CAT - 2	60	40	-	-	-	-	100
Individual Assignment 1/Case study 1/ Seminar 1/ Project 1	50	50	-	-	-	-	100
Individual Assignment 2/Case study 2/ Seminar 2/ Project 2	40	60	-	-	-	-	100
ESE	50	50	-	-	-	-	100

22BPE$24	SOLID STATE BIOPROCESSING

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	To understand the basic concepts involved in SSF, general considerations, kinetics and types of bioreactors for SSF, production of bulk chemicals and products by SSF.	
UNIT – I	**INTRODUCTION**	**9 Periods**
Solid-State Fermentation (SSF)-Difference Between Solid-State Fermentation and Submerged Fermentation-Advantages and Applications of SSF; Principles and Regulations of SSF based on biological and substrate characteristics; Biotechnology Principles of Solid State Fermentation-Microbial Growth and Metabolic Characteristics, Filamentous, Bacterial, yeast growth on the Solid Matrix; Properties of the Solid Matrix in SSF.		
UNIT – II	**GENERAL CONSIDERATIONS FOR SSF**	**9 Periods**
Factors affecting SSF-strain selection, medium, C/N ratio, temperature, moisture, water activity, pH, aeration and agitation, particle size; Energy balance ; Heat and Mass Transfer in SSF; Kinetics of SSF estimation of kinetic parameters		
UNIT – III	**BIOREACTORS FOR SSF**	**9 Periods**
Overview of bioreactors employed in SSF; Types-Unaerated and Unmixed (Tray reactor), Forcefully-Aerated Bioreactors Without Mixing (Packed bed reactor), Rotating-Drum and Stirred-Drum Bioreactors, Continuously-Mixed, Forcefully-Aerated Bioreactors (Stirred Beds with Mechanical Agitators, Gas-Solid Fluidized Beds), Intermittently-Mixed Forcefully-Aerated Bioreactors; Continuous SSF Bioreactors-Continuous Tubular Flow Bioreactors, Continuous Rotating Drum Bioreactor, Continuous Stirred Tank Bioreactor; Scale-up challenges in SSF.		
UNIT – IV	**SSF FOR BULK CHEMICALS AND PRODUCTS**	**9 Periods**
Production of organic acids (citric acid-lactic acid); Production of enzymes (proteases,lipases),factors affecting enzyme production in SSF system-recovery of enzymes- Production of mushroom microorganisms- substrates -physiological and environmental control for mushroom production by SSF- bioremediation and detoxification of mushroom strains-Microbial pigments production.		
UNIT – V	**APPLICATION PROSPECTS OF MODERN SSF**	**9 Periods**
Applicability of solid biomass used as substrate-characteristics of solid substrate-solid biomass bioconversion, Biomass bioconversion technology based on SSF- biological pretreatment-enzyme production for biomass bioconversion -high and Low value-added bioconversion of biomass.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOK :

1	*Chen, Hongzhang, **"Modern Solid State Fermentation: Theory and Practice"**, Springer Netherlands, 2013.*
2	*Ashok Pandey, C.R. Soccol, Christian Larroche, **"Current Developments in Solid-state Fermentation"**, Springer New York, 2008..*

REFERENCES

1	*Susanne Steudler, Anett Werner, Jay J. Cheng , **"Solid State Fermentation: Research and Industrial Applications"**, Springer International Publishing, 2019.*
2	*Krieger, Nadia., Mitchell, David A., **"Solid-State Fermentation Bioreactors: Fundamentals of Design and Operation"**, Springer Berlin Heidelberg, 2006.*
3	*B.K. Lonsane, G. Viniegra-Gonzalez, Gustavo Viniegra, M. Raimbault, S. Roussos, **"Advances in Solid State Fermentation"**, Springer Netherlands, 2013.*
4	*Ashok Pandey **"Solid-state Fermentation"**, Wiley Eastern, 1994.*

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Understand the basic concepts and biotechnological principles involved in SSF.	K1
CO2	Develop knowledge about the general considerations and kinetics of SSF.	K2
CO3	Explore about the various types of bioreactors for SSF.	K2
CO4	Gain knowledge about the production of bulk chemicals by SSF	K3
CO5	Inculcate the application prospects of modern SSF.	K3

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	1	1	-	-	1	-	-	-	-	-	-	1	2
CO2	1	1	2	1	1	-	-	-	-	-	-	-	1	2
CO3	1	1	2	1	2	-	-	-	-	-	-	-	2	2
CO4	1	1	1	-	-	-	-	-	-	-	-	-	1	1
CO5	1	1	1	-	-	-	-	-	-	-	-	-	1	2
22BPE$24	2	1	2	1	1	1	-	-	-	-	-	-	2	2

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.2.1,1.2.2, 2.2.2,3.1.1,6.2.1
CO2	1.2.1,2.2.2,3.2.2,3.4.1,4.1.2,5.1.1
CO3	1.2.1,2.2.2,3.2.2,3.4.1,4.1.2,5.1.1,5.2.1
CO4	1.2.1,2.2.2, 3.2.2
CO5	1.2.1,2.2.2,3.2.2,3.4.1,4.1.2,5.1.1,6.1.1

ASSESSMENT PATTERN – THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT - 1	50	50	-	-	-	-	100
CAT - 2	20	30	50	-	-	-	100
Individual Assignment 1/Case study 1/ Seminar 1/ Project 1	50	50	-	-	-	-	100
Individual Assignment 2/Case study 2/ Seminar 2/ Project 2	-	50	50	-	-	-	100
ESE	50	50	-	-	-	-	100

22BPE$25	CLINICAL TRIALS AND HEALTH CARE POLICIES IN BIOTECHNOLOGY

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	To understand the fundamentals of bioethics, quality assurance and governance. To develop advanced clinical trial management strategies including drug development and trial planning. To demonstrate project management in clinical trials. To apply consent and data protection methods.
UNIT – I : INTRODUCTION TO CLINICAL TRIALS	**9 Periods**
Fundamentals of clinical trials; Basic statistics for clinical trials; Clinical trials in practice; Reporting and reviewing clinical trials; Legislation and good clinical practice - overview of the European directives and legislation governing clinical trials in the 21stcentury; Principles of the International Committee on Harmonisation (ICH)-GCP.	
UNIT – II : REGULATIONS OF CLINICAL TRIALS	**9 Periods**
Drug development and trial planning - pre-study requirements for clinical trials; Regulatory approvals for clinical trials; Consort statement; Trial responsibilities and protocols - roles and responsibilities of investigators, sponsors and others; Requirements of clinical trials protocols; Clinical trials regulations in India- schedule Y- rules and regulations, Drugs and Cosmetics Act and Rules (DCA)	
UNIT – III : MANAGEMENT AND HEALTH CARE POLICIES	**9 Periods**
Clinical Trial Management System (CTMS), Software for CTMS study, SaaS. Legal issues in managing clinical data Health care informatics. Project management in clinical trials; Risk assessment; Research ethics and Bioethics - Principles of research ethics; Ethical issues in clinical trials; animal ethics; Use of humans in Scientific Experiments; Ethical committee system; Introduction to ethical codes and conduct; A case study on clinical trials of drugs in India with emphasis on ethical issues.	
UNIT – IV : INFORMED CONSENT	**9 Periods**
Consent and data protection- the principles of informed consent; Consent processes; Data protection; Legislation and its application; Data management – Introduction to trial master files and essential documents; Data management.	
UNIT – V : QUALITY CONTROL AND GUIDELINES	**9 Periods**
Quality assurance and governance - quality control in clinical trials; Monitoring and audit; Inspections; Pharmacovigilance; Research governance; Trial closure and pitfalls-trial closure; Reporting and legal requirements;	
Contact Periods: **Lecture: 45 Periods** **Tutorial:0 Periods** **Practical: 0 Periods** **Total: 45 Periods**	

TEXT BOOK

1	*Matoren, Gary M.* ***"The Clinical Research Process In The Pharmaceutical Industry.*** *"Marcel Dekker, 2004.*
2	*Lawrence M.Friedman et al,* ***"Fundamentals of Clinical Trials",*** *Mosby,2016*

REFERENCES:

1	*Lee, Chi-Jen et al, "**Clinical Trials or Drugs and Biopharmaceuticals**." CRC / Taylor & Francis,2011.*
2	*Curtis L Meinert et al, **"Clinical Trials - Design Conduct and Analysis"**, Oxford University Press 1986.*
3.	*Janet Woodcock, Frederick Ognibene, John Overbeke, **Assuring data quality and validity in clinical trials for regulatory decision making**, 2003.*
4.	Textbook of Clinical Trials edited by David Machin, Simon Day and Sylvan Green, March 2005, John Wiley and Sons.

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Apply ethical concepts and quality control measures in clinical trial projects	K1
CO2	Demonstrate project management in clinical trials.	K3
CO3	Develop clinical trials protocols, design consent and data protection.	K2
CO4	Operate consent and data protection methods.	K2
CO5	Manage the trial coordination process	K3

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**
CO1	-	1	-	-	-	2	2	2	-	-	1	2	2	2
CO2	1	-	-	1	1	-	-	2	3	3	2	2	1	3
CO3	1	1	-	-	-	-	-	1	1	-	-	-	1	3
CO4	-	-	-	-	1	-	-	2	3	3	1	1	1	3
CO5	-	2	-	1	3	-	-	-	-	-	-	-	2	2
22BPE$25	1	1	-	1	2	2	2	2	3	3	2	2	2	3

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	7.1.2, 9.1.1
CO2	7.2.1,11.1.2, 12.1.2
CO3	6.1.1, 7.1.1,11.2.1
CO4	6.2.1, 7.1.2,11.3.1, 12.1.2
CO5	7.1.2, 8.1.1,12.2.2

ASSESSMENT PATTERN							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT - 1	70	30	-	-	-	-	100
CAT - 2	60	40	-	-	-	-	100
Individual Assignment 1/Case study 1/ Seminar 1/ Project 1	50	50	-	-	-	-	100
Individual Assignment 2/Case study 2/ Seminar 2/ Project 2	40	60	-	-	-	-	100
ESE	60	40	-	-	-	-	100

22BPE$26	BIOTECHNOLOGICAL PRODUCTS AND ITS VALIDATION

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	Gain a thorough understanding of all aspects related to development, manufacturing an evaluation of bioproducts. Acquire adequate understanding of process design of pharmaceuticals. Understand the principles of validation in biotech industry.
UNIT – I : INTRODUCTION TO VALIDATION	**9 Periods**
Guidelines to process validation; Introduction to calibration of instruments and its guidelines, Introduction to Qualification and Validation, Importance and scope of Validation, Types of Validation, Validation master plan.	
UNIT – II : PROCESS VALIDATION OF PHARMACEUTICAL PRODUCTS	**9 Periods**
Process Validation of different dosage forms - solid, semisolids and parenterals ; Qualification of equipment: DQ, IQ, OQ and PQ(Validation of critical equipment - mixer, compression machine, fluidized bed dryer (FBD), filling equipment, sterilization tunnel)	
UNIT – III : STERILE EQUIPMENT VALIDATION	**9 Periods**
Sterile equipment train Validation, Validation of HVAC systems including clean room concepts, air handling equipment and water supply systems (purified, distilled and water for injection). • Cleaning Validation.	
UNIT – IV : COMPUTER ENABLED SYSTEM VALIDATION	**9 Periods**
Understanding of computer system validation (electronic records and digital signature21 CFR Part 11) concept of firmware, Commercial off the Shelf (COTS) and GAMP.	
UNIT – V : CASE STUDY	**9 Periods**
Analytical Test Methods for Biological and Biotechnological Products; Process Optimization and Characterization Studies for Purification of an E. coli -Expressed Protein Product – case study.	
Contact Periods: **Lecture: 45 Periods** **Tutorial:0 Periods** **Practical: 0 Periods** **Total: 45 Periods**	

TEXT BOOK

1	Haider SI. ***Pharmaceutical Master Validation Plan: The Ultimate Guide to FDA, GMP and GLP Compliance***. St. Lucie Press; 2002.
2	Wrigley GC. ***Facility Validation: Theory, Practice, and Tools***. CRC Press; 2004.

REFERENCES:

1	Segalstad SH. ***International IT Regulations and Compliance: Quality Standards in the Pharmaceutical and Regulated Industries.*** John Wiley & Sons; 2008.
2	Ira R. Berry and Robert A. Nash, ***Pharmaceutical process validation (Drugs and Pharmaceutical Series)***, Marcel Dekker Inc. New York.
3	Huber L. ***Validation and Qualification in Analytical Laboratories***. Informa Healthcare; 2007
4	Haider SI, Asif ES. ***Cleaning Validation Manual: A Comprehensive Guide for the Pharmaceutical and Biotechnology Industries.*** CRC Press; 2010.

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Apply ethical concepts and quality control measures in clinical trial projects	K1
CO2	Demonstrate project management in clinical trials.	K3
CO3	Develop clinical trials protocols, design consent and data protection.	K2
CO4	Operate consent and data protection methods.	K2
CO5	Manage the trial coordination process	K3

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2
CO1	-	1	-	-	-	2	2	2	-	-	1	2	2	2
CO2	1	-	-	1	1	-	-	2	3	3	2	2	1	3
CO3	1	1	-	-	-	-	-	1	1	-	-	-	1	3
CO4	-	-	-	-	1	-	-	2	3	3	1	1	1	3
CO5	-	2	-	1	3	-	-	-	-	-	-	-	2	2
22BPE$26	1	1	-	1	2	2	2	2	3	3	2	2	2	3

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	7.1.2, 9.1.1
CO2	7.2.1,11.1.2, 12.1.2
CO3	6.1.1, 7.1.1,11.2.1
CO4	6.2.1, 7.1.2,11.3.1, 12.1.2
CO5	7.1.2, 8.1.1,12.2.2

ASSESSMENT PATTERN

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3)%	Analyzing (K4) %	Evaluating (K5) %	Creating (K6)%	Total %
CAT - 1	70	30	-	-	-	-	100
CAT - 2	60	40	-	-	-	-	100
Individual Assignment 1/Case study 1/ Seminar 1/ Project 1	50	50	-	-	-	-	100
Individual Assignment 2/Case study 2/ Seminar 2/ Project 2	40	60	-	-	-	-	100
ESE	60	40	-	-	-	-	100

22BPE$27	QUALITY ASSURANCE AND QUALITY CONTROL IN BIOTECHNOLOGY

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	Identify the various aspects of quality control and quality assurance aspects of various biotechnological industries. Familiarize with cGMP, QC tests, documentation, quality certifications, GLP and regulatory affairs	
UNIT – I	INTRODUCTION	9 periods
Quality Assurance , Quality Control , Role of Quality Assurance, QA testing, Role of Quality Control, Test for quality control, Quality assurance – Quality control – Practice of cGMP- Overview of ICH Guidelines – QSEM, with special emphasis on Q-series guidelines. Good Laboratory Practices: Scope of GLP, Definitions, Quality assurance unit, protocol for conduct of non clinical testing, control on animal house, , scope of quality certifications – responsibilities of QA & QC departments, Analysis of raw materials, finished products, packaging materials, in process quality control (IPQC), Developing specification (ICH Q6 and Q3)		
UNIT – II	QUALITY ASSURANCE AND QUALITY CONTROL IN CLINICAL TRIALS	9 periods
Audit criteria, Audit process, Responsibilities of stakeholders in audit process, Audit follow-up and documentation, Audit resolution and Preparing for FDA inspections, Fraud and misconduct management – Clinical Trial Data Management- Standard Operating Procedures, Data management plan, CRF & Data base design considerations, Study set-up, Data entry, CRF tracking and corrections, Central lab, IVRS, source data. Data cleaning, managing laboratory and ADR data, Data transfer and database lock, Quality Control and Quality Assurance in CDM, Data mining and warehousing		
UNIT – III	DOCUMENTATION, ASSESSMENT AND EVALUATION OF QC / QA	9 periods
Document preparation for QC/QA norms of different sectors. Quality control in Microbiology. Laboratory, assessment of aseptic condition, evaluation of possible channels of contamination, QC /QA norms for handling pathological samples		
UNIT – IV	QUALITY SYSTEM REGULATIONS AND QUALITY CONTROL OF MEDICAL DEVICES	9 periods
Quality System Requirements 21 CFR Part 820, Labeling requirements 21 CFR Part 801, Post marketing surveillance of MD and Unique Device Identification (UDI), Quality System requirements and clinical evaluation and investigation. IMDRF study groups and guidance documents, ISO 13485, Quality Risk Management of Medical Devices: ISO 1497		
UNIT-V	QUALITY IN FOOD, NUTRACEUTICALS, BIOLOGICAL AND COSMETIC PRODUCTS	9 periods
WHO guidelines on nutrition. NSF International: Its Role in the Dietary Supplements and Nutraceuticals Industries, NSF Certification, NSF Standards for Food and Dietary Supplements. Good Manufacturing Practices for Nutraceuticals, Quality, safety and legislation for herbal products in India, USA and European Union, Analysis of Cosmetics, Toxicity screening and test methods: Quality control and toxicity studies as per Drug and Cosmetics Act, Analysis of Food additives- milk constituents and milk products- Pesticide analysis		

Contact Periods:
Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOK

1	Mindy J. Allport-Settle, ***Current Good Manufacturing Practices: Pharmaceutical, Biologics, and Medical Device Regulations and Guidance Documents Concise Reference,*** Pharmalogika Inc., USA, 2009.
2	J Evans and W Linsay, ***The Management and Control of Quality***, 6'th Edition, Thomson, 2005

REFERENCES

1	***Good Manufacturing Practices for Pharmaceutical***; A Plan for total Quality Control, 4^{th} Ed, Sidney willing, 2006
2	F. R., Berory and Robert A. Nash, ***Quality Assurance Guide by Organization of Pharmaceutical producers of India, Pharmaceutical Process Validation***, 2008
3	Mitra A., ***Fundamentals of Quality Control and Improvement*** PHI, 2nd Ed., 2012.
4	Willig, H., Tuckeman, M.M. and Hitchings, W.S., “Good Manufacturing Practices for Pharmaceuticals”, 5th Edition, Marcel Dekker Drugs and the Pharmaceutical Sciences, by CRC Press, New York, 2000.

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom’s Taxonomy Mapped**
CO1	Understand the basics and importance of QA and QC in biotechnology industries	K1
CO2	Understand the quality assurance and quality control in clinical trials	K1
CO3	Draft SOPs in accordance with QC/QA norms of different sectors of biotechnology	K2
CO4	Know policies and regulations and quality control of medical devices	K3
CO5	Understand the regulatory affairs of food, nutraceuticals, biological and cosmetic products based industries.	K3

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**
CO1	-	1	-	-	-	2	2	2	-	-	1	2	2	2
CO2	1	-	-	1	1	-	-	2	3	3	2	2	1	3
CO3	1	1	-	-	-	-	-	1	1	-	-	-	1	3
CO4	-	-	-	-	1	-	-	2	3	3	1	1	1	3
CO5	-	2	-	1	3	-	-	-	-	-	-	-	2	2
22BPES27	1	1	-	1	2	2	2	2	3	3	2	2	2	3

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	9.1.1, 9.1.2, 9.2.1, 9.2.2, 9.2.4, 10.1.2, 12.1.2, 12.3.2
CO2	9.1.1, 9.1.2, 9.2.1, 11.1.2, 11.3.1
CO3	3.1.1, 3.1.2, 10.1.1, 10.1.2, 11.1.2, 11.3.1
CO4	8.1.1, 8.2.1,
CO5	8.1.1, 8.2.1, 8.2.2

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT - 1	40	60	-	-	-	-	100
CAT - 2	10	40	50	-	-	-	100
Individual Assignment 1/Case study 1/ Seminar 1/ Project 1	40	60	-	-	-	-	100
Individual Assignment 2/Case study 2/ Seminar 2/ Project 2	10	40	50	-	-	-	100
ESE	10	40	50	-	-	-	100

22BPE$28	ENTREPRENEURSHIP AND PATENT DESIGN

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	To enable the students to get familiarize with the different sources of entrepreneurial opportunities, to train the students in developing entrepreneurial skills with an understanding of finance management, marketing strategies, ethical and legal issues related to various business affairs and to provide knowledge on various aspects of Patents law and practices.	
UNIT – I	**INTRODUCTION TO ENTREPRENEURSHIP**	**9 Periods**
Entrepreneurship Definition; Skills necessary for an Entrepreneur, Stages in entrepreneurship process, Role of entrepreneurship in economic development, Entrepreneurship- Innovation risk and failure.		
UNIT – II	**BUSINESS MODELS AND FUNDING SOURCES**	**9 Periods**
Business models- Vertical model, Platform business model, Service business model from bio based companies, Product model; Grants and Funding sources - Initial public offering, Government Grants, Informal funding, Pre seed and seed, Business angels, Venture capital, Incubators, Private investors, Creative financing, Corporate partners.		
UNIT – III	**BUSINESS PLANNING AND DEVELOPMENT**	**9 Periods**
Start-up Idea, Customers, Competitors, Resources, Technology, Planning, People, Writing business proposal, Checklist for business proposal writing; Location selection for business set up, Marketing Strategy, Financial management, Staff appointment and Management, Business Protection and Insurance- importance, Record Keeping and Accounting. Case studies on successful entrepreneurs- reason for success and failures.		
UNIT – IV	**INTRODUCTION TO IPR AND PATENT**	**9 Periods**
Introduction - Invention and Creativity - Intellectual Property (IP) - Importance - Protection of IPR. Patent- Historical development, Concepts, Novelty, Utility, Inventiveness/ Non-obviousness; Patentable subject matter, Patentability criteria, non-patentable inventions, Patent protection of pharmaceutical products and process, Software Patents, Patenting of Micro-organism.		
UNIT – V	**PATENT LAW AND PRACTICES**	**9 Periods**
Patent act and amendments, Rights of patentee, Procedure for granting a patent and obtaining patents, Grounds for opposition Working of Patents, Compulsory License Acquisition, Surrender, Revocation, Restoration, Transfer of patent rights; Patent infringement- types, determination of infringement, infringer, official machinery, controller, powers and functions, Defenses to infringement, Case Studies on - Patents (Basumati rice, Turmeric, Neem, etc.)		
Contact Periods: **Lecture: 45 Periods** **Tutorial: 0 Periods** **Practical: 0 Periods** **Total: 45 Periods**		

TEXT BOOK

1	Jogdand S.N, "***Entrepreneurship and Business of Biotechnology***", Himalaya Publishing Home, 2007.
2	Damian Hine, John Kapeleris and Edward Elgar, "***Innovation and Entrepreneurship in Biotechnology: An International Perspective, Concepts, Theories and Cases***", Edward Elgar Publishing Ltd, 2006.

REFERENCES

1	Oliver R, "***The coming biotech age: The business of biomaterials***", New York, McGraw Hill, 2000.
2	Cynthia Robbins-Roth, "***From Alchemy to IPO: The Business of Biotechnology***", Basic Books, 2001.
3	Subbaram N.R, "***Handbook of Indian Patent Law and Practice***", S. Viswanathan Printers and Publishers Pvt. Ltd., 1998
4	N.S.Gopalakrishnan and T.G. Agitha, "***Principles of Intellectual Property***", Eastern Book Company, Lucknow, 2nd edition, 2014.

