GOVERNMENT COLLEGE OF TECHNOLOGY

(An Autonomous Institution Affiliated to Anna University, Chennai)

COIMBATORE – 641 013

B. Tech. INDUSTRIAL BIOTECHNOLOGY
CURRICULUM & SYLLABI

REGULATIONS
2018

OFFICE OF THE CONTROLLER OF EXAMINATIONS

GOVERNMENT COLLEGE OF TECHNOLOGY

COIMBATORE – 641 013.

GOVERNMENT COLLEGE OF TECHNOLOGY

(An Autonomous Institution Affiliated to Anna University, Chennai)

Coimbatore-641 013

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, and professional behaviors for a harmonious and prosperous society

DEPARTMENT OF INDUSTRIAL BIOTECHNOLOGY

GOVERNMENT COLLEGE OF TECHNOLOGY

VISION AND MISSION OF THE DEPARTMENT

VISION

To achieve the highest caliber in Biotechnology Research and Teaching and to develop intellectual leaders for the betterment of the society, environmental protection and industry needs.

MISSION

To provide world class quality education to students through advanced skill based learning and molding them as technologically sound and ethically motivated youth through value added activities.

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DEPARTMENT OF INDUSTRIAL BIOTECHNOLOGY
GOVERNMENT COLLEGE OF TECHNOLOGY

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

The following Programme Educational 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.

DEPARTMENT OF INDUSTRIAL BIOTECHNOLOGY
GOVERNMENT COLLEGE OF TECHNOLOGY

PROGRAMME OUTCOMES (POs)

Students in the Industrial Biotechnology Programme should at the time of their graduation be in the possession of the following.

PO1 **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems.

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

PO3 **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4 **Conduct investigations of complex problems**: Use research-based knowledge and research methods 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 of 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 and apply these to 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 change.

DEPARTMENT OF INDUSTRIAL BIOTECHNOLOGY
GOVERNMENT COLLEGE OF TECHNOLOGY

PROGRAMME SPECIFIC OUTCOMES (PSOs)

PSO 1 : Demonstrate competence in basic science and engineering 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.

GOVERNMENT COLLEGE OF TECHNOLOGY, COIMBATORE – 641 013

B.TECH. INDUSTRIAL BIOTECHNOLOGY

CBCS 2018 REGULATIONS

FIRST SEMESTER

Sl. No.	Course Code	Course Title	CAT	CA Marks	End Sem Marks	Total Marks
		Induction Programme	MC	0	0	0

Details of the Programme:

Number of Days: 21 Days

Day0: College Admission

Day1: Orientation Programme

Day2: Registration.

Day3 to Day 23 : Induction Programme

Activities:
Physical activity,
Playground Events,
Yoga Practices,
Literary, Proficiency modules,
Team Building,
Lectures by Eminent people,
Familiarization to department,
Branch oriented information,
Motivational speakers,
Talent exposure,
Quiz completion,
Visit to local areas….etc.

GOVERNMENT COLLEGE OF TECHNOLOGY, COIMBATORE – 641 013

B.TECH. INDUSTRIAL BIOTECHNOLOGY

CBCS 2018 REGULATIONS

FIRST SEMESTER

Sl. No.	Course Code	Course Title	CAT	CA Marks	End Sem Marks	Total Marks	Hours/Week			
							L	T	P	C
		THEORY								
1	18BBS101	Chemistry for Biotechnology	BS	50	50	100	3	1	0	4
2	18BBS102	Calculus and Linear Algebra	BS	50	50	100	3	1	0	4
3	18BES103	Basics of Electrical and Electronics Engineering	ES	50	50	100	3	0	0	3
		PRACTICAL								
4	18BBS104	Chemistry Laboratory	BS	50	50	100	0	0	3	1.5
5	18BES105	Basics of Electrical and Electronics Engineering Laboratory	ES	50	50	100	0	0	3	1.5
6	18BES106	Engineering Graphics	ES	50	50	100	2	0	4	4
		TOTAL		**300**	**300**	**600**	**11**	**2**	**10**	**18**

SECOND SEMESTER

Sl. No.	Course Code	Course Title	CAT	CA Marks	End Sem Marks	Total Marks	Hours/Week			
							L	T	P	C
		THEORY								
1	18BHS201	Communicative English	HS	50	50	100	2	1	0	3
2	18BBS202	Differential Equations and Complex Variables	BS	50	50	100	3	1	0	4
3	18BBS203	Mechanics and Properties of Solids	BS	50	50	100	3	1	0	4
4	18BES204	Programming in C	ES	50	50	100	3	0	0	3
		PRACTICAL								
5	18BBS205	Physics Laboratory	BS	50	50	100	0	0	3	1.5
6	18BES206	Workshop Practice	ES	50	50	100	1	0	4	3
7	18BES207	Programming in C Laboratory	ES	50	50	100	0	0	3	1.5
		TOTAL		**350**	**350**	**700**	**12**	**3**	**10**	**20**

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THIRD SEMESTER

Sl. No.	Course Code	Course Title	CAT	CA Marks	End Sem Marks	Total Marks	Hours/Week			
							L	T	P	C
		THEORY								
1.	18BBS301	Transform Calculus and Partial Differential Equations	BS	50	50	100	3	1	0	4
2.	18BBS302	Microbiology	BS	50	50	100	3	0	0	3
3.	18BES303	Fluid Mechanics	ES	50	50	100	2	1	0	3
4.	18BPC304	Cell Biology	PC	50	50	100	3	0	0	3
5.	18BPC305	Biochemistry	PC	50	50	100	3	0	0	3
6.	18BMC3Z6	Constitution of India	MC	50	50	100	3	0	0	0
		PRACTICAL								
7.	18BPC307	Microbiology Laboratory	PC	50	50	100	0	0	4	2
8.	18BPC308	Biochemistry Laboratory	PC	50	50	100	0	0	4	2
9.	18BPC309	Cell Biology Laboratory	PC	50	50	100	0	0	4	2
		TOTAL		**450**	**450**	**900**	**17**	**2**	**12**	**22**

FOURTH SEMESTER

Sl. No.	Course Code	Course Title	CAT	CA Marks	End Sem Marks	Total Marks	Hours/Week			
							L	T	P	C
		THEORY								
1.	18BES401	Process Calculations and Heat Transfer	ES	50	50	100	3	1	0	4
2.	18BPC402	Basics of Industrial Biotechnology	PC	50	50	100	3	0	0	3
3.	18BPC403	Molecular Biology	PC	50	50	100	3	0	0	3
4.	18BPC404	Biochemical Thermodynamics	PC	50	50	100	2	1	0	3
5.	18BPC405	Analytical Techniques in Biotechnology	PC	50	50	100	3	0	0	3
6.	18BPC406	Enzyme Engineering and Technology	PC	50	50	100	3	0	0	3
7.	18BMC4Z7	Environmental Sciences and Engineering	MC	50	50	100	3	0	0	0
		PRACTICAL								
8.	18BES408	Chemical Engineering Laboratory	ES	50	50	100	0	0	3	1.5
9.	18BPC409	Analytical Techniques Laboratory	PC	50	50	100	0	0	3	1.5
		TOTAL		**450**	**450**	**900**	**20**	**2**	**6**	**22**

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B.TECH. INDUSTRIAL BIOTECHNOLOGY

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FIFTH SEMESTER

Sl. No.	Course Code	Course Title	CAT	CA Marks	End Sem Marks	Total Marks	Hours/Week			
							L	T	P	C
		THEORY								
1.	18BHS501	Clinical Trials and Bioethics	HS	50	50	100	3	0	0	3
2.	18BES502	Mass Transfer Operations	ES	50	50	100	2	1	0	3
3.	18BPC503	Bioprocess Principles	PC	50	50	100	2	1	0	3
4.	18BPC504	Genetic Engineering	PC	50	50	100	3	0	0	3
5.	18BPE5XX	Professional Elective I	PE	50	50	100	3	0	0	3
6.	18#OE5XX	Open Elective I	OE	50	50	100	3	0	0	3
		PRACTICAL								
7.	18BHS507	Business Communication Skills Laboratory	HS	50	50	100	0	0	2	1
8.	18BPC508	Bioprocess Laboratory I	PC	50	50	100	0	0	3	1.5
9.	18BPC509	Molecular Biology and Genetic Engineering Laboratory	PC	50	50	100	0	0	4	2
		TOTAL		**450**	**450**	**900**	**16**	**2**	**9**	**22.5**

SIXTH SEMESTER

Sl. No.	Course Code	Course Title	CAT	CA Marks	End Sem Marks	Total Marks	Hours/Week			
							L	T	P	C
		THEORY								
1.	18BPC601	Immunology	PC	50	50	100	3	0	0	3
2.	18BPC602	Bioinformatics	PC	50	50	100	3	0	0	3
3.	18BPC603	Bioprocess Engineering	PC	50	50	100	2	1	0	3
4.	18#OE6XX	Open Elective II	OE	50	50	100	3	0	0	3
5.	18#OE6XX	Open Elective III	OE	50	50	100	3	0	0	3
6.	18BEE606	Chemical Reaction Engineering	EEC	50	50	100	2	1	0	3
		PRACTICAL								
7.	18BPC607	Bioinformatics Laboratory	PC	50	50	100	0	0	2	1
8.	18BPC608	Bioprocess Engineering Laboratory	PC	50	50	100	0	0	4	2
9.	18BPC609	Immunology Laboratory	PC	50	50	100	0	0	3	1.5
		TOTAL		**450**	**450**	**900**	**16**	**2**	**9**	**22.5**

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SEVENTH SEMESTER

Sl. No.	Course Code	Course Title	CAT	CA Marks	End Sem Marks	Total Marks	Hours/Week			
							L	T	P	C
		THEORY								
1.	18BHS701	Technology Management	HS	50	50	100	3	0	0	3
2.	18BPC702	Downstream Processing	PC	50	50	100	2	1	0	3
3.	18BPE7XX	Professional Elective II	PE	50	50	100	3	0	0	3
4.	18BPE7XX	Professional Elective III	PE	50	50	100	3	0	0	3
5.	18BPE7XX	Professional Elective IV	PE	50	50	100	3	0	0	3
6.	18#OE7XX	Open Elective IV	OE	50	50	100	3	0	0	3
		PRACTICAL								
7.	18BPC707	Downstream Processing Laboratory	PC	50	50	100	0	0	4	2
8.	18BEE708	Mini Project	EEC	50	50	100	0	0	8	4
		TOTAL		**400**	**400**	**800**	**17**	**1**	**12**	**24**

EIGHTH SEMESTER

Sl. No.	Course Code	Course Title	CAT	CA Marks	End Sem Marks	Total Marks	Hours/Week			
							L	T	P	C
		THEORY								
1	18BPE8XX	Professional Elective V	PE	50	50	100	3	0	0	3
2	18BPE8XX	Professional Elective VI	PE	50	50	100	3	0	0	3
		PRACTICAL								
3	18BEE803	Project Work	EEC	50	50	100	0	0	16	8
		TOTAL		**150**	**150**	**300**	**6**	**0**	**16**	**14**

TOTAL CREDITS IN 2018 CURRICULUM 165

CATEGORY-WISE CREDIT DISTRIBUTION

HUMANITIES AND SOCIAL SCIENCES INCLUDING MANAGEMENT (HS)

Sl. No.	Course Code	Course Title	CAT	CA Marks	End Sem Marks	Total Marks	Hours/Week			
							L	T	P	C
1	18BHS201	Communicative English	HS	50	50	100	2	1	0	3
2	18BHS501	Clinical Trials and Bioethics	HS	50	50	100	3	0	0	3
3	18BHS507	Business Communication Skills Laboratory	HS	50	50	100	0	0	2	1
4	18BHS701	Technology Management	HS	50	50	100	3	0	0	3
									TOTAL CREDITS	**10**

BASIC SCIENCES (BS)

Sl. No.	Course Code	Course Title	CAT	CA Marks	End Sem Marks	Total Marks	Hours/Week			
							L	T	P	C
1	18BBS101	Chemistry for Biotechnology	BS	50	50	100	3	1	0	4
2	18BBS102	Calculus and Linear Algebra	BS	50	50	100	3	1	0	4
3	18BBS104	Chemistry Laboratory	BS	50	50	100	0	0	3	1.5
4	18BBS202	Differential Equations and Complex Variables	BS	50	50	100	3	1	0	4
5	18BBS203	Mechanics and Properties of Solids	BS	50	50	100	3	1	0	4
6	18BBS205	Physics Laboratory	BS	50	50	100	0	0	3	1.5
7	18BBS301	Transform Calculus and Partial Differential Equations	BS	50	50	100	3	1	0	4
8	18BBS302	Microbiology	BS	50	50	100	3	0	0	3
									TOTAL CREDITS	**26**

ENGINEERING SCIENCES (ES)

Sl. No.	Course Code	Course Title	CAT	CA Marks	End Sem Marks	Total Marks	Hours/Week			
							L	T	P	C
1	18BES103	Basics of Electrical and Electronic Engineering	ES	50	50	100	3	0	0	3
2	18BES105	Basics of Electrical and Electronic Engineering Laboratory	ES	50	50	100	0	0	3	1.5
3	18BES106	Engineering Graphics	ES	50	50	100	2	0	4	4
4	18BES204	Programming in C	ES	50	50	100	3	0	0	3
5	18BES206	Workshop Practice	ES	50	50	100	1	0	4	3
6	18BES207	Programming in C Laboratory	ES	50	50	100	0	0	3	1.5
7	18BES303	Fluid Mechanics	ES	50	50	100	2	1	0	3
8	18BES401	Process Calculations and Heat Transfer	ES	50	50	100	3	1	0	4
9	18BES408	Chemical Engineering Laboratory	ES	50	50	100	0	0	3	1.5
10	18BES502	Mass Transfer Operations	ES	50	50	100	2	1	0	3
									TOTAL CREDITS	**27.5**

PROFESSIONAL CORE (PC)

Sl. No.	Course Code	Course Title	CAT	CA Marks	End Sem Marks	Total Marks	Hours/Week			
							L	T	P	C
1.	18BPC304	Cell Biology	PC	50	50	100	3	0	0	3
2.	18BPC305	Biochemistry	PC	50	50	100	3	0	0	3
3.	18BPC307	Microbiology Laboratory	PC	50	50	100	0	0	4	2
4.	18BPC308	Biochemistry Laboratory	PC	50	50	100	0	0	4	2
5.	18BPC309	Cell Biology Laboratory	PC	50	50	100	0	0	4	2
6.	18BPC402	Basics of Industrial Biotechnology	PC	50	50	100	3	0	0	3
7.	18BPC403	Molecular Biology	PC	50	50	100	3	0	0	3
8.	18BPC404	Biochemical Thermodynamics	PC	50	50	100	2	1	0	3
9.	18BPC405	Analytical Techniques in Biotechnology	PC	50	50	100	3	0	0	3
10.	18BPC406	Enzyme Engineering and Technology	PC	50	50	100	3	0	0	3
11.	18BPC409	Analytical Techniques Laboratory	PC	50	50	100	0	0	3	1.5
12.	18BPC503	Bioprocess Principles	PC	50	50	100	2	1	0	3
13.	18BPC504	Genetic Engineering		50	50	100	3	0	0	3
14.	18BPC508	Bioprocess Laboratory I	PC	50	50	100	0	0	3	1.5
15.	18BPC509	Molecular Biology and Genetic Engineering Laboratory	PC	50	50	100	0	0	4	2
16.	18BPC601	Immunology	PC	50	50	100	3	0	0	3
17.	18BPC602	Bioinformatics	PC	50	50	100	3	0	0	3
18.	18BPC603	Bioprocess Engineering	PC	50	50	100	2	1	0	3
19.	18BPC607	Bioinformatics Laboratory	PC	50	50	100	0	0	2	1
20.	18BPC608	Bioprocess Engineering Laboratory	PC	50	50	100	0	0	4	2
21.	18BPC609	Immunology Laboratory	PC	50	50	100	0	0	3	1.5
22.	18BPC702	Downstream Processing	PC	50	50	100	2	1	0	3
23.	18BPC708	Downstream Processing Laboratory	PC	50	50	100	0	0	4	2
						TOTAL CREDITS				**56.5**

PROFESSIONAL ELECTIVES (PE)

Sl. No.	Course Code	Course Title	CAT	CA Marks	End Sem Marks	Total Marks	Hours/Week			
							L	T	P	C
1.	18BPE$01	Biofuels	PE	50	50	100	3	0	0	3
2.	18BPE$02	Biopolymer Technology	PE	50	50	100	3	0	0	3
3.	18BPE$03	Industrial Hazard Management	PE	50	50	100	3	0	0	3
4.	18BPE$04	Food Process Engineering	PE	50	50	100	3	0	0	3
5.	18BPE$05	Medical Biotechnology	PE	50	50	100	3	0	0	3
6.	18BPE$06	Marine Biotechnology	PE	50	50	100	3	0	0	3
7.	18BPE$07	Plant Biotechnology	PE	50	50	100	3	0	0	3
8.	18BPE$08	Cancer Biology	PE	50	50	100	3	0	0	3
9.	18BPE$09	Environmental Biotechnology	PE	50	50	100	3	0	0	3
10.	18BPE$10	Molecular Pathogenesis	PE	50	50	100	3	0	0	3
11.	18BPE$11	Nanobiotechnology	PE	50	50	100	3	0	0	3
12.	18BPE$12	Animal Biotechnology	PE	50	50	100	3	0	0	3
13.	18BPE$13	Genomics and Proteomics	PE	50	50	100	3	0	0	3
14.	18BPE$14	Mathematical and Numerical Methods for Biotechnology	PE	50	50	100	3	0	0	3
15.	18BPE$15	Bioentrepreneurship	PE	50	50	100	3	0	0	3
16.	18BPE$16	Immunotechnology	PE	50	50	100	3	0	0	3
17.	18BPE$17	Biopharmaceutical Technology	PE	50	50	100	3	0	0	3
18.	18BPE$18	Bioprocess Economics and Plant Design	PE	50	50	100	3	0	0	3
19.	18BPE$19	Tissue Engineering	PE	50	50	100	3	0	0	3
20.	18BPE$20	Metabolic Engineering	PE	50	50	100	3	0	0	3
21.	18BPE$21	Protein Engineering	PE	50	50	100	3	0	0	3
22.	18BPE$22	Pharmacogenomics	PE	50	50	100	3	0	0	3
23.	18BPE$23	Genetics	PE	50	50	100	3	0	0	3
24.	18BPE$24	Biostatistics	PE	50	50	100	3	0	0	3

OPEN ELECTIVES (OE)

Sl. No.	Course Code	Course Title	CAT	CA Marks	End Sem. Marks	Total Marks	Hours/Week			
							L	T	P	C
1.	18COE$01	Climate Change and Adaptation	OE	50	50	100	3	0	0	3
2.	18COE$02	Disaster Management and Mitigation	OE	50	50	100	3	0	0	3
3.	18COE$03	Energy Efficient Buildings	OE	50	50	100	3	0	0	3
4.	18MOE$04	Nanotechnology and Surface Engineering	OE	50	50	100	3	0	0	3
5.	18MOE$05	Mechatronics	OE	50	50	100	3	0	0	3
6.	18MOE$06	Renewable Energy Sources	OE	50	50	100	3	0	0	3
7.	18EOE$07	Renewable Power Generation Systems	OE	50	50	100	3	0	0	3
8.	18EOE$08	Electric Vehicles	OE	50	50	100	3	0	0	3
9.	18EOE$09	Smart Grid Systems	OE	50	50	100	3	0	0	3
10.	18LOE$10	Mobile Communication	OE	50	50	100	3	0	0	3
11.	18LOE$11	Introduction to VLSI System Design	OE	50	50	100	3	0	0	3
12.	18LOE$12	Microcontroller and Applications	OE	50	50	100	3	0	0	3
13.	18POE$13	Rapid Prototyping	OE	50	50	100	3	0	0	3
14.	18POE$14	Managerial Economics	OE	50	50	100	3	0	0	3
15.	18POE$15	Hydraulics and Pneumatics	OE	50	50	100	3	0	0	3
16.	18NOE$16	Measurement and Control	OE	50	50	100	3	0	0	3
17.	18NOE$17	Industrial Automation	OE	50	50	100	3	0	0	3
18.	18NOE$18	Virtual Instrumentation	OE	50	50	100	3	0	0	3
19.	18SOE$19	Programming in Java	OE	50	50	100	3	0	0	3
20.	18SOE$20	Cyber Security	OE	50	50	100	3	0	0	3
21.	18SOE$21	Network Essentials	OE	50	50	100	3	0	0	3
22.	18IOE$22	Programming in Python	OE	50	50	100	3	0	0	3
23.	18IOE$23	Big Data Science	OE	50	50	100	3	0	0	3
24.	18IOE$24	Object Oriented Programming Using C++	OE	50	50	100	3	0	0	3
25.	18BOE$25	Computational Biology	OE	50	50	100	3	0	0	3
26.	18BOE$26	Fundamental Concepts of Biology for Engineers	OE	50	50	100	3	0	0	3
27	18BOE$27	Fundamentals of Bioengineering	OE	50	50	100	3	0	0	3

EMPLOYABILITY ENHANCEMENT COURSES (EEC)

Sl. No.	Course Code	Course Title	CAT	CA Marks	End Sem Marks	Total Marks	Hours/Week			
							L	T	P	C
1	18BEE606	Chemical Reaction Engineering	EEC	50	50	100	2	1	0	3
2	18BEE708	Mini Project	EEC	50	50	100	0	0	8	4
3	18BEE801	Project Work	EEC	50	50	100	0	0	16	8
TOTAL CREDITS							**2**	**1**	**24**	**15**

MANDATORY COURSES (MC)

Sl. No.	Course Code	Course Title	CAT	CA Marks	End Sem Marks	Total Marks	Hours/Week			
							L	T	P	C
1	18BMC3Z6	Constitution of India	MC	50	50	100	3	0	0	0
2	18BMC4Z7	Environmental Sciences and Engineering	MC	50	50	100	3	0	0	0
TOTAL CREDITS										**0**

VALUE ADDED COURSES (VA)

Sl. No.	Course Code	Course Title	CAT	CA Marks	End Sem Marks	Total Marks	Hours/Week			
							L	T	P	C
1	18BVA$01	Introduction to Food Safety and Preservation	VA	100	-	100	1	0	0	1
2	18BVA$02	Safety Practices and Management in Process Industries	VA	100	-	100	1	0	0	1
TOTAL CREDITS										**2**

CURRICULAM DESIGN FOR CBCS 2018 REGULATIONS

FULL TIME B.TECH. INDUSTRIAL BIOTECHNOLOGY (U.G)

SUMMARY

Sl.No	Category	Credits Per Semester								Total Credits	% of Credits	AICTE Suggested Credits.
		I	II	III	IV	V	VI	VII	VIII			
1	HS		3			4		3		10	6.1	12
2	BS	9.5	9.5	7						26	15.8	25
3	ES	8.5	7.5	3	5.5	3				27.5	16.7	24
4	PC			12	16.5	9.5	13.5	5		56.5	34.2	48
5	PE					3		9	6	18	10.9	18
6	OE					3	6	3		12	7.3	18
7	EEC						3	4	8	15	9.1	15
8	MC			0	0					0	0	0
Total		18	20	22	22	22.5	22.5	24	14	165	100	160

HS	Humanities and Social Sciences including Management
BS	Basic Sciences
ES	Engineering Sciences
PC	Professional Core
PE	Professional Elective
OE	Open Elective
EEC	Employability Enhancement Courses
MC	Mandatory Course

18BBS101	CHEMISTRY FOR BIOTECHNOLOGY	SEMESTER I

Category: BS

PRE-REQUISITES: NIL

L	T	P	C
3	1	0	4

COURSE OBJECTIVES

- The course is aimed at imparting knowledge of organic chemistry topics which would be useful for students to understand chemistry applied in Biotechnology.

UNIT-I : INTRODUCTION TO BIOMOLECULES	(9+3 Periods)

Basic principles – Biomolecules, structure and properties of important biomolecules: Carbohydrates (mono, di, oligo & poly saccharides) , mutarotation, glycosidic bond, reducing sugars – Preparation, structure, properties and uses of amino Acids, peptides and proteins.

UNIT-II : STEREOCHEMISTRY AND HETEROCYCLIC COMPOUNDS	(9+3 Periods)

Stereoisomerism – types of stereoisomerism – configurational isomers – enantiomers and diastereosiomers – chirality, optical activity – Fischer projections – optical isomerism – configurations – D & L, R & S systems – Geometrical – E & Z nomenclature – applied to cyclic structures – conformational isomerism – ethane, and cyclo hexane. Hetero cyclic compounds– pyrrole, pyridine, quinoline, isoquinoline, indole – aromaticity, synthesis and reactions of the compounds.

UNIT-III : INSTRUMENTAL METHODS OF CHEMICAL ANALYSIS	(9+3 Periods)

Electromagnetic radiation – characteristics (wave length, wave no, frequency and energy) – Molecular spectroscopy – electronic spectra – Beer Lamberts law – deviations – analysis of ferrous iron, nucleic acids, electronic transitions in organic molecules – Woodward – Fischer rules for calculating absorption maximum in dienes and unsaturated ketones– IR spectroscopy – principle – fundamental vibrations, finger print region– simple instrumentation and sampling.

UNIT-IV : BASIC REACTION MECHANISM IN ORGANIC CHEMISTRY	(9+3 Periods)

Bonding in organic molecules– carbanion, carbocation and free radicals – inductive effect, electronic effect and resonance effect– Nucleophilic substitution – S_N1 and S_N2 – evidences– Electrophilic– substitution – aromatic and aliphatic –Elimination – E1 and E2 substitution.

UNIT-V : NANOCHEMISTRY	(9+3 Periods)

Nano materials – definitions of 1D, 2D and 3D structures –general methods of synthesis and characterisation – bottom up and top down approaches – laser ablation and ball milling techniques– self assembled structures – characteristics – classification – dendrimers – applications in biotechnology.

Contact periods:
Lecture: 45 Periods Tutorial:15 Periods Practical: 0 Periods Total: 60 Periods

TEXT BOOKS:

1. *Jain. P.C. and Monica Jain,* ***"Engineering Chemistry****", Dhanpat Rai Publications. Pvt. Ltd. New Delhi, 16th Edition, 2017.*
2. *Vairam.S, Subha Ramesh,* ***"Engineering Chemistry",*** *Wiley India, 2015.*

REFERENCE BOOKS:

1. *Nelson, D.L. and M.M. Cox,* ***"Lehninger's Principles of Biochemsitry"****, 7thEdition, Freemen W.H & Co., 2017.*
2. *Murray, R.K, Kennelly P.J, Rodwell V.W, et al.* ***"Harper's Illustrated Biochemistry"****, 29th Edition, McGraw–Hill, 2011.*
3. *Robert Neilson Boyd , Saibal kanti Robert, Thornton Morrison "****Organic Chemistry****" kindle Edition 2014*
4. *Said Salaheldeen Elnashaie, Firoozeh Danafar, Hassan Hashemipour Rafsanjani "****Nanotechnology for Chemical Engineers****" 1st Edition 2015, Kindle Edition.*
5. *Charles P.Poole, Jr., Frank J.Owens "****Introduction to NanoTechnology****", Wiley-India Edition, 2006.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Understand the mechanism of organic reactions and apply them in synthesis of biomolecules.

CO2: Learn the principles of stereoisomerism, configurations in simple organic molecules and extend the knowledge to biomolecules, and the properties of heterocyclic compounds.

CO3: Be familiar with the various instrumental methods used for the analysis of simple compounds and interpretation of biomolecules.

CO4: Know about the different types of spectroscopic techniques and applications.

CO5: Gain the knowledge about fundamental of nanomaterials, synthesis, structures and application in Biotechnology field.

COURSE ARTICULATION MATRIX:

PO / CO	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	M	L				L						L	M	
CO2	L	M	L	L								L		
CO3	L	L								L				
CO4	M	L		M	M								L	
CO5	H	M	M	L	M	L				L			M	
18BBS101	M	L	L	L	L	L				L		L	L	

L-Low, M-Moderate (Medium), H-High

18BBS102	CALCULUS AND LINEAR ALGEBRA *(Common to CIVIL, MECH, PRODN & IBT Branches)*	SEMESTER I

Category: BS

PRE-REQUISITES: NIL

L	T	P	C
3	1	0	4

COURSE OBJECTIVES:

- To be familiar with differentiation of single variable and its applications.
- To obtain the knowledge of definite and improper integration and applications.
- To acquire knowledge of differentiation for more than one variable and vector differentiation.
- To gain the knowledge of multiple integration and related applications and vector integration including theorems.
- To know about matrix theory used to solve linear system and diagonalise a matrix by transformation.

UNIT-I: Differential Calculus	**(9+3 Periods)**
Rolle's theorem, Mean value theorems, Taylor's and Maclaurin theorems, indeterminate forms and L'Hospital's rule, Maxima and minima, Evolute of a curve.	
UNIT-II: Integral Calculus	**(9+3 Periods)**
Evaluation of definite and improper integrals; Beta and Gamma functions and their properties, Applications of definite integrals to evaluate surface areas and volume of revolution.	
UNIT-III: Multivariable Calculus (Differentiation)	**(9+3 Periods)**
Limit, continuity and partial derivatives, total derivative, Jacobians, Maxima, minima and saddle points, Method of Lagrange multipliers, Gradient, curl and divergence.	
UNIT-IV: Multivariable Calculus (Integration)	**(9+3 Periods)**
Multiple integration - Double integrals, change of order of integration in double integrals, Change of variables (Cartesian to polar), Applications: areas and volumes, Triple integrals (Cartesian), Change of variables (Cartesian to spherical polar). Theorems of Green, Gauss and Stokes, Simple applications involving cubes, sphere and rectangular parallelepipeds.	
UNIT-V: Matrices	**(9+3 Periods)**
Inverse and rank of a matrix, System of linear equations, Eigenvalues and eigenvectors, Diagonalization of matrices, Cayley-Hamilton Theorem, Orthogonal transformation and quadratic to canonical forms.	