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Develop an ability to communicate effectively, inculcate entrepreneurial skills leading to innovation and risk management	K2
CO2	Demonstrate an ability to grab business opportunity and to gain support from various funding sources for the venture.	K2
CO3	Propose and develop appropriate business plan with a priority of business protection and analyse the reasons for success and failures of the real entrepreneurs to lead a profitable business.	K3
CO4	Classify the different forms of IPR and discriminate the patentable and non patentable inventions.	K3
CO5	Relate the patent law and application process and explore the patent infringement.	K3

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	-	-	-	-	-	-	-	-	3	1	-	1	-	3
CO2	-	-	-	-	-	-	-	-	3	-	3	-	-	3
CO3	-	-	2	-	-	-	-	-	-	2	3	-	-	3
CO4	-	-	-	-	-	-	-	3	-	-	-	-	-	3
CO5	-	-	-	-	-	-	-	3	-	-	-	-	-	3
22BPE$28	-	-	1	-	-	-	-	2	2	1	2	1	-	3

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	9.1.1, 9.1.2, 9.2.1, 9.2.2, 9.2.4, 10.1.2, 12.1.2, 12.3.2
CO2	9.1.1, 9.1.2, 9.2.1, 9.2.2, 9.2.4, 11.1.2, 11.3.1
CO3	3.1.1, 3.1.2, 10.1.1, 10.1.2, 10.2.1, 11.1.2, 11.3.1
CO4	8.1.1, 8.2.1, 8.2.2
CO5	8.1.1, 8.2.1, 8.2.2

ASSESSMENT PATTERN							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT - 1	40	60	-	-	-	-	100
CAT - 2	10	40	50	-	-	-	100
Individual Assignment 1/Case study 1/ Seminar 1/ Project 1	40	60	-	-	-	-	100
Individual Assignment 2/Case study 2/ Seminar 2/ Project 2	10	40	50	-	-	-	100
SESE	10	40	50	-	-	-	100

22BPE$29	INTELLECTUAL PROPERTY RIGHTS IN BIOTECHNOLOGY

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	To provide comprehensive knowledge to the students regarding the general principles of IPR, concept and theories, international regime relating to IPR. Students will learn the fundamentals and advanced strategies of IP. They will be given opportunity for understanding the same in MSME sector. They will be finally being provided with brief exposure about the valuation techniques and audits of IP.	
UNIT–I	**INTRODUCTION**	**9 Periods**
Introduction to IPR, Basic concepts and need for Intellectual Property - Patents, Copyrights, Geographical Indications, IPR in India and Abroad – Genesis and Development – the way from WTO to WIPO –TRIPS, Nature of Intellectual Property, Industrial Property, technological Research, Inventions and Innovations – Important examples of IPR.		
UNIT–II	**REGISTRATIONOFIPR**	**9 Periods**
Meaning and practical aspects of registration of Copy Rights, Trademarks, Patents, Geographical Indications, Trade Secrets and Industrial Design registration in India and Abroad.		
UNIT–III	**AGREEMENTSANDLEGISLATIONS**	**9 Periods**
International Treaties and Conventions on IPRs, TRIPS Agreement, PCT Agreement, Patent Act of India, Patent Amendment Act, Design Act, Trademark Act, Geographical Indication Act.		
UNIT–IV	**ENFORCEMENTOFIPR**	**9 Periods**
Infringement of IPRs, Enforcement Measures, Emerging issues–Case Studies.		
UNIT–V	**IPRINBIOTECHNOLOGY**	**9 Periods**
Basic features of Indian Plant Varieties Protection & Farmer's Rights Act, UPOV, Invention/ Discovery, Patentable subject matter, Generics, Compulsory Licensing, Exclusive Marketing Rights (EMR), Bolar provision, Bayh-Dole act, Second medical use.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXTBOOK

1	S.V.Satakar,*"**Intellectual Property Rights and Copy Rights**"*, Ess Ess Publications, New Delhi, 2002
2	Deborah E. Bouchoux, *"**Intellectual Property: The Law of Trademarks, Copy rights, Patents and Trade Secrets**"*, Cengage Learning, Third Edition, 2012

REFERENCES

1	V.Scople Vinod, ***Managing Intellectual Property***, Prentice Hall of India pvt Ltd, 2012.
2	Prabuddha Ganguli,***"Intellectual Property Rights: Unleashing the Knowledge Economy"***, McGraw Hill Education, 2011.
3	Edited by Derek Bosworth and Elizabeth Webster, ***The Management of Intellectual Property, Edward*** Elgar Publishing Ltd., 2013.
4	N.S.Gopalakrishnan and T.G.Agitha,"***Principles of Intellectual Property***", Eastern Book Company, Lucknow, 2nd edition, 2014.

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Identify different types of Intellectual Properties (IPs), the right of ownership, scope of protection as well as the ways to create and to extract value from IP.	K1
CO2	To learn the procedure of obtaining Patents, Copyrights, Trade Marks & Industrial design.	K2
CO3	To make the students to understand the statutory provisions of different forms of IPRs in simple forms.	K2
CO4	Identify activities and constitute IP infringements and the remedies available to the IP owner and describe the precautious steps to be taken to prevent infringement of Proprietary rights in products and technology development.	K3
CO5	Explore the visionary aspects in the areas of Biotechnology.	K3

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	-	-	-	-	-	1	-	-	-	-	-	1	1	2
CO2	-	-	-	-	-	-	1	-	-	-	-	-	1	2
CO3	-	-	-	-	-	-	2	-	-	-	-	1	1	2
CO4	-	-	-	-	-	1	-	-	-	-	-	-	1	2
CO5	-	-	-	-	-	-	-	-	-	-	2	1	1	2
22BPE$29	-	-	-	-	-	2	2	-	-	-	1	1	1	2

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.2.1, 2.1.2
CO2	1.2.1, 2.1.2
CO3	1.2.1, 2.1.2
CO4	1.2.1, 2.1.2
CO5	1.2.1, 2.1.2

ASSESSMENT PATTERN							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT - 1	40	60	-	-	-	-	100
CAT - 2	30	70	-	-	-	-	100
Individual Assignment 1/Case study 1/ Seminar 1/ Project 1	60	40	-	-	-	-	100
Individual Assignment 2/Case study 2/ Seminar 2/ Project 2	30	70	-	-	-	-	100
ESE	40	60	-	-	-	-	100

22BPE$30	BIOSAFETY AND HAZARD MANAGEMENT

PREREQUISITES: NIL	CATEGORY	L	T	P	C
	PE	3	0	0	3

Course Objectives	To enable the students to recognize the issues related to environment biosafety. To understand the various standards of GMOs. To acquire knowledge about the regulatory framework of GMOs in India & at international level. To study about the types of hazards and the measurement procedures. To demonstrate techniques involved in hazard waste management.	
UNIT – I	**INTRODUCTION - BIOSAFETY**	**9 periods**
Introduction - Historical Background - Introduction to Biological Safety Cabinets - Primary Containment for Biohazards - Biosafety Levels - Biosafety Levels for handling Infectious agents and GMOs - Biosafety guidelines - Government of India - Definition of GMOs & LMOs - Environmental release of GMOs - Risk Analysis - Risk Assessment; Risk management and communication.		
UNIT – II	**BIOSAFETY- REGULATORY FRAMEWORK FOR GMOS IN INDIA**	**9 periods**
Regulatory framework in India governing GMOs-Recombinant DNA Advisory Committee (RDAC) - Institutional Biosafety Committee (IBC) - Review Committee on Genetic Manipulation, Genetic Engineering Approval Committee (GEAC) - State Biosafety Coordination Committee (SBCC) - District Level Committee (DLC). Recombinant DNA Guidelines (2017) - Seed Policy (2002) The Food Safety and Standards Bill (2005) - Plant Quarantine Order (2003) - Regulation for Import of GM Products Under Foreign Trade Policy (2006-2007) - National Environment Policy (2006) - Rules for the manufacture, use/import/export and storage of hazardous microorganisms/genetically engineered organisms or cells (Ministry of Environment and Forests Notification, 1989), National biodiversity regulations.		
UNIT – III	**BIOSAFETY-REGULATORY FRAMEWORK FOR GMOS AT INTERNATIONALLEVEL**	**9 periods**
Convention of Biological Diversity (1992) – Cartagena Protocol on Biosafety – Objectives and salient features of Cartagena Protocol – Advanced Information Agreement (AIA) procedure – procedures for GMOs intended for direct use-risk assessment-risk management-handling, transport, packaging and identification of GMOs-Biosafety Clearing House-unintentional transboundary movement of GMOs-Benefits of becoming a party to the Cartagena Protocol status of implementation in India.		
UNIT – IV	**PHYSICAL, CHEMICAL AND BIOLOGICAL HAZARDS**	**9 periods**
Noise compensation aspects- noise exposure regulation-properties of sound, occupational damage-risk factors-sound measuring instruments- octave band analyser, Recognition of chemical hazards-dust, fumes, mist, vapor, fog, gases, Types- Measurement Procedure-Instruments Procedure- Gas and Vapor monitors- dust sample collection devices- personal sampling; Classification of Biohazardous agents–examples- bacterial agents- rickettsial and chlamydial agents-viral agents, fungal, parasitic agents, infectious diseases-Biohazard control program-employee health program-laboratory safety program.		

UNIT – V	HAZARDOUS WASTE MANAGEMENT	9 periods
Phytoremediation and Biomining; Biofertilizers and Biopesticides; Biofuel and Fundamentals of Composting process; Biosensors and its application in environmental issues. Production of bioelectricity from microbial fuel cell (MFC). Current status of biotechnology in environment protection and its future.		
Contact Periods: **Lecture: 45 Periods Tutorial:0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOK

1	Singh. B.D, ***"Biotechnology"***, 1st Edition, Kalyani Publishers, 2003.
2	Krishnan N.V, "***Safety Management in Industry***", 1st Edition, Jaico Publishing House, Bombay, 1997.
3	Hyatt N, ***"Guidelines for process hazards analysis, hazards identification & risk analysis",*** Dyadem Press, 2004.

REFERENCES:

1	Sasson A, ***"Biotechnologies and Development",*** UNESCO Publications, 2010.
2	Singh K, ***"Intellectual Property rights on Biotechnology",*** BCIL, New Delhi, 2010.
3	Regulatory Framework for GMOs in India, Ministry of Environment and Forest, Government of India, New Delhi, 2006.
4	Cartagena Protocol on Biosafety, Ministry of Environment and Forest, Government of India, New Delhi, 2006.

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Understand the basics and guidelines of biosafety.	K1
CO2	Familiarize about the Indian standard of GMOs.	K1
CO3	Familiarize about the International regulatory frameworks for GMOs.	K2
CO4	Identify and analyze various types of hazards present in physical, chemical, and biological agents in a process	K1
CO5	Gain the knowledge about the hazardous waste management.	K2

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs / POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	1	1	-	-	-	-	-	-	-	3	1	3	1
CO2	1	2	-	1	-	-	1	2	-	-	-	-	1	3
CO3	1	2	1	1	-	-	-	1	2	-	-	1	1	1
CO4	1	1	1	1	2	-	-	-	1	-	-	-	1	1
CO5	1	2	1	1	-	-	3	2	1	-	-	1	1	1
22BPE$30	1	2	1	1	1	-	1	2	1	-	-	1	1	1

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	2.2.2,3.1.1,11.3.1,12.2.2
CO2	2.2.3,4.1.2,7.2.1
CO3	1.3.1,2.1.2
CO4	1.4.1,2.2.4,4.3.1,9.2.1
CO5	1.2.1,7.1.1, 8.1.1

ASSESSMENT PATTERN

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3)%	Analyzing (K4) %	Evaluating (K5) %	Creating (K6)%	Total %
CAT - 1	70	30	-	-	-	-	100
CAT - 2	60	40	-	-	-	-	100
Individual Assignment 1/Case study 1/ Seminar 1/ Project 1	50	50	-	-	-	-	100
Individual Assignment 2/Case study 2/ Seminar 2/ Project 2	40	60	-	-	-	-	100
ESE	60	40	-	-	-	-	100

22BPE$31	CONSERVATION ECONOMICS

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	To understand the economics. To understand the conservation biology. To eligible to understand the role economics in conservation of ecosystem.	
UNIT -I	**INTRODUCTION TO ECONOMICS**	**9 Periods**
Economics and the economy, theory and models in economic analysis, positive and normative economics, introduction to micro and macroeconomics.		
UNIT – II	**CONSERVATION BIOLOGY**	**9 Periods**
Introduction to conservation biology; Values of biodiversity and conservation ethics; Patterns and process of biodiversity; Losses and threats to biodiversity, Community and ecosystem level conservation; Theories, planning and designing conservation reserves.		
UNIT – III	**ENVIRONMENTAL MANAGEMENT SYSTEMS**	**9 Periods**
Pollution control Vs Pollution prevention, cleaner production concepts, Source reduction, Raw material substitution, Process modification, Toxic use reduction and Elimination, Opportunities and barriers of CP, Cleaner production project development and implementation, cleaner production assessment and applications.		
UNIT – IV	**ENVIRONMENTAL ECONOMICS**	**9 Periods**
Market failure, Externalities, Common goods and public goods, Ecosystem valuation, Solution to correct externalities – Environmental regulation, Quotas on pollution, Taxes and tariff on pollution, Pigovian tax, Ecological Economics, Green economy, Ecolabel, Green washing, Low-carbon economy.		
UNIT – V	**CASE STUDIES**	**9 Periods**
Economics of protected area-sanctuaries, national parks, economics of environmental disasters-mercury contamination in fishes, The Delhi smog, The love canal, New York.		
Contact Periods: **Lecture: 45 Periods** **Tutorial: 0 Periods** **Practical: 0 Periods** **Total: 45 Periods**		

TEXT BOOK

1	*Ahmed, M. H.. "**Principles of Environmental Economics and Sustainability: An Integrated Economic and Ecological Approach**", Routledge publisher, ISBN 0415676908,2015.*
2	*llls, **Economics**, Worth Publishers Inc.,U.S.; 3rd edition,2012.*

REFERENCES

1	*Scott, J. C., Janet, M. T., "**Environmental Economics and Management Theory, Policy and Applications**", South Western publishers, ISBN-10: 8131527646,2015.*
2	*Sharma J.P., Ënvironmental Studies", 3rd Edition, University Science Press, New Delhi, 2009.*
3	*Anubha Kaushik and C.P. Kaushik, Ënvironmental Science and Engineering", 3rd Edition, New age International Publishers, New Delhi, 2008.*
4	*R.K.Trivedi, "Hand book of Environmental laws, Rules, Guidelines, Compliances and Standards", Vol.I&II.Environ Media, 2006.*

COURSE OUTCOMES: On completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	learn about the concept of economics	K1
CO2	establish the need of conservation of wildlife	K1
CO3	Understand various environmental management systems	K2
CO4	develop the skills of environmental economics	K2
CO5	Understand conservation economics	K2

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs / POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2
CO1	1	-	-	-	-	2	3	-	-	-	-	-	3	3
CO2	1	-	-	-	-	3	3	-	-	-	-	-	3	2
CO3	1	-	-	-	-	2	3	-	-	-	-	-	3	2
CO4	1	-	-	-	-	2	3	-	-	-	-	-	3	1
CO5	1	-	-	-	-	2	3	-	-	-	-	-	3	1
22BPE$31	1	-	-	-	-	2	3	-	-	-	-	-	3	1

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.2.1,1.3.1,1.4.1,2.2.1,4.1.2,4.1.3
CO2	1.2.1, 2.1.3
CO3	1.2.1, 1.3.1,2.1.3
CO4	1.2.1, 1.3.1,2.1.3
CO5	2.4.1, 3.2.1,4.2.1,5.2.1

ASSESSMENT PATTERN – THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT - 1	60	40	-	-	-	-	100
CAT - 2	50	50	-	-	-	-	100
Individual Assignment 1/Case study 1/ Seminar 1/ Project 1	50	50	-	-	-	-	100
Individual Assignment 2/Case study 2/ Seminar 2/ Project 2	60	40	-	-	-	-	100
ESE	50	50	-	-	-	-	100

22BPE$32	CHEMICAL PROCESS SAFETY

PREREQUISITES:	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	Become a skilled person in hazopard hazarel analysis and finding out the root cause of an accident. Gain knowledge in devising safety policy and procedures to be adopted to implement total safety in a plant.	
UNIT – I	**INTRODUCTION TO SAFETY IN INDUSTRIES**	**9 Periods**
Need for safety in industries; Safety Programmes – components and realization; Potential hazards - extreme operating conditions, toxic chemicals; safe handling.		
UNIT – II	**IMPLEMENTATION OF SAFETY PROCEDURES**	**9 Periods**
Implementation of safety procedures – periodic inspection and replacement; Accidents – identification and prevention; promotion of industrial safety.		
UNIT – III	**RISK ANALYSIS**	**9 Periods**
Overall risk analysis--emergency planning-on site & off site emergency planning, risk management ISO 14000, EMS models case studies. Quantitative risk assessment - rapid and comprehensive risk analysis; Risk due to Radiation, explosion due to over pressure, jet fire-fire ball.		
UNIT – IV	**HAZARD IDENTIFICATION ANALYSIS**	**9 Periods**
Hazard identification safety audits, checklist, what if analysis, vulnerability models event tree analysis fault tree analysis, Hazan past accident analysis Fixborough-Mexico-Madras-Vizag-Bopal analysis/		
UNIT – V	**HAZOP STUDIES**	**9 Periods**
Hazop-guide words, parameters, derivation-causes-consequences-recommendation-coarse Hazop study-case studies-pumping system-reactor-mass transfer system.		
Contact Periods: **Lecture: 45 Periods** **Tutorial:0 Periods** **Practical: 0 Periods** **Total: 45 Periods**		

TEXT BOOK

1	Daniel A. Crowl, J.F. Louvar, Prantice Hall, NJ,' ***Chemical Process Safety: Fundamentals with Applications***, 1990
2	Marcel, V.C., ***Major Chemical Hazard***- Ellis Harwood Ltd., Chi Chester, UK, 1987.

REFERENCES:

1	Handley, W., *"**Industrial Safety Hand Book** "*, 2nd Edn., McGraw-Hill Book Company, 1969
2	Heinrich, H.W. Dan Peterson, P.E. and Rood, N., " ***Industrial Accident Prevention***", McGraw Hill Book Co., 1980.
3	Taylor, J.R., ***Risk analysis for process plant, pipelines and transport***, Chapman and Hall, London, 1994.
4	Fawatt, H.H. and Wood, W.S., *"**Safety and Accident Prevention in Chemical Operation**",* Wiley Interscience, 1965.

COURSE OUTCOMES: On completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Demonstrate the awareness of plant safety in selection and layout of chemical plants and the usage of safety codes.	K1
CO2	Exhibit the skill in classifying chemical, fire, explosion hazards and to understand the occupational diseases.	K1
CO3	Analyze the bio medical and engineering response to health hazards and to implement the effective process control and instrumentation.	K2
CO4	Analyze various safety protocols involved in industries.	K1
CO5	Study on different situation pertaining in environmental management in chemical process industries.	K2

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs / POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	1	1	-	-	-	-	-	-	-	3	1	3	1
CO2	1	2	-	1	-	-	1	2	-	-	-	-	1	3
CO3	1	2	1	1	-	-	-	1	2	-	-	1	1	1
CO4	1	1	1	1	2	-	-	-	1	-	-	-	1	1
CO5	1	2	1	1	-	-	3	2	1	-	-	1	1	1
22BPE$32	1	2	1	1	1	-	1	2	1	-	-	1	1	1

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	2.2.2,3.1.1,11.3.1,12.2.2
CO2	2.2.3,4.1.2,7.2.1
CO3	1.3.1,2.1.2
CO4	1.4.1,2.2.4,4.3.1,9.2.1
CO5	1.2.1,7.1.1, 8.1.1

ASSESSMENT PATTERN

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT - 1	70	30	-	-	-	-	100
CAT - 2	60	40	-	-	-	-	100
Individual Assignment 1/Case study 1/ Seminar 1/ Project 1	50	50	-	-	-	-	100
Individual Assignment 2/Case study 2/ Seminar 2/ Project 2	40	60	-	-	-	-	100
ESE	60	40	-	-	-	-	100

22BPE$33	HUMAN ANATOMY AND PHYSIOLOGY

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	To understand the structure and functions of the various systems of human body. To acquire knowledge on the importance of anatomical features and physiology of different human systems	
UNIT – I	**HUMAN ANATOMY**	**9 Periods**
Basics of human anatomy, tissues of the human body- epithelial, connective, muscular and nervous tissues, their sub types and characteristics. Skeletal system- Structure, composition, classification of joint, anatomy of skeletal muscles.		
UNIT – II	**CIRCULATORY SYSTEM**	**9 Periods**
Circulatory system- Blood, lymph composition and function. Basic anatomy of the heart. Physiology of heart, blood vessels and circulation. Basic understanding of cardiac cycle, heart sounds and electrocardiogram. Blood pressure and its regulation. Brief outline of cardiovascular disorders like hypertension, hypotension, atherosclerosis, angina, myocardial infarction, congestive heart failure and cardiac arrhythmias.		
UNIT – III	**DIGESTIVE AND ENDOCRINE SYSTEM**	**9 Periods**
Digestive System- Anatomy of the gastro intestinal tract, functions of its different parts: liver, pancreas and gall bladder, various gastrointestinal secretions and their role in the absorption and digestion of food. Endocrine system- anatomy and functions of pituitary gland, adrenal gland, parathyroid gland, pancreas.		
UNIT – IV	**RESPIRATORY, URINARY AND REPRODUCTIVE SYSTEM**	**9 Periods**
Respiratory System- Anatomy of respiratory organs. Functions of respiration, mechanism and regulation of respiration, respiratory volumes and vital capacity. Urinary System- Various parts, structures and functions of the kidney and urinary tract. Reproductive system- testes and ovary, Anatomy and physiology of various parts of male and female reproductive systems.		
UNIT – V	**GLOBAL ISSUES**	**9 Periods**
Central Nervous System- Functions of different parts of brain and spinal cord. Neuro-chemical transmission in central nervous system, reflex action, cranial nerves and their functions. Autonomic Nervous System- Physiology and functions of autonomic nervous system-mechanism of neuro humoral transmission in A.N.S.		
Contact Periods: **Lecture: 45 Periods** **Tutorial: 0 Periods** **Practical: 0 Periods** **Total: 45 Periods**		

TEXT BOOK

1	*Gerad. J. Tortora and Bryan H. Derrickson, **Principles of Anatomy and Physiology**, 16th edition, Wiley, 2020.*
2	*C.C.Chatterjee, **Human Physiology**, 13th edition, Vol I and II, CBS publishers and distributors, 2020.*

REFERENCES

1	*John. E. Hall, Guyton and Hall* **Textbook of Medical Physiology**, *14th edition, Elseiver, 2*
2	*K. Sembulingam, Prema Sembulingam,* **Essentials of Medical Physiology**, *8th edition, Jaypee Brothers, New Delhi, 2019.*
3	*Marieb, Elaine N. and Katja Hoehn,* **Human Anatomy & Physiology**, *11th edition, Pearson publishers, 2018.*
4	*Frederic H. Martini, Judi L. Nath, Edwin F. Bartholomew,* **Fundamentals of Anatomy and Physiology**. *Tenth Edition, Pearson Publishers, 2014*

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Recognize the basic structural and functional elements of human body and human skeletal system.	K1
CO2	Identify the anatomical and physiological characteristics of human circulatory system.	K1
CO3	Differentiate the various structural and functional components of human digestive and endocrine system.	K2
CO4	Report the anatomical features and physiology of human respiratory, urinary and reproductive system	K2
CO5	Classify the structural framework and key functions of central nervous system.	K2

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2
CO1	1	1	-	-	-	2	-	-	-	-	-	-	3	1
CO2	1	1	-	-	-	2	-	-	-	-	-	-	3	1
CO3	1	1	-	-	-	2	-	-	-	-	-	-	3	1
CO4	1	1	-	-	-	2	-	-	-	-	-	-	3	1
CO5	1	1	-	-	-	2	-	-	-	-	-	-	3	1
22BPE$33	1	1	-	-	-	2	-	-	-	-	-	-	3	1

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.2.1, 2.1.2, 6.2.1
CO2	1.2.1, 2.1.2, 6.2.1
CO3	1.2.1, 2.1.2, 6.2.1
CO4	1.2.1, 2.1.2, 6.2.1
CO5	1.2.1, 2.1.2, 6.2.1

ASSESSMENT PATTERN							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT - 1	50	50	-	-	-	-	100
CAT - 2	40	60	-	-	-	-	100
Individual Assignment 1/Case study 1/ Seminar 1/ Project 1	60	40	-	-	-	-	100
Individual Assignment 2/Case study 2/ Seminar 2/ Project 2	30	70	-	-	-	-	100
ESE	50	50	-	-	-	-	100

22BPE7$34	BIOETHICS

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	To enlighten the students about the ethical issues and responsibilities. To discuss about the safety and risk assessment in various industrial process	
UNIT – I	**ENGINEERING ETHICS**	**9 Periods**
Cardinal virtues and their development, concept of morality, ordinal virtues, Senses of "Engineering Ethics" – Variety of moral issues – Types of inquiry – Moral dilemmas – Moral Autonomy – Kohlberg"s theory – Gilligan"s theory – Consensus and Controversy – Professions and Professionalism – Professional Ideals and Virtues – Uses of Ethical Theories		
UNIT – II	**ENGINEERING AS SOCIAL EXPERIMENTATION**	**9 Periods**
Engineering as Experimentation – Engineers as responsible Experimenters – Research Ethics - Codes of Ethics – Industrial Standards - A Balanced Outlook on Law – The Challenger Case Study..		
UNIT – III	**ENGINEER'S RESPONSIBILITY FOR SAFETY**	**9 Periods**
Safety and Risk – Assessment of Safety and Risk – Risk Benefit Analysis – Reducing Risk – The Government Regulator's Approach to Risk - Chernobyl and Bhopal Case Studies.		
UNIT – IV	**RESPONSIBILITIES AND RIGHTS**	**9 Periods**
Collegiality and Loyalty – Respect for Authority – Collective Bargaining – Confidentiality – Conflicts of Interest – Occupational Crime – Professional Rights – Employee Rights – Intellectual Property Rights (IPR) - Discrimination.		
UNIT – V	**GLOBAL ISSUES**	**9 Periods**
Multinational Corporations – Business Ethics - Environmental Ethics – Computer Ethics - Role in Technological Development – Weapons Development – Engineers as Managers – Consulting Engineers – Engineers as Expert Witnesses and Advisors – Honesty – Moral Leadership – Sample Code of Conduct.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOK

1	Mike Martin and Roland Schinzinger, "***Ethics in Engineering***", McGraw Hill, New York, 2005.
2	Charles E Harris, Michael S Pritchard and Michael J Rabins, "***Engineering Ethics – Concepts and Cases***", Thompson Learning, 2000.

REFERENCES

1	Charles D Fleddermann, "***Engineering Ethics***", Prentice Hall, New Mexico, 1999.
2	John R Boatright, "***Ethics and the Conduct of Business***", Pearson Education, 2003.
3	Edmund G Seebauer and Robert L Barry, "***Fundamentals of Ethics for Scientists and Engineers***", Oxford University Press, 2001.
4	Prof. (Col) P S Bajaj and Dr. Raj Agrawal, "***Business Ethics – An Indian Perspective***", Biztantra, New Delhi, 2004.

COURSE OUTCOMES: On completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Get familiarize with the basics of work ethics.	K2
CO2	Be aware of the engineer's social responsibility and standard industrial operating procedures.	K2
CO3	Acquire the responsibility of an engineer towards safety.	K2
CO4	Report the different ethical rights and responsibilities of an engineer.	K3
CO5	Explore the various global issues related to professional ethics.	K3

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	-	-	-	-	-	3	2	3	-	-	-	-	-	3
CO2	-	-	-	-	-	3	2	3	1	-	-	-	-	3
CO3	-	-	-	-	-	3	2	3	-	-	-	-	-	3
CO4	-	-	-	-	-	3	2	3	-	-	-	-	-	3
CO5	-	-	-	-	-	3	2	3	-	-	-	-	-	3
22BPE7$34	-	-	-	-	-	3	2	3	1	-	-	-	-	3

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	6.1.1, 6.2.1, 7.1.2, 7.2.2, 8.1.1, 8.2.1, 8.2.2
CO2	6.1.1, 6.2.1, 7.1.2, 7.2.2, 8.1.1, 8.2.1, 8.2.2, 9.1.2
CO3	6.1.1, 6.2.1, 7.1.2, 7.2.2, 8.1.1, 8.2.1, 8.2.2
CO4	6.1.1, 6.2.1, 7.1.2, 7.2.2, 8.1.1, 8.2.1, 8.2.2
CO5	6.1.1, 6.2.1, 7.1.2, 7.2.2, 8.1.1, 8.2.1, 8.2.2, 9.1.2

ASSESSMENT PATTERN

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT - 1	40	60	-	-	-	-	100
CAT - 2	10	40	50	-	-	-	100
Individual Assignment 1/Case study 1/ Seminar 1/ Project 1	40	60	-	-	-	-	100
Individual Assignment 2/Case study 2/ Seminar 2/ Project 2	10	40	50	-	-	-	100
ESE	10	40	50	-	-	-	100

22BPE7$35	BIOMASS AND BIOENERGY

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	To understand the importance of biomass as a resource. To familiarize with the various strategies in the production of biofuels. To evaluate various technologies on the basis of the substrates treated. To enable them to design elements and conceptualize bioenergy plants.	
UNIT – I	**BIOMASS: PROPERTIES AND TYPES**	**9 Periods**
Constituents of Biomass, Energy properties. Biomass typologies: Lignocellulosic, startchy, sugary, oilseeds,sewage sludge, manure. Biomass Conversion: Physical, Chemical, Biochemical process.		
UNIT – II	**MILESTONES IN BIOFUELS**	**9 Periods**
First generation biofuels-bioethanol; Second generation biofuels-methane and hydrogen – production mechanisms by microbes; Third generation biofuels-biobutanol-biodesel from algae; Fourth generation biofuels- solar to fuel method to produce biofuels, Microbial fuel cell		
UNIT – III	**BIODIESEL AND BIOMETHANE**	**9 Periods**
Sources and processing of biodiesel (fatty acid methyl ester); Sources and characteristics of lipids for use as biodiesel feedstock and conversion of feedstock into biodisel (transesterification); Biomethane or biogas-hydrolysis-anaerobic digestion-methanogenesis (acetoclastic, hydrogenotrophic) - rates of methane formation-one and two stage fermentation, Factors affecting gas production.		
UNIT – IV	**GASIFICATION & PYROLYSIS TECHNOLOGIES**	**9 Periods**
Gasification processes and the main types of gasifier designs-production of electricity by combining a gasifier with a gas turbine or fuel cell; Combined-cycle electricity generation with gas and steam turbines and generation of heat and steam; Fast pyrolysis technology to produce liquid bio oil or pyrolysis oil (synthetic oil) from biomass-refined to produce a range of fuels- chemicals and fertilizer, Biochar		
UNIT – V	**CHEMICAL ENGINEERING TOOLS FOR ENERGY DESIGN PROCESSES**	**9 Periods**
Reaction stoichiometry, reaction kinetics, reaction thermodynamics, reactors, process analysis and design		
Contact Periods: **Lecture: 45 Periods Tutorial:0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOK

1	Samir K. Khanal, ***"Bioenergy Production: Principles and Applications"***, Wiley-Blackwell Publishing, 1st edition, 2016.
2	David M. Mousdale, ***"Biofuels: Biotechnology, Chemistry, and Sustainable Development"***, CRC Press Taylor and Francis group,1st edition, 2008.

REFERENCES

1	Robert C. Brown, ***"Biorenewable Resources: Engineering New Products from Agriculture"***, Wiley-Blackwell Publishing, 2nd edition, 2014.
2	Pogaku, Ravindra, Sarbatly, rosalamhj. (Eds.), ***"Advances in Biofuels"***, Springer, 2013.
3	Martin Kaltschmitt and Hermann Hofbauer, ***"Biomass Conversion and Biorefinery"***, Springer Publishing, 2008.
4.	Donald L. Klass, ***"Biomass for Renewable Energy, Fuels, and Chemicals"***, Academic Press, Elsevier, 2006.

COURSE OUTCOMES: On completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Understand various organism in soil and their roles in ecosystem management	K1
CO2	Review on xenobiotic compounds and their degradation pathway.	K1
CO3	Able to explain the characteristics and biological treatment of waste water	K2
CO4	Analyze various industrial waste and their treatment process.	K2
CO5	Study on different applications of biotechnology in environmental management.	K2

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2
CO1	1	1	-	-	-	-	-	-	-	-	-	-	3	1
CO2	1	1	-	-	-	-	-	-	-	-	-	-	3	1
CO3	1	1	-	-	-	-	-	-	-	-	-	-	3	1
CO4	1	1	-	-	-	-	-	-	-	-	-	-	3	1
CO5	1	1	-	-	-	-	-	-	-	-	-	-	3	1
22BPE$35	1	1	-	-	-	-	-	-	-	-	-	-	3	1

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.4.1, 2.1.3.
CO2	1.4.1, 2.1.3.
CO3	1.4.1, 2.1.3.
CO4	1.4.1, 2.1.3.
CO5	1.4.1, 2.1.3.

ASSESSMENT PATTERN – THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT - 1	50	50	-	-	-	-	100
CAT - 2	50	50	-	-	-	-	100
Individual Assignment 1/Case study 1/ Seminar 1/ Project 1	50	50	-	-	-	-	100
Individual Assignment 2/Case study 2/ Seminar 2/ Project 2	30	70	-	-	-	-	100
ESE	50	50	-	-	-	-	100

22BPE$36	ENVIRONMENTAL BIOTECHNOLOGY

PREREQUISITES	CATEGORY	L	T	P	C
Nil	PE	3	0	0	3

Course Objectives	To enable the students to get familiar with the diverse microorganism present in the environment and their various roles in environmental safety. To furnish knowledge about various pollutants present in the environment	
UNIT – I	**FUNDAMENTALS OF SOIL MICROBIOLOGY**	**9 periods**
Microbial flora of soil, growth and ecological adaptations of soil microorganisms, interactions among soil microorganisms, biogeochemical role of soil microorganisms.		
UNIT – II	**BIODEGRADATION OF XENOBIOTIC COMPOUNDS**	**9 periods**
Xenobiotics - persistence and biomagnification; Types of Recalcitrant xenobiotic compounds; Factors causing molecular recalcitrance; microbial pathways for biodegradation of petroleum hydrocarbons – aliphatic, aromatic, polycyclic and chlorinated hydrocarbons; biodegradation of pesticides and synthetic detergents.		
UNIT – III	**WASTEWATER TREATMENT**	**9 periods**
Characteristics of Wastewater - Physical, chemical and biological; Wastewater treatment-Biological method- suspended growth and biofilm processes; design of activated sludge process; ponds and lagoons; trickling filters; anaerobic wastewater treatment; sludge digestion - design of anaerobic sludge digesters; nutrient removal – nitrogen and phosphorus.		
UNIT – IV	**INDUSTRIAL WASTEWATER MANAGEMENT**	**9 periods**
Industrial Waste management- Leather, pulp, pharmaceutical, dairy, textile and dye industries – production process, origin and characteristics of waste, waste minimization and treatment options; solid waste management; hazardous waste management – e-waste, radioactive and nuclear power waste.		
UNIT – V	**DEVELOPMENTS PERTAINING TO ENVIRONMENTAL BIOTECHNOLOGY**	**9 periods**
Phytoremediation and Biomining; Biofertilizers and Biopesticides; Biofuel and Fundamentals of Composting process; Biosensors and its application in environmental issues. Production of bioelectricity from microbial fuel cell (MFC). Current status of biotechnology in environment protection and its future.		
Contact Periods: **Lecture: 45 Periods** **Tutorial:0 Periods** **Practical: 0 Periods** **Total: 45 Periods**		

TEXT BOOK

1	Bruce E.R and Perry L.M, ***‘Environmental Biotechnology: Principle and Applications’***, McGraw Hill, 2012.
2	Patwardhan, A.D, ***‘Industrial wastewater treatment’***, PHI learning private limited, 2nd edition, 2017.

REFERENCES:

1	Scragg A, ***'Environmental Biotechnology'***, Oxford University press, 2nd edition. 2005.
2	Joanne M. W, Sherwood L, Woolverton C.J, ***'Prescott's Microbiology'***, McGraw-Hill, 8th edition, 2011.
3	Parimal pal, ***'Industrial water treatment process technology'***, Butterworth-Heinemann, 2017.
4	Mecalf & Eddy Inc, Tchobanoglous G, Burton F.L, Stensel H.D, ***'Wastewater Engineering: Treatment Disposal Reuse'***, McGraw Hill, 4th edition. 2002.

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Understand various organism in soil and their roles in ecosystem management	K1
CO2	Review on xenobiotic compounds and their degradation pathway.	K1
CO3	Able to explain the characteristics and biological treatment of waste water	K2
CO4	Analyze various industrial waste and their treatment process.	K2
CO5	Study on different applications of biotechnology in environmental management.	K2

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**
CO1	1	1	-	-	-	-	-	-	-	-	-	-	3	1
CO2	1	1	-	-	-	-	-	-	-	-	-	-	3	1
CO3	1	1	-	-	-	-	-	-	-	-	-	-	3	1
CO4	1	1	-	-	-	-	-	-	-	-	-	-	3	1
CO5	1	1	-	-	-	-	-	-	-	-	-	-	3	1
22BPE$36	1	1	-	-	-	-	-	-	-	-	-	-	3	1

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.4.1, 2.1.3.
CO2	1.4.1, 2.1.3.
CO3	1.4.1, 2.1.3.
CO4	1.4.1, 2.1.3.
CO5	1.4.1, 2.1.3.

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6)%**	**Total %**
CAT - 1	50	50	-	-	-	-	100
CAT - 2	50	50	-	-	-	-	100
Individual Assignment 1/Case study 1/ Seminar 1/ Project 1	50	50	-	-	-	-	100
Individual Assignment 2/Case study 2/ Seminar 2/ Project 2	30	70	-	-	-	-	100
ESE	50	50	-	-	-	-	100

22BPE$37	BIOPOLYMER TECHNOLOGY

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	To understand the different types of biopolymers in biomedical applications, environmental protection, application of bio surfactants in food industry and to examine the different properties and market analysis through case studies.	
UNIT – I	**INTRODUCTION**	**9 Periods**
Biopolymers - definition, Plant and Animal biopolymers- polynucleotide, polyamides, polysaccharides, polyisoprene, lignin, polyphosphate and polyhydroxyalkanoates. Application and chemical synthesis of super absorbent polymers-Polyethylene glycol, Polypropylene glycol, Polytetramethylene glycol, Polyglycerine. Bioplastics and environment, Commercial bioplastics. Natural fibers like silk, wool, flax, jute, linen, cotton, bamboo. Biocomposite-properties and applications.		
UNIT – II	**BIOPOLYMER TECHNOLOGY AND APPLICATIONS**	**9 Periods**
Industrial biopolymers: Production of polyphenol resins by the enzyme soybean peroxidase; Novel synthesis of Artificial Biopolymers in Biomedical Applications- An Overview, Hydrogel as potential Nano scale drug delivery system , Low cost foods and drugs using immobilized enzymes on Biopolymers, Physiochemical characteristics of biopolymers. Biodegradable polymers for medical purposes, Biopolymers in controlled release systems. Synthetic polymeric Membranes and their biological applications.		
UNIT – III	**BIOSURFACTANTS**	**9 Periods**
Biosurfactants: Source, characteristics and properties of Biosurfactants; Production of Biosurfactants via the fermentation and biotransformation routes; Production of Biosurfactants with immobilized cells; Integrated bioprocess for continuous production of Biosurfactants including downstream processing; Applications of Biosurfactants – Food Industry, Environmental Control.		
UNIT – IV	**MATERIAL TESTING AND ANALYTICAL METHODS**	**9 Periods**
An Overview of Available Testing Methods, Comparison of Test Systems for the Examination of the Fermentability of Biodegradable Materials, Evaluation of the properties of biopolymers to make good biomaterials; Tensile strength (both elasticity and breaking strength); Hydration, visco – elastic properties; viscosity. Criteria used in the evaluation of Biodegradable polymers – petridish screen – environmental chamber method – soil burial tests etc.		
UNIT – V	**CASE STUDIES**	**9 Periods**
Biopolymers: Synthesis from a simple biological monomer (i.e. Hyaluronate polymers); Dextran (used in chromatography columns); Rubberlike materials produced by bacteria and fungi – Polyhydroxybutyrate (PHB), Polycaprolactone (PCL), Xanthan gum; Production of a copolymer of PHB and PHV (Polyhydroxyvaleric acid), sold as Biopol by fermentation on *Alcaligenes eutrophus*; Biodegradable polymers		

Contact Periods:
Lecture: 45 Periods **Tutorial:0 Periods** **Practical: 0 Periods** **Total: 45 Periods**

TEXT BOOK

1	Emo Chiellini, Helena Gil, *“**Biorelated Polymers: Sustainable Polymer Science and Technology**”*, Springer 2001.
2	Johnson .R.M, L.Y. Mwaikambo and N. Tucker, *“**Biopolymers**”*, Rapra Technology, 2003

REFERENCES:

1	Carmen Scholz, Richard A Gross, ***“Polymers from Renewable Resources: Biopolymers and Biocatalysis”***, American Chemical Society, 2001.
2	David Plackett, ***“Biopolymers – New Materials for Sustainable films and Coatings”***, John Wiley and Sons Ltd, 2011
3	Naim Kosaric (Ed). *“**Biosurfactants**”*. Marcell Dekker Inc, 1993.
4.	Leopoido Javier Rios Gonzalez. “Handbook of Research on Bioenergy and Biomaterials: Consolidated and green process” Apple academic press, 2021.

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom’s Taxonomy Mapped**
CO1	To employ the greener technologies to solve the environmental issues.	K1
CO2	To illustrate the synthesis and application of biopolymers in nanoscale drug delivery systems, as biomimetic materials and waste water treatment methods.	K1
CO3	To understand the properties of biosurfactants and their use in food industries.	K2
CO4	To evaluate the tensile strength, hydration, viscoelastic properties using different testing methods.	K2
CO5	To analyze the different types of Biopolymers through case studies.	K2

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**
CO1	1	1	-	-	-	-	-	-	-	-	-	-	3	1
CO2	1	1	-	-	-	-	-	-	-	-	-	-	3	1
CO3	1	1	-	-	-	-	-	-	-	-	-	-	3	1
CO4	1	1	-	-	-	-	-	-	-	-	-	-	3	1
CO5	1	1	-	-	-	-	-	-	-	-	-	-	3	1
22BPE$37	1	1	-	-	-	-	-	-	-	-	-	-	3	1

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.4.1, 2.1.3.
CO2	1.4.1, 2.1.3.
CO3	1.4.1, 2.1.3.
CO4	1.4.1, 2.1.3.
CO5	1.4.1, 2.1.3.

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT - 1	50	50	-	-	-	-	100
CAT - 2	50	50	-	-	-	-	100
Individual Assignment 1/Case study 1/ Seminar 1/ Project 1	50	50	-	-	-	-	100
Individual Assignment 2/Case study 2/ Seminar 2/ Project 2	30	70	-	-	-	-	100
ESE	50	50	-	-	-	-	100

22BPE$38	NANOBIOTECHNOLOGY				
PREREQUISITES	**CATEGORY**	**L**	**T**	**P**	**C**
NIL	**PE**	**3**	**0**	**0**	**3**

Course Objectives	To understand the fundamentals of nanotechnology, various form of nanomaterials, various methods of synthesis and characterization of nanoparticles.	
UNIT – I	**UNIT – I : INTRODUCTION**	**9 Periods**
Nano – definition; Fundamental science behind nanotechnology- electrons- atoms- ions- molecules- metals- biosystems; Nanobiotechnology –definition; Nanomaterials- types- Carbon nanomaterials (fullerene-grapheme- nanotubes; Characteristics and applications)- Quantum Dots and Wires; Metal nanoparticles - properties and applications.		
UNIT – II	**METHODS OF NANOPARTICLES SYNTHESIS**	**9 Periods**
Nanoparticles fabrication- Top-down & bottom-up approaches- Physical- chemical- biological methods; Use of bacteria- fungi- actinomycetes and plants for nanoparticle synthesis; Magnetotatic bacteria for natural synthesis of magnetic nanoparticles- mechanism of formation.		
UNIT – III	**CHARACTERIZATION OF NANOPARTICLES**	**9 Periods**
Characterization of nanoparticles – AFM- SEM- TEM- STM- XRD- EDAX- FTIR – principle and applications.		
UNIT – IV	**NANOBIOMETRICS**	**9 Periods**
Introduction- DNA based nanostructures, Protein based nanoparticles- Peptide, albumin, S-Layer protein self assembled system; Nanoscale motors; Ion channel as sensors; Lipid based nanoparticles.		
UNIT – V	**BIOMEDICAL APPLICATIONS OF NANOPARTICLES**	**9 Periods**
Biocompatible In-organic devices (Implant coating- stems and seeds); Nanoparticles for drug delivery- Polymeric nanoparticles, nanoshells; Nanovectors for gene therapy; Nanobiosensors; *In-vivo* diagnostics in molecular imaging.		
Contact Periods: **Lecture: 45 Periods** **Tutorial: 0 Periods** **Practical : 0 Periods** **Total: 45 Periods**		

TEXT BOOK:

1	*Kumar, N., Kumbhat, S., "***Essentials in Nanoscience and Nanotechnology**", John Wiley & Sons, 2016.
2	*Niemeyer, C.M., Mirkin,C.A.,* "**Nanobiotechnology: Concepts, Applications and Perspectives**", Wiley-VCH, 2004.