Contact periods:
Lecture: 45 Periods Tutorial:15 Periods Practical: 0 Periods Total: 60 Periods

TEXT BOOKS:

1. *Veerarajan T.,* ***Engineering Mathematics for first year****, Tata McGraw-Hill, New Delhi,2008.*
2. *Srimanta Pal and suboth.C.Bhunia,* ***Engineering Mathematics****, Oxford university publications, New Delhi, 2015.*

REFERENCE BOOKS:

1. *B.S.Grewal,* ***Higher Engineering Mathematics****, Khanna Publishers, 43rd Edition,2015.*
2. *Erwinkreyszig,* ***Advanced Engineering Mathematics****,9th Edition, John Wiley&Sons, 2006.*
3. *Sivaramakrishnadas.P, Rukmangadachari.E,* ***Engineering Mathematics****, Pearson, Chennai & Delhi, 2nd Edition ,2013.*
4. *James Stewart,* ***Essential Calculus****, Cengage Learning, Delhi, 2nd Edition, 2013.*
5. *Howard Anton, IRL Bivens, Stephen Davis,* ***Calculus,*** *Wiley, New Delhi, 10th Edition, 2013.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Understand the standard theorems and applications like maxima and minima, evolute of a curve using principles of differentiation.

CO2: Acquire fluency in integration of one variable for definite and improper integrals like beta and gamma functions and also applications of area and volumes.

CO3: Understand the techniques of partial differentiation and vector differentiation.

CO4: Understand multiple integration for finding area, surface and volume and applications to Green's, Stoke's and Gauss theorems on Vector Calculus.

CO5: Solve the linear system of equations by rank of a matrix and matrix inversion and understand the process of diagonalisation by orthogonal transformation.

COURSE ARTICULATION MATRIX

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	L	L	-	-	-	-	-	-	-	-	M	L	-
CO2	H	L	L	-	-	-	-	-	-	-	-	M	L	-
CO3	H	L	L	-	-	-	-	-	-	-	-	M	L	-
CO4	H	L	L	-	-	-	-	-	-	-	-	M	L	-
CO5	H	L	L	-	-	-	-	-	-	-	-	M	L	-
18BBS102	H	L	L	-	-	-	-	-	-	-	-	M	L	-

L – Low, M – Moderate (Medium), H- High

18BES103	BASICS OF ELECTRICAL AND ELECTRONICS ENGINEERING *(Common to CIVIL & IBT Branches)*	SEMESTER I

Category: ES

PRE-REQUISITES: NIL

COURSE OBJECTIVES:

L	T	P	C
3	0	0	3

- To study the basic concepts of electric circuits, electronic devices and communication engineering.
- To know the fundamentals of DC and AC machines.
- 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 – Steady state solutions of DC circuits – 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 – Three phase balanced circuits – Voltage and current relations in star – delta connections.	
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 - Components of Hydroelectric power plant. Operating principles of Moving coil, Moving iron Instruments (Ammeter and Voltmeters), Dynamometer type watt meters and Energy meters.	
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 – Flip flops - Registers and Counters – A/D and D/A conversion – Introduction to Integrated Circuits (ICs)	
UNIT-IV: FUNDAMENTAL OF COMMUNICATION ENGINEERING	**(9 Periods)**
Types of Signals : Analog and Digital Signals – Modulation and Demodulation :Principles of Amplitude and Frequency Modulations Communication Systems : Radio, TV, Microwave, Satellite, RADAR and Optical Fibre (Block diagram approach only)	
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. Components of LT switchgear : Switch fuse unit, MCB, ELCB, MCCB, Types of wires and Cables – Earthing Batteries – Principle, characteristics, types and applications – DC-DC converters, Single phase /Three phase Inverters - Introduction to UPS and SMPS	

Contact periods:
Lecture: 45 Periods Tutorial: 0 Periods Practical: 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.*
*3. D.P.Kothari, I.J. Nagrath, "**Basic Electrical Engineering**", Tata McGraw Hill, 2010.*

REFERENCE BOOKS:

*1.Nagsarkar T.K and Sukhija M.S, "**Basic Electrical Engineering**", Oxford Press, 2005.*
*2.E.Hughes,"**Electrical and Elecronics Technology**", Pearson, 2010*
*3.Mohmood Nahvi and Joseph A.Edminister, "**Electric Circuits**", Shaum Outline series, McGraw Hill, Sixth edition, 2014*
*4.Premkumar N and Gnanavadivel J, "**Basic Electrical and Electronics Engineering**", Anuradha Publishers, 4th Edition, 2008.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Analyze the DC and AC circuits.
CO2: Explore the significance of Electrical Machines.
CO3: Acquire the knowledge on semiconductor devices and Digital electronics.
CO4: Familiarize the concept of Communication engineering.
CO5: Assembly of electrical wiring and electrical installations.

COURSE ARTICULATION MATRIX:

CO	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	H	M	H	M	L	-	L	M	L	-	L	-	L	L
CO2	H	M	M	L	L	M	L	M	M	M	M	L	M	L
CO3	M	M	M	L	M	-	-	L	L	L	-	-	L	M
CO4	H	H	M	M	L	M	L	L	M	M	L	L	M	L
C05	M	L	M	L	M	L	L	M	-	L	L	L	L	M
18BES103	H	M	M	L	L	M	L	M	M	M	L	L	L	L

L-Low. M-Moderate, H-High

18BBS104	CHEMISTRY LABORATORY *(Common to All Branches)*	SEMESTER I

Category: BS

PRE-REQUISITES: NIL

L	T	P	C
0	0	3	1.5

COURSE OBJECTIVES:

- To inculcate the practical applications of chemistry to student and make them apply in the fields of Engineering and Technology.

LIST OF EXPERIMENTS :	
1.	Estimation of hardness by EDTA method.
2	Estimation of chloride by Argentometric method.
3.	Conductometric titration of mixture of strong acid and weak acid using strong base.
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 HCL by pH titration.
8.	Determination of the rate constant of reaction.
9.	Estimation of Dissolved Oxygen.

Contact periods:

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

REFERENCE BOOKS:

1. *A.O. Thomas, "**Practical Chemistry"**, Scientific Book Centre, Cannanore, 2003.*
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

CO1: Understand the nature of hardness using EDTA Complex

CO2 Iron present in water can be estimated and chloride level, pollution level using dissolved oxygen content.

CO3: Apply the EMF and conductometric measurements in quantitative analysis of Substances.

CO4: pH of the liquid sample will be analysed and hence strength of the sample can be estimated using pH Meter

COURSE ARTICULATION MATRIX:

PO / CO	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	L	L	M	M		L						M	L	L
CO2	M	L		L										
CO3	L	L											M	
CO4	L			L	L								L	L
18BBS104	L	L	L	L	L	L						L	L	L

L-Low, M-Moderate (Medium), H-High

18BES105	BASICS OF ELECTRICAL AND ELECTRONICS ENGINEERING LABORATORY *(Common to CIVIL & IBT Branches)*	SEMESTER I

Category: ES

PRE-REQUISITES: NIL

COURSE OBJECTIVES:

L	T	P	C
0	0	3	1.5

- To understand the performance characteristics of DC and AC machines
- To calibrate and Measuring capability of the DC/AC meters and study the characteristics of electronics devices
- To impart practical knowledge on Wiring and study the performance characteristics of batteries

LIST OF EXPERIMENTS :	
1.	Verification of Ohm's law and Kirchoff's law
2.	Measurement of three phase power by two wattmeter method
3.	Calibrations of Ammeter, Voltmeter, Wattmeter and Single phase Energy meter
4.	Measurements of voltage, current, power on primary and secondary side of single phase and three phase transformers
5.	Measurement of AC signal parameters using CRO/DSO and Function generators
6.	Demonstration of cut out sections of DC and AC machines
7.	Open circuit characteristics and load test on d.c. shunt generator.
8.	Speed control of d.c. shunt motor.
9.	Load test on single phase transformer.
10.	Verification of logic gates, implementation of digital logic circuits
11.	Demonstration of DC-DC converters, DC-AC c converters
12.	Study of components of LT Switchgear
13.	Fluorescent lamp wiring, Stair case wiring and Residential house wiring using fuse, indicator, lamp and energy meter.
14.	Study of battery characteristics during charging and discharging.

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

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Verify Ohm's law and Kirchoff's law on electrical circuits
CO2: Performance characteristics of DC machines and transformers.
CO3: Perform Measurements on DC and AC Instruments

CO4: Implementation of logic circuits
CO5: Able to do domestic and industrial wiring

COURSE ARTICULATION MATRIX:

CO	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	**M**	**M**	**H**	**M**	**L**	**-**	**L**	**L**	**L**	**-**	**L**	**-**	**M**	**M**
CO2	**H**	**M**	**M**	**L**	**L**	**M**	**L**	**M**	**M**	**M**	**M**	**L**	**M**	**L**
CO3	**M**	**M**	**M**	**L**	**M**	**-**	**-**	**L**	**L**	**L**	**-**	**-**	**M**	**L**
CO4	**H**	**H**	**M**	**M**	**L**	**M**	**M**	**L**	**M**	**M**	**L**	**L**	**L**	**L**
C05	M	L	M	L	M	L	L	M	-	L	L	L	L	M
18BES105	M	M	M	L	L	M	L	L	L	L	L	L	M	L

L-LOW, M-MEDIUM, H-HIGH

18BES106	ENGINEERING GRAPHICS *(Common to all Branches)*	SEMESTER I

Category: ES

PRE-REQUISITES: NIL

L	T	P	C
2	0	4	4

COURSE OBJECTIVES:

- Geometrical constructions
- Orthographic projections.
- Performing section of solids and development of the same.
- Pictorial view of solids
- Familiarization of CAD packages.

UNIT-I : GEOMETRICAL CONSTRUCTIONS	**(6+12 Periods)**
Dimensioning-Lettering-Types of Lines-Scaling conventions-Dividing a given straight line in to any number of equal parts- Bisecting a given angle- Drawing a regular polygon given one side-Special methods of constructing a pentagon and hexagon.	
UNIT-II : ORTHOGRAPHIC PROJECTIONS	**(6+12 Periods)**
Introduction to Orthographic Projection-Projection of points-Projection of straight lines with traces - Conversion of pictorial views to orthographic views-Projection of solids	
UNIT-III : SECTION OF SOLIDS AND DEVELOPMENT	**(6+12 Periods)**
Section of solids- Development of surfaces	
UNIT-IV : PICTORIAL VIEWS	**(6+12 Periods)**
Isometric projections - Conversion of orthographic views to pictorial views (simple objects).	
UNIT-V : COMPUTER AIDED DRAFTING	**(6+12 Periods)**
Introduction to computer aided drafting package to make 2-D Drawings. OBJECT CONSTRUCTION – page layout – Layers and Line type – 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 be included in examinations)	

Contact periods:
Lecture: 30 Periods **Tutorial: 0 Periods** **Practical: 60 Periods** **Total: 90 Periods**

TEXT BOOKS:

1. *K.Venugopal,* ***"Engineering Graphics"****, New Age International (P) Limited, 2015.*
2. *K.L.Narayana and P.Kannaiah,* ***"Text book on Engineering Drawing,"*** *2nd Edition, SciTech Publications (India) Pvt. Ltd, Chennai, 2009.*

REFERENCE BOOKS:

1. *Dhananjay.A.Jolhe,* ***"Engineering Drawing"****, Tata McGraw Hill Publishing Co., 2007.*
2. *K.V.Nataraajan,* ***"A text book of Engineering Graphics"****, Dhanalakashmi Publishers, Chennai, 2006.*
3. *M.B.Shah and B.C. Rana,* ***"Engineering Drawing"****, Pearson Education, 2005.*
4. *Luzadder and Duff,* ***"Fundamentals of Engineering Drawing"****, Prentice Hall of India Pvt Ltd, XIth Edition, 2001.*
5. *Alan Kalameja, "****AutoCAD 2008: A tutor for Engineering Graphics",*** *Auto Desk Press 2007*

6. CAD Software manuals of latest version.

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Construct basic geometric shapes and dimension the drawing as per standards.

CO2: Project points, lines and solids in various positions, and convert 2D projections to pictorial projections.

CO3: Generate sectional views of solids and construct development drawings.

CO4: Generate and interrupt pictorial views.

CO5: Use AutoCAD to create simple Engineering Drawings.

COURSE ARTICULATION MATRIX:

CO/ PO	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			L		M	L			M	M	L		L	
CO2			L		M	L			M	M	L		L	
CO3			L		H	L			M	M	L		L	
CO4			L		H	L			M	M	L		L	
CO5			L		H	L			M	M	L		L	
18BES106			L		H	L			M	M	L		L	

L-LOW, M-MEDIUM, H-HIGH

18BHS201	COMMUNICATIVE ENGLISH *(Common to All Branches)*	SEMESTER II

Category: HS

PRE-REQUISITES: NIL

L	T	P	C
2	1	0	3

COURSE OBJECTIVES:

The course is intended to

- Make learners listen to audio files and replicate in speaking contexts.
- Make learners read widely and practice it in writing.
- Make learners develop vocabulary and strengthen grammatical understanding.

UNIT-I : LISTENING	**(6+3 Periods)**
Listening Comprehension, Pronunciation, Intonation, Stress, Pause, Rhythm, Listening to Short & Long Conversations/Monologues - Note-Taking.	
UNIT-II : SPEAKING	**(6+3 Periods)**
Self Introduction, Making Oral & Formal Presentation, Communication at Work Place, Mock Interviews, Role Play Activities, Group Discussions, Debates, Delivering Welcome Address, Proposing Vote of Thanks, Introducing the Chief Guest at a function.	
UNIT-III : READING	**(6+3 Periods)**
Reading Comprehension, Speed Reading, Interpreting Visual Materials (Signs, Post Cards Pictures, Labels Etc.), Reading for Specific Information-Reading to identify Stylistic Features (Syntax, Lexis, Sentence Structures)-Cloze Test.	
UNIT-IV : WRITING	**(6+3 Periods)**
Phrase, Clause And Sentence Structures, Punctuation, Discourse Markers, Coherence, Precision in Writing, Graph & Process Description-Definition, Writing Email-Paraphrasing, Note making, Job Application With Resume, Writing Review of a Book / Movie, Creative Writing.	
UNIT-V : GRAMMAR AND VOCABULARY	**(6+3 Periods)**
Word Formation with Prefix and Suffix, Synonyms and Antonyms, Tenses, Parts of Speech, Common Errors in English (Subject –Verb Agreement, Noun-Pronoun Agreement, Prepositions, Articles, Conditional statements, Redundancies, Clichés etc), Voices.	

Contact periods:

Lecture: 30 Periods **Tutorial: 15 Periods** **Practical: 0 Periods** **Total: 45 Periods**

TEXT BOOKS:

1. ***Board of Editors, Using English****, Orient Black Swan, 2015.*

REFERENCE BOOKS:

1. ***Practical English Usage****, Michael Swan. OUP 1995.*
2. ***Cambridge BEC Vantage*** *- Practice Tests, Self-study Edition, CUP, 2002*
3. ***Exercises in Spoken English****.Parts. I –III. EFLU, Hyderabad, OUP, 2014*
4. ***Indlish****. Jyothi Sanyal, Viva Books,2006*
5. ***Communicative English****. J.Anbazhagan Vijay, Global Publishers, Chennai. 2018*

WEB REFERENCES

1. *www.cambridgeenglish.org/exams/business.../business-**preliminary**/*
2. *http://www.examenglish.com/BEC/BEC Vantage.html*
3. *www.splendid-speaking.com/exams/bec_speaking.htmlhtml*

COURSE OUTCOMES:

At the end of the course, the learners will be able to

CO1: Enhance their listening capacity through various accents and discourse

CO2: Communicate better at various public meeting and work place environments

CO3: Read and strengthen their interpretive and linguistic skills

CO4: Write appropriately on technical, business and general contexts.

CO5: Understand the usage of grammar and vocabulary.

COURSE ARTICULATION MATRIX:

PO / CO	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				M	H	L	M		H	H	M	H		H
CO2				H	H	L	M	M	H	H	M	L		H
CO3				H	H	L	M	M		H	M	H		H
CO4				H	H	L	M	M		H	M	L		H
CO5				L	H	L				H	M	H		H
18BHS201				M	H	L	M	L	L	H	M	M		H

L-LOW, M-MEDIUM, H-HIGH

18BBS202	DIFFERENTIAL EQUATIONS AND COMPLEX VARIABLES *(Common to CIVIL, MECH, PRODN & IBT Branches)*	SEMESTER II

Category: BS

PRE-REQUISITES: NIL

COURSE OBJECTIVES:

L	T	P	C
3	1	0	4

- To gain methods to solve second order differential equations with constant and variable coefficients.
- To be familiarize with formation and solutions of first order partial differential equation.
- To be understood with solutions of higher order partial differential equation and product solutions to standard PDEs.
- To be known about analytic functions with properties, construction of analytic function and the knowledge of conformal transformation.
- To obtain the knowledge of Cauchy's integral theorems, calculus of residues and complex integration around unit circle and semicircle.

UNIT-I: ORDINARY DIFFERENTIAL EQUATIONS OF HIGHER ORDER	**(9+3 Periods)**
Second order linear differential equations with constant and variable coefficients, Cauchy-Euler equation, Cauchy-Legendre equation. Method of variation of parameters, Power series solutions of Differential equations with Bessel and Legendre functions.	
UNIT-II : PARTIAL DIFFERENTIAL EQUATIONS – FIRST ORDER	**(9+3 Periods)**
Formation of partial differential equations by elimination arbitrary constants and functions. Solutions to First order partial differential equations: Standard types of first order linear and non-linear PDE, Lagrange's linear PDE.	
UNIT-III : PARTIAL DIFFERENTIAL EQUATIONS – HIGHER ORDER	**(9+3 Periods)**
Solution to homogenous and non-homogenous linear partial differential equations second and higher order by complimentary function and particular integral method. Separation of variables method: simple problems in Cartesian coordinates, Laplacian equation in plane, cylindrical and spherical polar coordinates, one dimensional diffusion equation.	
UNIT-IV : COMPLEX DIFFERENTIATION	**(9+3 Periods)**
Functions of a Complex variable - Analytic functions - Cauchy Riemann equations and sufficient conditions (excluding proof) - Harmonic and orthogonal properties of analytic functions- Construction of analytic functions – Conformal mappings: w=z+a, az, 1/z, z^2, e^z, cosz, sinz and Bilinear transformations.	
UNIT-V: COMPLEX INTEGRATION	**(9+3 Periods)**
Cauchy's integral theorem - Cauchy's integral formula - Taylor's and Laurent's theorems (Statements only) and expansions - Poles and Residues - Cauchy's Residue theorem - Contour integration: Circular and semicircle contours with no pole on real axis.	

Contact periods:
Lecture: 45 Periods **Tutorial: 15 Periods** **Practical: 0 Periods** **Total: 60 Periods**

TEXT BOOKS:

1. *Veerarajan T., "**Engineering Mathematics" (for first year)**, Tata McGraw-Hill, New Delhi, 2008.*
2. *Srimanta Pal and suboth.C.Bhunia, "**Engineering Mathematics"**, Oxford university publications, New Delhi, 2015.*

REFERENCE BOOKS:

1. *B.S.Grewal, "**Higher Engineering Mathematics"**, Khanna Publishers, 43rd Edition,2015.*
2. *Erwinkreyszig, "**Advanced Engineering Mathematics"**,9th Edition, John Wiley & Sons, 2006.*
3. *N.P. Bali and Manish Goyal, "**A text book of Engineering Mathematics"**, Laxmi Publications, Reprint, 2008.*
4. *E. A. Coddington, "**An Introduction to Ordinary Differential Equations"**, Prentice Hall India, 1995.*
5. *G.F. Simmons and S.G. Krantz, "**Differential Equations"**, Tata McGraw Hill, 2007.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Understand the general solutions to higher order differential equations and power series solutions to second order differential equations leading to Bessel and Legendre functions.

CO2: Acquire fluency in solving first order partial differential equations.

CO3: Understand the techniques of solving second order partial differential equations and solutions by method of separation of variables.

CO4: Understand the properties of analytic function, formation of analytic function and mappings of standard functions, Mobius transformation.

CO5: Understand calculus of residues to evaluate contour integration.

COURSE ARTICULATION MATRIX

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	L	L	-	-	-	-	-	-	-	-	M	L	-
CO2	H	L	L	-	-	-	-	-	-	-	-	M	L	-
CO3	H	L	L	-	-	-	-	-	-	-	-	M	L	-
CO4	H	L	L	-	-	-	-	-	-	-	-	M	L	-
CO5	H	L	L	-	-	-	-	-	-	-	-	M	L	-
18BBS202	H	L	L	-	-	-	-	-	-	-	-	M	L	-

L – Low, M – Moderate (Medium), H- High

18BBS203	MECHANICS AND PROPERTIES OF SOLIDS *(Common to CIVIL & IBT Branches)*	SEMESTER II

Category: BS

PRE-REQUISITES: NIL

COURSE OBJECTIVES:

L	T	P	C
3	1	0	4

To enhance the fundamental knowledge in mechanics and properties of solids, and its applications relevant to their field of engineering. Upon completion of this course the students will be familiar with:

- Mechanics and Elastic behaviour of solids
- Thermal conduction and applications
- Principles of acoustics, ultrasonics and their industrial applications.
- Origin of quantum physics, Schrödinger's equation and applications.
- Emerging materials and their applications

UNIT-I : MECHANICS OF SOLIDS	**(9+3 Periods)**
Elasticity- Hooke's law-Types of strain-Classification of Modulus of Elasticity- Poisson's Ratio - Stress-Strain diagram - Factors affecting elasticity – Moment, Couple and Torque – Derivation of Twisting Couple on a Cylinder (or wire) - Bending moment –Young's modulus by Non Uniform Bending - Depression of a cantilever - Uniform bending - I shaped girders.	
UNIT-II : THERMAL PROPERTIES	**(9+3 Periods)**
Thermal Conductivity – Thermal Diffusivity - Specific Heat Capacity - Rectilinear Flow of Heat along a Uniform Bar - heat conduction in solids - flow of heat through compound media (parallel and perpendicular) – Determination of Thermal Conductivity of a Good Conductor by Forbe's Method: theory and experiment - Determination of Thermal Conductivity of a poor Conductor by Lee's Disc Method: theory and experiment.	
UNIT-III : ACOUSTICS & ULTRASONICS	**(9+3 Periods)**
Classification of sound - loudness and intensity - Weber-Fechner law - standard intensity and intensity level - decibel - reverberation - reverberation time - Determination of absorption coefficient - factors affecting acoustics of buildings. 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 ultrasonics- applications- ultrasonic drilling- ultrasonic welding- ultrasonic -Non- destructive Testing- Pulse echo system	
UNIT-IV : QUANTUM MECHANICS AND APPLICATIONS	**(9+3 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	
UNIT-V : MODERN ENGINEERING MATERIALS	**(9+3 Periods)**
Metallic glasses- preparation of metallic glasses - properties – applications of the metallic glasses - Shape Memory Alloys (SMA) - Characteristics, properties of NiTi alloy - applications of SMA - advantages and disadvantages of SMA - Nanomaterials-synthesis – chemical vapour deposition – Sol Gel – ball Milling – properties of nanoparticles and applications of nanoparticles.	

Contact periods:
Lecture: 45 Periods Tutorial: 15 Periods Practical: 0 Periods Total: 60 Periods

TEXT BOOKS:

1. *S. H. Crandall, N. C. Dahl & T. J. Lardner, "**An Introduction to the Mechanics of Solids"**, 2nd ed. with SI Units. – Unit I& II*
2. *P.K.Palanisamy, "**Engineering physics-I",** Scitech publications (India) Pvt. Ltd., 3 edition, 2015. – Unit I, II & III*

REFERENCE BOOKS:

1. *J. L. Meriam,**"Engineering Mechanics: Statics"**, 7th ed. – Unit I& II*
2. *Arumugam M- **"Engineering Physics"**, Anuradha Publishers, 2010.– Unit IV*
3. *EP Popov, **"Engineering Mechanics of Solids**"*
4. *Avadhanulu M. N. and Kshirsagar P. G., **"A Textbook of Engineering Physics"**, S.Chand and Company Ltd, New Delhi, 2010.*
5. *Dr. Jayakumar .S, **"Materials Science",** R. K. Publishers, 2008. -– Unit V*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Acquire knowledge in solid mechanics and properties of matter with its applications
CO2: Acquire knowledge in thermal physics [Application]
CO3: Familiarization on acoustics of building and generation and application of ultrasonic waves
CO4: Analyze the dual nature of matter using Heisenberg's Uncertainty principle, Schrodinger's time independent and dependent wave equations.[Assessment]
CO5: Exposing the properties and applications of modern engineering materials [Familiarity & Application]

COURSE ARTICULATION MATRIX

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	M	L	M								L	H	M
CO2	H	M	M	M								L	H	M
CO3	H	M	M	H	L							L	H	M
CO4	H	M	M	M								L	H	M
CO5	H	M	M	M	M							L	H	M
18BBS203	H	M	M	M	M							L	H	M

L – Low, M – Moderate (Medium), H- High

18BES204	**PROGRAMMING IN C** *(Common to all branches except MECH & PRODN Branches)*	**SEMESTER II**

Category: ES

PRE-REQUISITES: NIL

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

Upon completion of this course, the students will be familiar with,

- The Computer and Programming fundamentals
- Data types in C and Flow control statements
- Functions, Arrays, Pointers and Strings
- Bitwise Operators, Preprocessor Directives, Structures and Unions
- Structures, List Processing, Input and Output

UNIT-I : COMPUTER AND PROGRAMMING FUNDAMENTALS	**(9 Periods)**
Computer fundamentals – Evolution, classification, Anatomy of a computer: CPU, Memory, I/O – Introduction to software – Generation and classification of programming languages – Compiling – Linking and loading a program – Translator – loader – linker – develop a program – software development – Introduction to OS –Types of OS – Algorithms – Structured programming concept.	
UNIT-II : DATA TYPES AND FLOW OF CONTROL	**(9 Periods)**
An overview of C – Programming and Preparation – Program Output – Variables – Expressions, and Assignment, The use of #include, printf(), scanf() – Lexical elements, operators and the C systems – The fundamental data types – Flow of control	
UNIT-III : FUNCTIONS, ARRAYS, POINTERS AND STRINGS	**(9 Periods)**
Functions and storage classes - 1D Arrays – Pointers – Call by reference – Relationship between Arrays and Pointers – Pointer arithmetic and element size – Arrays as function argument – Dynamic memory allocation – Strings – String handing functions – Multidimensional Arrays.	
UNIT-IV : ARRAY OF POINTERS, BITWISE OPERATORS, PREPROCESSOR DIRECTIVES	**(9 Periods)**
Arrays of Pointers – Arguments to main () - Ragged Arrays – Functions as Arguments – Arrays of Pointers to Functions - Type qualifiers.-Bitwise operators and expressions – Masks – Software tools – Packing and unpacking – Enumeration types – The preprocessor directives.	
UNIT-V : STRUCTURES AND UNIONS, I/O AND FILE OPERATIONS	**(9 Periods)**
Structures and Unions – Operator precedence and associativity – Bit fields – Accessing bits and bytes - Input and Output functions – File Processing Functions – Environment variables – Use of make and touch.	

Contact periods:

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

TEXT BOOKS:

1. *Pradip Dey, Manas Ghosh,* ***"Computer Fundamentals and Programming in C"****, Second Edition, Oxford University Press, 2013.*
2. *Al Kelley, Ira Pohl,* ***"A Book on C-Programming in C"****, Fourth Edition, Addison Wesley, 2001.*

REFERENCE BOOKS:

1. *Stephen G. Kochan,* ***"Programming in C-A complete introduction to the C programming language"****, Third Edition, Sams Publication, 2004.*
2. *Yashavant P. Kanetkar,* ***"Let Us C"****, 13th edition, BPB Publications, 2013.*
3. *Brian W. Kernighan and Dennis Ritchie,* ***"The C Programming Language"****, Second Edition, Prentice Hall Software Series, 1988.*
4. *Stephen Prata,* ***"C Primer Plus"****, Fifth Edition, Sams Publishing, 2005.*

COURSE OUTCOMES:

Upon completion of this course, the students will be able to

CO1: Articulate the programming environment [Familiarity]
CO2: Write algorithm for solving the given problem statement [Usage]
CO3: Use right data types and flow control statements [Assessment]
CO4: Write programs using functions, arrays, pointers and strings [Usage]
CO5: Use right storage classes, preprocessor directives, bitwise operators in programs [Assessment]
CO6: Use structures, unions and files [Usage]

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	H	M	H	H		M	M	M	M	L	M		
CO2	H	H	M	H	H			M	M	M	L	M		M
CO3	H	H	M	H	H			M	M	M	L	M		L
CO4	H	H	M	H	H			M	M	M	L	M		
CO5	H	H	M	H	H			M	M	M	L	M		
CO6	H	H	M	H	H			M	M	M	L	M		
18BES204	H	H	M	H	H		M	M	M	M	L	M		L

L-Low, M-Moderate (Medium), H-High

18BBS205	PHYSICS LABORATORY *(Common to All Branches)*	SEMESTER II

Category: BS

PRE-REQUISITES: NIL

L	T	P	C
0	0	3	1.5

COURSE OBJECTIVES:

To improve the basic knowledge in Physics and its applications relevant to various streams of Engineering and Technology. Upon completion of this course the students will be familiar with:

* To have a practical knowledge about the concepts of physics and its applications in the emerging fields of engineering and technology

LABORATORY EXPERIMENTS :	
1.	Spectrometer - Diffraction Grating Normal Incidence Method
2	Air Wedge –Determination thickness of a paper
3.	Young's Modulus – Cantilever Bending Koenig's Method
4.	a) Laser - Particle size Determination b) Optical fiber - Determination of NA & Acceptance angle
5.	Ammeter and Voltmeter Calibration – Low Range
6.	Determination of Bandgap Energy of Semiconductor
7.	Ultrasonic Interferometer - Velocity of sound & Compressibility of liquids.
8.	Torsional pendulum –Determination of Rigidity Modulus & Moment of Inertia

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

COURSE OUTCOMES:

Upon the completion of the course, the student will be able to

CO1: Determine all physical properties of any matter,
CO2: Calibrate electrical measuring instruments and thereby effectively using it for particular application
CO3: Understand principle of Laser diffraction and its application in particle size determination
CO4: Understand the concept of light propagation through optical fibers and determination of its parameters
CO5: Determine the Intrinsic characteristic features of electronic devices for electrical and electronic applications.
CO6: Understand the ultrasonic wave propagation in liquids and the determination of compressibility of liquids for engineering applications.