REFERENCES

1	*Cao, G., "**Nanostructures and Nanomaterials-Synthesis, properties and applications**", Imperial College Press, 2004.*
2	*De la Fuente, J.M., Grazu, V., "**Nanobiotechnology**", In: **Frontiers in Nanoscience** (Vol.4), R.E. Palmer (Ed), Elsevier, 2012.*
3	*Challa S. S. R. Kumar., " **Nanotechnologies for the Life Sciences", Vol. 2 - Biological and Pharmaceutical Nanomaterials**, Wiley, 2006.*
4	*Nicolini, C., "**Nanobiotechnology and Nanobiosciences**", Pan Stanford, 2008*
5	*Yoseph, Bar-Cohen, "**Biomimetics : Biologically Inspired Technologies**", CRC Press, 2006.*

COURSE OUTCOMES: On completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Understand the different types of nanomaterials, its properties and	K1
	applications.	
CO2	Know about biological methods of nanoparticle synthesis	K2
CO3	Characterize the synthesized nanoparticles using different analytical techniques	K2
CO4	Understand the bionanomachinery in living cells to design bionanodevices	K2
CO5	Acquire knowledge about the biological applications of nanoparticles.	K2

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/POs	PO1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2
CO1	3	2	-	-	-	1	-	-	-	-		2	3	2
CO2	2	3	2	-	-	-	-	-	-	-		-	3	2
CO3	2	2	-	3	2	-	-	-	-	-		-	2	3
CO4	2	1	2	-	-	-	-	-	-	-		-	2	3
CO5	2	-	-	-	-	2	-	-	-			1	2	3
22BPE$38	2	2	2	3	2	2	-	-	-	-		2	2	3

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.2.1,1.2.2,2.2,3,6.1.1
CO2	1.2.1,2.2.2,3.2.2,3.4.1
CO3	1.2.1,2.2.2,,4.1.2,5.1.1,5.2.1
CO4	1.2.1,6.1.1
CO5	1.2.1,2.2.2,3.2.2,3.4.1,4.1.2,5.1.1,6.1.1

ASSESSMENT PATTERN – THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT - 1	50	50	-	-	-	-	100
CAT - 2	20	30	50	-	-	-	100
Individual Assignment 1/Case study 1/ Seminar 1/ Project 1	50	50	-	-	-	-	100
Individual Assignment 2/Case study 2/ Seminar 2/ Project 2	-	50	50	-	-	-	100
ESE	50	50	-	-	-	-	100

22BPE$39	BIOMASS CONVERSION AND BIOREFINERY

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	To provide an insight to the basics of biomass, several conversion technologies and the different types of biological products that can be obtained upon successful conversion	
UNIT – I	**INTRODUCTION**	**9 Periods**
World energy scenario, consumption pattern, fossil fuel depletion and environmental issues.		
UNIT – II	**BIOMASS**	**9 Periods**
Biomass - Availability and abundance, photosynthesis, composition and energy potential, virgin biomass production and selection, waste biomass (municipal, industrial, agricultural and forestry) availability, abundance and potential, biomass as energy resources: dedicated energy crops, annual crops (maize, sorghum sugar beet, hemp), perennial herbaceous crops (sugarcane, switchgrass, miscanthus), short rotation woody crops (poplar, willow), oil crops and their biorefinery potential, microalgae as feedstock for biofuels and biochemical, enhancing biomass properties for biofuels, challenges in conversion		
UNIT – III	**BIOREFINERY AND BIOMASS CONVERSION**	**9 Periods**
Basic concept, types of biorefineries, biorefinery feedstocks and properties, economics, Biomass Pretreatment - pretreatment technologies such as acid, alkali, autohydrolysis, hybrid methods, role of pretreatment in the biorefinery concept, Physical and Thermal Conversion Processes - Types, fundamentals, equipment and applications; thermal conversion products, Microbial Conversion Process: Types, fundamentals, equipment and applications, products.		
UNIT – IV	**BIODIESEL AND BIOOIL**	**9 Periods**
Diesel from vegetable oils, microalgae and syngas; transesterification; FT process, catalysts; biodiesel purification, fuel properties, Biooil and Biochar: Factors affecting biooil, biochar production, fuel properties, biooil upgradation		
UNIT – V	**BIOETHANOL AND BIOHYDROGEN**	**9 Periods**
Corn ethanol, lignocellulosic ethanol, microorganisms for fermentation, current industrial ethanol production technology, cellulases and their role in hydrolysis, concepts of SSF and CBP, advanced fermentation technologies, ABE fermentation pathway and kinetics, product recovery technologies, Biohydrogen generation, metabolic basics, feedstocks, dark fermentation by strict anaerobes, facultative anaerobes, thermophilic microorganisms, integration of biohydrogen with fuel cell; fundamentals of biogas technology, fermenter designs, biogas purification, methanol production and utilization		
Contact Periods: **Lecture: 45 Periods** **Tutorial:0 Periods** **Practical: 0 Periods** **Total: 45 Periods**		

TEXT BOOK

1	Donald L. Klass, ***"Biomass for Renewable Energy, Fuels, and Chemicals"***, Academic Press, Elsevier, 2006.
2	Prabir Basu, ***"Biomass Gasification, Pyrolysis and Torrefaction"***, Academic Press, Elsevier, 2013.

REFERENCES:

1	Shang-Tian Yang (Ed.), ***"Bioprocessing for Value Added Products from Renewable Resources"***, Elsevier, 2007.
2	A A Vertes, N. Qureshi, H.P. Blaschek, H. Yukawa (Eds.), ***"Biomass to Biofuels : Strategies for Global Industries"***, Wiley, 2010
3	A.A. Vertes, N. Qureshi, H.P. Blaschek, H. Yukawa (Eds.), ***"Biomass to Biofuels: Strategies for Global Industries"***, Wiley, 2010.
4	S. Yang, H.A. El-Enshasy, N. Thongchul (Eds.), ***"Bioprocessing Technologies in Biorefinery for Sustainable Production of Fuels, Chemicals and Polymers"***, Wiley, 2013.

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	To comprehend the environmental implications of fossil fuel, carbon credits and economics.	K1
CO2	To elaborate the different types biomass, their structure and composition.	K1
CO3	To emphasis the various pre-treatment technologies currently adapted to produce cellulose, conversion technologies basics along with reactor design for physical, chemical, thermal and microbial conversion techniques.	K2
CO4	To summarise the various products such as biodiesel and biooil from vegetable oil and its properties	K2
CO5	To understand the production of bioethanol and biohydrogen, fermentation process and metabolic pathway	K2

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**
CO1	1	1	-	-	-	-	-	-	-	-	-	-	3	1
CO2	1	1	-	-	-	-	-	-	-	-	-	-	3	1
CO3	1	1	-	-	-	-	-	-	-	-	-	-	3	1
CO4	1	1	-	-	-	-	-	-	-	-	-	-	3	1
CO5	1	1	-	-	-	-	-	-	-	-	-	-	3	1
22BPE$39	1	1	-	-	-	-	-	-	-	-	-	-	3	1

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.4.1, 2.1.3
CO2	1.4.1, 2.1.3
CO3	1.4.1, 2.1.3,
CO4	1.4.1, 2.1.3
CO5	1.4.1, 2.1.3,

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT - 1	50	50	-	-	-	-	100
CAT - 2	50	50	-	-	-	-	100
Individual Assignment 1/Case study 1/ Seminar 1/ Project 1	50	50	-	-	-	-	100
Individual Assignment 2/Case study 2/ Seminar 2/ Project 2	30	70	-	-	-	-	100
ESE	50	50	-	-	-	-	100

22BPE$40	INTRODUCTION TO BIOSTATISTICS

PREREQUISITES	CATEGORY	L	T	P	C
NIL	PE	3	0	0	3

Course Objectives	Understand and interpret commonly reported statistical measures published in healthcare research. Analyze the different type of data using appropriate statistical software. Demonstrate a good understanding of descriptive statistics and graphical tools. Explain fundamental concepts of estimation and hypothesis testing and be confident when interpreting P values and confidence intervals	
UNIT – I	**DESCRIPTIVE STATISTICS AND BASICS OF PROBABILITY**	**9 periods**
Measure of location, measure of spread, coefficient of variation, grouped data, graphic methods, Probability - definition of probability, multiplication law, addition law, conditional probability, Baye's rule and screening tests.		
UNIT – II	**PROBABILITY DISTRIBUTIONS**	**9 periods**
Discrete probability distribution - Random variables, probability mass function, expected value, variance, cumulative distribution function, binomial and Poisson distributions, continuous probability distribution -Probability density function, and normal distribution.		
UNIT – III	**ESTIMATION AND HYPOTHESIS TESTING-ONE SAMPLE INFERENCE**	**9 periods**
Relationship between population and sample, sampling distribution, point and interval estimation of mean and variance, one-sample inference- general concepts, test for mean of a normal distribution - one sided and two sided alternatives, one sample chi-square test for variance of a normal distribution.		
UNIT – IV	**HYPOTHESISTESTING-TWO-SAMPLE INFERENCE**	**9 periods**
The paired t- test, testing for equality of two variances, t-test for two independent samples for mean with equal and unequal variances, categorical data - R x C contingency table, Chisquare goodness of fit.		
UNIT-V	**REGRESSION METHODS AND ANOVA**	**9 periods**
General concepts, fitting regression lines - method of least squares, inferences about parameters from regression lines, goodness of fit of regression lines, analysis of variance-One way ANOVA-fixed effects model, random effect model.		
Contact Periods: **45** **Lecture: 45 Periods** **Tutorial: 0 Periods** **Practical: 0 Periods** **Total: 45 Periods**		

TEXT BOOK

1	Bernard Rosner , ***"Fundamental of Biostatistics"***, Duxbury Thomson Learning, New York, 2015.
2	Ronald N Forthofer and Eun Sul Lee , ***"Introduction to Biostatistics – A Guide to Design, Analysis and Discovery"***, Academic Press, New York, 2016

REFERENCES

1	Vee Bala and Rastogi , "***Biostatistics***", Scientific International, New Delhi, 2017..
2	Wayne W Daniel and Chad L Cross , ***"Biostatistics: Basic concepts and methodology for Health Sciences"***, Wiley, USA, 2017.
3	Sundar Rao PSS and Richard J , ***"An introduction to Biostatistics- A model for students in health sciences"***, Prentice Hall, New Delhi, 2012.
4	B. Burt Gerstman Basic Biostatistics: Statistics for Public Health Pratice 2nd Edition 2015. ISBN-13: 978-1284036015

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Apply descriptive techniques commonly used to summarize public health data.	K1
CO2	Apply basic statistical concepts commonly used in public health and health Sciences	K1
CO3	Apply statistical knowledge to test hypothesis and interpret results of commonly used statistical analyses	K2
CO4	Apply statistical knowledge to test hypothesis, design and conduct research studies and interpret results of commonly used statistical analyses	K3
CO5	Operate statistical software packages to conduct research studies and interpret results of commonly used statistical analyses in written summaries	K3

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/POs	**PO1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**
CO1	-	1	-	-	-	2	2	2	-	-	1	2	2	2
CO2	1	-	-	1	1	-	-	2	3	3	2	2	1	3
CO3	1	1	-	-	-	-	-	1	1	-	-	-	1	3
CO4	-	-	-	-	1	-	-	2	3	3	1	1	1	3
CO5	-	2	-	1	3	-	-	-	-	-	-	-	2	2
22BPE$40	1	1	-	1	2	2	2	2	3	3	2	2	2	3

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.4.1, 2.1.3
CO2	1.4.1, 2.1.3
CO3	1.4.1, 2.1.3,
CO4	1.4.1, 2.1.3
CO5	1.4.1, 2.1.3,

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT - 1	50	10	10	10	10	10	100
CAT - 2	50	10	10	10	10	10	100
Individual Assignment 1/Case study 1/ Seminar 1/ Project 1	20	20	20	20	10	10	100
Individual Assignment 2/Case study 2/ Seminar 2/ Project 2	20	20	20	20	10	10	100
ESE	50	10	10	10	10	10	100

22COE$01	DISASTER MANAGEMENT AND MITIGATION *(Common to All Branches)*					
PREREQUISITES		**CATEGORY**	**L**	**T**	**P**	**C**
NIL		**OE**	**3**	**0**	**0**	**3**

Course Objective	To impart knowledge to create appropriate planning, preparation and response for emergency treatment in disaster situation	
UNIT – I	**INTRODUCTION TO DISASTERS**	**9 Periods**
Definition: Disaster, Hazard, Vulnerability, Resilience, Risks – Disasters: Classification, Causes, Impacts - Global Trends in Disasters: Urban Disasters, Pandemics, Complex Emergencies, Climate Change- Dos and Don'ts during various types of Disasters.		
UNIT – II	**HAZARDS AND RISK VULNERABILITY**	**9 Periods**
Hazard Identification and Hazard Profiling - Hazard Analysis - Types of hazards - Natural and technological Components of Risk- likelihood and Consequence, Trends and Computation of likelihood and Consequence. Risk Evaluation – Purpose, Risk Acceptability, Alternatives, Personnel. Political/ Social, Economic. Vulnerability-Physical Profile, Social Profile, Environmental Profile, Economic Profile - Factors Influencing Vulnerability, Risk Perception.		
UNIT – III	**MITIGATION AND PREPAREDNESS**	**9 Periods**
Mitigation - Types, Obstacles, Assessment and Selection of Mitigation options, Emergency Response capacity, Incorporating Mitigation into Development and Relief Projects. Preparedness- Government Preparedness, Public Preparedness, Media as a Public educator. Obstacles to public education and preparedness.		
UNIT – IV	**RESPONSE AND RECOVERY**	**9 Periods**
Response the Emergency- Pre disaster, post disaster, Provision of Water, Food and Shelter, Volunteer Management, Command, Control and Coordination. Recovery- Short Term and Long-term Recovery- Components of Recovery- Planning, Coordination, Information, Money and Supplies, Allocation of Relief Funds, Personnel. Types of Recovery- Government, Infrastructure, Debris Removal Disposal and Processing, Environment, Housing, Economic and Livelihood, Individual, Family and Social Recovery- Special Considerations in Recovery.		
UNIT – V	**DISASTER MANAGEMENT: APPLICATIONS AND CASE STUDIES**	**9 Periods**
Concept of Environmental Health and Safety Management – Elements of Environmental Health and Safety Management Policy and implementation and review – ISO 45001-Strucure and Clauses-Case Studies.		
Contact Periods: **Lecture: 45 Periods Tutorial: 00 Periods Practical: 00 Periods Total: 45 Periods**		

TEXT BOOKS :

1	*Singhal J.P.* ***"Disaster Management",*** *Laxmi Publications, 2010.*
2	*Tushar Bhattacharya,* ***"Disaster Science and Management",*** *McGraw Hill India Education Pvt. Ltd., 2012.*

REFERENCES:

1	*Govt. of India: Disaster Management Act , Government of India, New Delhi, 2005.*
2	*Government of India, National Disaster Management Policy,2009.*
3	*Gupta Anil K, Sreeja S. Nair.* ***"Environmental Knowledge for Disaster Risk Management",*** *NIDM, New Delhi, 2011*
4	*Kapur Anu Vulnerable India:* ***A Geographical Study of Disasters****, IIAS and Sage Publishers, New Delhi, 2010*

COURSE OUTCOMES: On completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Identify the types of disasters, causes and their impact on environment and society	K2
CO2	Assess vulnerability and various methods of risk reduction measures as well as mitigation.	K2
CO3	Comprehend the mitigation and preparedness process.	K2
CO4	Describe about response and recovery process during disaster.	K2
CO5	Perform disaster damage assessment and management.	K2

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping

COs/POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	1	-	1	-	2	3	3	2	2	2	-	3	2	-	2
CO2	1	-	1	-	2	3	3	2	2	2	-	3	2	-	2
CO3	1	-	1	-	2	3	3	2	2	2	-	3	2	-	2
CO4	1	-	1	-	2	3	3	2	2	2	-	3	2	-	2
CO5	1	-	1	-	2	3	3	2	2	2	-	3	2	-	2
22COE$01	1	-	1	-	2	3	3	2	2	2	-	3	2	-	2

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.2.1, 3.1.5, 5.1.1, 5.2.1, 6.1.1, 6.2.1, 7.1.1, 7.1.2, 7.2.1, 8.1.1, 8.2.2, 9.1.1, 9.1.2, 9.2.1, 10.1.1, 10.1.2, 10.1.3
CO2	1.2.1, 3.1.5, 5.1.1, 5.2.1, 6.1.1, 6.2.1, 7.1.1, 7.1.2, 7.2.1, **7.2.2,** 8.1.1, 8.2.2, 9.1.1, 9.1.2, 9.2.1, 10.1.1, 10.1.2, 10.1.3
CO3	1.2.1, 3.1.5, 5.1.1, 5.2.1, 6.1.1, 6.2.1, 7.1.1, 7.1.2, 7.2.1, 7.2.2, 8.1.1, 8.2.2, 9.1.1, 9.1.2, 9.2.1, 10.1.1, 10.1.2, 10.1.3
CO4	1.2.1, 3.1.5, 5.1.1, 5.2.1, 6.1.1, 6.2.1, 7.1.1, 7.1.2, 7.2.1, 7.2.2, 8.1.1, 8.2.2, 9.1.1, 9.1.2, 9.2.1, 10.1.1, 10.1.2, 10.1.3
CO5	1.2.1, 3.3.6, 5.1.1, 5.2.1, 6.1.1, 6.2.1, 7.1.1, 7.1.2, 7.2.1, 7.2.2, 8.1.1, 8.2.2, 9.1.1, 9.1.2, 9.2.1, 10.1.1, 10.1.2, 10.1.3

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	40	40	20	-	-	-	100
CAT2	40	40	20	-	-	-	100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	-	25	50	25	-	-	100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	-	25	50	25	-	-	100
ESE	30	30	40	-	-	-	100

22COE$02	**WATER SANITATION AND HEALTH** *(Common to All Branches)*

PREREQUISITES	CATEGORY	L	T	P	C
NIL	**OE**	**3**	**0**	**0**	**3**

Course Objective	To understand the overview of Environment, Health and Safety (EHS) in industries and related Indian regulations, types of Health hazards, effect, assessment and control methods and EHS Management System	
UNIT – I	**INTRODUCTION**	**9 Periods**
Need for developing Environment, Health and Safety systems in work places- International initiatives, National Policy and Legislations on EHS in India - Regulations and Codes of Practice - Role of Trade Union Safety Representatives – Ergonomics.		
UNIT – II	**OCCUPATIONAL HEALTH AND HYGIENE**	**9 Periods**
Definition of occupational health and hygiene - Categories of health hazards – Exposure pathways and human responses–Exposure Assessment-occupational exposure limits - Hierarchy of control measures - Role of personal protective equipment and the selection criteria.		
UNIT – III	**WORKPLACE SAFETY AND SAFETY SYSTEMS**	**9 Periods**
Features of Satisfactory and Safe design of work premises – good housekeeping - lighting and color, Ventilation and Heat Control, Noise, Chemical and Radiation Safety – Electrical Safety – Fire Safety – Safety at Construction sites, ETP – Machine guarding – Process Safety, Working at different levels.		
UNIT – IV	**HAZARDS AND RISK MANAGEMENT**	**9 Periods**
Safety appraisal – Job Safety Analysis-Control techniques – plant safety inspection – Accident investigation - Analysis and Reporting – Hazard and Risk Management Techniques –Onsite and Offsite emergency Plans. Employee Participation- Education and Training- Case Studies.		
UNIT – V	**ENVIRONMENTAL HEALTH AND SAFETY MANAGEMENT**	**9 Periods**
Concept of Environmental Health and Safety Management – Elements of Environmental Health and Safety Management Policy and implementation and review – ISO 45001-Strucure and Clauses-Case Studies.		
Contact Periods: **Lecture: 45 Periods** **Tutorial: 0 Periods** **Practical: 0 Periods** **Total: 45 Periods**		

TEXT BOOKS:

1	***Industrial Health and Safety Acts and Amendments**, by Ministry of Labour and Employment, Government of India.*
2	*Dr.K.U.Mistry, Siddharth Prakashan, **"Fundamentals of Industrial Safety and Health"**, 2012*

REFERENCES:

1	*Bill Taylor, **"Effective Environmental, Health, and Safety Management Using the Team Approach"**, Culinary and Hospitality Industry Publications Services, 2005.*
2	*Nicholas P.Cheremisinoff and Madelyn L. Graffia, **"Environmental and Health and Safety Management"**, William Andrew Inc. NY, 1995.*
3	*Brian Gallant, **"The Facility Manager's Guide to Environmental Health and Safety"** , Government Inst Publ., 2007.*
4	*https://archive.nptel.ac.in/courses/114/106/114106017/*

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Outline the needs for EHS in industries and related Indian regulations	K2
CO2	Assess the various types of Health hazards, effect, assessment and control methods	K2
CO3	Identity the various safety systems in working environments	K2
CO4	Select the methodology for preparation of Emergency Plans and Accident investigation	K3
CO5	Describe the EHS Management System and its elements	K2

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	2	-	1	-	3	3	3	2	1	-	2	-	1	1	-
CO2	2	-	1	-	3	3	3	2	1	-	2	-	1	1	-
CO3	2	-	1	-	3	3	3	2	1	-	2	-	1	1	-
CO4	2	-	1	-	3	3	3	2	1	-	2	-	1	1	-
CO5	2	-	1	-	2	3	3	2	1	-	2	-	1	1	-
22COE$02	2	-	1	-	3	3	3	2	1	-	2	-	1	1	-

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.2.1, 1.3.1, 3.1.4, 3.1.5, 5.1.1, 5.2.1, 5.2.2, 5.3.1, 6.1.1, 6.2.1, 7.1.2, 7.2.1, 7.2.2, 8.1.1, 8.2.2, 9.1.2, 11.1.1, 11.2.1.
CO2	1.2.1, 1.3.1, 3.1.4, 3.1.5, 5.1.1, 5.2.1, 5.2.2, 5.3.1, 6.1.1, 6.2.1, 7.1.2, 7.2.1, 7.2.2, 8.1.1, 8.2.2, 9.1.2, 11.1.1, 11.2.1.
CO3	1.2.1, 1.3.1, 3.1.4, 3.1.5, 5.1.1, 5.2.1, 5.2.2, 5.3.1, 6.1.1, 6.2.1, 7.1.2, 7.2.1, 7.2.2, 8.1.1, 8.2.2, 9.1.2, 11.1.1, 11.2.1.
CO4	1.2.1, 1.3.1, 3.1.4, 3.1.5, 5.1.1, 5.2.1, 5.2.2, 5.3.1, 6.1.1, 6.2.1, 7.1.2, 7.2.1, 7.2.2, 8.1.1, 8.2.2, 9.1.2, 11.1.1, 11.2.1.
CO5	1.2.1, 1.3.1, 3.1.4, 3.1.5, 5.1.1, 5.2.1, 5.2.2, 5.3.1, 6.1.1, 6.2.1, 7.1.2, 7.2.1, 7.2.2, 8.1.1, 8.2.2, 9.1.2, 11.1.1, 11.2.1.

ASSESSMENT PATTERN – THEORY

Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	40	40	20	-	-	-	100
CAT2	40	40	20	-	-	-	100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	-	25	50	25	-	-	100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	-	25	50	25	-	-	100
ESE	30	30	40	-	-	-	100

22MOE$03	**NANOTECHNOLOGY AND SURFACE ENGINEERING** *(Common to All Branches)*

PREREQUISITES	CATEGORY	L	T	P	C
NIL	OE	3	0	0	3

Course Objectives	To educate the production techniques and characterization techniques of nano materials and to familiarize about the surface modification techniques using nano materials.	
UNIT – I	**ELEMENTS OF NANO-SCIENCE AND NANOTECHNOLOGY**	**(9 Periods)**
Engineering scale of nanotechnology, different classes of nano-materials, synthesis of nano-materials, fabrication and characterization of nanostructures, Engineering applications- Cosmetics and Consumer Goods, Nano Sensor, Nano catalysts, Water Treatment and the Environment, Paints, Food and Agriculture Industry.		
UNIT – II	**NANOTECHNOLOGY AND CERAMICS**	**(9 Periods)**
Introduction, Vapor Condensation Methods, Sputtering, Laser Method, Spray Pyrolysis, Thermo Chemical /Flame Decomposition of metal organic Precursors methods		
UNIT – III	**CHARACTERIZATION OF NANOMATERIALS**	**(9 Periods)**
X-Ray Diffraction (XRD), Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), Atomic Force Microscopy, UV / Visible Spectroscopy.		
UNIT – IV	**SURFACE ENGINEERING**	**(9 Periods)**
Introduction to surface engineering, Scope of surface engineering for different engineering materials, Surface Preparation methods such as Chemical, Electrochemical, Mechanical: Sand Blasting, Shot peening, Shot blasting, Hydro-blasting, Vapor Phase Degreasing etc., Coatings: Classification, Properties and applications of Various Coatings.		
UNIT – V	**SURFACE MODIFICATION TECHNIQUES**	**(9 Periods)**
Surface modification by use of directed energy beams, Plasma, Sputtering & Ion Implantation. Surface modification by Friction stir processing. Surface composites.		
Contact Periods: **Lecture: 45 Periods** **Tutorial: 0 Periods** **Practical: 0 Periods** **Total: 45 Periods**		

TEXT BOOKS:

1	*G. Cao, **"Nanostructures and Nanomaterials: Synthesis",** Properties and Applications by Imperial College Press, 2^{nd} edition, 2011.*
2	*Keith Austin "**Surface Engineering Hand Book"**, London : Kogan Page, 1998*

REFERENCES:

1	*Gregory Timp, "**Nanotechnology",** Springer, 2012*
2	*Dheerendra Kumar Dwivedi, **"Surface Engineering: Enhancing Life of Tribological Components"**, Springer, 2018*
3	*D. Phil Woodruff,**"Modern Techniques of Surface Science**", Cambridge University Press, 2016*
4	*Sulabha K. Kulkarni ,**"Nanotechnology: Principles and Practices**", Springer, 2019*

COURSE OUTCOMES: On completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Choose appropriate nano material and its manufacturing method.	K1
CO2	Select most suitable technique to deposit a layer of nano material on ceramic surface.	K2
CO3	Identify appropriate techniques to characterize nano materials.	K2
CO4	Select surface preparation, coating techniques and predict their combinational effect for engineering applications.	K2
CO5	Adopt different techniques to modify surfaces and make surface composites as per requirement.	K2

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping

COs/POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	0	1	2	1	1	0	0	0	0	0	0	0	2	2	3
CO2	0	1	2	1	1	0	0	0	0	0	0	0	2	2	3
CO3	0	1	2	1	1	0	0	0	0	0	0	0	2	2	3
CO4	0	2	2	1	1	0	0	0	0	0	1	0	2	3	3
CO5	0	1	2	1	1	0	0	0	0	0	1	0	3	2	3
22MOE$03	0	1	2	1	1	0	0	0	0	0	1	0	2	2	3

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	2.2.2, 2.2.3, 2.2.4, 2.3.1, 3.1.1, 3.1.2, 3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.3.2, 4.1.1, 4.3.4, 5.1.2
CO2	2.2.2, 2.2.3, 2.2.4, 2.3.1, 3.1.1, 3.1.2, 3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.3.2, 4.1.1, 4.3.4, 5.1.2
CO3	2.2.2, 2.2.3, 2.2.4, 2.3.1, 3.1.1, 3.1.2, 3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.3.2, 4.1.1, 4.3.4, 5.1.2
CO4	2.1.1, 2.1.2, 2.2.2, 2.2.3, 2.2.4, 2.3.1, 3.1.1, 3.1.2, 3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.3.2, 4.1.1, 4.3.4, 5.1.2, 5.3.1, 11.3.1
CO5	2.2.2, 2.2.3, 2.2.4, 2.3.1, 3.1.1, 3.1.2, 3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.3.2, 4.1.1, 4.3.4, 5.1.2, 5.3.1, 11.3.1

ASSESSMENT PATTERN – THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	50	50	-	-	-	-	100
CAT2	30	70	-	-	-	-	100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	50	50	-	-	-	-	100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	30	70	-	-	-	-	100
ESE	40	60	-	-	-	-	100

22MOE$04	**INDUSTRIAL SAFETY MANAGEMENT** *(Common to All Branches)*

PREREQUISITES	CATEGORY	L	T	P	C
NIL	**OE**	**3**	**0**	**0**	**3**

Course Objectives	To learn the techniques of industrial safety and management to implement and solve safety problems in engineering.	
UNIT – I	**ENVIRONMENT AND SAFETY PHILOSOPHY**	**9 Periods**
Henrichs Axioms Of Industrial Safety - Concepts Of Safety – Ethics of environmental conservation – Environmental Impact Assessment – Environmental economics – Safety philosophy – Planning for safety – Organising for safety – Directing for safety - Role of Occupier and Factory Manager, Factory Safety Committee, Structure and Functions and Working Tenure Details		
UNIT – II	**SAFETY APPRAISAL AND CONTROL TECHNIQUES**	**9 Periods**
Plant and equipment safety appraisal techniques – Laws and regulation – Hazards and Risks – Major accident hazard control – Importance of Disaster management		
UNIT – III	**ACCIDENT PREVENTION AND SAFETY MANAGEMENT**	**9 Periods**
Incident - Accident - Injury - Dangerous occurrence - Unsafe Act - Unsafe Conditions - Hazards - Error, Oversight - Mistake , Near Miss - Measurement of safety performance - Key elements of Safety Management system (ISO 14001, OHSAS 18001 etc.). ILO Legislations – Convention and Recommendation concerning Safety, Health and Environment – Objectives of Health, Safety and Environment Policy, Responsibility for Implementation of HSE Policy.		
UNIT – IV	**SAFETY MANAGEMENT IN INDUSTRIES**	**9 Periods**
Safe Guarding of machines – Manual handling and storage of materials – Mechanical handling of materials – Hand tools and portable power tools – Electrical hazards – Earth , insulation and continuity tests – Industrial lighting – Safety of pressure vessels – Ventilation and heat control – Housekeeping – Special precautions - Safety in Construction Industry – Safety in Engineering Industry – Safety in Chemical Industries – Safety in Textile Industries – Safety in Dock and Port – Transportation Safety – Safety in Fire and explosive industries.		
UNIT – V	**INDUSTRIAL HYGIENE AND POLLUTION CONTROL**	**9 Periods**
Industrial Hygiene – Air sampling – Noise and vibration – Industrial physiology - Occupational health – Personal Protective Equipment's – Pollution Control strategies.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOKS:

1	*Akhil Kumar Das*, ***"Principles of Industrial Safety Management":Understanding the Ws of Safety at Work"*** *PHI Learning , 2021*
2	*Jain R K and Sunil.S.Rao*, ***"Industrial Safety Health and Environment Management System"***, *Seventh reprint, Khanna publishers, 2023.*

REFERENCES:

1	*Prathibha Bansal and Anupama Prashar,* ***"Industrial safety and Environment"***, *S.K.Kattaria Sons, 2005.*
2	*A.K.Gupta,* ***"Industrial safety and Environment"***, *Laxmi Publication Pvt Limited, 2008.*
3	***"Accident Prevention Manual For Industrial Operations"***, *N.S.C Chicago, 13th Edition 2009.*
4	*Dan Petersen*, ***"Techniques of Safety Management"***, *Americal Society of Safety Emgineers, 4th edition, 2003.*

COURSE OUTCOMES: On completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Understand Environment and safety philosophy.	K1
CO2	Frame Safety appraisal and control technique to create safety management.	K2
CO3	Follow accident prevention procedure to solve safety problem.	K2
CO4	Implement safety management for Industries.	K3
CO5	Follow Industrial Hygiene and Pollution control	K3

COURSE ARTICULATION MATRIX:

a) CO/PO Mapping

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	0	1	3	0	0	0	0	0	0	0	3	1	2
CO2	3	3	0	1	2	0	0	0	0	0	0	0	3	2	2
CO3	3	3	0	0	3	0	0	0	0	0	0	0	3	1	2
CO4	3	3	0	1	2	0	0	0	0	0	0	0	3	2	2
CO5	3	3	0	0	3	0	0	0	0	0	0	0	3	1	2
22MOE$04	3	3	0	1	3	0	0	0	0	0	0	0	3	1	2

b) CO and Key Performance Indicators mapping

CO1	1.1.1, 1.1.2, 1.3.1, 1.4.1, 2.1.3, 2.2.1, 2.2.3, 2.2.4, 2.4.4, 4.3.4, 5.1.2, 5.2.1, 5.2.2, 5.3.1, 5.3.2
CO2	1.1.1, 1.1.2, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.2.4, 2.4.3, 2.4.4, 4.1.4, 5.1.2, 5.2.1, 5.3.1, 5.3.2
CO3	1.1.1, 1.1.2, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.2.4, 2.4.3, 2.4.4, 5.1.1, 5.1.2, 5.2.1, 5.3.1, 5.3.2
CO4	1.1.1, 1.1.2, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.2.4, 2.4.3, 2.4.4, 4.1.4, 5.1.2, 5.2.1, 5.3.1, 5.3.2
CO5	1.1.1, 1.1.2, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.2.4, 2.4.3, 2.4.4, 5.1.1, 5.1.2, 5.2.1, 5.3.1, 5.3.2

ASSESSMENT PATTERN

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	70	20	10	-	-	-	100
CAT2	50	30	20	-	-	-	100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	60	40	-	-	-	-	100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	50	30	20	-	-	-	100
ESE	50	30	20	-	-	-	100

22EOE$05	RENEWABLE POWER GENERATION SYSTEMS *(Common to All Branches)*					
PREREQUISITES		**CATEGORY**	**L**	**T**	**P**	**C**
NIL		OE	3	0	0	3
Course Objectives	To understand energy scenarios, energy sources and their utilization, society's present needs and future energy demands, the principles of renewable energy conversion systems					
UNIT – I	**ENERGY SCENARIO**	**9 Periods**				
Principles of renewable energy; energy and sustainable development, fundamentals and social implications. worldwide renewable energy availability, renewable energy availability in India, brief descriptions on solar energy, wind energy, tidal energy, wave energy, ocean thermal energy, biomass energy, geothermal energy, oil shale. Introduction to Internet of energy (IOE).						
UNIT – II	**SOLAR ENERGY**	**9 Periods**				
Solar Energy: Fundamentals; Solar Radiation; Estimation of solar radiation on horizontal and inclined surfaces; Solar radiation Measurements- Pyrheliometers, Pyrometer, Sunshine Recorder. Solar Thermal systems: Flat plate collector; Solar distillation; Solar pond electric power plant. Solar electric power generation- Principle of Solar cell, Photovoltaic system for electric power generation, advantages, Disadvantages and applications of solar photovoltaic system.						
UNIT – III	**WIND AND BIOMASS ENERGY**	**9 Periods**				
Wind Energy: Properties of wind, availability of wind energy in India, wind velocity and power from wind; major problems associated with wind power, Basic components of wind energy conversion system (WECS); Classification of WECS- Horizontal axis- single, double and multi blade system. Vertical axis- Savonius and Darrieus types. Biomass Energy: Introduction; Photosynthesis Process; Biofuels; Biomass Resources; Biomass conversion technologies -fixed dome; Urban waste to energy conversion; Biomass gasification (Downdraft).						
UNIT – IV	**TIDAL AND OCEAN THERMAL ENERGY**	**9 Periods**				
Tidal Power: Tides and waves as energy suppliers and their mechanics; fundamental characteristics of tidal power, harnessing tidal energy, advantages and limitations. Ocean Thermal Energy Conversion: Principle of working, OTEC power stations in the world, problems associated with OTEC.						
UNIT – V	**GREEN ENERGY**	**9 Periods**				
Introduction, Fuel cells: Classification of fuel cells – H_2; Operating principles, Zero energy Concepts. Benefits of hydrogen energy, hydrogen production technologies (electrolysis method only), hydrogen energy storage, applications of hydrogen energy, problem associated with hydrogen energy.						
Contact Periods: (Times New Roman, Size 11, BOLD, Sentence case) **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**						

TEXT BOOK

1	G D Rai, Non Conventional Energy sources, Khanna Publication, Fourth Edition, 2009
2	Boyle, "Renewable Energy – Power For A Sustainable Future", Oxford, 2012

REFERENCES

1	S Rao,B.B.Parulekhar, "Energy Technology 3/e: Nonconventional, Renewable and Conventional", Khanna Publishers, 1994
2	G. N. Tiwari,"Solar Energy - Fundamentals, Design, Modelling and Applications", 2002
3	Gilbert M. Masters, "Renewable and Efficient Electric Power Systems" Wiley,2005
4	Shobh Nath Singh, "Non-Convention Energy Resources", Pearson, 2018

COURSE OUTCOMES: On completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Describe the environmental aspects of renewable energy resources in comparison with various conventional energy systems, their prospects and limitations.	K2
CO2	Summarize the use of solar energy and the various components used in the energy production with respect to applications like - heating, cooling, desalination, electric power generation.	K2
CO3	Apply the conversion principles of wind and tidal energy for the production of electric power generation	K3
CO4	Apply the concept of biomass energy resources and green energy for developing sustainable electric power generation set-up	K3
CO5	Analyze the basic knowledge of ocean thermal energy conversion and hydrogen energy and hence design & evaluate the power generation system	K4

COURSE ARTICULATION MATRIX :

a) CO and PO Mapping

COs/POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	3	3	3	3	3	3	-	-	-	-	3	3	3	2
CO2	3	3	3	3	3	3	3	-	-	-	-	3	3	3	2
CO3	3	3	3	3	3	3	3	-	-	-	-	3	3	3	2
CO4	3	3	3	3	3	3	3	-	-	-	-	3	3	3	2
CO5	3	3	3	3	3	3	3	-	-	-	-	3	3	3	2
22EOE$05	3	3	3	3	3	3	3	-	-	-	-	3	3	3	2

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.1.1, 1.1.2, 1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.2.4, 2.3.1, 2.3.2, 2.4.1, 2.4.2, 2.4.3, 2.4.4, 3.1.1, 3.1.2, 3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.2, 3.2.3, 3.3.1, 3.3.2, 3.4.1, 3.4.2, 4.1.1, 4.1.2, 4.1.3, 4.1.4, 4.2.1, 4.2.2, 4.3.1, 4.3.2, 4.3.3, 4.3.4, 5.1.1, 5.1.2, 5.2.1, 5.2.2, 5.3.1, 5.3.2, 6.1.1, 6.2.1, 7.1.1, 7.1.2, 7.2.1, 7.2.2, 12.1.1, 12.1.2, 12.2.1, 12.2.2, 12.3.2.
CO2	1.1.1, 1.1.2, 1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3,2.2.4, 2.3.1, 2.3.2, 2.4.1, 2.4.2, 2.4.3, 2.4.4, 3.1.1, 3.1.2, 3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.2, 3.2.3, 3.3.1, 3.3.2, 3.4.1, 3.4.2, 4.1.1, 4.1.2, 4.1.3, 4.1.4, 4.2.1, 4.2.2, 4.3.1, 4.3.2, 4.3.3, 4.3.4, 5.1.1, 5.1.2, 5.2.1, 5.2.2, 5.3.1, 5.3.2, 6.1.1, 6.2.1, 7.1.1, 7.1.2, 7.2.1, 7.2.2, 12.1.1, 12.1.2, 12.2.1, 12.2.2, 12.3.2.
CO3	1.1.1, 1.1.2, 1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.2.4, 2.3.1, 2.3.2, 2.4.1, 2.4.2, 2.4.3, 2.4.4, 3.1.1, 3.1.2, 3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.2, 3.2.3, 3.3.1, 3.3.2, 3.4.1, 3.4.2, 4.1.1, 4.1.2, 4.1.3, 4.1.4, 4.2.1, 4.2.2, 4.3.1, 4.3.2, 4.3.3, 4.3.4, 5.1.1, 5.1.2, 5.2.1, 5.2.2, 5.3.1, 5.3.2, 6.1.1, 6.2.1, 7.1.1, 7.1.2, 7.2.1, 7.2.2, 12.1.1, 12.1.2, 12.2.1, 12.2.2, 12.3.2.
CO4	1.1.1, 1.1.2, 1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.2.4, 2.3.1, 2.3.2, 2.4.1, 2.4.2, 2.4.3, 2.4.4, 3.1.1, 3.1.2, 3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.2, 3.2.3, 3.3.1, 3.3.2, 3.4.1, 3.4.2, 4.1.1, 4.1.2, 4.1.3, 4.1.4, 4.2.1, 4.2.2, 4.3.1, 4.3.2, 4.3.3, 4.3.4, 5.1.1, 5.1.2, 5.2.1, 5.2.2, 5.3.1, 5.3.2, 6.1.1, 6.2.1, 7.1.1, 7.1.2, 7.2.1, 7.2.2, 12.1.1, 12.1.2, 12.2.1, 12.2.2, 12.3.2.
CO5	1.1.1, 1.1.2, 1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.2.4, 2.3.1, 2.3.2, 2.4.1, 2.4.2, 2.4.3, 2.4.4, 3.1.1, 3.1.2, 3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.2, 3.2.3, 3.3.1, 3.3.2, 3.4.1, 3.4.2, 4.1.1, 4.1.2, 4.1.3, 4.1.4, 4.2.1, 4.2.2, 4.3.1, 4.3.2, 4.3.3, 4.3.4, 5.1.1, 5.1.2, 5.2.1, 5.2.2, 5.3.1, 5.3.2, 6.1.1, 6.2.1, 7.1.1, 7.1.2, 7.2.1, 7.2.2, 12.1.1, 12.1.2, 12.2.1, 12.2.2, 12.3.2.

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	20	20	30	30	-	-	100
CAT2	20	20	30	30	-	-	100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	20	20	30	30	-	-	100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	20	20	30	30	-	-	100
ESE	20	20	30	30	-	-	100

22EOE$06	**SMART GRID TECHNOLOGY** *(Common to All Branches)*

PREREQUISITES	CATEGORY	L	T	P	C
NIL	OE	3	0	0	3

Course Objectives	To provide a comprehensive understanding of Smart Grid Technology, including its components, functions, applications and implications for Energy Management and Distribution.	
UNIT – I	**BASICS OF POWER SYSTEMS**	**9 Periods**
Basics of Power Systems: Load and Generation - Power Flow Analysis- Economic Dispatch and Unit Commitment Problems. Smart Grid: Definition – Applications- Government and Industry- Standardization		
UNIT – II	**SMART GRID COMMUNICATIONS**	**9 Periods**
Two-way Digital Communications Paradigm - Network Architectures - IP-based Systems - Power Line Communications - Advanced Metering Infrastructure		
UNIT – III	**WIDE AREA MEASUREMENT**	**9 Periods**
Sensor Networks - Phasor Measurement Units- Communications Infrastructure- Fault Detection and Self-Healing Systems -Applications and Challenges		
UNIT – IV	**SECURITY AND PRIVACY**	**9 Periods**
Cyber Security Challenges in Smart Grid - Load Altering Attacks- False Data Injection Attacks- Defense Mechanisms - Privacy Challenges- Cyber Security Standards		
UNIT – V	**ECONOMICS AND MARKET OPERATIONS**	**9 Periods**
Introduction, Reasons for restructuring / deregulation of power industry, Understanding the restructuring process - Entities involved. The market place mechanisms-Energy and Reserve Markets- Market Power - Generation Firms- Locational Marginal Prices- Financial Transmission Rights		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOK

1	*Janaka Ekanayake, Nick Jenkins, KithsiriLiyanage "***Smart Grid Technologies and applications"** *John Wiley Publishers Ltd., 2012.*
2	*P. Venkatesh, B.V. Manikandan, S. Charles Raja, A. Srinivasan "***Electrical Power Systems- Analysis, Security and Deregulation"** *PHI Learning Private Limited, New Delhi, 2012.*

REFERENCES

1	*Lars T. Berger, Krzysztof Iniewski "***Smart Grid applications, Communications and Security***"* *John Wiley Publishers Ltd., 2012.*
2	*Yang Xiao,* **"Communication and Networking in Smart Grids",** *CRC Press Taylor and Francis Group, 2012.*
3	*Caitlin G. Elsworth,* **"The Smart Grid and Electric Power Transmission"**, *Nova Science Publishers Inc, August 2010*
4	*Lars T. Berger, Krzysztof Iniewski "***Smart Grid applications, Communications and Security***"* *John Wiley Publishers Ltd., 2012.*

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Recollect the fundamentals of conventional power systems and learn the concept of smart grid	K1
CO2	Interpret the role of communication Technologies in a smart grid	K2
CO3	Apply the state-of-the-art measurement and protection techniques for reliable grid	K3
CO4	Utilize the techniques for ensuring safety and security of the smart grid	K3
CO5	Analyze the economical aspects of the smart grids	K4

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	2	2	2	2	2	2	2	-	-	1	1	-	3	2	1
CO2	3	3	1	2	2	-	-	-	-	2	3	2	3	2	1
CO3	3	3	1	2	2	-	-	-	-	2	3	2	3	3	2
CO4	3	3	1	2	2	3	2	2	1	-	-	3	3	3	2
CO5	3	2	2	2	2	-	2	2	-	1	3	3	3	3	2
22EOE$06	3	3	1	2	2	3	2	2	1	2	3	3	3	3	2

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.2.1, 1.3.1, 1.4.1, 2.3.1, 2.3.2, 2.4.4, 3.1.3, 3.1.6, 3.2.1, 4.1.4, 4.2.1, 4.3.4, 5.1.1, 5.3.1, 6.1.1, 7.1.1, 7.2.2, 10.1.1, 10.3.1, 11.1.1
CO2	1.1.1, 1.1.2, 1.2.1, 1.3.1, 1.4.1, 2.1.2, 2.1.3, 2.2.1, 2.2.3, 2.3.1, 2.3.2, 2.4.1, 2.4.2, 2.4.3, 2.4.4, 3.1.6, 3.2.13.2.2, 3.2.3, 4.1.1, 4.1.3, 4.1.4, 5.1.1, 5.2.1, 5.3.1, 12.1.2, 12.2.2, 12.3.2, 10.1.1, 10.2.2, 10.3.1, 11.1.1, 11.2.1, 11.3.1, 11.3.2, 12.3.1, 12.3.2
CO3	1.1.1, 1.1.2, 1.2.1, 1.3.1, 1.4.1, 2.1.2, 2.1.3, 2.2.1, 2.2.3, 2.3.1, 2.3.2, 2.4.1, 2.4.2, 2.4.3, 2.4.4, 3.1.6, 3.2.13.2.2, 3.2.3, 4.1.1, 4.1.3, 4.1.4, 5.1.1, 5.2.1, 5.3.1, 12.1.2, 12.2.2, 12.3.2, 10.1.1, 10.2.2, 10.3.1, 11.1.1, 11.2.1, 11.3.1, 11.3.2, 12.3.1, 12.3.2
CO4	1.1.1, 1.1.2, 1.2.1, 1.3.1, 1.4.1, 2.1.2, 2.1.3, 2.2.1, 2.2.3, 2.3.1, 2.3.2, 2.4.1, 2.4.2, 2.4.3, 2.4.4, 3.1.6, 3.2.13.2.2, 3.2.3, 4.1.1, 4.1.3, 4.1.4, 5.1.1, 5.2.1, 5.3.1, 8.2.2, 9.1.2, 7.2.1, 7.2.2, 6.2.1, 6.1.1, 5.3.2, 5.3.1, 5.3.212.1.2, 12.2.2, 12.3.2
CO5	1.1.1, 1.1.2, 1.2.1, 1.3.1, 1.4.1, 2.1.2, 2.1.3, 2.2.1, 2.2.3, 2.3.1, 2.3.2, 2.4.1, 2.4.2, 2.4.3, 2.4.4, 3.1.6, 3.2.13.2.2, 3.2.3, 4.1.1, 4.1.3, 4.1.4, 5.1.1, 5.2.1, 5.3.1, 12.1.2, 12.2.2, 12.3.2

ASSESSMENT PATTERN							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	10	30	40	20	-	-	100
CAT2	10	30	40	20	-	-	100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	-	30	30	20	20	-	100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	-	30	30	20	20	-	100
ESE	10	30	40	20	-	-	100