COURSE ARTICULATION MATRIX

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2
CO1	H	M	L	L	M							L	M	M
CO2	H	M	L	M	L							L	M	M
CO3	H	M	L	L								L	L	
CO4	H	M	M	L	M							L	L	M
CO5	H	M	M	L	M							L	M	L
CO6	H	M	M	M	M							L	M	M
18BBS205	H	M	M	M	M							L	M	M

L – Low, M – Moderate (Medium), H- High

18BES206	WORKSHOP PRACTICE *(Common to All Branches)*	SEMESTER II

Category: ES

PRE-REQUISITES: NIL

COURSE OBJECTIVES:

L	T	P	C
1	0	4	3

- To make various basic prototypes in the carpentry trade such as Lap joint, Lap Tee joint, Dove tail joint, Mortise & Tenon joint and Cross-Lap joint.
- To make various welding joints such as Lap joint, Lap Tee joint, Edge joint, Butt joint and Corner joint.

LIST OF EXPERIMENTS

1. Introduction to use of tools and equipments in Carpentry, Welding, Foundry and Sheet metal
2. Safety aspects in Welding, Carpentry and Foundry
3. Half lap Joint and Dovetail Joint in Carpentry
4. Welding of Lap joint, 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. Electrical wiring – simple house wiring
8. Plumbing
9. CNC Machines demonstration and lecture on working principle.
10. Additive manufacturing demonstration and lecture on working principle.

Contact periods:

Lecture: 15 Periods **Tutorial: 0 Periods** **Practical: 60 Periods** **Total: 75 Periods**

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO 1: Safely Use tools and equipment's used in Carpentry, Welding, Foundry and Sheet metal to create basic joints.

CO 2: Prepare sand mold for various basic pattern shapes.

CO 3: Fabricate parts like tray, frustum of cone and square box in sheet metal.

CO 4: Carry out minor works/repair related to electrical wiring and plumbing.

CO 5: Demonstrate the working of CNC machines and additive manufacturing.

COURSE ARTICULATION MATRIX

CO/ PO	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	H		L		L				L				M	L
CO2	H		L		L				L				M	L
CO3	H		L		L				L				M	L
CO4	H		L		M				L				M	L
CO5	H		L		H				L				M	L
18BES206	H		L		M				L				M	L

L – Low, M – Moderate (Medium), H- High

18BES207	PROGRAMMING IN C LABORATORY *(Common to all branches except MECH & PRODN Branches)*	SEMESTER II

Category: ES

PRE-REQUISITES: NIL

L	T	P	C
0	0	3	1.5

COURSE OBJECTIVES:

Upon completion of this course, the students will be familiar with,

- Data types in C and Flow control statements
- Functions, Arrays, Pointers And Strings
- Dynamic memory allocation and command line arguments
- Bitwise Operators, Preprocessor Directives, Structures and Unions
- Structures, List Processing, Input and Output

PRACTICALS 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	Structures
8	Unions
9	Files
10	Command line arguments
11	Mini Project

Contact periods:

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

COURSE OUTCOMES:

Upon completion of this practical classes, the students will be able to

CO1: Use appropriate data types and flow control statements **[Usage]**

CO2: Write programs using functions, arrays, pointers and strings **[Usage]**

CO3: Write programs using dynamic memory allocation **[Usage]**

CO4: Implement programs using right storage classes, preprocessor directives, bitwise operators **[Usage]**

CO5: Work with command line arguments, structures, unions and files **[Usage]**

CO6: Develop applications using C **[Usage]**

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2
CO1	H	H	M	H	H			M	M	M	L	M	M	M
CO2	H	H	M	H	H			M	M	M	L	M	L	L
CO3	H	H	M	H	H			M	M	M	L	M	M	M
CO4	H	H	M	H	H			M	M	M	L	M	M	M
CO5	H	H	M	H	H			M	M	M	H	H	L	M
CO6	H	H	M	H	H			M	M	M	M	M	M	M
18BES207	H	H	M	H	H			M	M	M	M	M	L	L

L-Low, M-Moderate (Medium), H-High

18BBS301	TRANSFORMS, CALCULUS AND PARTIAL DIFFERENTIAL EQUATIONS *(Common to CIVIL & IBT Branches)*	SEMESTER III

Category: BS

PRE-REQUISITES: NIL

L	T	P	C
3	1	0	4

COURSE OBJECTIVES:

- To gain the knowledge of construction of Fourier series.
- To acquire knowledge of techniques to solve one dimensional partial differential equations concerning to engineering applications
- To be familiar with concept and applications of Laplace, Fourier and Z transforms.

UNIT I: FOURIER SERIES	**(9 Periods)**
Dirichlet's Conditions – General Fourier series –Odd and even functions- Half range Sine and Cosine series – Parseval's Identity on Fourier series–Harmonic Analysis	
UNIT II: BOUNDARY VALUE PROBLEMS	**(9 Periods)**
Classification of partial differential equations – Method of separation of variables–One dimensional wave equation–One dimensional heat equation–Transient and Steady state conditions–Fourier series solution.	
UNIT III:LAPLACE TRANSFORMS	**(9 Periods)**
Laplace Transform, Properties of Laplace Transform, Laplace transform of periodic functions. Initial and Final value theorems, Finding inverse Laplace transform by different methods, convolution theorem. Evaluations of integrals by Laplace transform, solving ODEs by Laplace transform method.	
UNITIV:FOURIER TRANSFORMS	**(9 Periods)**
Statement of Fourier integral Theorem – Fourier transform pair–Fourier Sine and Cosine Transforms –Properties –Transforms of Simple functions –Convolution Theorem– Parseval's Identity-Finite Fourier transforms	
UNIT V:Z TRANSFORMS	**(9 Periods)**
Z-transforms - Elementary properties-Inverse Z-transforms - Initial and Final value theorems - 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 McGraw Hill Publishing Co., New Delhi.2015.*

REFERENCE BOOKS:

*1. B.S.Grewal ., **"Higher Engineering Mathematics"**, Khanna Publishers, New Delhi,44rd Edition, 2018*
*2. Kandasamy, Thilagavathy and Gunavathy., **"Engineering Mathematics"** for III Semester, S.Chand & Co, Ramnagar, New Delhi..*
*3. N.P.Bali and Manish Goyal., **"Transforms and partial Differential equations"**, University Science Press, New Delhi, 2010.*
*4. Veerarajan T., **"Engineering Mathematics"** for Semester I & II, Tata Mc Graw Hill Education(India)Pvt Ltd., New Delhi, Third Edition 2012.*
*5. Erwinkreyszig, **"Advanced Engineering Mathematics"**, 9th Edition, John Wiley & Sons, 2006.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Understand the concepts of Fourier series and its construction when discrete and continuous form is known.
CO2: Solve boundary value problems.
CO3: Utilize Laplace transforms in solving Differential equations.
CO4: Apply Fourier transforms in order to solve improper integrals.
CO5: Understand the Z transform methods to find solutions of difference equations.

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	H	M	H	M	M	M	M	L	L	L	M	M	L
CO2	H	H	M	H	M	M	L	L	L	L	L	M	M	L
CO3	H	H	H	M	L	M	L	L	L	M	L	M	M	M
CO4	H	H	H	M	L	M	M	L	L	M	L	M	M	M
CO5	H	H	M	M	L	M	M	M	L	M	L	M	M	M
18BBS 301	H	H	M	M	L	M	M	L	L	M	L	M	M	M

L - Low, M-Moderate (Medium), H- High

18BBS302	MICROBIOLOGY	SEMESTER III

Category: BS

L	T	P	C
3	0	0	3

PRE-REQUISITES: NIL

COURSE OBJECTIVES:

- Understand the basics of classification, types of microbes and its existence
- Understand the requirements of bacteria for its growth and will be able to quantify it by various techniques and methods of controlling it.
- Learn the application of microbes in industries and other bioremediation strategies.

UNIT – I : INTRODUCTION	**(9 Periods)**
History of microbiology, Microbial existence-Soil, Water and Air; classification and nomenclature of microorganism, microscopic examination of microorganisms, light and electron microscopy; principles of different staining techniques like gram staining, acid fast staining, capsular staining, flagella staining, Spore staining.	
UNIT – II : MICROBES-STRUCTURE AND MULTIPLICATION	**(9 Periods)**
Colony morphology and arrangement of bacterial cells- Structure and multiplication of bacteria- fungi (Rhizopus) and viruses (TMV)- life history of mycoplasma- actinomycetes (Streptomyces)- yeast- bacteriophages.	
UNIT – III : MICROBIAL NUTRITION, GROWTH AND METABOLISM	**(9 Periods)**
Nutritional requirements of bacteria and different media used for bacterial culture; growth curve and different methods to quantify the bacterial growth, aerobic and anaerobic bioenergetics and utilization of energy for biosynthesis of important molecules.	
UNIT – IV : APPLIED MICROBIOLOGY	**(9 Periods)**
Microbes in Wastewater treatment – aerobic and anaerobic digestion; Biogas; bioremediation; leaching of ores by microorganisms. Applications of microbial enzymes in dairy industries, Microbial production of Plastics (PHB, PHA).	
UNIT – V : CONTROL OF MICROORGANISMS	**(9 Periods)**
Host-microbe interactions, Clinically important microorganisms; Physical and chemical control of microorganisms; anti-bacterial, anti-fungal and anti-viral agents, mode of action of antibiotics and its resistance.	

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

TEXT BOOKS:

1. *Pelczar MJ, Chan ECS and Krein NR,* ***"Microbiology"****, McGraw Hill Education, 5th Edition, 2001.*
2. *Prescott LM, Harley JP, Klein DA, "****Microbiology"****, 4th Edition, Wm. C. Brown Publishers, 2010.*
3. *Talaron K, Talaron A, Casita, Pelczar and Reid,* ***"Foundations in Microbiology"****, W.C. Brown Publishers, 1993.*

REFERENCE BOOKS:

1. Kathleen Park Talaro and Barry Chess, ***"Foundations in Microbiology"****, McGraw Hill Education, 9th Edition, 2015.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Understand the Morphology, cell structure, growth and metabolism of Micro organisms
CO2: Demonstrate the ubiquity and diversity of microorganisms in the human body and the environment.
CO3: Differentiate the various types of microorganisms and the major diseases they cause.
CO4: Explore the routes of transmission of infection and the methods used to control the spread of infection.
CO5: Identify the importance of microbes in applied microbiology and biotechnology.

COURSE ARTICULATION MATRIX:

CO	PO 1	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	L	-	-	-	-	L	M	M	M	M	-	M	H	L
CO2	L	M	-	-	-	L	M	M	M	M	-	M	H	L
CO3	H	L	-	-	-	M	H	M	M	M	-	M	H	M
CO4	M	L	-	-	-	-	H	M	M	M	-	M	H	L
CO5	M	-	H	M	M	H	H	H	H	M	-	M	H	H
18BBS 302	M	-	M	-	-	H	M	M	L	M	-	M	H	L

L - Low, M-Moderate (Medium), H- High

18BES303	FLUID MECHANICS	SEMESTER III

Category: ES

PRE-REQUISITES: NIL

L	T	P	C
2	1	0	3

COURSE OBJECTIVES:

- Understand dynamics and properties of fluid flow.
- The engineering of fluid mechanics (flow measurements).
- Dynamic characteristics of fluid flow for through pipes and porous medium.

UNIT I : INTRODUCTION	**(6+3 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	**(6+3 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	**(6+3 Periods)**
Orifice meter, Venturimeter, Pitot tube, Rota meter, weirs and notches, hot wire anemometer, displacement meter, current meter, magnetic flow meter, pressure measurement by manometers, 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	**(6+3 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	**(6+3 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: 30 Periods **Tutorial:15 Periods** **Practical: 0 Periods** **Total: 45 Periods**

TEXT BOOKS

1. McCabe Smith and Harriott, ***"Unit Operations of Chemical Engineering",*** *5th Edition, Tata McGraw-Hill company, 1993.*

2. Geankoplis C.J, ***"Transport Processes and Unit Operations",*** *3rd Edition, Prentice Hall of India, , 2002.*

3. Frank M. White, ***"Fluid Mechanics",*** *8th Edition, Tata McGraw-Hill company, 2015.*

REFERENCE BOOKS

1. J. M. Coulson, J. F. Richardson and R. K. Sinnott, ***"Chemical Engineering. Vol I & II"****, 5th Edition, Butterworth-Heinemann Ltd, 1998.*

2. Bansal R K, ***"Fluid mechanics and Hydraulic machines"****, 5th Edition, Lakshmi publications (P) Ltd, New Delhi, 1997.*

COURSE OUTCOMES

Upon completion of the course graduates will be able to

CO1: Understand stress – strain relationship in fluids and analyse fluid flow problems.
CO2: To apply Bernouli principle and measure pressure drop in flow systems.
CO3: Describe the function and performance of flow metering devices.
CO4: Determine minimum fluidization velocity in fluidized bed.
CO5: Present characteristics of particulate solids, Principles of size reduction and screening, crushing and grinding equipment.

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	-	H	H	M	L	-	-	-	-	-	-	H	H	L
CO2	M	M	-	H	-	-	L	L	M	L	M	H	H	L
CO3	M	M	H	L	M	M	-	-	-	-	-	M	L	H
CO4	L	H	H	M	L	-	L	M	-	-	-	H	H	M
CO5	L	H	-	-	L	-	-	-	L	L	L	H	H	M
18BES 303	L	H	H	M	L	M	L	M	M	L	M	H	H	M

L- Low , M-Moderate(Medium), H- High

18BPC304	CELL BIOLOGY	SEMESTER III

Category: PC

L	T	P	C
3	0	0	3

PRE-REQUISITES: NIL

COURSE OBJECTIVES:

- Gain the knowledge related to the basics of different types cell structure and morphology
- Understand the biomolecules transport mechanism across the biomembranes and functions of receptor in cell signaling process
- Get familiarize the cell signaling and signal transduction process inside and outside the cell
- Know the basics of different types of cell culture

UNIT – I : CELL STRUCTURE AND FUNCTION OF THE ORGANELLES	(9 Periods)
Structure of Prokaryotic and Eukaryotic cells and brief on their organelles, principles of membrane organization, membrane proteins, extra cellular matrix, cytoskeleton structures, cell junction and cell adhesions, types of cell division, mitosis & meiosis, cell cycle and molecules that control cell cycle.	
UNIT – II : TRANSPORT ACROSS BIO MEMBRANES	**(9 Periods)**
Osmosis and reverse osmosis, Passive & active transport, permeases, sodium potassium pump, Ca2+ ATPase pumps, voltage and ligand gated channels, lysosomal and vacuolar membrane ATP dependent proton pumps, Co- transport - symport, antiport, Endocytosis and exocytosis. Entry of virus and toxins into cells.	
UNIT – III : RECEPTORS AND MODES OF CELL SIGNALLING	**(9 Periods)**
Cytosolic, nuclear and membrane bound receptors with examples, autocrine, paracrine and endocrine modes of action, quantification and characterisation of receptors.	
UNIT – IV : SIGNAL TRANSDUCTION	**(9 Periods)**
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, role of protein kinases - serine – threonine kinases, tumor necrosis factor receptor families.	
UNIT – V : BASICS OF CELL CULTURE	**(9 Periods)**
Cell line, generation of cell lines, maintenance of stock cells, characterization of cells, morphological analysis techniques in cell culture, primary cultures, contamination, differentiation, three dimensional cultures, role of matrix in cell growth.	

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

TEXT BOOKS:

1.Darnell J, Lodish H, Baltimore D, ***"Molecular Cell Biology"****, W.H.Freeman; 8th edition,2016*
2.Brai De Robertis & De Robertis, ***"Cell Biology"****, Fourth edition,2007*
3. Geoffrey M. Cooper and Robert E. Hausman, ***"The Cell: A Molecular Approach",*** *ASM Press and Sinauer Associates, Fifth Edition, 2009.*

REFERENCE BOOKS:

1. *Kimball T.W,* ***"Cell Biology"****, Wesley Publishers; Third edition, 1984.*
2. *James D. Watson,* ***"Molecular Biology of the Cell"****, Third edition, 2004*
3. *Channarayappa,* ***"Cell biology"****, Universities Press, 2010*
4. *Rastogi.S.C,* ***"Cell biology"****, New Age International publishers, 2005*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: understand the functions of cell and their structural organization
CO2: Describe the mechanisms and role of cell in immune system
CO3: Get familiarized biomolecules and human anatomy system
CO4: Illustrate the applications of microbes in industrial process
CO5: Apply the engineering concepts in biology

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	L	M	-	L	-	L	--	L	-	-	L	-	H	M
CO2	L	M	L	-	L	L	--	-	L	-	-	-	H	M
CO3	L	L	L	-	L	L	-	L	-	-	-	-	M	H
CO4	L	L	-	L	-	-	-	-	-	-	-	L	H	M
CO5	L	-	-	-	L	-	L	-	M	-	-	L	H	H
18BPC 304	L	M	L	L	L	L	L	L	M	-	L	L	H	M

L - Low, M-Moderate (Medium), H- High

18BPC305	BIOCHEMISTRY	SEMESTER III

Category: PC

PRE-REQUISITES: NIL

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- To understand structural, functional properties, synthesis of carbohydrates and proteins, lipids and nucleic acids
- To understand structural, functional properties and metabolic pathways of nucleic acids and lipids.
- To learn basic information and the mechanisms of structural and cytoskeletal proteins involved organelle movements

UNIT – I : CARBOHYDRATES	**(9 Periods)**
Carbohydrates- Classification, Structure and Properties of Carbohydrates (Mono, Di, Oligo& polysaccharides) - mutarotation, Conjugated carbohydrates, Metabolism concepts-Glycolysis, TCA cycle, pentose phosphate shunt and Respiratory chain- ATP synthesis- Metabolic disorders associated with carbohydrates.	
UNIT – II : PROTEINS	**(9 Periods)**
Classification of Amino acids, Structure and Properties of Amino acids-peptide bond-Classification of Proteins-Primary- Secondary- Tertiary and Quaternary structure of proteins - fibrous and globular proteins, Conjugated proteins, Metabolism concepts-Nitrogen metabolism and urea cycle, Biosynthesis of six essential amino acids (Met, Thr, Lys, Ile, Val, Leu) and aromatic amino acids- Metabolic disorders associated with chain and aromatic amino acid degradation.	
UNIT – III : NUCLEIC ACIDS	**(9 Periods)**
Nucleic Acids – Structure of Purines – Pyrimidines – Nucleosides - Nucleotides - Ribonucleic acids – Deoxyribonucleic acids - Nucleoprotein complexes, Metabolism concepts- Biosynthesis of nucleotides, denovo and salvage pathways for purines and pyrimidines- Metabolic disorders associated with nucleic acids.	
UNIT – IV : LIPIDS	**(9 Periods)**
Structure and properties of Lipids – Classification, (Fatty acids, Glycerolipids, Phospholipids, Glycolipids, Sphingolipids, Steroids), Metabolism concepts- Fatty acid synthesis and oxidative degradation, Triacylglycerol, phospholipid biosynthesis and degradation; Cholesterol biosynthesis-Metabolic disorders associated with lipids.	
UNIT – V : INTERMEDIARY METABOLISM AND REGULATION	**(9 Periods)**
High energy compounds, electronegative potential of Compounds, respiratory chain, ATP cycle, Calculation of ATP yield during oxidation of glucose and fatty acids- Protein targeting, signal sequence, secretion; Folding, Chaperone and 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. *Nelson, D.L., Cox,M.M.,* ***"Lehninger's —Principles of Biochemistry"****, 6th Edition, Macmillan, 2013.*
2. Berg, J.M., Tymoczko, J.L., Stryer, L., ***"Biochemistry"****, 6th Edition, WH Freeman, 2006.*
3. *Voet,D., Voet,J.G .,* ***"Biochemistry"****, 4th Edition, Wiley., 2010.*

REFERENCE BOOKS:

1. *Murray, R.K., Granner, B.K., Mayes, P.A., Rodwell. V.W.,* ***"Harper's Biochemistry"****, Prentice Hall, 2006.*
2. *Salway, J.G.,* ***"Metabolism at a Glance"****, 2nd Edition, Blackwell Science Ltd., 2000.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Understand the structural, functional properties of carbohydrates and its metabolism
CO2: Understand about basics of amino acids, biosynthesis and structure of protein
CO3: Acquire knowledge about nucleic acids and its synthesis pathways.
CO4: Classify the lipids and to understand the metabolic pathways of lipids.
CO5: Describe the metabolic disorders associated with the biomolecules.

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	M	-	-	-	-	-	-	-	-	-	M	H	M
CO2	M	M	-	-	-	L	-	-	-	-	-	-	H	M
CO3	M	-	L	-	-	-	-	-	-	-	-	-	H	M
CO4	M	-	-	-	-	-	-	-	M	M	-	-	H	M
CO5	M	-	-	L	-	-	-	-	-	-	-	L	M	H
18BPC 305	M	M	L	M	-	L	-	-	M	M	-	M	H	M

L - Low, M - Moderate (Medium), H – High

18BMC3Z6	CONSTITUTION OF INDIA *(Common to all Branches)*	SEMESTER III

PRE-REQUISITES: NIL

Category: MC

L	T	P	C
3	0	0	0

COURSE OBJECTIVES:

- To know about Indian constitution.
- To know about central and state government functionalities in India.
- To know about Indian society.

UNIT – I : INTRODUCTION	**(9 Periods)**
Historical Background – Constituent Assembly of India – Philosophical foundations of the Indian Constitution – Preamble – Fundamental Rights – Directive Principles of State Policy – Fundamental Duties – Citizenship – Role of the Election Commission.	
UNIT – II : STRUCTURE AND FUNCTION OF CENTRAL AND STATE GOVERNMENT	**(9 Periods)**
Union Government – Structures of the Union Government and Functions – President – Vice President– Prime Minister – Cabinet – Parliament – Supreme Court of India – Judicial Review. State Government – Structure and Functions – Governor – Chief Minister – Cabinet – State Legislature – Judicial System in States – High Courts and other Subordinate Courts.	
UNIT – III : CONSTITUTION FUNCTIONS OF INDIA AND INDIAN SOCIETY	**(9 Periods)**
Indian Federal System – Central – State Relations – President's Rule – Constitutional Amendments – Constitutional Functionaries - Assessment of working of the Parliamentary System in India. Society : Nature, Meaning and definition; Indian Social Structure; Caste, Religion, Language in India; Constitutional Remedies for citizens – Political Parties and Pressure Groups; Right of Women, Children and Scheduled Castes and Scheduled Tribes and other Weaker Sections.	
UNIT – IV : POLICIES AND ACTS - GENERAL	**(9 Periods)**
Insurance and Bonding – Laws Governing Sale, Purchase and use of Urban and Rural Land – Land Revenue Codes – Tax Laws – Income Tax, Sales Tax , Excise and Custom duties and their Influence on Construction Cost – Legal Requirements for Planning – Property Law– Agency Law – Local Government Laws for Approval.	
UNIT – V : POLICIES AND ACTS ON INFRASTRUCTURE DEVELOPMENT	**(9 Periods)**
A Historical Review of the Government Policies on Infrastructure – Current Public Policies on Transportations – Power and telecom Sector – Plans for Infrastructure Development – Legal framework for Regulating Private Participation in Roads and Highways – Ports and Airport and Telecom.	

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

TEXT BOOKS:

1. *Durga Das Basu,* ***"Introduction to the Constitution of India"****, Prentice Hall of India, New Delhi, 2018.*
2. *R.C.Agarwal,* ***"Indian Political System"****, S.Chand and Company, New Delhi, 2004.*
3. *Maciver and Page,* ***"Society: An Introduction Analysis"****, Mac Milan India Ltd., New Delhi, 2007.*
4. *K.L.Sharma,* ***"Social Stratification in India: Issues and Themes"****, Jawaharlal Nehru University, New Delhi, 2006.*

REFERENCE BOOKS:

1. *M.Laxmikanth,* ***"Indian Polity"****, Mcgraw Hill Education (India)Private limited,2016*
2. *Sharma, Brij Kishore,* ***" Introduction to the Constitution of India"****, Prentice Hall of India, New Delhi,2018*

COURSE OUTCOMES:

On completion of the course, the students will able to

CO1: Understand and abide the rules of the Indian constitution.
CO2: Understand the functions of Central government.
CO3: Understand the function of state government.
CO4: Understand the various constitutional functions.
CO5: Understand the different culture among the people of India.

COURSE ARTICULATION MATRIX:

PO/PSO CO	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						M	M					M			L
CO2						L						M		L	
CO3						L						M			
CO4						L						L		L	
CO5						L	L					L		L	L
18BMC 3Z6						L	L					M		L	L

L-Low, M-Moderate (Medium), H-High

18BPC307	MICROBIOLOGY LABORATORY	SEMESTER III

Category: PC

PRE-REQUISITES: NIL

L	T	P	C
0	0	4	2

COURSE OBJECTIVES:

- To identify and demonstrate the proper safety procedures concerning lab safety.
- To identify the parts & functions of microscope.
- To Perform different staining techniques to identify microorganisms.
- To identify the purpose & principle associated with different media types used in lab.
- To identify the purpose of using biochemical test in determining the metabolic differences between microbes.

LIST OF EXPERIMENTS	
1.	Laboratory safety and sterilization techniques
2.	Microscopic Methods- Identification of Microorganisms
3.	Preparation of culture media– nutrient broth and nutrient agar
4.	Culturing of microorganisms in broth and in plates(pour plates, streak plates and preservation of bacterial cultures)
5.	Staining techniques – simple and grams'
6.	Motility Test- Hanging drop technique
7.	Serial Dilution method
8.	Antibiotic sensitivity assay- Disc Diffusion method
9.	Growth kinetics- Growth curve of Bacteria and Yeast
10.	Biochemical Tests- Indole and Methyl red test

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

TEXT BOOKS:

1. *James G. Cappuccino & Natalie,* ***"Microbiology, A Laboratory manual"****, Pearson Education publishers, 6th edition, 2004.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: To identify and demonstrate the proper safety procedures concerning lab safety.
CO2: To identify the parts & function of microscope.
CO3: To demonstrate the ability to prepare the slides for microscopic examinations and to identify the different specimens using microscope.
CO4: To identify the purpose & principle associated with different media types used in lab.
CO5: To identify the purpose of using biochemical test in determining the metabolic differences between microbes.

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	-	-	-	-	-	-	M	M	-	-	-	M	H	H
CO2	M	M	-	-	L	-	M	-	M	H	-	M	H	L
CO3	M	M	-	-	L	-	M	-	M	H	-	M	H	L
CO4	L	M	M	-	-	-	L	-	M	L	-	L	H	M
CO5	M	M	H	-	M	L	L	L	M	M	-	M	M	L
18BPC 307	-	-	H	-	-	H	M	H	H	L	-	M	H	M

L - Low, M-Moderate (Medium), H- High

18BPC308	BIOCHEMISTRY LABORATORY	SEMESTER III

Category: PC

PRE-REQUISITES:

1. 18BBS101- Chemistry for Biotechnology
2. 18BBS104– Chemistry Laboratory

L	T	P	C
0	0	4	2

COURSE OBJECTIVES:

- To provide firm foundation of basic laboratory techniques
- To provide hands on training on the simple experiments for identification, quantification of bio molecules and preparation of bio active compounds

LIST OF EXPERIMENTS	
1.	Units, Volume/Weight measurements, concentrations, Sensitivity, Specificity, Precision and Accuracy
2.	Preparation of buffers and pH measurement
3.	Qualitative tests for carbohydrates
4.	Quantitative tests for reducing sugars by Benedict's method.
5.	Qualitative tests for Amino Acids
6.	Protein estimation - Biuret, Folin and Bradford Assay
7.	Extraction of lipids and Saponification of Fats
8.	Estimation of cholestrol
9.	Estimation of Nucleic acids : Test for ribose and deoxyribose
10.	Isolation and estimation of starch from potato tubers

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

TEXT BOOKS:

1. *David. T. Plummer,* ***"An Introduction to Practical Biochemistry"****, McGraw – Hill, 3rd edition., 2017.*
2. *Vogel A.I, Tatchell A.R, Fummis B.S., Hannaford A.J., Smith P.W.G.,* ***"Text Book of Practical Organic Chemistry"****, Prentice Hall, 5th edition., 1996.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

- **CO1:** Prepare reagents accurately and reproducibly for experiments
- **CO2:** Operate pH meter, weighing balance, colorimeter and spectrophotometer
- **CO3:** Do the experiments for isolation and extraction of any bioactive compounds
- **CO4:** Identify and quantify the bio molecules (Carbohydrate, Protein, Nucleic acid, Lipids) in any sample
- **CO5:** Understand the practical accession behind preparation and separation of various pharmaceutical and other organic chemicals

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	L	H	-	-	-	-	-	-	-	-	M	H	H
CO2	M	L	H	-	H	-	-	-	-	-	-	M	H	H
CO3	M	L	H	-	L	-	-	-	-	-	-	M	M	H
CO4	M	L	H	-	L	-	-	-	-	-	-	M	M	H
CO5	M	L	H	-	-	-	-	-	-	-	-	M	L	M
18BPC 308	M	-	H	-	M	-	-	-	-	-	-	M	L	H

L - Low, M-Moderate (Medium), H- High

18BPC309	CELL BIOLOGY LABORATORY	SEMESTER III

Category: PC

PRE-REQUISITES: NIL

L	T	P	C
0	0	4	2

COURSE OBJECTIVES:

- To know the basic sterile techniques related to laboratory safety.
- To operate and identify the parts & functions of microscope.
- To Perform different staining techniques to identify blood cells and cell division using microscope.
- To demonstrate the ability to prepare the slides for microscopic examinations.
- To work as a team to interpret practical data.