22LOE$07	**CMOS VLSIDESIGN** *(Common to All Branches)*

PREREQUISITES	CATEGORY	L	T	P	C
NIL	OE	3	0	0	3

Course Objective	To introduce various aspects of CMOS logic design in combinational and sequential circuit to design CMOS VLSI system components	
UNIT – I	**CMOSLOGICDESIGN**	**9 Periods**
Inverter- CMOS Logic Gates: Compound Gates – Pass Transistors and Transmission Gates –Tristated – Multiplexers –CMOS Fabrication and Layout: Fabrication Process – Layout Designrule–GateLayouts–StickDiagrams–DesignPartitioning.		
UNIT – II	**MOSTRANSISTORTHEORY**	**9 Periods**
Introduction – Long Channel I-V Characteristics – C-V Characteristics – Non-ideal I-V Effects –DC Transfer Characteristics – CMOS Technologies – Sources of Power Dissipation - DynamicPower–Static Power.		
UNIT – III	**COMBINATIONALCIRCUITDESIGN**	**9 Periods**
CircuitFamilies:StaticCMOS–RatioedCircuits–CascodeVoltageSwitchLogic–Dynamic Circuits–PassTransistorCircuits.Silicon-on-InsulatorCircuitDesign–SubthresholdCirucitDesign.		
UNIT – IV	**SEQUENTIALCIRCUITDESIGN**	**9 Periods**
Sequentialstaticcircuits–Circuitdesignoflatchedandflip-flops–Sequencingdynamiccircuits –Synchronizers–Wavepipelining -VLSIclocking:CMOS clockingstyles-Pipelinedsystems-Clockgenerationanddistribution.		
UNIT – V	**DESIGNOFVLSISYSTEMS**	**9 Periods**
System Specifications – Structural Gate Level Modeling – Switch Level Modeling – BehavioralandRTL Modeling-Addition/subtraction–Comparators–counters—Multiplexers-BinaryDecoders – Comparators – Priority Encoders – Latches - Flip-Flops and Registers – SRAM – DRAM–ROM.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOKS:

1	*N. Weste and David Money Harris, "**CMOS VLSI Design**", Fourth Edition, PearsonEducation,2011*
2	*Uyemura, John P, "**Introduction to VLSI Circuits and Systems**", Wiley & Sons, 8thReprint 2009*

REFERENCES:

1	*JanM.Rabaey,"**DigitalIntegratedCircuits:ADesignPerspective**",PHI,SecondEdition,2012.*
2	*R.JacobBaker,"**CMOS:CircuitDesign,Layout,andSimulation**",Wiley-IEEE,RevisedSecondEdition,2008.*
3	*Pucknell,"**BasicVLSIDesign**",PrenticeHall,2006.*

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Realize the CMOS logic design	K2
CO2	Explain the basic MOS transistor theory and power dissipation in CMOS logic.	K2
CO3	Develop combinational circuit design of CMOS logic	K3
CO4	Interpret sequential circuit design of CMOS logic	K2
CO5	Model the digital system using Hardware Description Language	K2

COURSE ARTICULATION MATRIX :

a) CO and PO Mapping

COs/POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	3	2	-	-	2	-	-	-	2	-	3	3	1	3
CO2	3	2	1	-	-	2	-	-	-	2	-	3	2	1	2
CO3	3	3	2	-	-	2	-	-	-	2	-	3	3	1	3
CO4	3	3	2	-	-	2	-	-	-	2	-	3	3	1	3
CO5	3	3	2	-	-	2	-	-	-	2	-	3	3	1	3
22LOE$07	**3**	**3**	**2**	**-**	**-**	**2**	**-**	**-**	**-**	**2**	**-**	**3**	**3**	**1**	**3**

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.1.2, 1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.3.1, 2.3.2, 2.4.1, 2.4.3, 3.1.4, 3.1.5, 3.1.6, 3.3.2, 3.4.1, 3.4.2, 6.1.1, 10.1.1, 10.1.2, 10.1.3, 12.1.1, 12.1.2, 12.2.1, 12.2.2, 12.3.1, 12.3.2
CO2	1.1.2, 1.2.1, 1.3.1, 1.4.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.3.1, 2.3.2, 2.4.1, 3.1.4, 3.3.2, 3.4.1, 3.4.2, 6.1.1, 10.1.1, 10.1.2, 10.1.3, 12.1.1, 12.1.2, 12.2.1, 12.2.2, 12.3.1, 12.3.2
CO3	1.1.2, 1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.3.1, 2.3.2, 2.4.1, 2.4.3, 3.1.4, 3.1.5, 3.1.6, 3.3.2, 3.4.1, 6.1.1, 10.1.1, 10.1.2, 10.1.3, 12.1.1, 12.1.2, 12.2.1, 12.2.2, 12.3.1, 12.3.2
CO4	1.1.2, 1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.3.1, 2.3.2, 2.4.1, 2.4.3, 3.1.4, 3.1.5, 3.1.6, 3.3.2, 3.4.1, 3.4.2, 6.1.1, 10.1.1, 10.1.2, 10.1.3, 12.1.1, 12.1.2, 12.2.1, 12.2.2, 12.3.1, 12.3.2
CO5	1.1.2, 1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.3.1, 2.3.2, 2.4.1, 3.1.4, 3.1.5, 3.1.6, 3.3.2, 3.4.1, 3.4.2, 6.1.1, 10.1.1, 10.1.2, 10.1.3, 12.1.1, 12.1.2, 12.2.1, 12.2.2, 12.3.1, 12.3.2

ASSESSMENT PATTERN – THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	40	40	20	-	-	-	100
CAT2	40	40	20	-	-	-	100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	-	50	50	-	-	-	100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	-	50	50	-	-	-	100
ESE	40	40	20	-	-	-	100

22LOE$08	**MOBILE COMMUNICATION** *(Common to All Branches)*

PREREQUISITES	CATEGORY	L	T	P	C
NIL	OE	3	0	0	3

Course Objective	To understand and recall the mobile radio propagation, cellular architectures, equalization and diversity techniques, digital modulation techniques and various wireless network standards.	
UNIT – I	**MOBILE RADIO PROPAGATION**	**9 Periods**
Review of free-space propagation - Radio Wave Propagation in wireless environment - Free Space Propagation Model - Ground Reflection Model, Diffraction, Scattering - Practical link budget design - Small scale fading - Time dispersion parameters - Coherence bandwidth - Doppler spread & Coherence time, Fading due to Multipath time delay spread - Fading due to Doppler spread.		
UNIT – II	**CELLULAR CONCEPT**	**9 Periods**
Hexagonal cell-Cell clustering-Frequency Reuse-Static and dynamic channel assignment strategies - Handoff Strategies - Interference and System Capacity - Trunking - Capacity in Cellular Systems. Multiple Access Techniques: FDMA, TDMA, CDMA, OFDMA.		
UNIT – III	**MULTIPATH MITIGATION TECHNIQUES**	**9 Periods**
Equalization – Adaptive equalization: Linear and Non-Linear equalization, - Diversity – Micro and Macro diversity - Diversity combining techniques - Rake receiver- MIMO Coding: Alamouti Scheme (Qualitative)		
UNIT – IV	**MODULATION TECHNIQUES**	**9 Periods**
Modulation in cellular wireless systems: Binary Phase Shift Keying (BPSK) – QPSK –Orthogonal QPSK-Minimum Shift Keying-Gaussian Minimum Shift Keying - Multicarrier modulation: Orthogonal Frequency Division Multiplexing (OFDM) -PAPR reduction –Windowed OFDM - Filtered OFDM		
UNIT – V	**WIRELESS NETWORKS**	**9 Periods**
Second Generation Cellular Standard: GSM - Third Generation Cellular standards: CDMA -WCDMA-Fourth Generation Cellular Standards: 4G LTE – LTE Advanced – 5G Network – Near Field Communication (NFC) systems – Wireless LAN technology – Hyper LAN – Bluetooth technology – Ultra Wideband (UWB) communication - Introduction to 60 GHz mmWave.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOKS:

1	*Theodore S. Rappaport, "Wireless communications", 2nd Edition, Pearson Education, 2010*
2	*Mischa Schwartz, "Mobile Wireless Communications", 1st Edition, Cambridge University Press, 2010*

REFERENCES:

1	*Suvra Sekhar Das and Ramjee Prasad, "Evolution of air interface towards 5G Radio Access Technology and Performance Analysis", River Publishers,2018*
2	*David Tse, Pramod Viswanath, "Fundamentals of Wireless Communication", 1st Edition, Cambridge University Press, 2006.*
3	*Andreas.F. Molisch, "Wireless Communications", 2nd Edition, Wiley, 2011.*
4	*Aditya K Jagannatham, "Principles of Modern Wireless Communication Systems Theory and Practice", 1st Edition, McGraw Hill Education (India) Private Limited, 2017*
5	*William Stallings, "Wireless Communications and networks", 2nd Edition, Pearson, 2009.*

COURSE OUTCOMES: On completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Interpret the concepts of radio propagation and fading channel models in wireless communication	K3
CO2	Interpret the functionalities of various cellular concepts and multiple access techniques and solve problems in channel assignment and traffic intensity in cellular system	K4
CO3	Explain various equalization and diversity combining techniques used in multipath propagation	K2
CO4	Discuss the need for digital and multicarrier modulation techniques used in modern cellular system	K2
CO5	Recall the functionalities of various wireless networks used in day-today life.	K2

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping

COs/POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	2	1	1	-	-	-	-	-	-	-	1	3	-	1
CO2	3	2	1	1	-	-	-	-	-	-	-	1	3	-	1
CO3	3	2	1	1	-	-	-	-	-	-	-	1	3	-	1
CO4	3	2	1	1	-	-	-	-	-	-	-	1	3	-	1
CO5	3	2	1	1	-	-	-	-	-	-	-	1	3	-	1
22LOE$08	3	2	1	1	-	-	-	-	-	-	-	1	3	-	1

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.1.1,1.1.2,1.2.1,1.3.1,1.4.1,2.1.1,2.1.2,2.1.3,2.2.2,2.2.3,2.3.1,2.3.2,2.4.1,2.4.4,3.1.1,3.1.2,3.3.1,4.1.1, 4.2.1,4.3.3, 12.1.1,12.2.2
CO2	1.1.1,1.1.2,1.2.1,1.3.1,1.4.1,2.1.1,2.1.2,2.1.3,2.2.2,2.2.3,2.3.1,2.3.2,2.4.1,2.4.4,3.1.1,3.1.2,3.3.1,4.1.1, 4.2.1,4.3.3, 12.1.1,12.2.2
CO3	1.1.1,1.1.2,1.2.1,1.3.1,1.4.1,2.1.1,2.1.2,2.1.3,2.2.2,2.2.3,2.3.1,2.3.2,2.4.1,2.4.4,3.1.1,3.1.2,3.3.1,4.1.1, 4.2.1,4.3.3, 12.1.1,12.2.2
CO4	1.1.1,1.1.2,1.2.1,1.3.1,1.4.1,2.1.1,2.1.2,2.1.3,2.2.2,2.2.3,2.3.1,2.3.2,2.4.1,2.4.4,3.1.1,3.1.2,3.3.1,4.1.1, 4.2.1,4.3.3,12.1.1,12.2.2
CO5	1.1.1,1.1.2,1.2.1,1.3.1,1.4.1,2.1.1,2.1.2,2.1.3,2.2.2,2.2.3,2.3.1,2.3.2,2.4.1,2.4.4,3.1.1,3.1.2,3.3.1,4.1.1, 4.2.1,4.3.3,12.1.1,12.2.2

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	20	40	20	20	-	-	100
CAT2	50	50	-	-	-	-	100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	20	40	20	20	-	-	100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	50	50	-	-	-	-	100
ESE	20	40	20	20	-	-	100

22POE$09	**RAPIDPROTOTYPING** *(Common to All Branches)*

PREREQUISITES	CATEGORY	L	T	P	C
NIL	OE	3	0	0	3

Course Objectives	*To educate the students with fundamental and advanced knowledge in the field of Rapid Prototyping technology and associated Aerospace, Architecture, Art, Medical and Industrial applications.	
UNIT- I	**INTRODUCTION**	**(9 Periods)**
Overview - Need - Development of Rapid Prototyping (RP) Technology: Rapid Prototyping -Rapid Tooling - Rapid Manufacturing - Additive Manufacturing. RP Process Chain, Benefits, Applications: Building Printing, Bio Printing, Food Printing, Electronics Printing, Automobile, Aerospace, Healthcare.		
UNIT- II	**VAT POLYMERIZATION AND MATERIAL EXTRUSION**	**(9 Periods)**
Photo polymerization: Stereo lithography Apparatus (SLA) - Materials -Process - top down and bottom up approach - Advantages - Limitations - Applications. Digital Light Processing (DLP) - Process - Advantages - Applications. Material Extrusion: Fused Deposition Modelling (FDM) - Process-Materials -Applications and Limitations.		
UNIT- III	**POWDER BED FUSION AND BINDER JETTING**	**(9 Periods)**
Powder Bed Fusion: Selective Laser Sintering (SLS): Process - Powder Fusion Mechanism - Materials and Application. Selective Laser Melting (SLM), Electron Beam Melting (EBM): Materials - Process - Advantages and Applications. Binder Jetting: Three-Dimensional Printing - Materials - Process - Benefits - Limitations - Applications.		
UNIT- IV	**MATERIAL JETTING AND DIRECTED ENERGY DEPOSITION**	**(9 Periods)**
Material Jetting: Multi jet Modelling- Materials - Process - Benefits - Applications. Directed Energy Deposition: Laser Engineered Net Shaping (LENS) - Process - Material Delivery -Materials –Benefits - Applications.		
UNIT- V	**SHEET LAMINATION AND DIRECT WRITE TECHNOLOGY**	**(9 Periods)**
Sheet Lamination: Laminated Object Manufacturing (LOM)- Basic Principle- Mechanism: Gluing or Adhesive Bonding - Thermal Bonding - Materials - Application and Limitation. Ink-Based Direct Writing (DW): Nozzle Dispensing Processes, Inkjet Printing Processes, Aerosol DW - Applications of DW.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOK

1	*Ian Gibson, David Rosen, Brent Stucker, Mahyar Khorasani “**Additive manufacturing technologies”.** 3rd edition Springer Cham, Switzerland, 2021.*
2	*Andreas Gebhardt and Jan-Steffen Hötter “**Additive Manufacturing: 3D Printing for Prototyping and Manufacturing**”, Hanser publications, United States, 2015.*

REFERENCES

1	*Andreas Gebhardt, **"Understanding Additive Manufacturing: Rapid Prototyping, Rapid Manufacturing"**, Hanser Gardner Publication, Cincinnati., Ohio, 2011.*
2	*Milan Brandt, **"Laser Additive Manufacturing: Materials, Design, Technologies, and Applications"**, Woodhead Publishing., United Kingdom, 2016.*
3	*Amit Bandyopadhyay and Susmita Bose, **"Additive Manufacturing",** 1st Edition, CRC Press., United States, 2015.*
4	*Kamrani A.K. and Nasr E.A., **"Rapid Prototyping: Theory and practice",** Springer., United States ,2006.*
5	*Liou, L.W. and Liou, F.W., **"Rapid Prototyping and Engineering applications: A tool box for prototype development"**, CRC Press., United States, 2011.*

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Discuss the development of RP technology and how RP technology propagated into various businesses and developing opportunities.	K3
CO2	Demonstrate the Vat polymerization and material extrusion processes and its applications.	K3
CO3	Elaborate the process and applications of powder bed fusion and binder jetting.	K3
CO4	Evaluate the advantages, limitations, applications of material jetting and directed energy deposition processes.	K3
CO5	Describe the sheet lamination and direct write technology.	K3

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping

COs/POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	2	2	2	0	2	0	3	0	3	3	3	3	0	0	0
CO2	2	2	3	2	3	0	3	0	3	3	1	2	0	0	0
CO3	2	2	3	2	3	0	3	0	3	3	1	2	0	0	0
CO4	2	2	3	2	3	0	3	0	3	3	1	2	0	0	0
CO5	2	2	3	2	3	3	3	0	3	3	1	3	0	0	0
22POE$09	2	2	3	2	3	1	3	0	3	3	2	3	0	0	0

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.3, 2.2.2, 2.2.3, 2.2.4, 2.3.1, 2.3.2, 2.4.2, 3.1.1, 3.1.2, 3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.2.3, 5.2.2, 5.3.1, 5.3.2, 7.1.2, 7.2.1, 7.2.2, 9.2.1, 9.2.2, 9.2.3, 9.2.4, 9.3.1, 10.1.1, 10.1.2, 10.1.3, 10.2.1, 10.2.2, 10.3.1, 10.3.2, 11.1.1, 11.1.2, 11.2.1, 11.3.1, 11.3.2, 12.1.1, 12.1.2, 12.2.2, 12.3.1, 12.3.2.
CO2	1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.3, 2.2.2, 2.2.3, 2.2.4, 2.3.1, 2.3.2, 2.4.2, 3.1.1, 3.1.2, 3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.2, 3.2.3, 3.3.2, 3.4.1, 3.4.2, 4.1.1, 4.1.2, 4.2.1, 4.3.1, 5.1.1, 5.1.2, 5.2.1, 5.2.2, 5.3.1, 5.3.2, 7.1.1, 7.1.2, 7.2.1, 7.2.2, 9.2.1, 9.2.2, 9.2.3, 9.2.4, 9.3.1, 10.1.1, 10.1.2, 10.1.3, 10.2.1, 10.2.2, 10.3.1, 10.3.2, 11.3.1, 12.1.2, 12.2.2, 12.3.1, 12.3.2.
CO3	1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.3, 2.2.2, 2.2.3, 2.2.4, 2.3.1, 2.3.2, 2.4.2, 3.1.1, 3.1.2, 3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.2, 3.2.3, 3.3.2, 3.4.1, 3.4.2, 4.1.1, 4.1.2, 4.2.1, 4.3.1, 5.1.1, 5.1.2, 5.2.1, 5.2.2, 5.3.1, 5.3.2, 7.1.1, 7.1.2, 7.2.1, 7.2.2, 9.2.1, 9.2.2, 9.2.3, 9.2.4, 9.3.1, 10.1.1, 10.1.2, 10.1.3, 10.2.1, 10.2.2, 10.3.1, 10.3.2, 11.3.1, 12.1.2, 12.2.2, 12.3.1, 12.3.2.

CO4	1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.3, 2.2.2, 2.2.3, 2.2.4, 2.3.1, 2.3.2, 2.4.2, 3.1.1, 3.1.2, 3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.2, 3.2.3, 3.3.2, 3.4.1, 3.4.2, 4.1.1, 4.1.2, 4.2.1, 4.3.1, 5.1.1, 5.1.2, 5.2.1, 5.2.2, 5.3.1, 5.3.2, 7.1.1, 7.1.2, 7.2.1, 7.2.2, 9.2.1, 9.2.2, 9.2.3, 9.2.4, 9.3.1, 10.1.1, 10.1.2, 10.1.3, 10.2.1, 10.2.2, 10.3.1, 10.3.2, 11.3.1, 12.1.2, 12.2.2, 12.3.1, 12.3.2.
CO5	1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.3, 2.2.2, 2.2.3, 2.2.4, 2.3.1, 2.3.2, 2.4.2, 3.1.1, 3.1.2, 3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.2.1, 3.2.2, 3.2.3, 3.3.2, 3.4.1, 3.4.2, 4.1.1, 4.1.2, 4.2.1, 4.3.1, 5.1.1, 5.1.2, 5.2.1, 5.2.2, 5.3.1, 5.3.2, 6.1.1, 6.2.1, 7.1.1, 7.1.2, 7.2.1, 7.2.2, 9.2.1, 9.2.2, 9.2.3, 9.2.4, 9.3.1, 10.1.1, 10.1.2, 10.1.3, 10.2.1, 10.2.2, 10.3.1, 10.3.2, 11.3.1, 12.1.1, 12.1.2, 12.2.2, 12.3.1, 12.3.2.

ASSESSMENT PATTERN– THEORY

Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	15	52	33	-	-	-	100
CAT2	15	68	17	-	-	-	100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	-	50	50	-	-	-	100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	-	-	100	-	-	-	100
ESE	9	75	16	-	-	-	100

22POE$10	MANAGERIALECONOMICS *(Common to All Branches)*

PREREQUISITES	CATEGORY	L	T	P	C
NIL	OE	3	0	0	3

Course Objectives	To introduce the fundamental economic principles necessary for production managers	
UNIT- I	**FUNDAMENTALS OF MANAGERIAL ECONOMICS**	**(9 Periods)**
Introduction to Economics - Scope of Managerial Economics - General Foundations of Managerial Economics: Economic Approach, Working of Economic System and Circular Flow of Activities - Economics and Business Decisions: Relationship between Economic Theory and Managerial Economics - Role of managerial Economics in Decision making - Concept of Economic Rationality - Opportunity Cost - Marginal and Incremental approach.		
UNIT- II	**DEMAND ANALYSIS**	**(9 Periods)**
Demand and Supply - Determinants of Demand - Demand Estimation and Forecasting - Price Elasticity of Demand - Price Elasticity- Factors Affecting Price Elasticity - Cross Price Elasticity - Income Elasticity of Demand - Advertisement or Promotional Elasticity - Elasticity of Supply.		
UNIT- III	**DEMAND THEORY**	**(9 Periods)**
Utility Analysis - Total and Marginal Utility - Law of Diminishing marginal utility - Indifference curve analysis - Consumer Equilibrium - Consumer Surplus - Price effect, Substitution Effect and Income Effect.		
UNIT- IV	**THEORY OF PRODUCTION AND COST**	**(9 Periods)**
The Production Function - Profit-Maximizing Input Usage - Isoquants and Isocosts – CostMinimization and Optimal Input Substitution - The Cost Function - Breakeven analysis,Contribution analysis - Long-run Costs and Economies of Scale - Multiple Cost Functions andEconomies of Scope - Learning curve.		
UNIT- V	**THEORY OF MARKET AND PRICING**	**(9 Periods)**
Forms of Markets: Meaning and Characteristics - Market Equilibrium: Practical Importance, Market Equilibrium and Changes in Market Equilibrium. Pricing Functions: Market Structures - Pricing and output decisions under different competitive conditions: Monopoly Monopolistic completion and Oligopoly.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOK:

1	*Maheshwari.Y* ***"Managerial Economics",*** *Prentice Hall of India, 2012*
2	*Thomas and Maurice* ***"Managerial Economics: Concept and Applications",*** *McGrawHill, 2005*

REFERENCES:

1	*D.N. Dwivedi,* ***"Managerial Economics",*** *Vikas Publishing house, 2015.*
2	*Christopher R Thomas, S Charles Maurice,* ***"Managerial economics",*** *Mcgraw Hill, 2014.*
3	*M. A. Beg, "****Managerial Economics****",Global Professional Publishing Ltd, 2010.*
4	*K.C. Sankaranarayanan, "****Managerial Economics****", CBS, 2015.*

COURSE OUTCOMES: On completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Explain fundamentals of managerial economics	K2
CO2	Discuss the dynamics of Demand	K3
CO3	Explain about various theories of demand	K3
CO4	Discuss about the factors influencing production	K4
CO5	Describe about the theory of market and pricing method	K4

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	2	1	3	1	3	3	0	1	3	3	3	0	1	2
CO2	1	3	2	3	1	3	3	0	1	3	3	3	0	1	2
CO3	1	3	2	3	1	3	3	0	1	3	3	3	0	1	2
CO4	1	3	2	3	1	3	3	0	1	3	3	3	1	1	2
CO5	1	3	2	3	1	3	3	0	1	3	3	3	0	1	2
22POE$10	**1**	**3**	**2**	**3**	**1**	**3**	**3**	**0**	**1**	**3**	**3**	**3**	**0**	**1**	**2**

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.2.1, 2.1.2, 2.2.2, 2.2.3, 2.2.4, 2.3.1, 2.4.4, 3.1.1, 3.1.3, 3.1.5, 3.2.3, 3.3.1, 3.4.1, 4.1.1, 4.1.2, 4.3.4, 5.2.1, 5.3.1, 6.1.1, 6.2.1, 7.1.1, 7.1.2, 7.2.1, 7.2.2, 9.2.1, 10.1.1, 10.1.2, 10.1.3, 10.2.1, 10.2.2, 10.3.1, 10.3.2, 11.1.1, 11.2.1, 11.3.1, 12.1.1, 12.1.2, 12.2.1, 12.2.2, 12.3.1, 12.3.2
CO2	1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.2.4, 2.3.1, 2.3.2, 2.4.2, 2.4.3, 2.4.4, 3.1.1, 3.1.2, 3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.2.3, 3.3.2, 3.4.1, 4.1.1, 4.1.2, 4.1.3, 4.1.4, 4.2.1, 4.3.1, 4.3.4, 5.1.2, 5.2.1, 5.2.2, 5.3.1, 5.3.2, 6.1.1, 6.2.1, 7.1.1, 7.1.2, 7.2.1, 7.2.2, 9.2.1, 9.3.1, 10.1.1, 10.1.2, 10.2.1, 10.2.2, 10.3.1, 10.3.2, 11.1.1, 11.2.1, 11.3.1, 12.1.1, 12.1.2, 12.2.1, 12.2.2, 12.3.1, 12.3.2
CO3	1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.2.4, 2.3.1, 2.3.2, 2.4.2, 2.4.3, 2.4.4, 3.1.1, 3.1.2, 3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.2.3, 3.3.2, 3.4.1, 4.1.1, 4.1.2, 4.1.3, 4.1.4, 4.2.1, 4.3.1, 4.3.4, 5.1.2, 5.2.1, 5.2.2, 5.3.1, 5.3.2, 6.1.1, 6.2.1, 7.1.1, 7.1.2, 7.2.1, 7.2.2, 9.2.1, 9.3.1, 10.1.1, 10.1.2, 10.2.1, 10.2.2, 10.3.1, 10.3.2, 11.1.1, 11.2.1, 11.3.1, 12.1.1, 12.1.2, 12.2.1, 12.2.2, 12.3.1, 12.3.2
CO4	1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.2.4, 2.3.1, 2.3.2, 2.4.2, 2.4.3, 2.4.4, 3.1.1, 3.1.2, 3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.2.3, 3.3.2, 3.4.1, 4.1.1, 4.1.2, 4.1.3, 4.1.4, 4.2.1, 4.3.1, 4.3.4, 5.1.2, 5.2.1, 5.2.2, 5.3.1, 5.3.2, 6.1.1, 6.2.1, 7.1.1, 7.1.2, 7.2.1, 7.2.2, 9.2.1, 9.3.1, 10.1.1, 10.1.2, 10.2.1, 10.2.2, 10.3.1, 10.3.2, 11.1.1, 11.2.1, 11.3.1, 12.1.1, 12.1.2, 12.2.1, 12.2.2, 12.3.1, 12.3.2
CO5	1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.2.4, 2.3.1, 2.3.2, 2.4.2, 2.4.3, 2.4.4, 3.1.1, 3.1.2, 3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.2.3, 3.3.2, 3.4.1, 4.1.1, 4.1.2, 4.1.3, 4.1.4, 4.2.1, 4.3.1, 4.3.4, 5.1.2, 5.2.1, 5.2.2, 5.3.1, 5.3.2, 6.1.1, 6.2.1, 7.1.1, 7.1.2, 7.2.1, 7.2.2, 9.2.1, 9.3.1, 10.1.1, 10.1.2, 10.2.1, 10.2.2, 10.3.1, 10.3.2, 11.1.1, 11.2.1, 11.3.1, 12.1.1, 12.1.2, 12.2.1, 12.2.2, 12.3.1, 12.3.2

ASSESSMENT PATTERN– THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	50	50		-	-	-	100
CAT2	50	50		-	-	-	100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	33.33	33.33	33.33	-	-	-	100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	33.33	33.33	33.33	-	-	-	100
ESE	42	42	16	-	-	-	100

22NOE$11	**MEASUREMENT AND CONTROL** *(Common to All Branches)*

PREREQUISITES	CATEGORY	L	T	P	C
NIL	OE	3	0	0	3

COURSE OBJECTIVES	To teach about the concepts of variable sensors for industrial parameter measurement and to impart knowledge on automatic control system	
UNIT - I	**INTRODUCTION TO MEASUREMENTS**	**9 Periods**
Elements of measurement system - Classification of Instruments – Static and dynamic characteristics of a measurement system - Errors in measurement - Calibration of instruments.		
UNIT - II	**STRAIN AND DISPLACEMENT MEASUREMENT**	**9 Periods**
Strain: Types of strain gauges, theory of operation, strain gauge materials, strain gauge circuits and applications. Displacement: Resistive potentiometer: Linear, circular and helical – LVDT - RVDT - Capacitance transducers – Piezoelectric transducers – Hall Effect devices - Proximity sensors.		
UNIT - III	**PRESSURE AND TEMPERATURE MEASUREMENT**	**9 Periods**
Pressure: Mechanical devices: Diaphragm, bellows, and bourdon tube - Electrical devices: Variable resistance, inductance and capacitance transducers. Temperature: Resistance type temperature sensors: RTD , Thermocouples, Thermopiles and Thermistor - Laws of thermocouple – Radiation methods for temperature measurement.		
UNIT - IV	**FLOW AND LEVEL MEASUREMENT**	**9 Periods**
Flow: Variable head type flow meters: Orifice plate, Venturi tube, Flow nozzle, Pitot tube - Variable area type: Rotameter - Turbine flow meter - Electromagnetic flow meter - Ultrasonic flow meter. Level: Resistive, inductive and capacitive techniques – Ultrasonic methods – Air purge system .		
UNIT - V	**AUTOMATIC CONTROL SYSTEM**	**9 Periods**
Elements of control system – Concept of open loop and closed loop systems – Mathematical modelling - Controllers – Brief idea of Proportional, Derivative and Integral Modes – Pneumatic Controller – Hydraulic Controller.		
Contact Periods: 45 Periods **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOKS

1	*A.K. Sawhney, Puneet Sawhney,* ***"A Course in Mechanical Measurements and Instrumentation & Control"*** *Dhanpat Rai & Co, 2012.*
2	*S. K. Singh, "**Industrial Instrumentation and Control**", McGraw Hill Publication, 3rd Edition, 2016.*

REFERENCES

1	*William Bolton, "**Instrumentation and Control Systems,**" Newnes, Publication, 3rd Edition, 2021.*
2	*E. D. Doeblin,* ***"Measurement Systems: Application and Design",*** *McGraw Hill Publication, 6th Edition, 2017.*
3	*E.W. Golding and F.C. Widdis,* ***"Electrical Measurements and Measuring Instruments"*** *A.H.Wheeler and Co., 5th Edition, 2011.*
4	*Alan S. Morris,* ***"Measurement and Instrumentation Principles",*** *Butterworth-Heinemann Publications, 3rd Edition, 2011.*

COURSE OUTCOMES On Completion of the course, the students will be able to		Bloom's Taxonomy Mapped
CO1	Describe the methods of measurement and classification of measuring instruments.	K2
CO2	Suggest suitable sensor for the measurement of strain and displacement.	K2
CO3	Explain the construction and working of transducers for pressure and temperature measurement.	K2
CO4	Elucidate the characteristics of flow and level measuring instruments.	K2
CO5	Elaborate the concept of automatic control system.	K2

COURSE ARTICULATION MATRIX

a) CO/PO Mapping

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	2	-	-	-	-	-	-	-	-	-	3	2
CO2	3	2	2	2	-	-	-	-	-	-	-	-	-	3	2
CO3	3	2	2	2	-	-	-	-	-	-	-	-	-	3	2
CO4	3	2	2	2	-	-	-	-	-	-	-	-	-	3	2
CO5	3	3	3	2	-	-	-	-	-	-	-	-	-	3	3
22NOE$11	3	3	3	2	-	-	-	-	-	-	-	-	-	3	2

b) CO and Key Performance Indicators mapping

CO1	1.1.1, 1.1.2, 1.2.1,1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.3.1, 2.3.2, 2.4.1, 2.4.2, 3.2.1, 3.2.3, 3.3.1, 3.3.2, 3.4.1, 3.4.2, 4.1.2, 4.1.3, 4.1.4
CO2	1.1.1, 1.1.2, 1.2.1,1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.2,2.2.3, 2.3.1, 2.3.2, 3.1.6, 3.3.2, 3.4.1, 3.4.2, 4.1.2, 4.1.3, 4.1.4
CO3	1.1.1, 1.1.2, 1.2.1,1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.2, 2.2.3, 2.2.4, 2.3.1, 2.3.2, 3.1.5, 3.1.6, 3.3.2, 3.4.1, 3.4.2, 4.1.2, 4.1.3, 4.1.4, 4.2.1, 4.2.2
CO4	1.1.1, 1.1.2, 1.2.1,1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.2,2.2.3, 2.2.4, 2.3.1, 2.3.2, 3.1.5, 3.1.6, 3.3.2, 3.4.1, 3.4.2, 4.1.2, 4.1.3, 4.1.4, 4.2.1, 4.2.2
CO5	1.1.1, 1.1.2, 1.2.1,1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.2.4, 2.3.1, 2.3.2, 2.4.1, 2.4.2, 3.1.5, 3.1.6, 3.2.1, 3.2.3, 3.3.1, 3.3.2, 3.4.1, 3.4.2, 4.1.2, 4.1.3, 4.1.4, 4.2.1, 4.2.2

ASSESSMENT PATTERN - THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	40	60	-	-	-	-	100
CAT2	40	60	-	-	-	-	100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	30	70	-	-	-	-	100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	30	70	-	-	-	-	100
ESE	40	60	-	-	-	-	100

22NOE$12	**INDUSTRIAL AUTOMATION** *(Common to All Branches)*

PREREQUISITES	CATEGORY	L	T	P	C
NIL	OE	3	0	0	3

COURSE OBJECTIVE	To elaborate on the basic concept of automation, including the necessary components and various automation controllers utilized in industrial automation.	
UNIT - I	**INTRODUCTION TO AUTOMATION**	**9 Periods**
Automation overview – Requirement of automation systems – Architecture of industrial automation system –Industrial bus systems: Modbus and Profibus.Introduction to Industry 4.0 and its evolution.		
UNIT - II	**AUTOMATION COMPONENTS**	**9 Periods**
Sensors for temperature – Pressure – Force – Displacement - Speed – Flow- level – Humidity and pH measurement. Actuators – Process control valves –Power electronic drives: DIAC- TRIAC –power MOSFET – IGBT. Introduction to DC and AC servo drives for motion control.		
UNIT - III	**PROGRAMMABLE LOGIC CONTROLLERS**	**9 Periods**
PLC Hardware – power supplies and isolators –Relays – Switches -Seal-in circuits – PLC programming – ladder diagram – sequential flow chart – PLC communication and networking – PLC selection – PLC installation – Advantages – Application of PLC to process control industries and Robotics.		
UNIT - IV	**DISTRIBUTED CONTROL SYSTEM**	**9 Periods**
Overview of DCS – DCS hardware – DCS software configuration – DCS communication – DCS supervisory computer tasks – DCS integration with PLC and Computers.		
UNIT - V	SUPERVISORY CONTROL AND DATA ACQUISITION SYSTEMS	**9 Periods**
Introduction - Supervisory Control and Data Acquisition Systems – SCADA HMI Essentials – SCADA Components – SCADA Configuration and Software – HMI hardware and software.		
Contact Periods: 45 Periods **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOKS:

1	*Frank D. Petruzella, "**Programmable Logic Controllers**", 5th Edition, McGraw Hill, 2016.*
2	*S.K. Singh "**Industrial Instrumentation and Control**", 3rd Edition, McGraw Hill Companies, 2004.*

REFERENCES:

1	*Sudip Misra, Chandana Roy, Anandarup Mukherjee, **"Introduction to Industrial Internet of Things and Industry 4.0"**, CRC Press, 1st edition, 2021*
2	*Bela G Liptak, "**Process software and digital networks – Volume 3**", 4th Edition, CRC press, 2012.*
3	*Romily Bowden, "**HART application guide and the OSI communication foundation**",1999.*
4	*John.W. Webb Ronald A Reis, "**Programmable Logic Controllers - Principles and Applications**", Prentice Hall Inc., 5th Edition, 2003.*
5	*M. P. Lukcas, "**Distributed Control Systems"**, Van Nostrand Reinhold Co., 1986.*

COURSE OUTCOMES On Completion of the course, the students will be able to		Bloom's Taxonomy Mapped
CO1	Elaborate the basic architecture of automation systems and Industry 4.0.	K2
CO2	Describe the various automation components and industrial bus system involved in industrial automation	K2
CO3	Construct ladder logic diagram using PLC basic functions, timer and counter functions for simple applications	K3
CO4	Illustrate the functionary components and supervisory control of DCS with relevant diagrams	K2
CO5	Describe the basics of SCADA technology.	K2

COURSE ARTICULATION MATRIX

a) CO/PO Mapping

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1	-	-	-	-	-	-	-	-	-	1	3	3
CO2	3	2	1	-	-	-	-	-	-	-	-	-	1	3	3
CO3	3	3	2	2	-	-	-	-	1	-	-	2	1	3	3
CO4	3	2	2	-	-	-	-	-	-	-	-	-	1	3	3
CO5	3	2	`1	-	-	-	-	-	-	-	-	-	1	3	3
22NOE$12	3	3	2	1	-	-	-	-	1	-	-	1	1	3	3

b) CO and Key Performance Indicators mapping

CO1	1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.3.1, 2.4.3,3.1.1, 3.1.2, 3.1.3, 3.3.1,3.3.2.
CO2	1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.3.1, 2.4.3,3.1.1, 3.1.2, 3.1.3, 3.3.1,3.3.2.
CO3	1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.3.1, 2.4.3,3.1.1, 3.1.2, 3.1.3, 3.3.1,3.3.2, 4.1.1, 4.1.2, 4.2.1, 4.2.2, 9.1.1, 9.1.2, 10.1.1, 10.1.2, 10.1.3, 12.1.1, 12.1.2.
CO4	1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.3.1, 2.4.3,3.1.1, 3.1.2, 3.1.3, 3.3.1,3.3.2.
CO5	1.2.1, 1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.3.1, 2.4.3,3.1.1, 3.1.2, 3.1.3, 3.3.1,3.3.2.

ASSESSMENT PATTERN - THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	20	60	20	-	-	-	100
CAT2	20	60	20	-	-	-	100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	20	60	20	-	-	-	100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	20	60	20	-	-	-	100
ESE	20	60	20	-	-	-	100

22SOE$13	**PROGRAMMING IN JAVA** *(Common to All Branches)*

PREREQUISITES	CATEGORY	L	T	P	C
NIL	OE	3	0	0	3

Course Objectives	The objective of this course is to provide students with the essential Java constructs necessary for developing an object-oriented program.	
UNIT – I	**FUNDAMENTALS OF JAVA PROGRAMMING**	**9 Periods**
History and Evolution of Java- Overview of java– Operators- Control Structures– Methods- Classes and Objects– Inheritance- Packages and Interfaces- Exception Handling.		
UNIT – II	**THREADS , I/O AND STRING HANDLING**	**9 Periods**
Multi threaded Programming– Enumeration- Auto boxing– Annotations- String Handling- Input/Output: Exploring java.io		
UNIT – III	**EVENT HANDLING**	**9 Periods**
Introducing the AWT: working with windows- graphics and text- Using AWT controls- Layout Manager - Menus - Introducing Swing		
UNIT – IV	**IMAGING AND DATABASE CONNECTIVITY**	**9 Periods**
Imaging: Creating- loading and displaying- Image observer- Double buffering- Media tracker- Image producer– consumer– filters– animation- Java Database Connectivity		
UNIT – V	**NETWORKING**	**9 Periods**
Networking – Remote Method Invocation – Java Beans –Java servlets		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOKS

1	*Herbert Schildt, "Java**, The Complete Reference** ", Tata McGrawHill, 12th Edition, 2022*

REFERENCES

1	*Deitel .H.M and Deitel.P.J, " **Java: How to Program** ", Pearson Education Asia, 9th Edition 2011*
2	*Lay.S&Horstmann Gary Cornell, " **Core Java Vol I** ", The Sun Microsystems & press Java Series, 9th Edition, 2012*
3	*NPTEL Course : "**PROGRAMMING IN JAVA"** **https://archive.nptel.ac.in/courses/106/105/106105191/***

COURSE OUTCOMES: On completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Write simple java programs using fundamental concepts of java like control structures, inheritance, packages, interfaces and exception handling	K4
CO2	Write java program using multithreading and string handling	K3
CO3	Write java programs for managing events and to access database	K4
CO4	Write java programs to display and manipulation of graphical images	K3
CO5	Develop client server programs using RMI and servlets	K3

COURSE ARTICULATION MATRIX:

a) CO/PO Mapping

COs/POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	P O1 1	PO 12	PS O1	PSO 2	PSO 3
CO1	2	2	2	2	1	0	0	0	0	2	0	0	1	2	2
CO2	2	1	2	2	1	0	0	0	0	2	0	0		2	3
CO3	2	1	2	2	1	0	0	0	0	2	0	0	1	2	3
CO4	2	1	2	2	1	0	0	0	0	2	0	0	1	2	3
CO5	2	1	2	2	1	0	0	0	0	2	0	2	1	2	3
22SOE$13	2	2	2	2	1	0	0	0	0	2	0	1	1	2	3

b) CO and Key Performance Indicators Mapping

CO1	1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.2.1, 2.2.3, 2.2.4, 2.4.3, 3.1.5, 3.1.6, 3.2.2, 3.3.1, 3.3.2, 4.1.1, 4.1.2, 4.1.3, 4.2.1, 4.3.1, 4.3.2, 5.2.2,10.1.1,10.1.2,10.1.3
CO2	1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.4.3, 3.1.5, 3.1.6, 3.2.2, 3.3.2, 4.1.1, 4.1.2, 4.1.3, 4.2.1, 4.3.1, 4.3.2, 5.2.2,10.1.1,10.1.2,10.1.3
CO3	1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.4.3, 3.1.5, 3.1.6, 3.2.2, 3.3.2, 4.1.1, 4.1.2, 4.1.3, 4.2.1, 4.3.1, 4.3.2, 5.2.2,10.1.1,10.1.2,10.1.3
CO4	1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.4.3, 3.1.5, 3.1.6, 3.2.2, 3.3.2, 4.1.1, 4.1.2, 4.1.3, 4.2.1, 4.3.1, 4.3.2, 5.2.2,10.1.1,10.1.2,10.1.3
CO5	1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.4.3, 3.1.5, 3.1.6, 3.2.2, 3.3.2, 4.1.1, 4.1.2, 4.1.3, 4.2.1, 4.3.1, 4.3.2, 5.1.1, 5.2.2,10.1.1,10.1.2,10.1.3,12.1.1,12.2.1,12.2.2

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	-	30	40	30	-	-	100
CAT2	10	30	40	20	-	-	100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	-	-	70	30	-	-	100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	-	-	50	50	-	-	100
ESE	-	30	40	30	-	-	100

22SOE$14	**NETWORK ESSENTIALS** *(Common to All Branches)*

PREREQUISITES	**CATEGORY**	**L**	**T**	**P**	**C**
NIL	**OE**	**3**	**0**	**0**	**3**

Course Objectives	The objective of the course is to understand the basics of networking and able to configure and troubleshoot switches and routers.	
UNIT – I	**INTRODUCTION**	**9 Periods**
Introduction to Computer Networks - Goals and advantages of Computer Networks - Network Topologies – Basic networking devices – Protocols – the need for a layered architecture - The OSI Model and the TCP/IP reference model – the Ethernet LAN – Home Networking – Assembling an office LAN – Testing and Troubleshooting a LAN – Physical layer cabling: Twisted pair and Fiber optics		
UNIT – II	**WIRELESS NETWORKING**	**9 Periods**
Importance of Wireless Networking – IEEE 802.11 Wireless LANs – Bluetooth- WIMAX – RFIDs – Securing the Wireless LANs – Configuring a Point to Multipoint Wireless LAN – Interconnecting network LANs – Switch, Bridges and Routers. Interconnecting LANs with the router, Configuring the network interface-Auto negotiation		
UNIT – III	**ADDRESSING AND ROUTING FUNDAMENTALS**	**9 Periods**
IPv4 and IPv6 addressing – Subnet masks – CIDR blocks – configuration of a router – Console port connection - user EXEC mode – Privileged EXEC mode - Configuration of a switch – Static VLAN configuration - Spanning Tree protocol – Network Management – Power over Ethernet		
UNIT – IV	**ROUTING PROTOCOLS**	**9 Periods**
Static Vs Dynamic Routing Protocols – Distance vector Routing – Link State Routing – Hybrid Routing – Configuring RIP - Network Services – DHCP, DNS - Analyzing Internet Traffic.		
UNIT – V	**TROUBLESHOOTING AND NETWORK SECURITY**	**9 Periods**
Analyzing Computer Networks – FTP data packets – Analyzing Campus Network data traffic – Troubleshooting the router and switch interface, Troubleshooting fiber optics – Intrusion – DOS – Security software and hardware.		
Contact Periods: **Lecture: 45 Periods** **Tutorial: 0 Periods** **Practical: 0 Periods** **Total: 45 Periods**		

TEXT BOOK :

1	*Jeffrey S.Beasley Piyasat Nilkaew "**Network Essentials**" 3 rd Edition, Pearson, 2018*
2	*Larry L. Peterson and Bruce S. Davie "**Computer Networks, A Systems Approach**" 5 th edition, Morgan Kaufmann Publishers Inc, 2014.*

REFERENCES :

1	*Behrouz A. Forouzan, "**Data Communications and Networking with TCP/IP Protocol Suite**", Sixth Edition TMH, 2022.*
2	*James F. Kurose, Keith W. Ross, "**Computer Networking, A Top-Down Approach Featuring the Internet**", Eighth Edition, Pearson Education, 2021.*
3	*Ying-Dar Lin, Ren-Hung Hwang, Fred Baker, "**Computer Networks: An Open Source Approach**", McGraw Hill, 2012.*
4	*Nader F. Mir, "**Computer and Communication Networks",** Second Edition, Prentice Hall, 2014.*

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Identify topologies and types of Computer Networks and enumerate the layers of the OSI model and TCP/IP	K2
CO2	Explain the significance of wireless networks and configure a Wireless LAN	K3
CO3	Configure a switcher and a router	K3
CO4	Describe basic routing algorithms and network services	K3
CO5	Troubleshoot the router and switch interface	K3

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping

COs/POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**
WCO1	2	3	-	-	-	1	-	-	-	-	-	-	1	2	-
CO2	2	3	-	-	-	1	-	-	-	-	-	-	1	2	-
CO3	2	3	-	2	2	1	-	-	-	-	-	-	1	2	-
CO4	2	3	-	2	2	1	-	-	-	-	-	-	1	2	-
CO5	2	3	-	2	2	1	-	-	-	-	-	-	1	2	-
22SOE$1 4	2	3	-	2	2	1	-	-	-	-	-	-	1	2	-