LIST OF EXPERIMENTS	
1.	Laboratory safety and sterilization techniques
2.	Microscopic Methods- Identification of cells,
3.	Identification of cells in a blood smear using Leishman stain.
4.	Giemsa staining.
5.	Haemotoxylin Eosin Staining.
6.	Counting of cells using haemocytometer
7.	Osmosis and Tonicity.
8.	Tryphan Blue Assay
9.	Separation and identification of peripheral Blood mononuclear cells from blood.
10.	Identification of meiosis cell division in grass hopper testis.
11.	Staining for different stages of mitosis in *Allium cepa* (Onion)

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

TEXT BOOKS:

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

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

- **CO1:** To know the basic sterile techniques related to laboratory safety.
- **CO2:** To operate and identify the parts & functions of microscope.
- **CO3:** To Perform different staining techniques to identify blood cells and cell division using microscope.
- **CO4:** To demonstrate the ability to prepare the slides for microscopic examinations.
- **CO5:** To work as a team to interpret practical data.

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	-	-	-	-	-	-	-	-	-	-	-	-	-
CO2	-	-	L	-	-	-	-	-	-	-	H	-	-	-
CO3	-	-	L	-	-	-	-	-	-	-	H	-	-	-
CO4	L	-	-	-	-	-	-	-	-	-	-	H	-	-
CO5	-	-	H	-	-	-	-	-	-	-	-	-	-	-
18BPC 309	-	-	H	-	-	-	-	-	-	-	L	H	-	-

L - Low, M-Moderate (Medium), H- High

18BES401	PROCESS CALCULATIONS AND HEAT TRANSFER	SEMESTER IV

Category: ES

L	T	P	C
3	1	0	4

PRE-REQUISITES: NIL

COURSE OBJECTIVES:

- To develop skills of the students in the area of chemical engineering with emphasis in stoichiometry.
- To understand the basic laws of heat transfer and to develop solutions for the problems involving steady state and transient heat conduction in simple geometries.
- To obtain numerical solutions for radiation heat transfer problems and to analyze the heat transfer efficiencies of any engineering systems involving heat exchange.

UNIT – I : OVERVIEW OF PROCESS INDUSTRY	**(9+3 Periods)**
Systems of units - fundamental and derived quantities, 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 BALANCES	**(9+3 Periods)**
Overall and component balances; material balances without and with chemical reactions; degrees of freedom; steady and unsteady state; unit operations; recycle and by pass; humidity calculations.	
UNIT – III : ENERGY BALANCE	**(9+3 Periods)**
Fundamentals of energy balance calculations–concepts of heat capacity, latent heat, sensible heat, vapor pressure and internal energy – energy balance with and without chemical reactions.	
UNIT – IV: CONDUCTION ANDCONVECTION	**(9+3 Periods)**
Introduction – Conduction – Basic concepts of conduction in solids, liquids and gases – One and two dimensional heat conduction – Critical and optimum insulation thickness. Introduction to unsteady state heat transfer. Principles of convection – Equations of forced and free convection.	
UNIT – V: RADIATION AND HEATEXCHANGERS	**(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. Heat Transfer equipment – Double pipe, Shell & tube and Plate type heat exchanger.	

Contact Periods:
Lecture: 45 Periods **Tutorial: 15 Periods** **Practical: 0 Periods** **Total: 60 Periods**

TEXT BOOKS:

1. *Bhatt B.I and Vora S.M.* ***"Stoichiometry"****, Tata McGraw-Hill, New Delhi, 4th Edition. 2004*
2. *Incropera F.P.* ***"Fundamentals of Heat and Mass Transfer"****, John Wiley, 7th edition. 2011.*

REFERENCE BOOKS:

1. *Yunus Cengel,* ***"Heat and Mass Transfer – Fundamentals & Applications"****, McGraw-Hill, 5th edition, 2015.*
2. *K.V. Narayanan, B.Lakshmikutty,* ***"Stoichiometry and Process calculations"****, Prentice hall of India, 2nd edition. 2017.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Present an overview of industrial chemical Bioprocesses.

CO2: Develop a fundamental understanding of the basic principles of chemical engineering processes and calculations.

CO3: Establish mathematical methodologies for the computation of material balances and energy balances.

CO4: Understand the basic laws of heat transfer & to develop solutions for the problem involving steady state & transient heat conduction in simple geometries.

CO5: Calculate heat transfer by conduction, convection & thermal radiation realistic cases.

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	L	-	-	-	-	L	M	L	L	L	L	L	H	M
CO2	M	M	H	-	-	-	-	-	M	M	-	M	H	M
CO3	M	M	M	L	-	-	-	-	L	L	-	L	L	M
CO4	M	M	-	H	-	-	L	L	M	L	M	H	H	L
CO5	L	H	H	M	L	-	L	M	-	-	-	H	H	M
18BES 401	M	M	M	M	H	-	L	M	L	L	-	M	H	H

L - Low, M-Moderate (Medium), H- High

18BPC402	BASICS OF INDUSTRIAL BIOTECHNOLOGY	SEMESTER IV

Category: PC

L	T	P	C
3	0	0	3

PRE-REQUISITES: NIL

COURSE OBJECTIVES:

- To understand the basics of traditional and modern industrial fermentation process.
- To gain the knowledge about the primary and secondary microbial metabolites.
- To learn about the production process of pharmaceutically important bioproducts

UNIT – I : INTRODUCTION TO INDUSTRIAL BIOPROCESS	**(9 Periods)**
Biotechnology: Scope and importance, Commercial potential of Biotechnology in India. Historical overview of industrial fermentation process -traditional and modern Biotechnology. Industrial Fermentation- microorganisms, mode of operation, fermentation processes-pictorial representation.	
UNIT – II : PRODUCTION OF PRIMARY METABOLITES	**(9 Periods)**
A brief outline of processes for the production of some commercially important organic acids (citric acid, lactic acid & acetic acid); amino acids (glutamic acid & tryptophan) and alcohols (ethanol & butanol).	
UNIT – III : PRODUCTION OF SECONDARY METABOLITES	**(9 Periods)**
Production processes for various classes of secondary metabolites: antibiotics: (penicillin streptomycin & erythromycin), vitamins (Vit B_{12} and Vit B_2) and steroid biotransformation.	
UNIT – IV : PRODUCTION OF ENZYMES AND OTHER BIOPRODUCTS	**(9 Periods)**
Production of industrial enzymes (proteases & amylases), Production of biopesticide, Biofertilizers, biopreservative (Nisin), biopolymers (xanthan gum & PHB), cheese, SCP.	
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 BOOKS:

1. *Lee, S.Y., Nielsen, J. and Stephanopoulos, G.,* ***"Industrial Biotechnology: Products and Processes"****, John Wiley & Sons, 2016.*
2. *Waites, M.J., Morgan,N.L., Rockey,J.S., Higton, G.,* ***"Industrial Microbiology: An Introduction"*** *Blackwell, 2001.*
3. *Cruger, W., Cruger, A.,* ***"A Textbook of Industrial Microbiology"****, Panima Publishing Corporation, 2nd Edition, 2005.*

REFERENCE BOOKS:

1. *Pandey, A., Negi, S., Soccol, C.R.,* ***"Current Developments in Biotechnology and Bioengineering: Production, isolation and purification of industrial products"****, Elsevier, 2016.*
2. *Okafor, N.,* ***"Modern Industrial Microbiology and Biotechnology"****, CRC Press, 2007*
3. *Presscott and Dunn's* ***"Industrial Microbiology"****, CBS Publisher, 1987.*
4. *Casida Jr, L. E.,* ***"Industrial Microbiology"****, Wiley, 1968.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Understand the basics of fermentation process which helps to develop new microbial product.

CO2: Gain the knowledge about the steps and operations involved in microbial primary metabolites production.

CO3: Illustrate the secondary metabolites production with flow-sheeting.

CO4: Acquire knowledge about the industrially relevant microbial strains and processes for production of enzyme, biopolymer and food products.

CO5: Learn about the use of recombinant technology in pharmaceutically important microbial bioproducts production.

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	M	M	-	M	L	-	-	-	-	-	M	H	H
CO2	M	M	-	M	H	-	-	-	-	-	-	-	M	M
CO3	M	M	-	-	M	-	-	-	-	-	-	-	M	H
CO4	M	M	-	-	M	-	-	-	-	-	-	-	M	H
CO5	M	-	-	M	M	L	M	L	-	-	-	-	M	H
18BPC 402	M	M	M	M	H	L	M	L	-	-	-	M	M	H

L - Low, M-Moderate (Medium), H- High

18BPC403	MOLECULAR BIOLOGY	SEMESTER IV

Category: PC

PRE-REQUISITES:

1. 18BBS302- Microbiology
2. 18BPC304- Cell Biology

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

* To learn the fundamental aspects of nucleic acids
* To understand the principle and process of DNA replication, transcription and translation
* To study the basics of regulation of gene activity, mutation and DNA repair

UNIT- I : CLASSICAL & MOLECULAR GENETICS	**(9 Periods)**
Linkage- crossing over, classical experiments – Hershey and Chase; Avery McLeod & McCarty; Conformation of DNA and RNA; classes of RNA; Organization of eukaryotic chromosome – c0t value; Bacterial conjugation; transduction and transformation- sexduction.	
UNIT- II : DNA REPLICATION	**(9 Periods)**
Overview of differences in prokaryotic and eukaryotic DNA replication Rules of replication in all nucleic acid; enzymology; replication – continuous, discontinuous; Replication in prokaryotes - D-loop and rolling circle mode of replication; replication of linear viral DNA. Replication of telomeres in eukaryotes.	
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 BOOKS:

1. *David Friefelder,* ***"Molecular Biology"****, Narosa Publ. House.2nd edition, 1999*

REFERENCE BOOKS:

1. *Benjamin Lewin,* ***"Gene VII".,*** *Oxford University Press,7th edition, (2000).*
2. *Watson JD, Hopkins WH, Roberts JW, Steitz JA, Weiner AM,* ***"Molecular Biology of the Gene"****, McGraw Hill,2nd edition, (1986.)*

COURSE OUTCOMES:

Upon completion of the course, the students will be able to
CO1: Get familiarize with the biomolecules and their functions
CO2: Understand the fundamentals of classical & molecular genetics
CO3: Understand the regulatory mechanism of molecular biology
CO4: Solve molecular biology problems and to think analytically
CO5: Articulate applications of molecular biology in the modern world

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	-	-	-	-	-	-	-	-	-	-	-	H	L
CO2	H	-	-	-	-	-	-	-	-	-	-	-	H	M
CO3	L	M	H	-	-	-	-	-	-	-	-	-	H	M
CO4	-	H	M	-	M	-	-	-	-	-	-	-	M	H
CO5	-	L	H	-	M	-	-	-	-	-	-	M	M	H
18BPC 403	H	H	H	-	M-	-	-	-	-	-	-	M	H	H

L – Low, M – Moderate, H- High

18BPC404	BIOCHEMICAL THERMODYNAMICS	SEMESTER IV

Category: PC

PRE-REQUISITES: NIL

L	T	P	C
2	1	0	3

COURSE OBJECTIVES:

- To design & solve problem in realistic cases by applying thermodynamics concepts.
- To estimate or locate necessary thermodynamic data.
- To estimate thermodynamic properties of substances in gas and liquid states
- To understand about biochemical equilibrium and able to calculate the kinetics of biological systems.

UNIT – I : THERMODYNAMIC LAW AND PROPERTIES OF FLUIDS	**(6+3 Periods)**
Review of laws of thermodynamics and their applications; thermodynamic analysis of processes. Thermodynamic properties of fluids and their interrelationship: PVT behavior of pure substances; Equation of state; Generalized correlations and acentric factor; Thermodynamics charts; Estimation of thermodynamic properties.	
UNIT – II : SOLUTION THERMODYNAMICS	**(6+3 Periods)**
Partial molar properties; Chemical potential; Gibbs-Duhem equation; Ideal and non-ideal solutions; Fugacity and fugacity coefficient; Activity and activity coefficient; Excess properties of mixtures.	
UNIT – III : PHASE EQUILIBRIA	**(6+3 Periods)**
General criterion for equilibrium and their application; Stability constraints; Gibbs phase rule and its derivation for reacting and non-reacting systems; Vapour-liquid, liquid-liquid, and vapour-solid equilibrium for ideal and non-ideal systems.	
UNIT – IV : CHEMICAL REACTION EQUILIBRIA	**(6+3 Periods)**
Chemical equilibrium constants; Homogeneous and heterogeneous reactions; Standard Gibbs free energy change; Equilibrium conversion in single and multiple reactions.	
UNIT – V : THERMODYNAMIC DESCRIPTION OF MICROBIAL GROWTH AND PRODUCT FORMATION	**(6+3 Periods)**
Thermodynamics of microbial growth stoichiometry, maintenance, Calculation of the Operational Stoichiometry of a growth process including Heat using the Herbert – Pirt Relation for Electron Donor, thermodynamics and stoichiometry of Product Formation.	

Contact Periods:

Lecture: 30 Periods **Tutorial: 15 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, 7th edition, 2005*

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.*

REFERENCE BOOKS:

1. Hougen O.A., Watson K.M., and Ragatz R.A., ***"Chemical Process Principles Part II"****, John Wiley & Sons, 2nd edition. 2004.*

2. Sandler S.I. ***"Chemical and Engineering Thermodynamics"****, John Wiley & Sons, 4th edition, 2006.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Illustrate the application of thermodynamics in design & operation of process industries.
CO2: Design & solve problem in realistic cases by applying thermodynamics concepts.
CO3: Estimate thermodynamic properties of substances in gas and liquid states
CO4: Interpret the phase equilibria concepts in multi-component systems
CO5: Understand about biochemical equilibrium and able to calculate the kinetics of biological systems.

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	M	-	-	-	-	L	M	L	L	-	M	H	H
CO2	H	H	H	-	H	-	-	-	M	M	-	M	H	H
CO3	M	M	M	L	-	-	-	-	L	L	-	L	L	M
CO4	M	M	M	M	M	-	-	-	L	L	-	L	L	M
CO5	-	M	L	M	H	-	-	-	-	-	-	M	M	H
18BPC 404	M	M	M	M	H	-	L	M	L	L	-	M	H	H

L - Low, M-Moderate (Medium), H– High

18BPC405	ANALYTICAL TECHNIQUES IN BIOTECHNOLOGY	SEMESTER IV

Category: PC

PRE-REQUISITES: NIL

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- To analyse the research findings and interpretation can be ascertained by the knowledge gained from this course.
- To understand the structural behavior of molecule using molecular spectroscopy.
- To inculcate knowledge on the various separation and purification methods.

UNIT – I : BASICS OF MEASUREMENT	**(9 Periods)**
Classification of methods – calibration of instrumental methods – electrical components and circuits -signal to noise ratio – signal – noise enhancement; Properties of electromagnetic radiations and their interaction with matter.	
UNIT – II : MOLECULAR SPECTROSCOPY	**(9 Periods)**
UV and visible light spectroscopy-Qualitative and Quantitative absorption Measurement, Beer-Lambert law, Spectrofluorimetry, IR spectroscopy, Raman spectroscopy, NMR spectroscopy, X-ray crystallography– principle, instrumentation and applications; X-Ray Photoelectron Spectroscopy.	
UNIT – III : ELECTROPHORESIS	**(9 Periods)**
General principle of electrophoresis, support media (agarose and polyacrylamide gels), electrophoresis of proteins by SDS-PAGE, native PAGE, gradient gels, isoelectric focusing, two dimensional PAGE, electrophoresis of nucleic acids using agarose gel, PFGE, FIGE, CHEF, capillary electrophoresis.	
UNIT – IV : CHROMATOGRAPHY	**(9 Periods)**
Principles of chromatography, distribution coefficient, retention time, capacity factor, plate height and resolution, peak broadening and van Deemter plot, TLC and column chromatography, matrix materials, HPLC, Affinity chromatography, ion exchange chromatography, gel exclusion chromatography and Gas chromatography.	
UNIT – V : THERMAL METHODS	**(9 Periods)**
Differential thermal analysis techniques. Differential scanning calorimetry - instrumentation & application. Differential thermal analysis - instrumentation & application, DTA curve. Thermogravimetry – instrumentation & application, TG curve.	

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

TEXT BOOKS:

1. *Willard H.W., Merritt L.L., Dean J.A. & Settle F.A* ***"Instrumental Methods of Analysis"****, East West Publishers, 6th Edition. 2004*
2. *Skoog, D.A. F. James Holler, and Stanky, R. Crouch* ***"Instrumental Methods of Analysis"****. Cengage Learning, 2007.*

REFERENCE BOOKS:

1. Harrison, R.G., Todd, P., Rudge, S.R. and Petrides, B.B. ***"Bioseparations: Science and Engineering"****, Oxford University Press, 2006.*
2. Wilson K. and Walker J. ***"Principles and Techniques of Biochemistry and Molecular Biology"****, Cambridge University Press, 6th edition, 2005.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: To understand the Basics of Measurement in instrumental methods.
CO2: To impart knowledge on spectroscopic analytical methods.
CO3: To inculcate knowledge on the separation of nucleic acids and proteins in molecular biology.
CO4: To study the different chromatographic separation methods and their analysis.
CO5: To analyse the thermal behavior of the bioproducts.

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	H	M	-	-	-	-	-	L	L	-	L	M	H
CO2	L	M	H	-	-	-	L	-	L	L	-	-	M	H
CO3	M	L	H	-	-	-	L	-	-	-	-	L	H	L
CO4	M	L	H	-	-	-	L	L	-	-	-	-	H	L
CO5	L	H	M	-	-	-	L	-	-	-	-	-	M	M
18BPC 405	M	L	L	-	-	-	L	L	L	L	-	L	H	M

L - Low, M - Moderate (Medium), H - High

18BPC406	ENZYME ENGINEERING AND TECHNOLOGY	SEMESTER IV

Category: PC

PRE-REQUISITES:

1. 18BPC305 – Biochemistry

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- To inculcate the knowledge of enzyme catalytic reaction kinetics.
- To provide broad idea on production and industrial application of enzymes.

UNIT – I : INTRODUCTION TO ENZYMES	**(9 Periods)**
Introduction of enzymes, Classification of enzymes, concept of active site and energetic s of enzyme substrate complex formation, Mechanisms of enzyme action – General catalysis and acid base catalysis principles of catalysis – collision theory and transition state theory, Introduction to enzyme activity and specific activity.	
UNIT – II : ENZYME KINETICS	**(9 Periods)**
Kinetics of single substrate reactions - Michelis – Menten equation and Briggs Haldane equation, Estimation of Michelis – Menten parameters – Lineweaver - Burk plot, Eadie Hofstee plot and Hanes plot, Bisubstrate reactions – single displacement and ping pong mechanism, multi substrate reactions- King and Altmann equation, types of inhibition– Competitive, Uncompetitive, non competitive and substrate, Allosteric regulation of enzymes - Monod-Changeux-Wyman model.	
UNIT – III : ENZYME IMMOBILIZATION	**(9 Periods)**
Physical and chemical techniques for enzyme immobilization – adsorption, matrix entrapment, encapsulation, cross-linking and covalent binding, Applications of immobilized enzymes.	
UNIT – IV : PURIFICATION AND CHARACTERIZATION OF ENZYMES FROM NATURAL SOURCES	**(9 Periods)**
Production and purification of crude enzyme extracts from plant, animal and microbial sources – Methods of characterization of enzymes	
UNIT – V : ENZYME APPLICATIONS AND BIOSENSORS	**(9 Periods)**
Application of enzymes in industries– Food, detergent, leather and wool, brewery, healthcare and environment; Enzyme electrodes and their application as biosensors in various industries – Calorimetric, potentiometric, amperometric, optic and immunosensors. Examples of biosensors.	

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

TEXT BOOKS:

*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.*

REFERENCE BOOKS:

1. ***"Biochemical Engineering"**, James M. Lee, PHI, USA, 2009.*
2. ***"Biochemical Engineering Fundamentals"**, James. E. Bailey & David F. Ollis, McGraw Hill, 2011.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to
CO1: Understand the enzyme classification and catalysis mechanism.
CO2: Utilize the kinetics to study about various new enzymes.
CO3: Implement enzyme immobilization techniques for practical applications.
CO4: Utilize the knowledge in production and purification of enzymes for industrial needs.
CO5: Analyze the industrial importance of various enzymes.
CO6: Fabricate enzyme based biosensor based on the problems.

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	L	L	-	-	-	-	-	L	L	-	L	H	L
CO2	L	M	H	-	-	-	L	-	L	L	-	-	H	M
CO3	L	M	H	-	-	-	L	-	-	-	-	-	H	M
CO4	L	L	L	-	M	-	L	L	-	-	-	-	M	H
CO5	L	L	H	-	M	-	L	-	-	-	-	-	M	H
CO6	L	H	H	-	-	-	M	-	H	-	-	-	L	H
18BPC 406	L	M	H	-	M	-	L	L	L	L	-	L	H	H

L - Low, M - Moderate (Medium), H – High

18BMC4Z7	ENVIRONMENTAL SCIENCES AND ENGINEERING *(Common to all Branches)*	SEMESTER IV

Category: MC

PRE-REQUISITES: NIL

COURSE OBJECTIVES:

L	T	P	C
3	0	0	0

* The course is aimed at creating awareness among students and also to inseminate the critical ideas of preserving environment.

UNIT I: ENVIRONMENTAL RESOURCES	**(9 Periods)**
Natural resources-Forest – benefits, over exploitation, deforestation & consequences – Water-unique features, hydrological cycle & over exploitation – Food -effect of modern agriculture, fertilizers, pesticides, eutrophication & biomagnifications- Energy resources - renewable & non-renewable resources - wind, solar and tidal-harnessing methods.	
UNIT II: ECO SYSTEM AND BIODIVERSITY	**(9 Periods)**
Ecology - ecosystem, physical and chemical components of ecosystem, biological components of ecosystem, forest ecosystem, desert ecosystem and pond ecosystem, Energy flow in ecosystem, nitrogen cycle and carbon dioxide cycle, food pyramid, Ecological succession, Biodiversity - types, values of biodiversity, hot spots of biodiversity, endangered and endemic species, conservation of biodiversity – in situ – ex situ conservation.	
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, control methods - cyclone separator and electrostatic precipitator, water pollution - classification of water pollutants, organic and inorganic pollutants, sources, effects and control of water pollutants, soil pollution- sources, effects and control, noise pollution - decibel scale , sources, effects and control.	
UNIT IV: ENVIRONMENTAL THREATS	**(9 Periods)**
Acid rain, greenhouse effect, global warming and ozone depletion, disaster management - flood, drought, earthquake and tsunami, Threats to biodiversity-destruction of habitat, habit fragmentation-hunting, over exploitation and man-wildlife conflicts, The IUCN red list categories, status of threatened species.	
UNIT V: SOCIAL ISSUES AND ENVIRONMENT	**(9 Periods)**
Sustainable development- sustainable technologies, need for energy and water conservation, rain water harvesting, water shed management, waste land reclamation, Pollution control Act, Wild life protection act, Forest conservation 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, HIV/AIDS - effects and preventive measures.	

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

TEXT BOOKS:

1. *Sharma J.P., **"Environmental Studies"**, 3rd Edition, University Science Press, New Delhi 2009.*
2. *Anubha Kaushik and C.P.Kaushik, **"Environmental Science and Engineering"**, 3rd Edition, New age International Publishers, New Delhi, 2008.*

REFERENCE BOOKS:

1. *R.K.Trivedi,* ***"Hand book of Environmental laws, Rules, Guidelines, Compliances and Standards"****, Vol.I&II, Environ Media, 2006.*
2. *G.TylerMiller, JR,* ***"Environmental Science"****, Tenth Edition, Thomson BROOKS / COLE Publishing, 2004.*
3. *Gilbert M.Masters,* ***"Introduction to Environmental Engineering and Science"****, 2nd Edition, Pearson Education, 2004.*

COURSE OUTCOMES:

Upon the completion of the course, Students will be able to

CO1: To know about the various environmental resources, the effective utility and problems accompanied in over exploitation.

CO2: To acquire knowledge about the interaction of biosphere with environment and conservation methods of bio diversity.

CO3: To be aware of the sources of various types of pollution, their ill effects and preventive methods.

CO4: To understand the environmental threats, Acid rain, Green house effect and Ozone depletion and natural disasters.

CO5: To create an idea about sustainable development and social issues.

COURSE ARTICULATION MATRIX:

CO	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	M	L	H	L	M	M	M	M	M	M	L	L	L	L	M
CO2	M	L	L	L	L	L	L	L	L	L	L	L	M	L	L
CO3	L	L	H	L	L	L	M	M	L	M	L	L	L	L	L
CO4	L	L	H	L	L	L	L	L	L	L	L	L	L	L	L
CO5	M	L	H	L	L	L	H	H	L	M	L	L	M	L	M
18BMC 4Z7	M	L	H	L	L	L	M	M	L	M	L	L	L	L	L

L - Low, M - Moderate (Medium), H - High

18BES408	CHEMICAL ENGINEERING LABORATORY	SEMESTER IV

Category: ES

PRE-REQUISITES: NIL

L	T	P	C
0	0	3	1.5

COURSE OBJECTIVES:

- To understand the principles of flow rate measurement & hydrodynamics of the specialized reactor systems.
- To select the appropriate equipment for mechanical sizing & sieving operations.
- To analyze & calculate heat transfer efficiency in systems involving heat exchange processes.
- To understand the principles & kinetics of mass transfer operations.
- To operate & calculate the efficiency of the separation process equipment

LIST OF EXERCISES

Fluid Mechanics:

- Flow measurement using Venturimeter, Orificemeter for liquids.
- Studies on flow behavior and friction loss in Fluidized bed.

Mechanical Operations:

- Product size distribution analysis using Roll Crusher, Jaw Crusher.
- Product size distribution analysis using Ball Mill.

Heat Transfer:

- Performance analysis of Double pipe Heat Exchanger.
- Performance analysis of Shell & Tube Heat Exchanger.

Mass Transfer:

- Studies on Simple Distillation.
- Studies on Fractional Distillation.

Unit Operations:

- Calculations of filter and medium resistances in Leaf filter apparatus.
- Calculation of filter and medium resistances in Plate and Frame filter press.

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

REFERENCE BOOKS:

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.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Understand the principles of flow rate measurement & hydrodynamics of the specialized reactor systems.
CO2: Select the appropriate equipment for mechanical sizing & sieving operations.
CO3: Analyze & calculate heat transfer efficiency in systems involving heat exchange processes.
CO4: Understand the principles & kinetics of mass transfer operations.
CO5: Operate & calculate the efficiency of the separation process equipment.

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	L	M	-	-	-	-	-	H	H	-	M	H	H
CO2	M	L	H	-	-	-	-	-	H	H	-	M	H	H
CO3	M	L	H	-	-	-	-	-	H	H	-	M	L	H
CO4	M	M	H	-	-	-	-	-	-	-	-	-	L	M
CO5	M	M	M	-	-	-	-	-	H	H	-	M	L	M
18BES 408	M	L	H	-	-	-	-	-	H	H	-	M	L	H

L - Low, M-Moderate (Medium), H- High

18BPC409	ANALYTICAL TECHNIQUES LABORATORY	SEMESTER IV

Category: PC

PRE-REQUISITES:

1. 18BPC405 Analytical Techniques in Biotechnology

L	T	P	C
0	0	3	1.5

COURSE OBJECTIVES:

* The students will be able to get familiar on different analytical techniques to employ their knowledge to solve the research problem.

LIST OF EXERCISES

- Precision and Validity in an experiment.
- Validating Lambert-Beer's law using $KMnO_4$.
- Absorption spectrum of ferrous ions using absorption spectroscopy.
- Finding the concentration of the Iron content present in the tablet using absorption spectrometry.
- Finding the concentration of Na and Ca using flame photometer.
- Finding the Concentration of Phosphate content in soft drinks.
- 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
- Raman spectroscopy – Identification of functional groups
- Finding the concentration of Na and Ca using atomic absorption spectrophotometer.
- Data interpretation of FTIR spectra and X-Ray Diffraction techniques.

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

REFERENCE BOOKS:

1. *Skoog, D.A. F. James Holler, and Stanky, R. Crouch, **"Instrumental Methods of Analysis"**, Cengage Learning, 2007.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: To understand the Lambert-Beers law and validation of Absorption spectroscopy.
CO2: To get familiarize with the working of UV-Visible spectroscopy and to find the concentration of organic compounds using absorption spectroscopy
CO3: To understand the working of Flame photometer and Atomic Absorption Spectrophotometer.
CO4: To impart knowledge on separation methods for bioproducts.

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	M	H	L	H	-	-	-	L	M	-	-	H	M
CO2	L	M	H	L	M	-	-	-	L	L	-	-	M	L
CO3	L	H	M	L	H	-	-	-	L	M	-	-	M	H
CO4	L	M	L	L	H	-	-	-	L	L	-	-	M	L
18BPC 409	L	M	H	L	H	-	-	-	L	L	-	-	M	M

L - Low, M - Moderate (Medium), H - High

18BHS501	CLINICAL TRIALS AND BIOETHICS	SEMESTER V

Category: HS

PRE-REQUISITES: NIL

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- The course will provide Fundamental ethical to Advanced clinical trial management including drug development and trial planning; Project management in clinical trials;
- Consent and data protection; Quality assurance and governance.