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.3.1, 1.4.1, 2.1.2, 2.2.2, 2.4.4, , 4.1.2, 5.1.1, 5.1.2,5.2.1, 5.2.2, 5.3.2, 6.1.1, 6.1.2
CO2	1.3.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3,2.2.4, 4.1.2, 5.1.1, 5.1.2,5.2.1, 5.2.2, 5.3.2, 6.1.1, 6.1.2
CO3	1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3,2.2.4, 4.1.1, 4.1.2, 5.1.1, 5.1.2,5.2.1, 5.2.2, 5.3.2, 6.1.1, 6.1.2
CO4	1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3,2.2.4, 4.1.1, 4.1.2, 5.1.1, 5.1.2,5.2.1, 5.2.2, 5.3.2, 6.1.1, 6.1.2
CO5	1.3.1, 1.4.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.2.3,2.2.4, 4.1.1, 4.1.2, 5.1.1, 5.1.2,5.2.1, 5.2.2, 5.3.2, 6.1.1, 6.1.2

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	30	35	35	-	-	-	100
CAT2	10	45	45	-	-	-	100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	-	50	50	-	-	-	100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	-	50	50	-	-	-	100
ESE	10	40	50	-	-	-	100

22I0E$15	**VIDEO CREATION AND EDITING** *(Common to All Branches)*

PREREQUISITES	**CATEGORY**	**L**	**T**	**P**	**C**
NIL	**OE**	**3**	**0**	**0**	**3**

Course Objectives	Upon completion of the course the students will be familiar with the principles and techniques of video creation and editing, video production equipment and software, visual storytelling and video production, planning, executing, and editing video projects. also able to foster critical thinking and creativity in developing and executing video projects.	
UNIT – I	**INTRODUCTION TO VIDEO CREATION AND EDITING**	**9 Periods**
Overview of video creation and editing -Brief history of video and film production -Understanding visual storytelling: developing documentary and dramatic projects- introduction to digital and film systems		
UNIT – II	**PRE-PRODUCTION**	**9 Periods**
Developing a concept and idea - Scriptwriting and storytelling -The Digital image - Film systems and cameras -The film image - Case Study : Non linear editing system		
UNIT – III	**PRODUCTION**	**9 Periods**
Camera operation and techniques: The video camcorder- The Lens - Lighting and sound recording techniques - Directing actors and crew -Conducting interviews -Shooting the movie - Case Study : Professional video zoom lenses		
UNIT – IV	**POST-PRODUCTION**	**9 Periods**
Picture and Dialogue editing - Editing digital video -sound editing and mixing -Color grading and correction-Sound editing and mixing – working with film in post production Case Study : Digital Audio Recording		
UNIT – V	**DISTRIBUTION AND PROMOTION**	**9 Periods**
Presenting the project - funding sources - budgets- business arrangements- legal and copyright issues-distribution and marketing - publicity and the marketing campaigns-building and sustaining a career - Case Study : Creating a short movie.		
Contact Periods: **Lecture: 45 Periods** **Tutorial: 0 Periods** **Practical: 0 Periods** **Total: 45 Periods**		

TEXT BOOK

1	Steven Ascher and Edward Pincus,The Filmmaker's Handbook: A Comprehensive Guide for the Digital Age,Fifth edition Penguin Publishing Group, 2012

REFERENCES

1	Walter Murch,In the Blink of an Eye: A Perspective on Film Editing", Silman-James Press,2001
2	Karel Reisz and Gavin Millar,The Technique of Film Editing",second edition ,Taylor and Francis Group 2017
3	Ken Dancyger, The technique of film and video editing , fifth edition , Elsevier 2011.
4	Chris Kenworthy,Digital video production cookbook, OReillyMedia ,2006
5	Mark Brindle, The Digital Filmmaking Handbook ,Quercus Publishing, 2014

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Demonstrate an understanding of the history and evolution of video production and editing.	K2
CO2	Develop and execute a concept, script, and storyboard for a video project	K3
CO3	Plan and prepare for a video shoot, including casting, location scouting, and budgeting.	K3
CO4	Edit and assemble video footage using basic and advanced editing techniques.	K2
CO5	Promote and distribute the final video on various platforms.	K1

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**
CO1	2	1	1	1	0	0	0	0	0	0	0	0	1	1
CO2	1	2	3	2	3	0	0	0	0	0	0	0	1	1
CO3	1	2	1	3	3	0	1	0	3	1	2	0	1	1
CO4	1	2	2	2	3	3	0	0	3	1	2	0	1	1
CO5	1	2	2	2	3	3	1	3	3	3	2	0	1	1
22IOE$15	1	2	2	2	2	1	1	1	2	1	1	0	1	1

1– Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.1.1,1.2.1,1.31,2.1.1,2.1.2,2.2.4,2.4.1,3.1.4,3.4.1,4.1.3,
CO2	1.1.1,2.1.1,2.1.2,2.1.3,2.2.1,2.2.2,2.4.3,3.1.1,3.1.2,3.1.3,3.1.6,3.2.1,3.2.2,3.2.3,3.3.1,3.4.1,3.4.2,4.1.1,4.1.3,4.2.1,4.3.1,4.3.2,4.3.4,5.1.1,5.1.2,5.2.1,5.2.2,5.3.1,5.3.2,
CO3	1.1.1,2.1.1,2.1.3,2.1.3,2.2.1,2.2.2,2.2.3,2.2.4,2.3.2,2.4.3,3.2.1,3.2.2,3.3.1,3.4.2,4.1.1,4.1.3,4.1.4,4.2.2,4.3.1,4.3.2,4.3.3,,5.1.1,5.1.2,5.2.1,5.2.2,5.3.2,7.1.1,9.1.1,9.1.2,9.2.1,9.2.2,9.2.3,10.1.1,11.2.1,11.3.1,11.3.2
CO4	1.1.1,2.1.1,2.1.3,2.1.3,2.2.1,2.2.2,2.2.3,2.2.4,2.3.2,2.4.3,3.2.1,3.2.2,3.3.1,,3.3.2,3.4.2,4.1.1,4.1.3,4.2.1, 4.3.1, 4.3.2, 5.1.1, 5.1.2, 5.2.1, 5.2.2, 5.3.2, 6.1.1, 6.1.2, 9.1.1, 9.1.2, 9.2.1, 9.2.2, 9.2.3, 10.1.1, 11.3.1, 11.3.2
CO5	1.1.1 , 2.1.3, 2.2.1, 2.2.2, 2.2.3, 2.2.4 2.3.2, 2.4.3, 3.2.1, 3.2.3, 3.3.1, 3.3.2, 3.4.2, 4.1.1, 4.1.3, 4.3.1, 4.3.2, 4.3.3, 5.1.1, 5.1.2, 5.2.1, 5.2.2, 5.3.1, 5.3.2, 6.1.1, 6.2.1, 7.12, 8.1.1, 8.2.1,8.2.2, , 9.1.1, 9.1.2, 9.2.1,9.2.2, 9.2.3,9.2.4, 9.3.1, 10.1.1, 10.1.2, 10.1.3,10.2.1, 10.2.2, 10.3.1, 10.3.2, 11.1.1, 11.1.2, 11.2.1

ASSESSMENT PATTERN – THEORY

Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	30	30	40	-	-	-	100
CAT2	30	30	40	-	-	-	100
Assignment 1	30	30	40	-	-	-	100
Assignment 2	30	30	40	-	-	-	100
Other mode of internal assessments, if any	-	-	-	-	-	-	-
ESE	30	30	40	-	-	-	100

22IOE$16	**DIGITAL MARKETING** *(Common to All Branches)*

PREREQUISITES	CATEGORY	L	T	P	C
NIL	OE	3	0	0	3

Course Objectives	To give insight on the framework to analyze, strategies and plan digital marketing and communication activities for typical marketing situations. Familiarize with the key tools and techniques of digital marketing that are popularly used by professionals in the real world of digital marketing and help them develop the ability to formulate and analyze key metrics to evaluate the performance of typical digital marketing efforts.	
UNIT – I	**INTRODUCTION TO DIGITAL MARKETING**	**9 Periods**
Basics of Digital Marketing - online marketplace analysis: digital marketing environment - consumer choice and digital influence online consumer behavior-competitors -suppliers- new channel structures - rate of environment change - economic force-political force -legal force - social force- cultural force.		
UNIT – II	**DIGITAL MARKETING STRATEGY DEVELOPMENT**	**9 Periods**
Digital marketing strategy - The impact of digital media and technology on the marketing mix: product-price-place-promotion -people, process and physical evidence - relationship marketing using digital platforms: the challenge of customer engagement - customer lifecycle management		
UNIT – III	**DIGITAL MARKETING IMPLEMENTATION AND PRACTICE**	**9 Periods**
Delivering the online customer experience: planning website design and redesign projects - initiation of the website project - defining site or app requirement - designing the user experience - development and testing of content - site promotion or traffic building - campaign planning for digital media		
UNIT – IV	**MARKETING COMMUNICATIONS USING DIGITAL MEDIA CHANNELS**	**9 Periods**
Search engine marketing - online public relations - affiliated marketing - interactive display advertising - email marketing and mobile text messaging- social media and viral marketing - offline promotion techniques		
UNIT – V	**EVALUATION OF DIGITAL CHANNEL PERFORMANCE**	**9 Periods**
Create a performance management system - performance metric framework - tools and techniques for collecting metrics -customer experience and content management - online consumer behavior- online retailing - customer acquisition in B2B marketing -online inter- organizational trading		
Contact Periods: **Lecture: 45 Periods** **Tutorial: 0 Periods** **Practical: 0 Periods** **Total: 45 Periods**		

TEXT BOOK

1	Dave Chaffey Fiona Ellis-Chadwick, Digital Marketing, sixth edition, 2016

REFERENCES

1	Puneet singh Bhatia, Fundamentals of Digital Marketing , Pearson India Education services,2017
2	Mathur, Vibha, Arora, Saloni,"DigitalMarketing",PHI Learning Pvt. Ltd.,2020
3	Ian Dodson, The Art of Digital Marketing: The Definitive Guide to Creating Strategic, Targeted, and Measurable Online Compaigns, Wiley 2016
4	Dr.Shakti Kundu, Digital Marketing Trends and Prospects:Develop an effective Digital Marketing strategy with SEO, SEM, PPC, Digital Display Ads & Email Marketing techniques,BPB PUBN,2021
5	Seema Gupta , Digital Marketing,Third Edition, McGraw Hill 2022
6.	Simon Kingsnorth, Digital Marketing Strategy:An Integrated Approach to Online Marketing, Kogan page,2022

COURSE OUTCOMES: On completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Explain the role and importance of digital marketing in a rapidly changing business landscape	K1
CO2	Discuss the key elements of a digital marketing strategy	K2
CO3	Demonstrate advanced practical skills in common digital marketing tools such as Social media and Blogs	K2
CO4	Demonstrate advanced practical skills in common digital marketing tools such as SEM	K2
CO5	understand online consumer behavior and influence the extent to which individuals are likely to engage with the digital marketplace	K2

COURSE ARTICULATION MATRIX:

a) CO and PO Mapping

COs / POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	1	1	2	2	-	-	-	-	-	-	-	-	2	2
CO2	1	1	2	2	-	-	-	-	-	-	-	-	2	2
CO3	1	1	2	2	3	-	-	-	-	-	-	-	2	2
CO4	1	1	2	2	3	2	3	3	3	3	3	3	2	2
CO5	1	1	2	2	1	-	3	3	3	3	3	3	2	2
22IOE$16	1	1	2	2	1	1	1	1	1	1	1	1	2	2

1– Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.1.1,2.1.1,2.1.2,3.1.1,3.1.6,3.2.1,3.2.2,3.2.3,3.3.1,4.1.1,4.1.3,4.2.1,4.3.3,
CO2	1.1.1,2.1.1,2.1.2,3.1.1,3.1.6,3.2.1,3.2.2,3.2.3,3.3.1,4.1.1,4.1.3,4.2.1,4.3.3,
CO3	1.1.1,2.1.1,2.1.2,3.1.1,3.1.6,3.2.1,3.2.2,3.2.3,3.3.1,4.1.1,4.1.3,4.2.1,4.3.3,5.1.1,5.1.2,5.2.1,5.2.2,5.3.1,5.3.2
CO4	1.1.1,2.1.1,2.1.2,3.1.1,3.1.6,3.2.1,3.2.2,3.2.3,3.3.1,4.1.1,4.1.3,4.2.1,4.3.3, 5.1.1,5.1.2,5.2.1, 5.2.2,5.3.1,5.3.2,6.1.1,7.1.1,7.1.2,7.2.1,7.2.2,8.1.1,8.2.1,8.2.2,9.1.1,9.1.2,9.2.1,9.2.2,9.2.3,9.2.4,9.3.1,10.1.1, 10.1.2,10.1.3,10.2.1,10.2.2,10.3.1,10.3.2,11.1.1,11.1.2,11.2.1,11.3.1,11.3.2,12.1.1,12.1.2,12.2.1,12.2.2,12.3.1,12.3.2
CO5	1.1.1,2.1.1,2.1.2,3.1.1,3.1.6,3.2.1,3.2.2,3.2.3,3.3.1,4.1.1,4.1.3,4.2.1,4.3.3, 5.1.1,5.1.2,5.2.1, 7.1.1,7.1.2,7.2.1,7.2.2,8.1.1,8.2.1,8.2.2,9.1.1,9.1.2,9.2.1,9.2.2,9.2.3,9.2.4,9.3.1, 10.1.1,10.1.2,10.1.3,10.2.1,10.2.2,10.3.1,10.3.2,11.1.1,11.1.2,11.2.1,11.3.1,11.3.2,12.1.1,12.1.2,12.2.1,12.2.2,12.3.1,12.3.2

ASSESSMENT PATTERN – THEORY

Test / Bloom's Category*	Remembering (K1) %	Understanding (K2) %	Applying (K3) %	Analyzing (K4) %	Evaluating (K5) %	Creating (K6) %	Total %
CAT1	30	30	40	-	-	-	100
CAT2	30	30	40	-	-	-	100
Assignment 1	30	30	40	-	-	-	100
Assignment 2	30	30	40	-	-	-	100
Other mode of internal assessments, if any	-	-	-	-	-	-	-
ESE	30	30	40	-	-	-	100

22BOE$17	**PRINCIPLES OF FOOD TECHNOLOGY** ***(Common to All Branches)***

PREREQUISITES	CATEGORY	L	T	P	C
NIL	OE	3	0	0	3

Course Objectives	To learn about the various food constituents and its additives. To learn about various microbes associated with food. To learn about different food processing and preservation techniques.	
UNIT – I	**FOOD AND ENERGY**	**9 Periods**
Constituents of food – carbohydrates, lipids, proteins, water, vitamins and minerals, dietary sources, role and functional properties in food, contribution to organoleptic and textural characteristics.		
UNIT – II	**FOOD BORNE DISEASES**	**9 Periods**
Classification – food infections – bacterial and other types; food intoxications and poisonings– bacterial and non-bacterial; food spoilage – factors responsible for spoilage, spoilage of vegetable, fruit, meat, poultry, beverage and other food products.		
UNIT – III	**FOOD ADDITIVES**	**9 Periods**
Classification, intentional and non-intentional additives, functional role in food processing and preservation; food colourants – natural and artificial; food flavours; enzymes as food processing aids.		
UNIT – IV	**FOOD PRESERVATION**	**9 Periods**
Principles involved in the use of sterilization, pasteurization and blanching, thermal death curves of microorganisms, canning; frozen storage-freezing characteristics of foods, microbial activity at low temperatures, factors affecting quality of foods in frozen storage; irradiation preservation of foods.		
UNIT – V	**FOOD PACKAGING**	**9 Periods**
Types of packaging material and containers; Interactions between packaging and foods; Packing - meat, dairy, fresh fruits and vegetables, beverages and confectionaries; Food packaging closure and sealing system; Nutrition labelling and legislative requirements.		
Contact Periods: **Lecture: 45 Periods** **Tutorial: 0 Periods** **Practical: 0 Periods** **Total: 45 Periods**		

TEXT BOOK

1	*T.P. Coultate , **Food – The Chemistry Of Its Components**, 6th Edn. Royal Society,London, 2015.*
2	*W.C. Frazier And D.C. Westhoff , **Food Microbiology**, 4th Ed., Mcgraw-Hill Book Co., NewYork 2013.*

REFERENCES

1	*Srinivasan Damodaran and Kirk L. Parkin., "Fennema's Food Chemistry", CRC Press, 5 thedition. 2017.*
2	*Fellows P.J, "Food Processing Technology: Principles and Practices", Woodhead Publishing 4 th edition,2016·*
3	*B. Sivasanker , Food Processing And Preservation, Prentice-Hall Of India Pvt. Ltd. New Delhi 2002.*
4	T.P. Coultate – Food – The Chemistry Of Its Components, 2nd Edn. Royal Society,London, 1992.

COURSE OUTCOMES: Upon completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	learn different constituents present in food and microorganism involved in processing of food.	K1
CO2	learn principles and different preservations techniques of food can also be known.	K1
CO3	learn techniques involved in modern food processing and impact of the process on food quality.	K2
CO4	Explain various preservation and packaging techniques for food product	K2
CO5	Describe the relationship between food and microorganism that basis for fermentation and preservation	K2

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	-	-	1	-	-	-	-	2	3	-	-	1	3
CO2	1	-	-	-	-	-	-	-	-	3	-	-	1	3
CO3	1	-	-	2	-	2	-	-	-	3	-	-	1	3
CO4	1	-	1	-	-	-	-	-	-	3	-	-	1	3
CO5	1	-	2	-	-	-	-	-	-	3	-	-	1	3
22BOE$17	1	-	1	1	-	2	-	-	2	3	-	-	1	3

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	1.4.2, 2.1.3
CO2	1.4.1, 3.1.3
CO3	1.4.4, 2.1.4
CO4	1.4.1, 2.1.3,3.4.2
CO5	1.4.1,2.2.1

ASSESSMENT PATTERN – THEORY

Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	50	50	-	-	-	-	100
CAT2	60	40	-	-	-	-	100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	50	50	-	-	-	-	100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	50	50	-	-	-	-	100
ESE	50	50	-	-	-	-	100

22BOE$18	**BIOLOGY FOR ENGINEERS** *(Common to All Branches)*

PREREQUISITES	CATEGORY	L	T	P	C
NIL	OE	3	0	0	3

Course Objectives	Understand and interpret commonly reported statistical measures published in healthcare research. Analyze the different type of data using appropriate statistical software. Demonstrate a good understanding of descriptive statistics and graphical tools. Explain fundamental concepts of estimation and hypothesis testing and be confident when interpreting P values and confidence intervals	
UNIT – I	**BASICS OF CELL BIOLOGY**	**9 periods**
An overview of cells – origin and evolution of cells-cell theory-classification of cells – prokaryotic cells and eukaryotic cells; Structure of prokaryotic and eukaryotic cells and their organelles comparison of prokaryotic and eukaryotic cells; Transport across membranes – diffusion - active and passive diffusion.		
UNIT – II	**BASICS OF MICROBIOLOGY**	**9 periods**
Classification of microorganism-microscopic examination of microorganisms; Structural organization and multiplication of bacteria-viruses-algae and fungi; Microorganism used for the production of penicillin-alcohol and vitamin B-12.		
UNIT – III	**HUMAN ANATOMY AND PHYSIOLOGY**	**9 periods**
Basics of human anatomy-tissues of the human body-epithelial-connective-nervous and muscular; Nervous system-Respiratory System-Circulatory system and Digestive system.		
UNIT – IV	**BIO MOLECULES AND IMMUNE SYSTEM**	**9 periods**
Introduction to Biochemistry-classification-structure and properties of carbohydrates-proteins- lipids and nucleic acids; Innate and acquired immunity; Types of immune responses.		
UNIT-V	**APPLIED BIOLOGY FOR ENGINEERS**	**9 periods**
Overview of biosensors - glucometer applications-medicine; Microarray analysis to diagnose the cancer; Microbial production of biofuels; Applications of stem cells.		
Contact Periods: **45** **Lecture: 45 Periods** **Tutorial: 0 Periods** **Practical: 0 Periods** **Total: 45 Periods**		

TEXT BOOK

1	*Darnell J, Lodish H, Baltimore D.* ***"Molecular Cell Biology"****, W.H.Freeman; 8th Edition, 2016.*
2	*Pelczar MJ, Chan ECS and Krein NR,* ***"Microbiology",*** *Tata McGraw Hill, 5thEdition, New Delhi.2001.*
3	*Wulf Cruger and Anneliese Cruger,* ***"A Textbook of Industrial Microbiology",*** *Panima Publishing Corporation, 2nd Edition, 2000.*

REFERENCES

1	*David L. Nelson and Michael M Cox,* ***"Lehninger's Principles of Biochemistry",*** *Macmillan Worth Publisher, 4th edition, 2004.*
2	*Brain R.Eggins ,* ***"Chemical Sensors and Biosensors",*** *John Wiley & Sons, 2002.*
3	*Anton Moser,* ***"Bioprocess Technology, Kinetics and Reactors",*** *Springer, Berlin (Verlag),1st edition, 1998*
4	*Kuby J,* ***"Immunology",*** *WH Freeman & Co., 7th edition, 2013.*

COURSE OUTCOMES: On completion of the course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Understand the functions of cell and their structural organization	K1
CO2	Describe the mechanisms and role of cell in immune system	K1
CO3	Get familiarized biomolecules and human anatomy system	K2
CO4	Illustrate the applications of microbes in industrial process	K3
CO5	Apply the engineering concepts in biology	K3

COURSE ARTICULATION MATRIX

a) CO and PO Mapping

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2
CO1	-	1	-	-	-	2	2	2	-	-	1	2	2	2
CO2	1	-	-	1	1	-	-	2	3	3	2	2	1	3
CO3	1	1	-	-	-	-	-	1	1	-	-	-	1	3
CO4	-	-	-	-	1	-	-	2	3	3	1	1	1	3
CO5	-	2	-	1	3	-	-	-	-	-	-	-	2	2
22BOE$18	1	1	-	1	2	2	2	2	3	3	2	2	2	3

1 – Slight, 2 – Moderate, 3 – Substantial

b) CO and Key Performance Indicators Mapping

CO1	2.2.2, 6.1.1, 7.1.2, 8.1.1, 11.1.1, 12.1.2
CO2	1.1.1, 4.2.1, 5.2.1, 8.1.1, 9.1.1,9.2.1,10.1.1, 10.1.2, 11.1.1, 12.1.2
CO3	1.1.1, 2.1.1, 8.1.1, 9.1.1
CO4	5.2.1, 8.1.1, 9.1.1,9.2.1,10.1.1, 10.1.2, 11.1.1, 12.1.2
CO5	1.1.1,2.2.2, 4.2.1, 5.2.1, 6.1.1,7.1.2, 8.1.1, 9.1.1,9.2.1,10.1.1, 10.1.2, 11.1.1, 12.1.2

ASSESSMENT PATTERN – THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	50	10	10	10	10	10	100
CAT2	50	10	10	10	10	10	100
Individual Assessment 1 /Case Study 1/ Seminar 1 / Project1	20	20	20	20	10	10	100
Individual Assessment 2 /Case Study 2/ Seminar 2 / Project 2	20	20	20	20	10	10	100
ESE	50	10	10	10	10	10	100