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; International perspectives; 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; Legislative requirements for investigational medicinal products.	
UNIT – III : MANAGEMENT AND ETHICS OF CLINICAL TRIALS	**(9 Periods)**
Project management in clinical trials - principles of project management; Application in clinical trial management; Risk assessment; Research ethics and Bioethics - Principles of research ethics; Ethicalissues in clinical trials; Use of humans in Scientific Experiments; Ethical committee system including ahistorical overview; the informed consent; Introduction to ethical codes and conduct; Introduction to animal ethics; Animal rights and use of animals in the advancement of medical technology; Introduction to laws and regulation regarding use of animals in research.	
UNIT – IV : INFORMED CONSENT	**(9 Periods)**
Consent and data protection- the principles of informed consent; Consent processes; Dataprotection; Legislation and its application; Data management – Introduction to trial masterfiles 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; Common pitfalls in clinical trial management.	

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

REFERENCE BOOKS:

1. *Lee, Chi-Jen et al,* ***"Clinical Trials or Drugs and Biopharmaceuticals"*** *CRC/Taylor & Francis,2011.*
2. *Matoren, Gary M.* ***"The Clinical Research Process in the Pharmaceutical Industry"****, Marcel Dekker, 1984.*
3. *Lawrence M.Friedman et al,* ***"Fundamentals of Clinical Trials"****, Mosby,1996*
4. *Curtis L Meinert et al,* ***"Clinical Trials - Design Conduct and Analysis"****, Oxford University Press 1986.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: To provide fundamental ethical to advanced clinical trial management including drug development and trial planning.

CO2: To understand Project management in clinical trials.

CO3: To design consent and data protection.

CO4: To understand quality assurance and governance.

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	L	-	-	-	-	L	M	M	M	M	-	M	H	L
CO2	L	M	-	-	-	L	M	M	M	M	-	M	H	L
CO3	H	L	-	-	-	M	H	M	M	M	-	M	H	M
CO4	M	L	-	-	-	-	H	M	M	M	-	M	H	L
18BHS 501	M	-	M	-	-	H	M	M	L	M	-	M	H	L

L - Low, M-Moderate (Medium), H- High

18BES502	MASS TRANSFER OPERATIONS	SEMESTER V

Category: ES

PRE-REQUISITES:

1. 18BES401 Process calculations and Heat transfer
2. 18BPC404 Biochemical Thermodynamics

L	T	P	C
2	1	0	3

COURSE OBJECTIVES:

- To demonstrate an understanding of mass transfer principles
- To design an ideal tray/packing tower
- To trouble-shoot a mass transfer tower operation

UNIT – I : DIFFUSION AND MASS TRANSFER	**(6+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	**(6+3 Periods)**
Principles of gas absorption; Single and Multi component absorption; Absorption with chemical reaction; Design principles of absorbers; Industrial absorption equipments; HTU, NTU concepts.	
UNIT – III : VAPOUR - LIQUID OPERATIONS	**(6+3 Periods)**
Vapour-Liquid equilibria; Simple, Steam and Flash Distillation; Continuous distillation; McCabe - Thiele & enthalpy concentration method; Industrial distillation equipments, HETP, HTU and NTU concepts.	
UNIT – IV : EXTRACTION OPERATIONS	**(6+3 Periods)**
Liquid-Liquid equilibria, Staged and continuous extraction, Solid-liquid equilibria, Leaching principles, Equipments for extraction and leaching	
UNIT – V : SOLID - FLUID OPERATIONS	**(6+3 Periods)**
Adsorption equilibria – Types - Batch and fixed bed adsorption; Drying – Mechanism - Drying curves - Time of drying; Equipments for drying - Batch and continuous dryers	

Contact Periods:
Lecture: 30 Periods **Tutorial: 15 Periods** **Practical: 0 Periods** **Total: 45 Periods**

TEXT BOOKS:

*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.*

REFERENCE BOOKS:

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.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Understand the basic laws of diffusion & to develop solutions for the problem involving solid, liquids and gas systems.

CO2: Understand design concepts of absorption column.

CO3: Understand the process of distillation and to design the types of distillation columns.

CO4: Understand the designing of extraction / leaching equipment used in process industries.

CO5: Utilize the technological methods in design and troubleshooting of solid-fluid operations in process industries.

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	M	L	-	-	-	-	-	H	L	-	L	H	H
CO2	H	-	H	M	M	-	-	-	H	M	-	M	H	H
CO3	L	L	M	M	M	-	-	-	M	L	-	L	L	M
CO4	M	M	M	M	M	-	M	L	M	M	-	M	L	M
CO5	M	L	M	L	L	-	-	M	M	M	M	M	M	H
18BES 502	H	M	M	M	M	-	M	L	H	M	M	M	L	H

L - Low, M-Moderate (Medium), H- High

18BPC503	BIOPROCESS PRINCIPLES	SEMESTER V

Category: PC

L	T	P	C
2	1	0	3

PRE-REQUISITES

1. 18BPC402 Basics of Industrial Biotechnology

COURSE OBJECTIVES:

- To learn the basic principles of fermentation process.
- To understand the basic configuration and parts of a fermentor.
- To study the basics of metabolic stoichiometry and microbial kinetics in batch, fed-batch and continuous mode of operation.

UNIT I	FERMENTATION PROCESSES AND BASIC CONFIGURATION OF FERMETER	(6+3 Periods)
General requirements of fermentation processes, Basic concepts of Upstream and Downstream processing in Bioprocess, Process flow sheeting – block diagrams, pictorial representation, Basic configuration of Fermentor and ancillaries, main parameters to be monitored and controlled in fermentation processes. Case studies: Production of Ethanol		
UNIT II	**RAW MATERIALS AND MEDIA DESIGN FOR FERMENTATION PROCESS**	**(6+3 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, examples of simple and complex media, design of various commercial media for industrial fermentations – medium optimization methods- OFAT, PB , RSM. **Case Study: Optimization of Amylase production by Plackett and Burman method.**		
UNIT III	**STERILIZATION KINETICS**	**(6+3 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**	**(6+3 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**	**(6+3 Periods)**
Modes of operation – batch, fed-batch and continuous cultivation, 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: 30 Periods Tutorial: 15 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOKS:

1. Peter F. Stanbur.,, 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.*

REFERENCE BOOKS:

1. *Bailey, James E., David F. Olli.,* ***"Biochemical Engineering Fundamentals"****, 2 nd 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. Najafpour.,* ***"Biochemical Engineering and Biotechnology"****, Elsevier, 2007.*
5. *D.M. Himmelbla,* ***"Basic principles and calculations in chemical Engineering"****, 6th edition, Pearson education,2006.*

COURSE OUTCOME

Upon completion of the course, the student will be able to

CO1: Understand the general requirements of a fermentation process.

CO2: Understand the basic configuration of a fermentor and its ancillaries.

CO3: Demonstrate an ability to design good media.

CO4: Explain the sterilization kinetics and design the sterilization equipments for batch and continuous process.

CO5: Able to model microbial growth, substrate utilization and product formation.

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	M	L	L	L	-	-	-	-	-	-	L	L	L
CO2	H	H	H	M	M	-	-	H	M	-	-	-	L	H
CO3	H	H	H	H	H	-	M	-	M	-	-	M	L	M
CO4	H	H	H	H	M	-	L	-	L	-	-	M	L	M
CO5	H	H	H	H	-	-	L	-	L	-	-	M	L	H
18BPC 503	H	H	H	H	M	-	L	-	L	-	-	M	L	M

L- Low , M-Moderate(Medium), H- High

18BPC504	GENETIC ENGINEERING	SEMESTER V

Category: PC

PRE-REQUISITES:

L	T	P	C
3	0	0	3

1. 18BPC304- Cell Biology
2. 18BPC403 – Molecular Biology

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 : BASICS OF 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 ;Safety guidelines of recombinant DNA research.	
UNIT- II : CREATION OF RECOMBINANT MOLECULES AND VECTORS	**(9 Periods)**
Restriction mapping; Design of Linkers and Adaptors; Characteristics of plasmid and phage vectors, Prokaryotic and Eukaryotic expression vectors. Insect, Yeast and Mammalian vectors.	
UNIT- III : CONSTRUCTION OF LIBRARIES	**(9 Periods)**
Construction of cDNA and genomic libraries; Screening of libraries with DNA probes and antisera; Characterization of recombinant clones by Southern, Northern, Western - PCR analysis.	
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.	
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 BOOKS:

1. *Old RW, Primrose SB –* ***"Principles of Gene Manipulation, An Introduction To Genetic Engineering"****, Blackwell Science Publications, 2013.*

REFERENCE BOOKS

1. *Ansubel FM, Brent R, Kingston RE, Moore DD,* ***"Current Protocols In Molecular Biology",*** *Green Publishing Associates, NY, 1988*
2. *Berger Sl, Kimmer AR,* ***"Methods In Enzymology"****, Vol 152, Academic Press, 1987*

COURSE OUTCOME

Upon the completion of the course, the student will be able to

CO1: Recall various components essential for Gene expression.

CO2: Determine appropriate techniques for DNA manipulation.

CO3: Construct various recombinant proteins.

CO4: Analyze the clones.

CO5: Apply Genetic Engineering principles for the production of transgenics.

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	L	-	M	-	-	-	-	-	-	-	-	-	H	L
CO2	L	-	M	-	-	-	-	M	-	-	-	-	H	L
CO3	M	L	L	-	M	-	-	-	-	-	-	-	L	H
CO4	M	L	-	-	L	-	-	-	-	-	-	-	L	H
CO5	-	-	-	-	-	M	M	-	-	-	-	L	L	H
18BPC 504	M	L	M	-	M	M	M	M	-	-	-	L	L	H

L – Low, M – Moderate, H- High

18BHS507	BUSINESS COMMUNICATION SKILLS LABORATORY	SEMESTER V

Category: HS

PRE-REQUISITES:

1. 18BHS201- Communicative English

L	T	P	C
0	0	2	1

COURSE OBJECTIVES:

- To develop a provisional attitude
- To improve interpersonal and social skills

LIST OF EXPERIMENTS

1. **PERSONAL COMMUNICATION:** Day-to-day conversation
2. **WRITTEN COMMUNICATION:** Writing – emails, cover letters
3. **GROUP COMMUNICATION:** Debate, Panel discussion
4. **PUBLIC SPEAKING:** Reading a speech, Writing a speech
5. **PRESENTATION SKILLS:** Writing a business or research proposal, Defending model/ hypothesis
6. **EMPLOYABILITY SKILLS:** Preparation for interview, mock interview

Contact Periods:

Lecture: 0 Periods **Tutorial: 0 Periods** **Practical: 30 Periods** **Total: 30 Periods**

TEXT BOOKS:

1. *Richard Denny, "**Communication to Win", 3rd Edition, Kogan Page India Pvt. Ltd, 2008.***
2. *Jongewardm D & Seyer P C, "**Choosing Success (Transactional Analysis on the job)", John Wiley & Sons, 1978.***

REFERENCE BOOKS:

1. *Luthans F, "**Organisational Behaviour"**, McGraw-Hill 12th edition, 2010.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO 1 : Converse confidently in a personal and social gathering.
CO 2 : Competent in Group activities
CO 3 : Address a group or gathering
CO 4 : Present views and opinion
CO 5 : Effectively handle interviews

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	-	-	-	-	-	-	-	-	H	M	-	-	L	H
CO2	-	-	-	-	-	-	-	-	H	M	-	-	L	H
CO3	-	-	-	-	-	-	-	-	M	H	-	-	L	H
CO4	-	-	-	-	-	-	-	-	M	H	-	-	M	H
CO5	-	-	-	-	-	-	-	-	-	H	-	-	L	H
18BHS 507	-	-	-	-	-	-	-	-	H	M	L	-	L	H

L - Low, M-Moderate (Medium), H- High

18BPC508	BIOPROCESS LABORATORY I	SEMESTER V

Category: PC

L	T	P	C
0	0	3	1.5

PRE-REQUISITES: NIL

COURSE OBJECTIVES:

- To train the students on enzyme characterization.
- To familiarize the students on medium optimization techniques.
- To understand the microbial growth kinetics.
- To train the students on operation of fermentors.

Sl. No	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.	Preparation of bioreactor; utilities of bioreactor operation. (Batch, Fed-batch and continuous).

Contact Periods:

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

REFERENCE BOOKS

1. *Peter F. Stanbur., Stephen J. Hall ., A. Whitake.,* ***"Principles of Fermentation Technology"****, Science & Technology Books. 2007.*
2. *Shuler Michael L., FikretKarg.,* ***"Bioprocess Engineering"****, Prentice Hall, 2008.*
3. *Doran M Pauline.,* ***"Bioprocess Engineering Principles"*** *. 2nd Edition, Elsevier, 2012*
4. *Bailey, James E., David F. Ollis.,* ***"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., D.P. Ballou.,* ***"Fundamental Lab approaches for Biochemistry and Biotechnology"****, 2st Edition, Oxford University press, UK, 1998.*

COURSE OUTCOMES:

Upon completion of the course graduates will be able to

CO1: Understand enzyme kinetics and estimate MM parameters.
CO2: Learn the basic configuration of fermentor and its ancillaries.
CO3: Analyze and estimate the growth kinetics of bacteria and yeast.
CO4: Familiarize with medium optimization techniques.
CO5: Understand sterilization kinetics.

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	H	H	H	H	-	-	-	-	-	-	M	L	M
CO2	H	H	H	M	M	-	-	H	M	-	-	-	L	H
CO3	H	H	H	H	H	-	-	L	M	-	-	-	L	M
CO4	M	M	H	H	H	-	-	-	M	-	-	-	L	M
CO5	H	H	H	H	M	-	L	-	L	-	-	M	L	M
18BPC 508	H	H	H	H	H	-	L	L	M	-	-	M	L	M

L- Low , M-Moderate(Medium), H- High

18BPC509	MOLECULAR BIOLOGY AND GENETIC ENGINEERING LABORATORY	SEMESTER V

Category: PC

PRE-REQUISITES:

1. 18BPC307 – Microbiology Laboratory

L	T	P	C
0	0	4	2

COURSE OBJECTIVES:

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

LIST OF EXERCISES

1. Agarose gel electrophoresis for quality and quantity assessment
2. DNA Extraction from plant cells
3. DNA Extraction from animal cells
4. DNA Extraction from Human blood
5. Denaturing gel electrophoresis for RNA
6. Plasmid Extraction from bacterial cell
7. Elution of DNA from Agarose gel.
8. Restriction and ligation of DNA fragments
9. Competent cells preparation and transformation
10. SDS-PAGE
11. Western blotting
12. PCR

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

REFERENCE BOOKS:

1. *Sambrook, Joseph and David W. Russell,* ***"The Condensed Protocols: From Molecular Cloning: A Laboratory Manual"****, Cold Spring Harbor, 2006.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Understand the principles underlying in the techniques of molecular biology and genetic engineering.
CO2: Analyze the applications of these techniques.
CO3: Carry out lab experiments and interpret the results.
CO4: Take safety precautions on usage of hazardous chemicals in case of emergency.

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	L	M	H	L	H	-	-	-	L	M	-	-	H	M
CO2	L	M	H	L	M	-	-	-	L	L	-	-	H	H
CO3	L	M	H	L	H	-	-	-	L	H	-	-	H	M
CO4	M	L	L	L	-	-	-	-	L	L	-	-	H	M
18BPC 509	L	M	H	L	H	-	-	-	L	L	-	-	H	M

L - Low, M - Moderate (Medium), H – High

18BPC601	IMMUNOLOGY	SEMESTER VI

Category: PC

PRE-REQUISITES: NIL

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- To articulate the role of various cells and organs involved in immune responses and associated functions
- To gain knowledge on the interaction between the immune system and pathogens
- To develop the ability to identify issues in clinical immunology

UNIT – I: CELLS AND ORGANS OF THE IMMUNE SYSTEM	**(9 Periods)**
First line and second line of defense - Innate and acquired immunity; cells of immune system, primary and secondary lymphoid organs.	
UNIT – II : ANTIGENS AND ANTIBODIES	**(9 Periods)**
Antigens: chemical and molecular nature; haptens; adjuvants; B and T-cell epitopes; antigenic determinants on antibodies; antibodies: structure and functions; antibodies: genes and generation of diversity; antigen-antibody reactions; monoclonal antibodies: principles and applications.	
UNIT – III : CELLULAR RESPONSES	**(9 Periods)**
Development, maturation, activation and differentiation of T-cells and B-cells; antigen presenting cells; major histocompatibility complex; antigen processing and presentation; regulation of T-cell and B-cell responses; cytokines.	
UNIT – IV : INFECTION AND IMMUNITY	**(9 Periods)**
Immune responses to infections: immunity to viruses, bacteria, fungi and parasites; complement; immunosuppression, tolerance; allergy and hypersensitivity; vaccines, Immunotherpies.	
UNIT – V : AUTOIMMUNITY AND TRANSPLANTATION IMMUNOLOGY	**(9 Periods)**
Autoimmunity, Auto immune diseases: systemic and organ specific autoimmune disorders, proposed mechanisms for induction of Autoimmunity, Treatment of Autoimmune diseases; Types of grafts, Basis of Graft rejection, specificity and memory of graft rejection, Mechanisms involved in Graft rejections, Tests for HLA matching, General and specific immune suppression therapies.	

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

TEXT BOOKS:

*1.Kuby J. **"Immunology"**, WH Freeman & Co., 5th edition, 2000.*
*2. MRoitt I., Male., Brostoff, **"Immunology"**, Mosby Publ., 12th edition, 2002.*

REFERENCE BOOKS:

*1. Chakaravarthy A.K., **"Immunology and Immunotechnology",** Oxford University Press India, 1st Edition, 2006.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Outline the basic components of immune system and their functions.
CO2: Illustrate various diagnostic methods based on antigen-antibody interaction
CO3: Describe principles and methods of various cellular immune responses
CO4: Demonstrate the state of immune system during infection
CO5: Find effective solutions for the treatment of autoimmune disorders and problem associated with organ transplantation

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	L	-	-	L	-	-	-	-	-	L	-	H	L
CO2	L	M	H	-	M	L	-	L	M	M	L	M	L	M
CO3	L	L	-	-	-	-	-	-	-	M	-	-	H	L
CO4	L	M	-	-	L	L	M	-	-	M	L	-	M	L
CO5	L	M	H	L	M	H	-	-	L	M	H	M	L	H
18BPC 601	L	M	H	L	M	L	M	L	M	M	L	M	H	L

L - Low, M-Moderate (Medium), H- High

18BPC602	BIOINFORMATICS	SEMESTER VI

Category: PC

PRE-REQUISITES:

1. 18BES204 –Programming in C

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- To learn the basics of Unix commands and Perl programming.
- To understand the string alignment methods.
- To learn the methods to construct phylogenetic trees and structure prediction.

UNIT – I : UNIX AND PERL PROGRAMMING	**(9 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 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 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 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 Periods)**
3D Structure prediction methods– Homology modeling, Threading, Ab-initio prediction; Micro array analysis –Principle and methods; Introduction to Computer Aided Drug Design (CADD).	

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

TEXT BOOKS:

1.David. W. Mount, ***"Bioinformatics genome and sequence analysis"****, Cold Spring House Laboratory publications, Second 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 , Fourth Edition, 2013*

3.Arthur Lesk, ***"Introduction to Bioinformatics"****, Oxford University Press, Second edition, 2002.*

REFERENCE BOOKS:

1. Andreas D. Baxevanis, ***"Bioinformatics, A Practical Guide to the Analysis of Genes and Proteins"****, Third edition; Wiley-Interscience, 2004.*
2. David J. Parry-Smith, Dr Samiron Phukan, Teresa Attwood, ***"Introduction to Bioinformatics"****, Pearson Education India, 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.*

COURSE OUTCOMES:

Upon completion of the course the students will be able to

CO1: Gain expertise on UNIX operating system commands and Perl programming.
CO2: Acquire knowledge on different biological databases.
CO3: Demonstrate an ability to align the macromolecular string by dynamic programming and heuristic methods.
CO4: Construct and interpret the phylogenetic trees.
CO5: Understand the methods for structure prediction of proteins and computer aided drug design.

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COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	L	M		H	M				M				M	L
CO2	L	M		M	M								L	
CO3	L	L	L	M	H		L						L	
CO4	M	M		H	M				L				M	M
CO5	L	M		H	M				M				M	H
18BPC602	L	M	L	H	M		L		M				M	M

L - Low, M-Moderate (Medium), H – High

18BPC603	BIOPROCESS ENGINEERING	SEMESTER VI

Category: PC

PRE-REQUISITES:

1. 18BPC406-Enzyme Engineering & Technology
2. 18BES502- Mass Transfer Operations
3. 18BPC503- Bioprocess Principles

L	T	P	C
2	1	0	3

COURSE OBJECTIVES:

- To acquire the knowledge on design, performance, stability analysis of bioreactors
- To learn about the bioreactors scale up methods.
- To understand the monitoring and control of bioprocess.
- To acquire knowledge about the fundamentals of modeling and simulations of bioprocess.
- To understand the kinetics of immobilized enzyme system.

UNIT – I : DESIGN AND ANALYSIS OF BIOREACTORS	**(6+3 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	**(6+3 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	**(6+3 Periods)**
Bioprocess monitoring- modes- On-line measurement of physico-chemical and biochemical parameters; Methods of on-line and off-line biomass estimation; microbial calorimetry; Flow injection analysis; Computer based data acquisition- LabView; Data interpretation – regression models- correlation coefficient.	
UNIT – IV : MODELLING AND SIMULATION OF BIOPROCESSES	**(6+3 Periods)**
Structured models for analysis of various bioprocess – compartmental models, models of cellular energetics and metabolism, single cell models, plasmid replication and plasmid stability model; Dynamic simulation of batch - continuous and fed-batch system.	
UNIT – V : BIOREACTOR CONSIDERATION IN ENZYME SYSTEMS	**(6+3 Periods)**
Analysis of film and pore diffusion effects on kinetics of immobilized enzyme reactions; formulation of dimensionless groups and calculation of effectiveness factors; Kinetics of immobilized enzyme reactors – packed bed and fluidized bed.	

Contact Periods:
Lecture: 30 Periods Tutorial: 15 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOKS:

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. *Blanch, H.W., Clark,D.S.,* ***"Biochemical Engineering"****, 2nd Edition , CRC Press, 1997.*
4. *Bailey, J.E., Ollis, D.F.****"Biochemical Engineering Fundamentals"****, 2nd Edition , McGraw Hill, 1986.*

REFERENCE BOOKS:

1. *Katoh, S., Horiuchi, J.I., Yoshida, F.,* ***"Biochemical Engineering: A Textbook for Engineers, Chemists and Biologists"****, John Wiley & Sons, 2015.*
2. *Liu, S.,* ***"Bioprocess Engineering-Kinetics, Biosystems, Sustaninability and Reactor Design"****, Elsevier, 2013.*
3. *Mosier, N.S., Ladisch, M.R.,* ***"Modern Biotechnology: Connecting Innovations in Microbiology and Biochemistry to Engineering Fundamentals"****, John Wiley & Sons, 2011.*
4. *Lee, J.M.,* ***"Biochemical Engineering"****, Prentice Hall, 1992.*
5. *Moser, A.,* ***"Bioprocess Technology, Kinetics and Reactors"****, Springer Verlag.1998.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Design and analyze the performance of bioreactors.
CO2: Scale up the bioreactors based on various criteria.
CO3: Clearly understand the monitoring and control of bioprocess.
CO4: Perform modeling and simulations of bioprocess using software.
CO5: Understand the immobilized enzyme kinetics and apply for enzyme bioreactor design.

COURSE ARTICULATION MATRIX

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	M	H	M	M	-	L	-	-	-	-	M	H	M
CO2	M	M	M	M	M	-	-	-	-	-	-	-	H	M
CO3	M	-	-	H	H	-	-	-	-	-	-	-	M	H
CO4	M	M	-	H	M	-	-	-	-	-	-	-	M	H
CO5	M	L	-	M	-	-	L	-	-	-	-	-	L	H
18BPC 603	M	M	H	H	M	-	L	-	-	-	-	M	M	H

L - Low, M-Moderate (Medium), H- High

18BEE606	CHEMICAL REACTION ENGINEERING	SEMESTER VI

Category: EEC

PRE-REQUISITES:

L	T	P	C
2	1	0	3

1. 18BES401- Process calculations and Heat transfer
2. 18BPC404- Biochemical Thermodynamics
3. 18BES502- Mass Transfer Operations

COURSE OBJECTIVES:

- Impart the basic concepts in reaction kinetics.
- Develop knowledge for design of ideal reactors
- Understand the practical aspects of Non-Ideal flow.

UNIT – I : KINETICS OF HOMOGENOUS REACTIONS	**(6+3 Periods)**
Concentration and temperature dependent term of rate equation – searching for mechanism – predictability of reaction rate from theory; Interpretation of batch reactor data – constant volume and variable volume batch reactors – temperature and reaction rate - development of rate equations for different homogeneous reactions (up to second order reactions both reversible and irreversible reactions) .	
UNIT – II : REACTOR DESIGN	**(6+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 for first and second order reactions – multiple reactor systems -graphical comparison;	
UNIT – III : NON IDEAL FLOW	**(6+3 Periods)**
RTD of fluid in vessel – relationship between F,C& E curve – conversion from tracer information - non-ideal flow models – Dispersion model and Tanks in series Model.	
UNIT – IV : GAS – LIQUID REACTION	**(6+3 Periods)**
Absorption combined with chemical reaction. Mass transfer coefficients and kinetic constants. Application of film penetration and surface renewal theories. Hatta number and enhancement factor for first order reaction.	
UNIT – V :CATALYSIS	**(6+3 Periods)**
Catalysis-General characteristics and classification of catalysis-Physical adsorption and chemisorptions- Adsorption isotherms-Determination of surface area of a catalyst-Classification of catalyst-catalyst preparation- Mechanism of Catalyst deactivation-Pore diffusion resistance combined with surface kinetics-performance equations for reactors containing porous catalyst particles.	

Contact Periods:
Lecture: 30 Periods **Tutorial: 15 Periods** **Practical: 0 Periods** **Total: 45 Periods**

TEXT BOOKS:

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.*

REFERENCE BOOKS:

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*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Solve the kinetics of Homogeneous reactions.
CO2: Develop design aspects for different ideal reactors.
CO3: Familiarity with applications of multiple reactions in process industries.
CO4: Demonstrate non ideal flow in chemical reactors.
CO5: Design reactor for catalyzed reaction by understanding the heterogeneous chemical reactor system.

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	L	M	-	L	-	L	--	L	-	-	L	-	M	-
CO2	L	M	L	-	L	L	--	-	L	-	-	-	L	-
CO3	L	L	L	-	L	L	-	L	-	-	-	-	L	-
CO4	L	L	-	L	-	-	-	-	-	-	-	L	-	M
CO5	L	-	-	-	L	-	L	-	M	-	-	L	-	L
18BEE 606	L	L	L	L	L	L	L	-	M	-	-	L	M	L

L - Low, M-Moderate (Medium), H- High

18BPC607	BIOINFORMATICS LABORATORY	SEMESTER VI

Category: PC

PRE-REQUISITES:

1. 18BES207-Programming in C Laboratory

L	T	P	C
0	0	2	1

COURSE OBJECTIVES:

- To acquire knowledge on basics of Perl programming.
- To demonstrate an ability to utilize the tools such as BLAST, CLUSTAL, EMBOSS, PHYLIP etc.
- To predict and validate the 3D structure of protein using different methods.

LIST OF EXPERIMENTS	(30 Periods)
1. Perl Programming 2. Biological Databases- Sequence Databases, Structure Databases, Specialized Databases; Data Retrieval tools and methods; Database file formats. 3. Molecular visualization tools - Rasmol, Cn3D and Swiss PDB Viewer. 4.Pairwise alignment-dynamic programming – NEEDLE and Water; Dotplot analysis 5. Database similarity searching using Heuristic methods- BLAST, FASTA 6.Multiple sequence alignment- CLUSTAL 7. Protein sequence analysis -ExPASy proteomics tools 8. Construction of Phylogenetic tree - Maximum Parsimony & Maximum Likelihood method - NJ,UPGMA method - PHYLIP program 9. Homology Modeling - Homology modeling using SPDBV 10. Model validation using Ramachandran plot, ProSA, Pro Check. 11.Prediction of binding affinity of Ligand and Receptor using Docking studies	

Contact Periods:
Lecture: 0 Periods **Tutorial: 0 Periods** **Practical: 30 Periods** **Total: 30 Periods**

TEXT BOOKS:

1. *Orpita Bosu, Simminder Kaur Thukral , **"Bioinformatics Databases, Tools and Algorithms"**, Oxford University Press, 2007.*
2. *K. Mani, N. Vijayaraj, **"Bioinformatics: a Practical Approach"**, Aparna Publications,2004.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to
CO1: Acquire an ability to perform programming using PERL language.
CO2: Retrieve sequences from different biological databases.
CO3: Analyse the pattern matching by pairwise and multiple sequence alignment
CO4: Able to construct phylogenetic tree by using distance based and character based methods
CO5: Able to predict and validate 3D structure of protein

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	L	L	M	M	M				L				M	L
CO2	M	L		L	M									L
CO3	M	M	L	M	M	L								
CO4	L	M	L	H	H		L		L				M	M
CO5		H		M	H				L			L		H
18BPC 607	M	M	L	M	M	L	L		L			L	M	M

L - Low, M-Moderate (Medium), H- High

18BPC608	BIOPROCESS ENGINEERING LABORATORY	SEMESTER VI

Category: PC

L	T	P	C
0	0	4	2

PRE-REQUISITES:

1. 18BPC508 –Bioprocess Laboratory -I

COURSE OBJECTIVES:

- To possess hands on experience to understand the basic concepts involved in the bioprocess engineering such as sterilization and growth kinetics
- To acquire the knowledge to determine RTD and heat, mass transfer rate in fermentation process
- To use MATLAB and Simulink tools for bioprocess simulations.

LIST OF EXERCISES	(60 Periods)

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. Residence time distribution in CSTR
8. Residence time distribution in PFR
9. Estimation of overall heat transfer coefficient in batch fermenter
10. Solving the bioreactor kinetic data using MATLAB
11. Solving the bioreactor kinetic data using Simulink
12. Dynamic Simulation of Batch, Continuous and Fed batch reactor using Berkeley Madonna software

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

REFERENCE BOOKS:

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 student will be able to

CO1: Design, analyze the growth kinetics in bioreactor and interpret the data meaningfully
CO2: Understand sterilization kinetics and its data interpretation
CO3: Estimate the residence time distribution in CSTR and PFR to demonstrate the non-ideality existence in reactors.
CO4: Calculate heat and mass transfer coefficients in fermentation process
CO5: Solve and simulate the bioreactor data using MATLAB and Simulink tools

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	M	H	-	-	-	-	-	M	-	-	M	H	M
CO2	M	L	M	L	-	-	-	-	-	-	-	-	H	L
CO3	M	M	M	-	-	-	-	-	-	-	-	-	M	M
CO4	M	M	M	-	L	-	-	-	-	-	-	-	M	H
CO5	M	L	M	-	H	-	-	-	-	-	-	-	M	H
18BPC 608	M	M	M	L	H	-	-	-	M	-	-	M	H	M

L - Low, M-Moderate (Medium), H- High

18BPC609	IMMUNOLOGY LABORATORY	SEMESTER VI

Category: PC

PRE-REQUISITES: NIL

L	T	P	C
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.	Immunoelectrophoresis
9.	Enzyme Linked Immuno Sorbent Assay (ELISA)

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

TEXT BOOKS:

1.De Robertis & De Robertis, ***"Cell Biology"****, 4th edition, Lippincott, 2007.*
2.Roitt I., ***"Essential Immunology"****, 9th edition, Blackwell Scientific, 1997.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Identify the different specimens using microscope
CO2: Perform different staining techniques for the study of blood cells and cell division
CO3: Demonstrate various strategies of antigen-antibody interactions
CO4: Perform experiments to quantify immune molecules
CO5: Interpret the data obtained based on pathological processes

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	-	-	-	L	-	-	-	M	-	-	-	L	H
CO2	M	-	-	-	L	-	-	-	H	-	M	-	M	H
CO3	M	H	M	-	-	-	-	-	L	H	-	L	H	M
CO4	-	M	H	-	M	-	-	M	H	-	H	-	H	H
CO5	M	-	H	-	-	-	-	-	H	L	H	H	H	M
18BPC 609	M	H	H	-	L	-	-	M	H	H	H	H	H	H

L - Low, M - Moderate (Medium), H - High

18BHS701	TECHNOLOGY MANAGEMENT *(Common to EEE, EIE, CSE, IT & IBT Branches)*	SEMESTER VII

Category: HS

PRE-REQUISITES: NIL

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

Upon completion of this course, the students will be familiar with,

- Intricacies of technology selection.
- Role of technology in today's business.

UNIT – I : INTRODUCTION	**(9 Periods)**
Evolution, growth of technology, role and significance of technology management, forms of technology – process, product technology, impact of technology on society and business, technology and competition.	
UNIT – II : TECHNOLOGY FORECASTING	**(9 Periods)**
Technology forecasting, characteristics, principles, process, forecasting methods and techniques.	
UNIT – III : ACQUISITION OF NEW TECHNOLOGY	**(9 Periods)**
Alternative for acquiring new technology, reasons to obtain new technology, management of acquired technology, measures of scale and mechanisms for acquiring technologies. Technology transfer-models, modes of transfer, dimensions of technology transfer, features of technology package- routes of technology transfer.	
UNIT – IV : HUMAN ASPECTS OF TECHNOLOGY MANAGEMENT	**(9 Periods)**
Integration of people and technology, factors considered in technology management – organizational, psychological, organizational structure and technology –technological change and industrial relations.	
UNIT – V : SOCIAL ASPECTS OF TECHNOLOGY MANAGEMENT	**(9 Periods)**
Technology assessment and environmental impact analysis(EIA)-EIA-process, scope, issues in report preparation, elements of environmental problem, case study on social impact of technology.	

Contact Periods:

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

TEXT BOOKS:

1. *Sanjiva Shankar Dubey,* ***"Technology and Innovation Management",*** *PHI Learning Private Ltd., 2017.*

REFERENCE BOOKS:

1. *Gerard H. Gaynor,* ***"Hand Book Technology of Management"****, McGraw Hill professional, 2009.*
2. *Khalil, T,* ***"Management of technology: The Key to competitiveness and wealth creation"*** *Tata McGraw Hill, Delhi, 2013.*
3. *Ralph Katz****, "The human side of Managing Technological Innovation: A Collection of Readings",*** *2nd Edition Oxford University Press, 2003*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to,

CO1: Learn to manage ideas and knowledge in a technology-based organization. [**Familiarize]**

CO2: Equipped with skills needed to implement technology polices and strategies. [**Familiarize]**

CO3: Formulate technology polices and strategies for businesses. **[Understand]**

CO4: Appropriately choose the new technologies. **[Analyse]**

CO5: Future technological requirements. [**Familiarize]**

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	-	-	-	L	-	-	-	M	-	-	-	L	H
CO2	M	-	-	-	L	-	-	-	H	-	M	-	M	H
CO3	M	H	M	-	-	-	-	-	L	H	-	L	H	M
CO4	-	M	H	-	M	-	-	M	H	-	H	-	H	H
CO5	M	-	H	-	-	-	-	-	H	L	H	H	H	M
18BHS 701	M	H	H	-	L	-	-	M	H	H	H	H	H	H

L - Low, M-Moderate (Medium), H- High

18BPC702	DOWNSTREAM PROCESSING	SEMESTER VII

Category: PC

PRE-REQUISITES:

1. 18BPC405- Analytical techniques in Biotechnology
2. 18BPC503- Bioprocess Principles
3. 18BPC603- Bioprocess Engineering

L	T	P	C
2	1	0	3

COURSE OBJECTIVES:

* Impart knowledge for various cell disruption methods
* Study the physical methods for separation of Bioproduct
* Learn the techniques involved for the isolation and extraction of bioproduct

UNIT – I : INTRODUCTION TO BIOSEPARATIONS	**(6+3 Periods)**
Synthesis of biosepartion processes – Engineering analysis of bioseparations – stages in downstream processing –Cell disruption for product release – mechanical, enzymatic and chemical methods-Pretreatment and stabilisation of bioproducts.	
UNIT – II : PHYSICAL METHODS OF SEPERATION	**(6+3 Periods)**
Filtration principle – conventional and cross flow filtration – filter media – membrane fouling-rotary vacuum filtration – equipment details; sedimentation principle- sedimentation coefficient – sigma analysis –centrifugation – tubular and disk centrifuges – comparison and engineering analysis – ultracentrifugation – sedimentation at low accelerations – centrifugal elutriation- flocculation principle – electrical double layer, Schulze Hardy Rule – flocculation rate – flocculants.	
UNIT – III : PRODUCT ENRICHMENT	**(6+3 Periods)**
Adsorption – Description of adsorption process and their application-Types of adsorption-nature of adsorbents-Adsorption equilibrium isotherm and its kinetics- Aqueous two-phase extraction principle – phase separation and portioning equilibria – counter current stage calculations – membrane separation – ultrafiltration and dialysis-precipitation of proteins by different methods – precipitate breakage and aging.	
UNIT – IV : PRODUCT PURIFICATION	**(6+3 Periods)**
Chromatography principle-Column dynamics – plate models – chromatography column mass balance with negligible dispersion – calculation of elution profile – dispersion effects in chromatography – gradients and modifiers – adsorbent types – equipments and detectors – Principles of reverse phase- ion-exchange-size exclusion- hydrophobic interaction- bioaffinity and pseudo affinity chromatographic techniques.	
UNIT – V :PRODUCT FORMULATION	**(6+3 Periods)**
Crystallization principle – batch crystallizers – process crystallization of proteins- drying principle – heat and mass transfer – dryers description and operations of vacuum shelf dryers- batch vacuum rotary dryers, freeze dryers and spray dryers. Design of drying systems.	

Contact Periods:
Lecture: 30 Periods Tutorial: 15 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOKS:

*1.B. Sivasankar, **"Bioseparations: Principles and Techniques"**, Prentice-Hall of India Pvt. Ltd, 1st Edition, 2007.*

*2.P.A Belter, E.L Cussler Hu, **"Bioseparation –Downstream Processing for Biotechnology"**, Wiley Inter Science Publication, 1st Edition, 2011.*

*3.W.L. McCabe, J.C.Smith and P.Harriot, **"Unit Operations in Chemical Engineering"**, McGraw-Hill Inc, 7thEdition, 2013.*

*4.Ghosh R, **"Principles of Bioseparation Engineering"**, World Scientific Co. Ltd, 1st Edition ,2006*

REFERENCE BOOKS:

1. *Roger G.Harrison, Paul Todd, Scott R.Rudge and Demetri P.Pterides,* ***"Biosepartions Science and Engineering"****, Oxford University Press, 2nd Edition, 2003.*
2. *R.O. Jenkins,* ***"Product Recovery In Bioprocess Technology – Biotechnology By Open Learning Series"****, Butterworth-Heinemann, 2nd Edition,1992.*
3. *Jansons. J.C and Ryden L. (Ed),* ***"Protein purification-Principles, High Resolution Methods and Application"****. VCH Publications, 3rd Edition1989.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Impart the skills in various cell disruption methods
CO2: Illustrate the solid-liquid unit operation involved in downstream processing
CO3:Gain the Knowledge of principles and working of different unit operations for the isolation and extraction of bio-products
CO4: Demonstrate the various methods of chromatography used in protein purification
CO5: Knowledge of different methods and industrial equipments used for the concentration purification and final polishing of bio-products at the industrial level

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	L	-	L	-	-	L	-	L	-	-	-	L	-
CO2	L	-	M	-	M	-	L	L	L	-	M	-	-	M
CO3	L	-	L	M	-	-	-	H	L	-	L	-	-	H
CO4	L	M	M	-	-	L	-	M	-	-	-	-	L	-
CO5	L	-	-	-	-	-	-	M	L	L	M	-	-	H
18BPC 702	L	L	M	M	-	L	L	M	L	L	M	-	L	H

L - Low, M-Moderate (Medium), H- High

18BPC707	DOWNSTREAM PROCESSING LABORATORY	SEMESTER VII

Category: PC

PRE-REQUISITES:

1. 16BPC405- Analytical techniques in Biotechnology
2. 16BPC503- Bioprocess Principles
3. 18BPC603- Bioprocess Engineering

L	T	P	C
0	0	4	2

COURSE OBJECTIVES:

- Perform the different cell disruption methods
- perform different precipitation techniques to isolate the desired protein
- Work as a team to perform final formulation and polishing of biomolecules

LIST OF EXERCISES

1. Solid liquid separation – centrifugation
2. Cell disruption techniques – ultrasonication
3. Cell disruption techniques – Mechanical method
4. Enzymatic method of cell disruption
5. Precipitation – ammonium sulphate precipitation
6. Membrane separation – Dialysis
7. Batch sedimentation
8. Aqueous two phase extraction
9. High resolution purification – ion exchange chromatography
10. Product polishing – gel filtration chromatography
11. Product polishing – spray drying, freeze drying (Lyophilization)

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

REFERENCE BOOKS:

*1.Roger G.Harrison, Paul Todd, Scott R.Rudge and Demetri P.Pterides , **"Biosepartions Science and Engineering"**, Oxford University Press,2nd Edition,2003*

*2. R.O. Jenkins, (Ed.), **"Product Recovery In Bioprocess Technology – Biotechnology By Open Learning Series"**, Butterworth-Heinemann,1st Edition,1992.*

COURSE OUTCOME

Upon completion of the course, the students will be able to

CO1: Impart the skills in various cell disruption methods
CO2: Illustrate the solid-liquid unit operation involved in downstream processing
CO3: Gain the Knowledge of principles and working of different unit operations for the isolation and extraction of bio-products
CO4: Demonstrate the various methods of chromatography used in protein purification
CO5: Knowledge of different methods and industrial equipments used for the concentration purification and final polishing of bio-products at the industrial level

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	L	-	L	-	-	L	-	L	-	-	-	H	L
CO2	L	-	M	-	M	-	L	L	L	-	M	-	L	H
CO3	L	-	L	M	-	-	-	H	L	-	L	-	L	L
CO4	L	M	M	-	-	L	-	M	-	-	-	-	L	L
CO5	L	-	-	-	-	-	-	M	L	L	M	-	L	H
18BPC 707	L	L	M	M	-	L	L	-	L	-	M	-	L	L

L - Low, M-Moderate (Medium), H- High

18BEE708	MINI PROJECT	SEMESTER VII

Category: EEC

PRE-REQUISITES: NIL

L	T	P	C
0	0	8	4

COURSE OBJECTIVES:

- To design the research work and research after review
- To analyze and interpret results using new tools
- To develop writing and presentation skills

DESCRIPTION	(120 Periods)
* Students should do a separate mini project or part of their main project as mini project. * Students can finalize their topic of specialization for their eighth semester project in seventh semester and do literature survey related to major project. * At the end of the semester, a report has to be submitted.	

Contact Periods:
Lecture: 0 Periods **Tutorial: 0 Periods** **Practical: 120 Periods** **Total: 120 Periods**

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Analyze the preliminary literature related to major project.
CO2: Evaluate the experimental methods and hypothesis through available literature.
CO3: Write the research thesis.
CO4: Present the report to an audience.
CO5: Defend the result outcomes to an audience.

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	H	M	M	-	H	M	M	-	-	-	H	H	M
CO2	M	H	H	M	M	M	-	-	M	-	M	-	H	M
CO3	L	-	-	-	-	-	-	-	M	H	-	-	M	M
CO4	-	-	-	-	-	-	-	-	M	H	-	-	M	M
CO5	-	-	-	-	-	L	-	-	-	H	M	-	M	H
18BEE 708	M	H	H	M	M	M	M	M	M	H	M	H	H	M

L - Low, M-Moderate (Medium), H- High

18BEE803	PROJECT WORK	SEMESTER VIII

Category: EEC

PRE-REQUISITES: NIL

L	T	P	C
0	0	16	8

COURSE OBJECTIVES:

- To design the research work and research after review
- To analyze and interpret results using new tools
- To develop writing and presentation skills

DESCRIPTION	(240 Periods)

The project should be done 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:

Upon completion of the course, the student will be able to

CO1: Acquire practical knowledge on the selected area of biotechnology project.
CO2: Identify, design and analyze the experiments in the systematic and ethical approach.
CO3: Develop a project as an individual or in a team.
CO4: Develop the communication skills for project presentation.
CO5: Develop the writing skills for drafting the project report.

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	-	-	-	-	L	-	L	-	-	-	M	H	M
CO2	-	H	M	H	H	-	-	M	M	-	M	L	H	M
CO3	-	-	-	-	-	-	-	-	H	M	-	-	M	H
CO4	-	-	-	-	M	-	-	-	-	H	M	-	M	H
CO5	-	-	-	-	-	-	-	-	-	H	M	-	M	H
18BEE 803	H	H	M	H	H	L	-	M	M	H	M	M	M	H

L - Low, M-Moderate (Medium), H– High

18BPE$01	BIOFUELS

Category: PE

PRE-REQUISITES:

1. 18BPC402-Basics of Industrial Biotechnology

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- To understand the fundamental concepts in biofuels/ bioenergy.
- To learn the production mechanisms of different types of biofuels.
- To obtain the knowledge related to processing technologies of biofuels.
- To get familiarize the policies and guidelines available for the production of biofuels.

UNIT – I : ENERGY	**(9 Periods)**
Introduction-resources-renewable and non-renewable resources (water, minerals, and energy) use and overexploitation; Classification and sources of energy; Problems relating demand and supply of various energy sources-Coal-Petroleum.	
UNIT – II : MILESTONES IN BIOFUELS	**(9 Periods)**
First generation biofuels-bioethanol – production mechanisms by microbes; Second generation biofuels-methane and hydrogen – production mechanisms by microbes; Factors affecting biogas yields; Third generation biofuels-biobutanol-biodesel from algae; Fourth generation biofuels- solar to fuel method to produce biofuels.	
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.	
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 fertilizers.	
UNIT – V : POLICIES AND FUTURE R&D OF BIOFUELS & BIOENERGY	**(9 Periods)**
Analysis of both current and future Indian regulations - directives on biofuels and bioenergy; Evaluation of different production alternatives to produce bioenergy; Evaluation of current and future R&D needs-legal framework to support sustainable development and increased use of biofuels; Government policies and programs with regard to biofuels and investment opportunities worldwide.	

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

TEXT BOOKS:

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*

3. Gupta, Vijai Kumar; Tuohy, Maria G. (Eds.), ***"Biofuel Technologies Recent Developments,*** *Springer, 1st edition, 2013*

REFERENCE BOOKS:

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. *B Pandya,* ***"Conventional Energy Technology - Fuels and chemical Energy"****, TMH(1987)*
5. *S.P. Sharma and Chander Mohan,* ***"Fuels and Combustion"****, TMH, 1st editon, 1984*
6. *Kash Kori, C,* ***"Energy resources, demand and conservation with special reference to India"****, TMH, 1st edition, 1975.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to
CO1: Understand the functions of cell and their structural organization
CO2: Describe the mechanisms and role of cell in immune system
CO3: Get familiarized biomolecules and human anatomy system
CO4: Illustrate the applications of microbes in industrial process
CO5: Apply the engineering concepts in biology

COURSE ARTICULATION MATRIX:

CO	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	L	L	L	-	-	-	-	-	-	-	-	-	H	M
CO2	L	M	-	L	-	-	L	M	-	-	-	-	H	M
CO3	L	M	L	L	-	-	-	L	M	-	-	L	M	H
CO4	L	L	L	L	M	-	-	-	L	-	-	-	H	M
CO5	-	-	-	-	-	-	-	-	-	-	-	-	H	H
18BPE $01	L	M	L	L	M	-	L	M	M	-	-	L	H	M

L - Low, M-Moderate (Medium), H- High

18BPE$02	BIOPOLYMER TECHNOLOGY

Category: PE

L	T	P	C
3	0	0	3

PRE-REQUISITES: NIL

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 polymericMembranes 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 BOOKS:

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*

REFERENCE BOOKS:

1. *Naim Kosaric (Ed).,* ***"Biosurfactants"****, Marcell Dekker Inc, 1993.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: To employ the greener technologies to solve the environmental issues.
CO2: To familiar the different types of plant and animal derived biopolymers and their application as commercial bioplastics.
CO3: To illustrate the synthesis and application of biopolymers in nanoscale drug delivery systems, as biomimetic materials and waste water treatment methods.
CO4: To understand the properties of biosurfactants and their use in food industries.
CO5: To evaluate the tensile strength, hydration, viscoelastic properties using different testing methods.
CO6: To analyze the different types of Biopolymers through case studies.

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	L	M	H	-	-	-	-	-	L	L	-	L	M	H
CO2	M	H	L	M	-	-	L	-	L	L	-	-	M	H
CO3	H	L	M	-	-	-	L	-	-	-	-	L	H	L
CO4	M	L	H	-	-	-	L	L	-	-	-	-	H	L
CO5	M	M	M	-	-	-	L	-	-	-	-	-	M	M
CO6	L	L	M	-	-	-	L	L	L	L	-	L	H	M
18BPE $02	M	L	M	L	-	-	-	-	L	L	-	L	M	H

-

L - Low, M-Moderate (Medium), H- High

18BPE$03	INDUSTRIAL HAZARD MANAGEMENT

Category: PE

PRE-REQUISITES: NIL

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- Identify and causes of various Hazards
- Enable the students to compare the hazards of chemicals with the permissible levels.
- Acquire knowledge about types of hazards arising out of physical, chemical and biological agents.
- Demonstrate various techniques involved in Hazard waste Management.
- Recognize the issues related to environment and safety.

UNIT – I : PHYSICAL HAZARD	**(9 Periods)**
Noise, compensation aspects, noise exposure regulation, properties of sound, occupational damage, risk factors, sound measuring instruments, octave band analyzer, noise networks, noise surveys, noise control program, industrial audiometry, hearing conservation programs-vibration, types, effects, instruments, surveying procedure, permissible exposure limit.	
UNIT – II : CHEMICAL HAZARD	**(9 Periods)**
Recognition of chemical hazards-dust, fumes, mist, vapor, fog, gases, types, concentration, Exposure vs. dose, TLV-Methods of Evaluation, process or operation description, Field Survey, Sampling methodology, Industrial Hygiene calculations, Comparison with OSHAS Standard. Air Sampling instruments, Types, Measurement Procedures, Instruments Procedures, Gas and Vapor monitors, dust sample collection devices, personal sampling	
UNIT – III : BIOLOGICAL AND ERGONOMICAL HAZARDS	**(9 Periods)**
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-animal care and handling-biological safety cabinets.Work Related Musculoskeltal Disorders–carpal tunnel syndrome CTS-Tendon pain-disorders of the neck-back injuries.	
UNIT – IV : HAZARDOUS WASTE MANAGEMENT	**(9 Periods)**
Waste generation, control and sustainable reuse of Biodegradable waste after segregation, Transportation of waste and identified areas with blocks marked out for separate categories. Identifying target application of processed waste and costs involved - Documentation procedures and understanding standard permissible waste limits as per statutory regulations. Storage and identification of processed waste. Evaluation of time and scope of reuse. Tabulation and documentation. Laboratory tests for potability of such reprocessed material. Health hazards-toxic and radioactive wastes-incineration and vitrification-hazards due to bio-process-dilution-standards and restrictions–recycling and reuse.	
UNIT – V : SAFETY MANAGEMENT	**(9 Periods)**
Organising for safety, Health and Enviornment, Organisation : Structure, Function and responsibilities, Safety Committee : Structure and function,The competent person in relation to safety legislation - duties and responsibilities, Competence Building Technique (CBT), Concept for training, Employee participation in safety - Colour coding and its awareness, Types of fire and its control, SOPs for machinery and process, Packing and storage, Emergency preparedness procedures, Training towards risk elimination, Role of Trade union in safety, health and environment. Safety promotion and safety awards, safety, competitions, audio visual publication.	

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

TEXT BOOKS

1. *S.P.Mahajan, "**Pollution control in process industries",** 1st Edition, Tata McGraw Hill Publishing Company, New Delhi, 1993.*
2. *Krishnan N.V. **"Safety Management in Industry",** 1st Edition, Jaico Publishing House, Bombay, 1997.*

REFERENCE BOOKS

1. *B.D. Singh, **"Biotechnology"**, Kalyani Publishers, 1st Edition,2003.*

COURSE OUTCOME

Upon completion of the course, the students will be able to

CO1: Identify and analyse various types of hazards present in physical, chemical, biological agents and ergonomical aspects in a process.

CO2: Identify and understand notifiable occupational diseases arising out of occupation and suggest methods for the prevention of such diseases.

CO3: Evaluate the safety performance of an organization.

CO4: Gain the knowledge about the safety management.

CO5: Identify and recognize issues related to Environment and safety.

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	L	L	L	-	-	-	-	-	-	-	-	-	H	L
CO2	L	M	-	L	-	-	L	M	-	-	-	-	L	H
CO3	L	M	L	L	-	-	-	L	M	-	-	L	L	L
CO4	L	L	L	L	M	-	-	-	L	-	-	-	L	L
CO5	-	-	-	-	-	-	-	-	-	-	-	-	L	H
18BPE $03	L	M	L	L	-	-	-	M	L	-	-	L	L	L

1. Slight (Low) 2. Moderate (Medium) 3. Substantial (High)

18BPE$04	FOOD PROCESS ENGINEERING

Category: PE

PRE-REQUISITES:

1. 18BBS302- Microbiology
2. 18BES303– Fluid Mechanics
3. 18BPC305 – Biochemistry
4. 18BES502 –Mass Transfer operations

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- To enable the student to understand the chemistry and microbiology of aspects food.
- To gain knowledge in various aspects of food processing & its importance.

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 BOOKS:

*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.*

REFERENCE BOOKS:

*1. Srinivasan Damodaran and Kirk L. Parkin., **"Fennema's Food Chemistry"**, CRC Press, 5th edition. 2017.*

*2. Frazier W.C and Westoff D.C., **"Food Microbiology"**, McGraw Hill, 5th edition, 2013.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Understand the basic constituents of foods and their functional role
CO2: Describe the relationship between food and microorganism that basis for fermentation and preservation
CO3: Explain various preservation and packaging techniques for food product
CO4: Describe the operation principles involved in food processing
CO5: Sketch food quality, safety and regulations

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	L	-	-	-	-	-	-	-	-	-	L	H	L
CO2	H	L	-	-	-	L	-	-	-	-	-	L	H	L
CO3	-	H	-	-	L	-	-	-	-	-	-	L	H	H
CO4	-	H	L	-	L	-	-	-	-	-	-	L	H	H
CO5	-	-	M	-	-	H	L	-	-	-	L	L	M	H
18BPE $04	-	-	-	-	-	H	L	M	-	-	L	L	M	H

L - Low, M-Moderate (Medium), H- High

18BPE$05	MEDICAL BIOTECHNOLOGY

Category: PE

L	T	P	C
3	0	0	3

PRE-REQUISITES:

1. 18BBS302 Microbiology

COURSE OBJECTIVES:

- To understand the classification, diagnosis and therapy of pathogenic infections.
- To understand the concepts of stem cells and tissue engineering.
- To learn the importance of recombinant products and growth factors.

UNIT – I : MEDICALLY IMPORTANT INFECTIOUS ORGANISMS	**(9 Periods)**
Classification of pathogenic microbes; *Leptospira*, *Brucella*, *Bacillus anthraces*; Medical Parasitology: Amoebiasis, Cryptoporidiosis, Giardiasis, Malaria, Toxoplasmosis; Viruses: Adenoviruses, Retroviruses; Medical Mycology: Superfical Mycoses, Subcutaneous Mycoses, Systemic Mycoses.	
UNIT – II : DIAGNOSTICS	**(9 Periods)**
Prenatal diagnosis: Invasive techniques - Amniocentesis, Fetoscopy; Non-invasive techniques – Ultrasonography, X-ray, Diagnosis using protein and enzyme markers, DNA/RNA based diagnosis; Hepatitis, HIV - CD 4 receptor; Microarray technology in cancer diagnosis.	
UNIT – III : MODERN ADVANCES IN THERAPY	**(9 Periods)**
Monoclonal Antibodies: Production, Target drug delivery using monoclonal antibodies; Gene Therapy: types, vectors used in gene therapy; Immunotherapy in cancer; Application of nano biosystems in diagnosis and therapy.	
UNIT – IV : STEM CELL AND TISSUE ENGINEERING	**(9 Periods)**
Embryonic and adult stem cells: Totipotent, pluripotent and multipotent cells: Testing and generation of embryonic stem cells; Potential uses of stem cells: cell based therapies and clinical applications. Biomaterials: Characterization, Host reactions, Extracellular matrix, Scaffolds, Artificial organs, Applications.	
UNIT – V : PHARMACEUTICAL BIOTECHNOLOGY	**(9 Periods)**
Vaccines- Preparation and testing, standardization and storage study; New generation of vaccines: Hepatitis, AIDS, Malaria; Minicells as vaccine; Production of recombinant pharmaceutical products–Biotechnologically derived products (therapeutic proteins): Interferons, Interleukins, Insulin, Growth Hormones; Recombinant coagulation factors and thrombolytic agents, Somatostatin, Somatotropin, Ketopeptide.	

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

TEXT BOOKS:

1. *Judit Pongracz, Mary Keen,* ***"Medical Biotechnology"****, Elsevier Health Sciences, 2009.*
2. *Bernard R. Glick, Terry L. Delovitch, Cheryl L. Patten,* ***"Medical Biotechnology",*** *ASM Press, Washington DC, 2014*

REFERENCE BOOKS:

1. *Albert Sasson ,* ***"Medical biotechnology: achievements, prospects and perceptions",*** *United Nations University Press, 2005.*
2. *Yuan Kun Lee,* ***"Microbial biotechnology: principles and applications",*** *World Scientific, Edition 2006.*

COURSE OUTCOMES:

Upon completion of the course, the students will be able to

CO 1 : Understand the classification, diagnosis and therapy for pathogenic infections.
CO 2 : Exhibit knowledge on recent trends in diagnosis of various disorders.
CO 3 : Learn the production of monoclonal antibodies as diagnostic tools and therapeutic agents.
CO 4 : Exhibit knowledge on stem cells, tissue engineering and gene products.
CO 5 : Learn the types, preparation and testing of vaccines, recombinant products and growth factors

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	L	L	-	-	-	-	L	-	-	-	-	-	L	L
CO2	-	M	L	-	-	L	-	-	-	-	-	L	H	H
CO3	-	M	H	M	-	-	-	-	L	-	-	-	M	H
CO4	-	-	-	-	M	-	L	-	-	-	-	-	M	L
CO5	-	L	-	L	H	-	-	-	-	-	-	-	M	L
18BPE $05	L	M	H	M	H	L	L	-	L	-	-	L	M	L

L – Low, M – Moderate (Medium), H – High

18BPE$06	MARINE BIOTECHNOLOGY

Category: PE

PRE-REQUISITES:
1. 18BBS302- Microbiology
2. 18BMC4Z7– Environmental Sciences and Engineering

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- To learn the basis of marine environment and various applications of marine organisms
- 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 BOOKS:

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, Oxford & IBH Publishing company, 1999.*

REFERENCE BOOKS:

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.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Learn the basic of ocean structure and characteristics
CO2: Explain the marine eco system
CO3: Describe the important microorganism in marine system
CO4: Understand importance of biotechnological solution for marine problems
CO5: Elaborate on various active compounds extract from marine organisms
CO6: Review on basic aqua culture methods

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	-	-	-	-	L	L	-	-	-	-	L	H	H
CO2	L	-	-	-	-	-	L	-	-	-	-	L	M	L
CO3	-	M	-	-	M	L	L	-	-	-	-	L	H	M
CO4	L	-	-	-	-	-	-	-	-	-	-	L	L	L
CO5	L	-	L	-	-	-	-	-	-	-	-	L	L	M
CO6	M	H	-	-	L	-	-	-	L	-	-	L	M	L
18BPE $06	L	M	-	-	L	-	L	-	L	-	-	M	H	-

L - Low, M-Moderate (Medium), H- High

18BPE$07	PLANT BIOTECHNOLOGY

Category: PE

PRE-REQUISITES

1. 18BPC403- Molecular biology
2. 18BPC504- Genetic Engineering

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

* To provide the basics of Agrobacterium and applications of plant biotechnology
* To provide the fundamentals of plant cell culture and offer the knowledge about the micromanipulation and transgenic plants.

UNIT- I : PLANT GENOMES AND PLANT TISSUE CULTURE	**(9 Periods)**
Introduction-gene structure and gene expression-regulation, implication for plant transformation-heterologous promoters, genome size and organization, mitochondrial and chloroplast genome. Plant tissue culture-plasticity and totipotency, culture, environment, growth regulators, media regulators, culture types, plant regeneration.	
UNIT- II : PLANT TRANSFORMATION TECHNIQUES	**(9 Periods)**
Introduction- Agrobacterium mediated gene transfer –Ti-plasmid-process of T-DNA transfer and integration, transformation in plant, Direct gene transfer methods, Binary vectors- basic features of vectors-optimization, clean gene technology, viral vectors- Gemini virus - cauliflower mosaic virus.	
UNIT- III : TRANSGENIC PLANTS-HERBICIDE AND PEST RESISTANCE	**(9 Periods)**
Herbicide resistance-use of herbicide in modern agriculture-strategies for engineering herbicide-resistance. Environmental impact, pest resistance-nature and scale of insect / pest damage to crop-GM strategies- Bt approach to insect resistance-copy nature strategy-insect resistant crops and food safety.	
UNIT- IV : PLANT DISEASE RESISTANCE AND STRESS TOLERANCE	**(9 Periods)**
Introduction-plant-pathogen interactions-natural disease resistance pathways biotechnological approaches to disease resistance. Plant viruses- types-entry and replication transgenic approach-PDR Stress tolerance-abiotic stress-water deficit stress and various approaches for tolerance.	
UNIT- V : MOLECULAR FARMING AND GM CROPS FUTURE PROSPECTS	**(9 Periods)**
Introduction-carbohydrates and lipids production-molecular farming of proteins, economic considerations for molecular farming.GM crops-current status-concerns about GM crops-regulations of GM crops and products-Greener genetic engineering.	

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

TEXT BOOKS

1. *Adrian Slate., Nigel W.Scott.., Mark R.Fowler.,* ***"Plant Biotechnology-The genetic manipulation of plant's"****, Second edition Oxford University Press 2008.*
2. *Ignacimuthu .S., "****Plant Biotechnology****", Oxford and IBH Publishing Co Pvt. Ltd. New Delhi, 2003.*
3. *Singh B.D.,* ***"Text Book of Plant Biotechnology"****, Kalyani Publishers, 1998.*

REFERENCE BOOKS

1. *Heldt H.,* ***"Plant Biochemistry & Molecular Biology",*** *Oxford University Press, 1997.*
2. *Bhojwani S.S., Razdan M.K.* ***"Plant tissue culture: Theory and Practice"****, A revised edition, Elsevier science, 1996.*
3. *Dseke L.J., Kirakosyan A., Kanfman P., Warber S., Duke J.A., Brielmann H.L, "****Natural Products from plants"****, second edition, Taylor and Francis groups, 2006.*
4. *Ignacimuthu.****"Plant Biotechnology",*** *Oxford Publishing co Pvt. Ltd, New Delhi, 1997.*

COURSE OUTCOME

Upon completion of the course, the students will be able to

CO1: Apply the basic concepts of genetic engineering to establish plant tissue culture.
CO2: Gain knowledge about the significance of viral vectors in genetic transformation.
CO3: Understand GM strategies and BT approaches to develop pesticide and herbicide resistance plants.
CO4: Demonstrate plant-pathogen interactions and various approaches for resistances.
CO5: Understand the importance of Molecular Pharming.

COURSE ARTICULATION MATRIX

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	M	-	-	-	-	-	-	-	-	-	-	H	-
CO2	H	M	-	-	-	-	-	-	-	-	-	-	M	-
CO3	H	L	-	-	-	H	-	M	-	-	-	-	M	H
CO4	H	M	-	-	-	-	-	-	-	-	-	-	M	-
CO5	H	M	-	-	-	-	-	-	-	-	-	-	H	-
18BPE $07	H	M	-	-	-	H	-	M	-	-	-	-	H	H

L – Low, M – Moderate, H- High

18BPE$08	CANCER BIOLOGY

Category: PE

L	T	P	C
3	0	0	3

PRE-REQUISITES:

1.18BPC304 Cell Biology
2.18BPC403 Molecular Biology

COURSE OBJECTIVES:

- To gain an appreciation of the complexity of cancer development process in cellular and molecular level.
- To understand the regulatory networks involved in the growth control and tissue organization.
- To understand the current strategies of cancer diagnosis, prevention and treatment.

UNIT – I : FUNDAMENTALS OF CANCER BIOLOGY	**(9 Periods)**
Epidemiology of cancer: Environmental factors, Viruses, Life style habits, Mutations and DNA repair. 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. Signalling Pathways: GPCR, RAS, JAK-STAT, Wnt-β-Catenin, Notch, Hedgehog, Myc, NF-κB. Growth factors related to transformation, Telomerases, Apoptosis: p53.	
UNIT – IV : PRINCIPLES OF CANCER METASTASIS	**(9 Periods)**
Clinical significances of invasion, Three step theory of invasion, Proteinases and tumour 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. Different forms of therapy- Chemotherapy, Radiation therapy, Immunotherapy, Molecular therapy, Use of signal targets towards therapy of cancer; Gene therapy.	

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

TEXT BOOKS:

1. *Stella Pelengaris, Michael Khan,* ***"The Molecular Biology of Cancer"****, Blackwell Publishing 1st edition, 2006.*
2. *Robert A. Weinberg,* ***"The Biology of Cancer",*** *Garland Science, 2nd edition, 2014.*

REFERENCE BOOKS:

1. *R. W. Ruddon, "****Cancer Biology****", Oxford, Oxford University Press, 2007.*
2. *C. Athena Aktipis, Randolph M Nesse,* ***"Evolutionary foundations for cancer biology",*** *Evol Appl. 2013 January; 6(1): 144–159.*

COURSE OUTCOMES:

Upon completion of the course, the students will be able to

CO 1: Understand the epidemiology of carcinogenesis.

CO2: Understand the complex pathways and molecular switches involved in the transformation of a normal cell to a cancer cell.

CO 3: Understand the stages of cancer leading to the movement of cancer cells throughout the body.

CO 4: Develop knowledge on the current strategies of cancer diagnosis and treatment.

CO5: Summarize the importance of understanding cell biology in the study of cancer, its causes, its progression and its treatment

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	L	L	-	-	L	L	-	-	-	-	-	L	L	L
CO2	-	-	-	L	L	-	-	-	-	-	-	-	H	M
CO3	-	-	-	L	L	-	-	-	-			-	L	M
CO4	-	H	-	-	-	M	H	H	H	-	-	-	L	H
CO5	-	M	M	-	-	-	H	L	H	-	-	-	L	H
18BPE $08	L	H	M	L	L	M	H	H	H	-	-	L	L	H

L – Low, M – Moderate (Medium), H – High

18BPE$09	ENVIRONMENTAL BIOTECHNOLOGY

Category: PE

PRE-REQUISITES:

L	T	P	C
3	0	0	3

1. 18BBS302- Microbiology
2. 18BMC4Z7– Environmental Sciences and Engineering

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 : WASTE WATER TREATMENT	**(9 Periods)**
Characteristics of Waste Waters - Physical, chemical and biological; Waste water 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 WASTE WATER MANAGEMENT	**(9 Periods)**
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.	
UNIT – V : DEVELOPMENTS PERTAINING TO ENVIRONMENTAL BIOTECHNOLOGY	**(9 Periods)**
Case studies: Bioleaching and Biomining; Biofertilizers and Biopesticides; Biofuel and Biogas; Bioremediation, Biosensors. Production of bioelectricity from microbial fuel cell (MFC).	

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

TEXT BOOKS:

1. *Bruce E.R & Perry L.M,* ***"Environmental Biotech: Principle & Applications"****, McGraw Hill, 2012.*
2. *Mecalf & Eddy Inc, Tchobanoglous G, Burton F.L, Stensel H.D,* ***"Wastewater Engineering: Treatment Disposal Reuse"****, McGraw Hill, 4th edition, 2002.*
3. *Patwardhan, A.D,* ***"Industrial wastewater treatment"****, PHI learning private limited,2nd edition, 2017.*

REFERENCE BOOKS:

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.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Understand various organism in soil and their roles in ecosystem management
CO2: Gain knowledge on various terms of pollutants and their accumulations
CO3: Review on xenobiotic compounds and their degradation pathway
CO4: Able to explain the characteristics and biological treatment of waste water
CO5: Analyze various industrial waste and their treatment process
CO6: Study on different applications of biotechnology for environmental problems

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	-	-	-	-	-	M	-	-	-	-	L	H	L
CO2	M	-	-	-	-	-	H	-	L	-	-	L	M	L
CO3	M	H	-	-	-	-	H	-	-	-	-	L	H	L
CO4	M	L	L	-	-	-	M	-	-	-	-	L	M	M
CO5	M	L	-	-	-	-	H	-	L	-	-	L	M	M
CO6	-	H		L	L	L	H	-	-	-	-	L	H	M
18BPE $09	M	H	-	-	-	-	H	-	L	-	-	L	H	L

L - Low, M-Moderate (Medium), H- High

18BPE$10	MOLECULAR PATHOGENESIS

Category: PE

L	T	P	C
3	0	0	3

PRE-REQUISITES:

1. 18BPC302-Microbiology
2. 18BPC601-Immunology

COURSE OBJECTIVES:

- To understand the principles of microbial pathogenesis, clinical importance of specific pathogens.
- To inculcate knowledge on recent outbreaks and their disease transmission.
- To 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.	
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 BOOKS:

1. Iglewski B.H and Clark V.L ***"Molecular basis of Bacterial Pathogenesis"****, Academic Press, 1990.*

2. Peter Williams, Julian Ketley & George Salmond, ***"Methods in Microbiology: Bacterial Pathogenesis"****, Vol. 27, Academic Press, 1998.*

3.Talaron K, Talaron A, Casita, Pelczar and Reid, ***"Foundations in Microbiology"****, W.C. Brown Publishers, 1993.*

REFERENCE BOOKS:

1. *Recent reviews in Infect. Immun., Mol. Microbiol., Biochem. J., EMBO 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.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: To understand the basics of microbiology and the discovery.
CO2: To know how to analyze pathological condition in molecular level.
CO3: To acquire knowledge on the pathogenesis of recent outbreaks.
CO4: To learn basic molecular biology and experimental skills.
CO5: To Study the modern approaches to control pathogens.

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	L	M	-	-	L	-	L	-	-	-	-	H	L
CO2	L	-	M	-	L	M	-	-	-	-	-	-	L	M
CO3	H	L	M	-	M	M	-	-	-	-	-	-	M	M
CO4	M	L	L	-	H	L			-	-	-	-	M	H
CO5	L	L	L	-	H	L			-	-	-	-	M	L
18BPE $10	M	L	M	-	H	L		L	-	-	-	-	M	M

L - Low, M-Moderate (Medium), H- High

18BPE$11	NANOBIOTECHNOLOGY

Category: PE

PRE-REQUISITES: NIL

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- To understand the fundamentals of nanotechnology, various form of nanomaterials, its properties and applications.
- To acquire knowledge about various methods of synthesis and characterization of nanoparticles.
- To understand the bionanomachinery in living cells for generating energy, motion, synthesizing biomolecules and to apply the knowledge to design bionanodevices.
- To understand and exploit the nanoparticles in biological applications.

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; Magnetotactic 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- Lipids as nanobricks and mortor- Self assembled monolayers; Nanoscale motors; Ion channel as sensors; DNA based nano-cubes and nano-hinges; Protein based nanomotors- bacteriorhodopsin.	
UNIT – V : BIOMEDICAL APPLICATIONS OF NANOPARTICLES	**(9 Periods)**
Biocompatible In-organic devices (Implant coating- stems and seeds); Chips for molecular diagnostics –DNA microarrays- Protein microarrays- lab on a chip; Nanoparticles for drug delivery; 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 BOOKS:

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.*
3. *Cao, G.,* ***"Nanostructures and Nanomaterials-Synthesis, properties and applications"****, Imperial College Press, 2004.*
4. *de la Fuente, J.M., Grazu, V.,* ***"Nanobiotechnology"****, In: Fronteries in Nanoscience (Vol.4), R.E. Palmer (Ed), Elsevier, 2012.*

REFERENCE BOOKS:

1. *Nicolini, C.,* ***"Nanobiotechnology and Nanobiosciences"****, Pan Stanford, 2008.*
2. *Yoseph, Bar-Cohen,* ***"Biomimetics : Biologically Inspired Technologies"****, CRC Press, 2006.*
3. *Roszek, B., de Jong, W.H., Geertsma, R.E.,* ***"Nanotechnology in medical applications: State-of-the-art in materials and devices"****, 2005.*
4. *Kirkland, A.I., Hutchison, J.L.,* ***"Nanocharacterization"****, RSC Publishing, 2007.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Understand the different types of nanomaterials, its properties and applications.
CO2: Know about biological methods of nanoparticle synthesis
CO3: Characterize the synthesized nanoparticles using different analytical techniques
CO4: Understand the bionanomachinery in living cells to design bionanodevices.
CO5: Acquire knowledge about the biological applications of nanoparticles.

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	M	-	-	-	L	-	-	-	-	-	M	H	M
CO2	M	H	M	-	-	-	L	L	-	-	-	-	H	M
CO3	M	M	-	H	M	-	-	-	-	L	-	-	M	H
CO4	M	L	M	-	-	-	-	-	-	-	-	-	M	H
CO5	M	-	-	-	-	M	-	-	-	-	-	L	M	H
18BPE $11	M	M	M	H	M	M	L	L	-	L	-	M	M	H

L - Low, M-Moderate (Medium), H- High

18BPE$12	ANIMAL BIOTECHNOLOGY

Category: PE

PRE-REQUISITES:
1. 18BBS302- Microbiology
2. 18BPC504- Genetic Engineering
3. 18BPC601- Immunology

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:
- To provide the basics and applications of animal cell culture.
- To inculcate knowledge about the micromanipulation technology and transgenic animal production.

UNIT – I : ANIMAL CELL CULTURE	**(9 Periods)**
Introduction to basic tissue culture techniques, Equipment and instruments in ATC - Chemically defined and Serum free media - Animal cell cultures - Maintenance and preservation - Various types of cultures; Suspension cultures – Continuous flow cultures – Immobilized cultures - Somatic cell fusion - Organ cultures.	
UNIT - II: ANIMAL DISEASES AND THEIR DIAGNOSIS	**(9 Periods)**
Bacterial and viral diseases in animals - Monoclonal antibodies – Diagnosis - Molecular diagnostic techniques; PCR - *in-situ* hybridization - Northern blotting, Southern blotting, RFLP.	
UNIT – III : THERAPY OF ANIMAL DISEASES	**(9 Periods)**
Recombinant cytokines – Therapeutic applications of monoclonal antibody, Vaccines - DNA, sub unit, cocktail vaccines - Gene therapy for animal diseases.	
UNIT – IV : MICROMANIPULATION OF EMBRYO	**(9 Periods)**
Micromanipulation technology - Equipment - Enrichment of x and y bearing sperms from semen samples – Artificial insemination - Germ cell manipulations – *In vitro* fertilization -Embryo transfer - Micromanipulation technology and breeding of farm animals.	
UNIT – V : TRANSGENIC ANIMALS	**(9 Periods)**
Concepts of transgenic animal technology; Strategies for the production of transgenic and knock out animals– significance in biotechnology - Stem cell cultures in production of transgenic animals.	

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

TEXT BOOKS:

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.*
3. *Sasidhara.R,* ***"Animal Biotechnology"****, MJP Publishers, 2009.*

REFERENCE BOOKS:

1. *Ashish S.Varma and Anchal singh,* ***"Animal biotechnology-Models in Discovery and Translation"****, Elsevier publication, 2014.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

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 beimplemented in field of veterinary science.

CO2: Perceive and deduce the contemplative ethical problems subjective to testing protocols involving animals**.**

CO3: Demonstrate various diagnostic and therapeutic techniques for the identification and curing of animal diseases.

CO4: Reckon and utilize the concept of gamete and embryo manipulation technology for the production of transgenic animals and cloning.

CO5: Acquire knowledge about the concept of transgenic animal production and its significance in biotechnology.

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	L	H	-	-	-	-	-	-	-	-	-	-	H	L
CO2	-	-	-	-	-	M	-	H	-	-	-	-	L	H
CO3	M	H	M	-	-	-	-	-	-	-	-	-	M	M
CO4	M	M	M	-	-	L	-	M	-	-	-	-	H	M
CO5	H	M	M	-	-	L	M	M	-	-	-	-	H	L
18BPE $12	M	H	M	-	-	L	M	M	-	-	-	-	H	M

L - Low, M-Moderate (Medium), H- High

18BPE$13	GENOMICS AND PROTEOMICS

Category: PE

L	T	P	C
3	0	0	3

PRE-REQUISITES:

1. 18BPC304 Cell Biology
2. 18BPC403 Molecular Biology
3. 18BPC504 Genetic Engineering

COURSE OBJECTIVES:

- Provide basic knowledge of genomes and proteomes.
- Introduce relevant tools for the analysis of genomes.
- Describe methodologies of genomic and proteomic techniques.

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, Human genome project, Introduction to functional and comparative genomics.	
UNIT – II : PHYSICAL MAPPING TECHNIQUES	**(9 Periods)**
Cytogenetic mapping, Radiation hybrid mapping, Fish-STS mapping, SNP mapping, Optical mapping. Top down and bottom up approach, Linking and jumping of clones, Gap closure, Pooling strategies, 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, Subtractive DNA library screening, Differential display and representational difference analysis, SAGE.	
UNIT – IV : PROTEOMICS TECHNIQUES	**(9 Periods)**
Protein level estimation-Edman protein microsequencing, Protein cleavage, 2D gelelectrophoresis, 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)**
Post translational modification, Protein-protein interactions, Glycoprotein analysis, Phosphoprotein analysis.	

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

TEXT BOOKS:

1. *R.M.Twyman, S.B. Primrose,* ***"Principle of Genome Analysis and Genomics"****, Wiley Blackwell Publications, 2007.*
2. *T.A Brown,* ***"Introduction to Genetic: A molecular Approach"****, Garland Science, Taylor and Francis, 2012.*

REFERENCE BOOKS:

1. *Liebler,* ***"Introduction to Proteomics"****, Humana Press, 2002*
2. *T.W. Veenstra, Tates III Jr,* ***"Proteomics for Biological Discovery"****, Wiley Publications, 2006.*

COURSE OUTCOMES:

Upon completion of the course, the students will be able to

CO1: Understand the basic structure and organization of genomes of Prokaryotes

CO2: Understand the basic structure and organization of genomes of Eukaryotes

CO3: Have insight on basic organization of proteomes.

CO4: Analyze proteomes and genomes using the relevant tools.

CO5: Get familiarize with the principles of the methodologies of genomic and proteomic technique.

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	-	-	-	-	-	-	-	-	-	-	-	H	L
CO2	H	-	-	-	-	-	-	-	-	-	-	-	H	L
CO3	H	-	-	-	-	-	-	-	-	-	-	-	H	L
CO4	M	H	H	-	H	-	-	-	-	-	-	-	L	H
CO5	M	H	M	-	H	-	-	-	-	-	-	M	L	H
18BPE $13	H	H	H	-	H	-	-	-	-	-	-	M	H	L

L – Low, M – Moderate (Medium), H – High

18BPE$14	MATHEMATICAL AND NUMERICAL METHODS FOR BIOTECHNOLOGY

Category: PE

PRE-REQUISITES: NIL

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- This course introduces a range of numerical methods for the approximate solution of mathematical equations encountered in biochemical engineering.
- The methods are introduced in a problem specific context, such as Bioprocess engineering, Heat and Mass transfer and chemical reaction engineering.

UNIT I	APPROXIMATIONS AND ERRORS & SOLUTION OF ALGEBRAIC EQUATIONS	(9 Periods)
Types of Errors, Significant figures, Accuracy of Numbers, Precision, Error Propagation, Applications in Biochemical Engineering, Basic Properties of Equations, Relations between Roots and Coefficients, Descartes Rule of Sign, Synthetic Division of a Polynomial by a Linear Expression, Bracketing Methods (Bisection, Secant, Method of False Position or Regula Falsi, etc.), Convergence of Iterative Methods, Newton-Raphson Method, Newton-Raphson Method for Non Linear Equations in Two Variables.		
UNIT II	**SOLUTION OF LINEAR EQUATIONS**	**(9 Periods)**
Mathematical Background, Matrix inversion, Gauss Elimination, Gauss-Jordan Method, Gauss-Seidel Iteration Method, Jacobi's Method, Gauss-Seidel Method, Eigen Value Problem.		
UNIT III	**CURVE FITTING &FINITE DIFFERENCES & INTERPOLATION**	**(9 Periods)**
Method of Least Squares, Fitting a Straight Line and a Polynomial, Fitting a Non-linear Function, Finite Differences: Forward, Backward and Divided Differences Table, Central Differences, Newton's Forward, Backward and Divided Differences Interpolation Formula, Interpolation Polynomials, Lagrange Interpolation Formula, Inverse Interpolation,		
UNIT IV	**NUMERICAL DIFFERENTIATION & INTEGRATION**	**(9 Periods)**
Differentiation Formula based on Tabulator at Equal and Unequal Intervals, Newton-Cotes Integration Formulas, Trapezoidal Rule and Simpson's 1/3 and 3/8 Rule.		
UNIT V	**ORDINARY DIFFERENTIAL EQUATIONS**	**(9 Periods)**
Taylor's Series and Euler's Method, Modifications and Improvements in Euler's Method, Runge - Kutta 2nd Order & 4th Order Methods, Boundary Value Problems, Applications in Biochemical Engineering		

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

TEXT BOOKS:

1. *Jain, M.K, Iyengar S.R.K and Jain R.K,* ***"Numerical Methods for Scientific and Engineering Computation"****, New Age International Publishers, 2007.*
2. *Pushpavanam S,* ***"Mathematical Methods in Chemical Engineering"****, Prentice Hall of India, 1998.*
3. *Alkis Constantinicles,* ***"Numerical methods for chemical and Bioprocess engineers with MAT LAB applications"****,Prentice Hall India, 2002.*

REFERENCE BOOKS:

1. *W. L. Luyben,* ***"Process Modeling, Simulation and control for chemical engineers"****, McGraw Hill, 1990.*
2. *B.W. Bequette,* ***"Process control modeling, Design and Simulation"****, Prentice Hall India, 2003.*

COURSE OUTCOMES

Upon completion of the course the graduates will be able to

CO1: Formulate a chemical engineering problem as a mathematical model, and select an appropriate solution method.
CO2: Analyze the accuracy of the numerical solution and identify alternate strategies and methods to achieve greater accuracy when it is needed.
CO3: Understand the basic algorithms for fitting curves to data.
CO4: Understand the basic algorithms for solution of and be able to solve numerical integration problems.
CO5: Select the appropriate software package to perform the numerical solution to a biochemical engineering problem.

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1		H	H	L	M							L	H	L
CO2	M	M		H			L	L	M	L	L	H	H	L
CO3	M	L	H	L	M	M						M	L	H
CO4	L	H	H	L	M		H	M				L	H	M
CO5	L	H			M				L	M	L	H	L	M
18BPE $14	M	H	H	L	M	M	H	M	M	M	L	H	H	M

L- Low , M-Moderate(Medium), H- High

18BPE$15	BIOENTREPRENEURSHIP

Category: PE

PRE-REQUISITES:

1. 18BHS201- Communicative English
2. 18BHS507- Business Communication Skills

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- To enable the students to get familiarize with the different sources of opportunities and development of the skills to identify and analyze these opportunities for entrepreneurship and innovation.
- To develop entrepreneurial skills with an understanding of finance management, marketing strategies and ethical and legal issues related various business affairs.

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, Bio entrepreneur	
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 : PROJECT PLANNING	**(9 Periods)**
Start-up Idea, Customers, Competitors, Resources, Technology, Planning, People, Writing business proposal, Checklist for business proposal writing.	
UNIT – IV : BIOBUSINESS DEVELOPMENT	**(9 Periods)**
Location selection for business set up, Marketing Strategy, Financial management, Staff appointment and Management, Business Protection and Insurance- importance, Record Keeping and Accounting.	
UNIT – V : LEGAL, ETHICAL AND SOCIAL OBLIGATIONS	**(9 Periods)**
Legal, Ethical and Social issues involved in bio business management, Growth in Today's Marketplace**,** Case studies on real bio entrepreneurs- reason for success and failures.	

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

TEXT BOOKS:

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.*

REFERENCE BOOKS:

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.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO 1: Develop an ability to communicate effectively, inculcate entrepreneurial skills leading to innovation and risk management.
CO2: Demonstrate an ability to grab business opportunity and to gain support from various funding sources for the venture.
CO3: Propose and develop appropriate business plan with an understanding of local and global business environment.
CO4: Understand the priority of business protection and to find an attractive market that can be reached economically.
CO5: Utilise critical thinking skills and apply ethical and legal understanding to business situations.

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	-	-	-	-	-	-	M	L	M	H	M	L	-	H
CO2	-	-	-	-	-	-	H	L	L	M	M	L	-	H
CO3	-	-	-	-	-	M	M	M	L	M	H	M	-	H
CO4	-	-	-	-	-	M	M	-	-	L	H	M	-	H
CO5	-	-	-	-	-	H	H	H	-	L	M	M	-	H
18BPE $15	-	-	-	-	-	M	H	L	-	-	H	H	-	H

L - Low, M-Moderate (Medium), H- High

18BPE$16	IMMUNOTECHNOLOGY

Category: PE

PRE-REQUISITES:
1. 18BPC601 Immunology

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

1. To find therapeutical solutions to health problems based on immunological principles
2. To demonstrate use of various diagnostic kits to identify antigens at cellular and tissue levels
3. To develop strategies to produce engineered immune molecules.

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 : ASSESMENT 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 BOOKS:

*1.Talwar G.P., and Gupta S.K., **"A hand book of practical and clinical immunology"**, vol. 1 & 2, CBS Publications,1992.*

*2. MRoitt I., Male., Brostoff, **"Immunology"**, Mosby Publ., 12th edition, 2002.*

*3. Rose, N.R., Hamilton, R.G. and Detrick, B, **"Manual of Clinical laboratory Immunology"**, 6th edition., ASM Press, Washington DC, 2002.*

REFERENCE BOOKS:

1. *Chakaravarthy A.K.,* ***"Immunology and Immunotechnology"****, Oxford University Press Indid, 1st edition, 2006.*
2. *Goldsby R.A., Kindt T.J., Osbome B.A. and Kuby J.* ***"Immunology"****, 5th edition, W.H. Freeman,2003*
3. *Weir D.M. and Stewart J,* ***"Immunology"****, 8th edition, Cheerchill, Linvstone, 1997.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Describe the preparation and use of antigens
CO2: Demonstrate various diagnostic methods based on antigen-antibody interactions
CO3: Critically analyze and assess health problems with immunological background
CO4: Outline the state of pathogenesis of infectious diseases at cellular and tissue level based on immunopathology
CO5: Define strategies for the production of engineered antibodies and design of vaccines.

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	L	-	-	L	-	-	-	-	-	L	-	M	L
CO2	L	M	H	-	M	L	-	L	M	M	L	M	M	M
CO3	L	L	-	-	-	-	-	-	-	M	-	-	L	H
CO4	L	M	-	-	L	L	M	-	-	M	L	-	M	H
CO5	L	M	H	L	M	H	-	-	L	M	H	M	M	M
18BPE $16	L	M	H	L	M	L	M	L	M	M	L	M	M	H

L - Low, M-Moderate (Medium), H- High

18BPE$17	BIOPHARMACEUTICAL TECHNOLOGY

Category: PE

L	T	P	C
3	0	0	3

PRE-REQUISITES: NIL

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.	
UNIT – II : DRUG ACTION, METABOLISM AND PHARMACOKINETICS	**(9 Periods)**
Mechanism of drug action, physico-chemical principles of drug metabolism, barriers to distribution of drugs, pharmacokinetics. (ADME), pharmacokinetics - Zero, First, Second order reactions, compartment modeling, kinetics of protein – drug binding, bioavailability and bioequivalence, Biotransformation of drugs, 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; Parenterals), 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. *Remington's,* ***"Pharmaceutical Sciences"*** *Mark publishing.*
3. *Leon Lachman et al,* ***"Theory and Practice of Industrial Pharmacy"****, Lea and Febiger, 3 Edition,1986.*

REFERENCE BOOKS:

1. *Gareth Thomas.* ***"Medicinal Chemistry"****. An introduction. John Wiley. 2000.*
2. *Katzung B.G.* ***"Basic and Clinical Pharmacology"****, Prentice Hall of Intl. 1995.*
3. *Leon Lachman et al,* ***"Theory and Practice of Industrial Pharmacy"****, 3 Edition, Lea and Febiger, 1986.*
4. *Brahmankar D M, Jaiswal S B,* ***"Biopharmaceutics and Pharmacokinetics A Treatise"****, Vallabh Publisher, (2008)*

COURSE OUTCOMES

Upon completion of the course in Biopharmaceutical Technology graduates will be able to
CO1: Perceive the pharmacological terms and drug development and its regulation.
CO2: Interpret the basic concepts of pharmacokinetics and drug metabolism.
CO3: Understand the forms of dosage, packing and contaminant analysis.
CO4: Enlighten the process involved in bulk drug manufacturing.
CO5: Discuss novel methods for production and delivery of biopharmaceuticals.

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	L	L	M	L	H	L	-	-	M	-	L	H	H	L
CO2	L	H	L	-	L	L	-	-	H	-	L	-	L	H
CO3	-	H	H	L	M	-	-	-	-	-	M	L	L	H
CO4	L	L	-	-	H	-	-	-	M	-	M	M	H	L
CO5	L	H	H	L	M	M	-	-	H	-	L	L	L	M
18BPE $17	L	H	H	L	M	L	-	-	H	-	L	L	L	H

L - Low, M-Moderate (Medium), H – High

18BPE$18	BIOPROCESS ECONOMICS AND PLANT DESIGN

Category: PE

PRE-REQUISITES:

1. 18BES502- Mass Transfer Operations
2. 18BPC603- Bioprocess Engineering

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- To understand the basic engineering fundamentals that include process selection, design and flow sheet preparation for the particular bioprocess plant
- To develop knowledge to select plant location, layout, utilities and safety considerations that will help in installation procedures of new process plants
- To understand the basic concepts of cost estimation and profitability analysis of bioprocess 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- 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 other factors affecting investment and production costs; 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 purchased costs – inflation – rapid and factorial method of cost estimation, Lang factors; plant overheads; Administration- safety and other auxiliary services - payroll overheads- warehouse and storage facilities etc.	
UNIT – V : ECONOMIC EVALUATION OF PROJECTS	**(9 Periods)**
Cash flow diagrams – tax depreciation – discounted cash flow – rate of return – payback time-sensitivity analysis; 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 BOOKS:

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.*
3. *Sinnott.R.K.,* ***"Coulson & Richardson's Chemical Engineering, Series Vol-6"****, 2nd Edition, Butterworth Heinemann, 2005.*
4. *Peters, M., Timmerhaus,K., West,R.,* ***"Plant Design and Economics for Chemical Engineers"****, 5th Edition , McGraw Hill, 2003.*

REFERENCE BOOKS:

1. *Backhurst, J.R., Harker, J.H.,* ***"Process Plant Design"****, Butterworth-Heinemann, 2013.*
2. *Baasal, W.D.,* ***"Preliminary Chemical Engineering Plant Design"****, Springer, 1989.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Understand the basics engineering fundamentals for project development and process design.
CO2: Design process equipment and consider safety, operability and other design constraints in bioprocess plant design.
CO3: Develop knowledge to select plant location, layout and utilities for new process plants.
CO4: Calculate capital investment and operating costs for process plants.
CO5: Understand the basic concepts of cost estimation and profitability analysis.

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	M	H	-	L	L	L	L	L	L	L	M	H	L
CO2	M	M	H	M	M	-	-	-	-	-	-	-	M	M
CO3	M	-	-	-	-	-	L	-	-	-	L	-	L	H
CO4	M	M	-	-	M	-	-	-	-	-	-	-	M	H
CO5	M	M	-	-	M	-	-	-	-	-	M	-	M	H
18BPE $18	M	M	H	M	M	L	L	L	L	L	L	M	M	H

L - Low, M-Moderate (Medium), H- High

18BPE$19	TISSUE ENGINEERING

Category: PE

PRE-REQUISITES: NIL

L	T	P	C
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 BOOKS:

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.*

REFERENCE BOOKS:

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 Biology"****, 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.*
6. *Naggy N. Habib, M.Y. Levicar, , L. G. Jiao,.and N. Fisk,* ***"Stem Cell Repair and Regeneration"****, volume-2, Imperial College Press,2007.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Ability to understand the components of the tissue architecture.

CO2: Opportunity to get familiarized with the stem cell characteristics and their relevance in medicine.

CO3: Awareness about the properties and broad applications of biomaterials.

CO4: Overall exposure to the role of tissue engineering and stem cell therapy in Organogenesis.

CO5: Understand the role of tissue engineering and materials in clinical applications.

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	L	-	-	-	-	L	M	M	M	M	-	M	H	L
CO2	L	M	-	-	-	L	M	M	M	M	-	M	H	L
CO3	H	L	-	-	-	M	H	M	M	M	-	M	H	M
CO4	M	L	-	-	-	-	H	M	M	M	-	M	H	L
CO5	M	-	H	M	M	H	H	H	H	M	-	M	H	H
18BPE $19	M	-	M	-	-	H	M	M	L	M	-	M	H	L

L - Low, M-Moderate (Medium), H- High

18BPE$20	METABOLIC ENGINEERING

Category: PE

L	T	P	C
3	0	0	3

PRE-REQUISITES: NIL

COURSE OBJECTIVES:

- To provide a quantitative basis, based on thermodynamics, enzyme kinetics, for the understanding of metabolic networks in single cells and at the organ level.
- To enable the students to use organisms to produce valuable substances on an industrial scale in cost effective manner.

UNIT – I : INTRODUCTION TO EXAMPLES OF PATHWAY MANIPULATION - QUALITATIVE TREATMENT	**(9 Periods)**
Enhancement of Product Yield and Productivity, Extension of substrate Range, Extension of Product spectrum and Novel products, Improvement of Cellular properties, Xenobiotic degradation.	
UNIT – II : MATERIAL BALANCES AND DATA CONSISTENCY	**(9 Periods)**
Comprehensive models of cellular reactions; stoichiometry of cellular reactions, reaction rates, dynamic mass balances, yield coefficients and linear rate equations, analysis of over determined systems- identification of gross measurement errors. Introduction to MATLAB®	
UNIT – III : METABOLIC FLUX ANALYSIS	**(9 Periods)**
Theory, over determined systems, underdetermined systems- linear programming, sensitivity analysis, methods for the experimental determination of metabolic fluxes by isotope labeling, applications of metabolic flux analysis.	
UNIT – IV : METABOLIC CONTROL ANALYSIS	**(9 Periods)**
Fundamentals of Metabolic Control Analysis, control coefficients and the summation theorems, Determination of flux control coefficients, MCA of linear pathways, branched pathways, theory of large deviations	
UNIT – V : ANALYSIS OF METABOLIC NETWORKS	**(9 Periods)**
Control of flux distribution at a single branch point, Grouping of reactions, case studies, extension of control analysis to intermetabolite, optimization of flux amplifications, consistency tests and experimental validation.	

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

TEXT BOOKS:

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*
3. *Nielsen J and Villadsen J. (1994),* ***"Bioreaction Engineering Principles"****, New york: Plenum Press.*

REFERENCE BOOKS:

1. ***"Computational Analysis of Biochemical Systems: A Practical Guide for Biochemists and Molecular Biologists"*** *by Eberhard O. Voit Cambridge University Press 2000.*
2. *"Applications of Plant Metabolic Engineering", R. Verpoorte, A. W. Alfermann and T. S. Johnson (eds). 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.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: To learn stoichiometry and energetics of metabolism.

CO2: To apply practical applications of metabolic engineering in chemical, energy, medical and environmental fields.

CO3: To integrate modern biology with engineering principles.

CO4: To design a system, component, or process to meet desired needs.

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	L	-	-	-	-	L	M	M	M	M	-	M	H	L
CO2	L	M	-	-	-	L	M	M	M	M	-	M	H	L
CO3	H	L	-	-	-	M	H	M	M	M	-	M	H	M
CO4	M	L	-	-	-	-	H	M	M	M	-	M	H	L
18BPE $20	M	-	M	-	-	H	M	M	L	M	-	M	H	L

L - Low, M-Moderate (Medium), H- High

18BPE$21	PROTEIN ENGINEERING

Category: PE

PRE-REQUISITES:

1. 18BPC305 -Biochemistry

L	T	P	C
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 of protein 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- Modular nature and formation of complexes.	
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 T_4-lysozyme, recombinant insulin to reduce aggregation and inactivation, de novo protein design – principles and examples.	

Contact Periods:

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

TEXT BOOKS:

1. *Voet D. and Voet G, **"Biochemistry"**, John Wiley and Sons, Third edition,2001.*
2. *Branden C. and Tooze, **"Introduction to Protein Structure"**, Second Edition, Garland Publishing, NY, USA, 1999.*
3. *Creighton T.E, **"Proteins"**, Second Edition, Freeman WH publishers, 1993.*

REFERENCE BOOKS:

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. *Moody P.C.E. and Wilkinson A.J., **"Protein Engineering"**, IRL Press, Oxford, UK, 1990.*

COURSE OUTCOMES:

Upon completion of the course the students will be able to
CO1: Acquire knowledge about the bonds and energies in protein and elucidation of protein structure.
CO2: Understand the basics of post translational modification and peptide analysis.
CO3: Understand the architecture of proteins
CO4: Elucidate the structure function relationship of proteins
CO5: Understand the basics and steps involved in protein engineering

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	L		L	M								M	L
CO2	L	L			H		L					L		M
CO3	M	L								L			M	L
CO4	H	L				L							M	
CO5		L	L	M	L									M
18BPE $21	M	L	L	M	H	L	L			L		L	M	M

L - Low, M-Moderate (Medium), H- High

18BPE$22	PHARMACOGENOMICS

Category: PE

PRE-REQUISITES: NIL

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

* The course intends to provide knowledge about pharmacogenomics and drug design using genomic applications for drug action and toxicity.
* To understand how individualization of drug therapy can be achieved based on a person's genetic makeup while reducing unwanted drug effects.

UNIT – I : PHARMACOGENOMICS AND PERSONALIZED MEDICINE	**(9 Periods)**
Pharmacogenetics- Roots of pharmacogenomics and it is not just pharmacogenomics, Genetic drug response profiles, the effect of drugs on Gene expression, pharmacogenomics in drug discovery and drug development. Concept of individualized drug therapy, Drivers and the promise of personalized medicine, Strategies for application of pharmacogenomics to customize therapy, Barriers.	
UNIT – II : HUMAN GENOME	**(9 Periods)**
Expressed sequence Tags (EST) and computational biology, Microbial genomics, computational analysis of whole genomes, computational genome analysis, Genomic differences that affect the outcome of host pathogen interactions, 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, Multiple inherited genetic factors influence the outcome of drug treatments, Association studies in pharmacogenomics, Strategies for pharmacogenomics Association studies, Benefits of Pharmacogenomics in Drug R & D.	
UNIT – IV : GENOMICS APPLICATIONS FOR DRUG ACTION, TOXICITY AND DESIGN	**(9 Periods)**
Platform technologies and Pharmaceutical process, its applications to the pharmaceutical industry, Understanding biology and diseases, Target identification and validation, Drug candidate identification and optimization, safety and toxicology studies. 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.	
UNIT – V : PHARMACOGENOMICS – CASE STUDIES	**(9 Periods)**
Study of pharmacogenomics of human P-Glycoprotein, drug transporters, lipid lowering drugs, chemotherapeutic agents for cancer treatment.	

TEXT BOOKS

1. *Russ B. Altman , David Flockhart , David B. Goldstein,* ***"Principles of Pharmacogenetics and Pharmacogenomics"****, Cambridge University Press; 1 edition.*

COURSE OUTCOMES:

Upon completion of the course the students will be able to

CO1: Distinguish the effect of genetic differences between individuals in the outcome of drug therapy and in drug efficacy and toxicity.

CO2: Describe the role of single nucleotide polymorphism as a biomarker for the prediction of risk, therapeutic response and prognosis of malignancies.

CO3: Understand the role of the protein structural techniques in drug identification

CO4: Utilize and manage the new genomics based tools as they become available as well as make best treatment choices.

CO5: Understand the concept of personalized medicines and the possible applicability.

COURSE ARTICULATION MATRIX:

CO	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	M	L		L	M								M	L
CO2	L	L			H		L					L		M
CO3	M	L								L			M	L
CO4	H	L				L							M	
CO5		L	L	M	L									M
18BPE $22	M	L	L	M	H	L	L			L		L	M	M

L - Low, M-Moderate (Medium), H- High

18BPE$23	GENETICS

Category: PE

PRE-REQUISITES: NIL

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

1. To give an understanding on the fundamentals of conventional genetics and its relevance in disease and therapy.
2. To describe various genetic laws, learn the chromosome structure function and understand methodologies for cytogenetic applications.

UNIT – I: BACTERIAL GENETICS	**(9 Periods)**
Transformation, Transduction, Conjugation – mapping, fine structure in merozygotes- plasmids and episomes.	
UNIT – II : CLASSICAL GENETICS	**(9 Periods)**
Mendel's Principles and experiments, segregation, mutiple 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, 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, non random mating, population analysis, Models for population genetics. Mutation and Migration size, Genetic variation and Sociobiology.	
UNIT – V : GENETIC DISEASES	**(9 Periods)**
Inborn errors of metabolism, Sickle cell, 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 BOOKS:

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, 2001.*

REFERENCE BOOKS:

1. *Gardner, E.J, Simmons, M.J, and Snustad, D.P.,* ***"Principles of Genetics"****, 8th Edition, JohnWiley & Sons, Singapore, 2003.*
2. *Strickberger, M.W.,* ***"Genetics"****, 3rd Edition, Prentice Hall of India, New Delhi, 2008.*

3. *Klug, W.S. and Cummings, M.R.,* ***"Concepts of Genetics"****, Pearson Education, New Delhi, 2003.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: To give an understanding on the fundamentals of conventional genetics and its relevance in disease and therapy.

CO2: To describe various genetic laws, learn the chromosome structure function and understand methodologies for cytogenetic applications.

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	L	-	-	L	-	-	-	-	-	L	-	H	L
CO2	L	M	H	-	M	L	-	L	M	M	L	M	L	M
18BPE $23	L	M	H	L	M	L	M	L	M	M	L	M	H	L

L - Low, M - Moderate (Medium), H - High

18BPE$24	BIOSTATISTICS

Category: PE

PRE-REQUISITES: NIL

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- Understand the role of biostatistics in public health or medical studies
- Use descriptive tools to summarize and display data from public health or medical studies;
- Understand the principles of various study designs, and explain their advantages and limitations;
- Identify appropriate tests to perform hypothesis testing, and interpret the outputs adequately;
- Differentiate between quantitative problems from public health or medical studies that can be addressed by statistical tools.

UNIT – I: INTORDUCTION TO BIOSTATISTICS	**(9 Periods)**
Measure of location, properties of arithmetic mean, measure of spread, coefficient of variation, grouped data, graphic methods.	
UNIT – II : PROBABILITY AND PROBABILITY DISTRIBUTIONS	**(9 Periods)**
Definition of probability, multiplication law, addition law, conditional probability, Baye‟s rule, prevalence and incidence. Discrete probability distribution: Random variables, probability mass function, expected value, variance, cumulative distribution function, binomial and Poisson distributions. Continuous probability distribution: Probability density function, expectation, normal distribution, linear combinations of random variables.	
UNIT – III : STATISTICAL ESTIMATION	**(9 Periods)**
Relationship between population and sample. Estimation of the Mean and variance of a distribution: point estimation, standard error of the mean, central limit theorem, interval estimation.	
UNIT – IV : TESTING OF HYPOTHESIS	**(9 Periods)**
One-sample inference: Introduction, general concepts, test for mean of a normal distribution – one sided, two sided alternatives, the power of a test, sample size determination. Two-sample inference: Paired t- test, comparison of means from two paired samples, t-test for two independent samples with equal variances, testing for equality of two variances, t-test for independent samples with unequal variances. Chi-square test for independence of attributes and goodness of fit.	
UNIT – V : REGRESSION CORRELATION	**(9 Periods)**
General concepts, fitting regression lines- method of least squares, inferences about parameters, goodness of fit, simple correlation.	

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

TEXT BOOKS:

1. *Bernard Rosner,* ***"Fundamental of Biostatistics"****, Duxbury Thomson Learning, New York, 2006.*
2. *Richard I Levin and David. S. Rubin,* ***"Statistics for Management"****, Pearson Education, New Delhi, 2009.*

REFERENCE BOOKS:

1. *Ronald N Forthofer, Eun Sul Lee,* ***"Introduction to Biostatistics – A Guide to Design, Analysis and Discovery"****, Academic Press, New York, 2006.*
2. *Glantz SA.,* ***"Primer of Biostatistics"****, McGraw Hill, New York, 1997.*
3. *Zar JH.,* ***"Biostatistical Analysis"****, Pearson Education, New Delhi, 2003.*
4. *Sundar Rao PSS, Richard J,* ***"An Introduction to Biostatistics. A model for students in health sciences"****, Prentice Hall, New Delhi, 2006.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Understand the role of biostatistics in public health or medical studies
CO2: Use descriptive tools to summarize and display data from public health or medical studies;
CO3: Understand the principles of various study designs, and explain their advantages and limitations;
CO4: Identify appropriate tests to perform hypothesis testing, and interpret the outputs adequately;
CO5: Differentiate between quantitative problems from public health or medical studies that can be addressed by statistical tools.

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	L	-	-	L	-	-	-	-	-	L	-	H	L
CO2	L	M	H	-	M	L	-	L	M	M	L	M	L	M
CO3	L	M	H	L	M	L	M	L	M	M	L	M	H	L
CO4	L	M	-	L	M	L	M	M	M	M	L	M	H	L
CO5	L	M	H	L	M	L	M	L	M	M	L	M	H	L
18BPE $24	L	M	H	L	M	L	M	L	M	M	L	M	H	L

L - Low, M - Moderate (Medium), H – High

18COE$01	CLIMATE CHANGE AND ADAPTATION *(Common to All Branches)*

Category : OE

L	T	P	C
3	0	0	3

PRE-REQUISITES: NIL

COURSE OBJECTIVES:

- Able get knowledge about Climate system and its changes and causes
- Able to learn about impacts, adaptation and mitigation of climate change
- Able to learn about clean technology and clean energy

UNIT – I : EARTH'S CLIMATE SYSTEM	**(9 Periods)**
Introduction-Climate in the spotlight - The Earth's Climate Machine – Climate Classification - Global Wind Systems – Trade Winds and the Hadley Cell – The Westerlies - Cloud Formation and Monsoon Rains – Storms and Hurricanes - The Hydrological Cycle – Global Ocean Circulation – El Nino and its Effect - Solar Radiation – The Earth's Natural Green House Effect – Green House Gases and Global Warming – Carbon Cycle.	
UNIT – II : OBSERVED CHANGES AND ITS CAUSES	**(9 Periods)**
Observation of Climate Change – Changes in patterns of temperature, precipitation and sea level rise – Observed effects of Climate Changes – Patterns of Large Scale Variability – Drivers of Climate Change – Climate Sensitivity and Feedbacks – The Montreal Protocol – UNFCCC – IPCC – Evidences of Changes in Climate and Environment – on a Global Scale and in India – climate change modeling.	
UNIT – III : IMPACTS OF CLIMATE CHANGE	**(9 Periods)**
Impacts of Climate Change on various sectors – Agriculture, Forestry and Ecosystem – Water Resources – Human Health – Industry, Settlement and Society – Methods and Scenarios – Projected Impacts for Different Regions – Uncertainties in the Projected Impacts of Climate Change – Risk of Irreversible Changes.	
UNIT – IV : CLIMATE CHANGE ADAPTATION AND MITIGATION MEASURES	**(9 Periods)**
Adaptation Strategy/Options in various sectors – Water – Agriculture –- Infrastructure and Settlement including coastal zones – Human Health – Tourism – Transport – Energy – Key Mitigation Technologies and Practices – Energy Supply – Transport – Buildings – Industry – Agriculture – Forestry - Carbon sequestration – Carbon capture and storage (CCS) - Waste (MSW & Bio waste, Biomedical, Industrial waste – International and Regional cooperation.	
UNIT – V : CLEAN TECHNOLOGY AND ENERGY	**(9 Periods)**
Clean Development Mechanism – Carbon Trading - examples of future Clean Technology – Biodiesel – Natural Compost – Eco- Friendly Plastic – Alternate Energy – Hydrogen – Bio-fuels – Solar Energy – Wind – Hydroelectric Power – Mitigation Efforts in India and Adaptation funding.	

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

TEXT BOOKS:

1 *Jan C. van Dam,* ***"Impacts of Climate Change and Climate Variability on Hydrological Regimes"****, Cambridge University Press, 2009.*
2 *Bates, B.C., Z.W. Kundzewicz, S. Wu and J.P. Palutikof, Eds.,* ***"Climate Change and Water"****. Technical Paper of the Intergovernmental Panel on Climate Change, IPCC Secretariat, Geneva, 2008.*
3 *Dash Sushil Kumar,* ***"Climate Change – An Indian Perspective"****, Cambridge University Press India Pvt. Ltd, 2007.*
4 *IPCC Report Technical paper VI – Climate change and Water, 2008.*

REFERENCE BOOKS:

1 *IPCC fourth assessment report - The AR4 synthesis report, 2007*
2 *IPCC fourth assessment report –Working Group I Report, " The physical Science Basis",2007*
3 *IPCC fourth assessment report - Working Group II Report,* ***"Impacts, Adaptation and Vulnerability"****, 2007*
4 *Climate change 2014: Impacts, Adaptation and Vulnerability, IPCC*
5 *Climate change 2013: The Physical Science basis, IPCC.*
6 *www.environment.gov.au/climate-change/adaptation.*
7 *www.environment.org/explore-topics/climate-change/what.we.do/climate-adaptation.*

COURSE OUTCOMES:

On completion of the course, the students will be able to
CO1: Understand the climatic system and the factors influencing the climatic changes
CO2: Assess the uncertainty and impact of climatic changes
CO3: Understand the impacts of climate change in various sectors.
CO4: Develop strategies for adaptation and mitigation of climatic changes
CO5: Identify clean technologies for sustainable growth

COURSE ARTICULATION MATRIX:

PO / CO	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	PSO 4
CO1			M			L	L					L	L	L	L	L
CO2	L					L	L					L	M	M	M	L
CO3						L	L					L		H	H	
CO4	M	M	L	M		L	M					L	L	M	M	M
CO5	L	M	M	M		L	H					L	L	M	L	M
18COE $01	L	M	M	M		L	M					L	L	M	M	M

L-Low, M-Moderate (Medium), H-High

18COE$02	DISASTER MANAGEMENT AND MITIGATION *(Common to All Branches)*

Category : OE

L	T	P	C
3	0	0	3

PRE-REQUISITES: NIL

COURSE OBJECTIVES:

- To give knowledge about basics of Disaster Management.
- To impart knowledge about Hazards and Vulnerability.
- To give knowledge about mitigation and preparedness.
- To teach about Response and Recovery.
- To impart knowledge about the participants involved in the disaster management activity.

UNIT - I : INTRODUCTION	**(9 Periods)**
Disaster throughout history, History of disaster management, Capacity by demand, UN International strategy for disaster reduction, the Hyogo framework for action, Post 2015 framework, Disaster trends.	
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 Acceptibility, Alternatives, Personnel. Political/ social, Economic. vulnerability-Physical Profile, Social Profile, Environmental Profile, Economic Profile. Factors Influncing Vulnerability, risk Perception.	
UNIT - III : MITIGATION AND PREPAREDNESS	**(9 Periods)**
Mitigation - types of mitigation ,Ostacles in mitigation, Assement and selection of Mitigation options, Emergency response capacity as , Incorporating Mitigation into development and relief projects. Prepareness- 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 : PARTICIPANTS	**(9 Periods)**
Governmental Disaster management agencies- Fire, law, emergency management, Emergency medical service, Millitary and other resources. Structures- local, regional, national. Bilateral assistance and its types. Types of national agencies involved in international disaster management. Political implications of bilateral assistance. Non GovernmentalOrganaisations – operations, NGO/ Millitary coordination, standard of conduct. The role of Private sector and academia. Multilateral organaisations - UN agencies and progammes, Regional &Inernationalorganaisations. International Financial Institutions- the world bank, IMF, ADB, IADB. Special considerations.	

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

TEXT BOOKS:

1. *Damon P. Coppola,* ***"Introduction to International Disaster management"****, Elsevier publication, 2015*

REFERENCE BOOKS:

1. Brassard, Caroline, Giles, David W., Howitt, Arnold M., ***"Natural Disaster Management in the Asia-Pacific"****, Policy and Governance.*
2. ***"Disaster Management",*** *Global Challenges and Local Solutions, Universities Press, 2009.*
3. Jack Pinkowski, ***"Disaster Management Handbook"****, CRC Press , January 22, 2008.*
4. Disaster Management Guidelines, GOI-UNDP Disaster Risk Reduction Programme (2009-2012).

COURSE OUTCOME:

CO1: Able to get knowledge about basics of Disaster management.
CO2: Able to impact knowledge about Hazards and vulnerability
CO3: Able to know about Mitigation and preparedness.
CO4: Able to attain knowledge about response and recovery.
CO5: Able to learn about the participants involved in the disaster management activity.

COURSE ARTICULATION MATRIX:

PO/PSO CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS01	PS02	PS03	PS04
CO1		L			L	L		L								L
CO2	L	H		M	L	M						L	L			L
CO3	L	L			H	M						L	L			L
CO4	L	M		L	L	M	M									L
CO5		M		L	L	M										L
18COE $02	L	M		L	L	M	M					L	L			L

L-Low, M-Moderate (Medium), H-High

18COE$03	ENERGY EFFICIENT BUILDINGS *(Common to All Branches)*

Category : OE

L	T	P	C
3	0	0	3

PRE-REQUISITES: NIL

COURSE OBJECTIVES:

- To understand the Concepts of Sustainable Environment, basics of energy analysis, simulation and management.
- To understand the concept of managing air quality.
- To understand the Green building concepts.

UNIT – I : INTRODUCTION	**(9 Periods)**
Life cycle impacts of materials and products – sustainable design concepts – strategies of design for the environment -the sun-earth relationship and the energy balance on the earth's surface, climate, wind – solar radiation and solar temperature – sun shading and solar radiation on surfaces – energy impact on the shape and orientation of buildings – thermal properties of building materials.	
UNIT – II : ENERGY EFFICIENT TECHNIQUES	**(9 Periods)**
Passive Cooling And Day Lighting – Active Solar And Photovoltaic- Building Energy Analysis Methods- Building Energy Simulation- Building Energy Efficiency Standards- Lighting System Design- Lighting Economics and Aesthetics- Impacts of Lighting Efficiency – Energy Audit and Energy Targeting- Technological Options For Energy Management.	
UNIT – III : INDOOR ENVIRONMENTAL QUALITY MANAGEMENT	**(9 Periods)**
Psychrometry- Comfort Conditions- Thermal Comfort- Ventilation And Air Quality Air Conditioning Requirement- Visual Perception- Illumination Requirement- Auditory Requirement-Energy Management Options- Air Conditioning Systems- Energy Conservation In Pumps- Fans And Blowers-Refrigerating Machines- Heat Rejection Equipment- Energy Efficient Motors- Insulation.	
UNIT – IV : GREEN BUILDING CONCEPTS	**(9 Periods)**
Green Building Concept- Green Building Rating Tools- Leeds And IGBC Codes. – Material Selection Embodied Energy- Operating Energy- Façade Systems- Ventilation Systems- Transportation- Water Treatment Systems- Water Efficiency- Building Economics.	
UNIT – V : GREEN BUILDING DESIGN CASE STUDY	**(9 Periods)**
Students To Work Through A Controlled Process of Analysis And Design To Produce Drawings and Models Of Their Own Personal Green Building Project. Topics Include Building Form, Orientation and Site Considerations; Conservation Measures; Energy Modeling; Heating System And Fuel Choices; Renewable Energy Systems; Material Choices; and Construction Budget-Students Will Research Green Construction and Design in A Particular -Construction Context and Report Their Results to the Class.	

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

TEXT BOOKS:

1 *Kibert, C.* ***"Sustainable Construction: Green Building Design and Delivery"****, John Wiley & Sons, 4th Edition, 2016.*
2 *Edward G Pita,* ***"An Energy Approach- Air-Conditioning Principles and Systems"****, Pearson Education, 2003.*
3 *Satyajit Ghosh, Abhinav Dhaka,* ***"Green structures: Energy efficient buildings"****, 2015.*

REFERENCE BOOKS:

1 *Colin Porteous,* ***"The New Eco-Architecture"****, Spon Press, 2002.*
2 *Ganesan T P,* ***"Energy Conservation in Buildings"****, ISTE Professional Center, Chennai, 1999.*
3 *NPTEL* ***"Energy Efficiency and Simulation"****, Prof.E.Rajsekar., IIT Roorkee.*
4 *Energy Conservation Building Codes: www.bee-india.nic.in*
5 *Lever More G J,* ***"Building Energy Management Systems"****, E And FN Spon, London, 2000.*
6 *NPTEL* ***"Energy efficiency acoustics and day lighting in building"****, Prof.B.Bhattacharjee., IIT Delhi.*

COURSE OUTCOMES:

On completion of the course, the students will be able to
CO1: Understand the Concepts of Sustainable Environment.
CO2: Understand the basics of energy analysis, simulation and management.
CO3: Understand the concept of managing air quality.
CO4: Understand the Green building concepts.
CO5: Create drawings and models of their own personal green building project

COURSE ARTICULATION MATRIX:

PO / CO	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	PSO 4
CO1	L	M	L			M	M	L	L	L		L	L	M	L	L
CO2			L	L		L	L					L		L		
CO3		L				L	M	L				L		L		
CO4	L	M					H					M		M		
CO5	M	M	H	L			H	L	M		M	M		H	L	M
18COE $03	L	M	H	L		M	H	L	L	L	M	M	L	H	L	M

L-Low, M-Moderate (Medium), H-High

18MOE$04	NANOTECHNOLOGY AND SURFACE ENGINEERING *(Common to All Branches)*

Category : OE

L	T	P	C
3	0	0	3

PRE-REQUISITES: NIL

COURSE OBJECTIVES:

- To Understand and analyze the concepts of Quantum confinement, Dimensional structures and Properties of Nanosystems
- To be familiar with various methods of synthesis of Nanomaterials
- To analyze and understand the mechanical and electrical properties of Nanomaterial and its applications

UNIT – I: PROPERTIES OF NANOMATERIALS	**(9 Periods)**
Size effect and properties of nanoparticles - particle size - particle shape - particle density - melting point, surface tension, wettability - specific surface area and pore size – Properties of Individual nanoparticles. Quantum confinement in 3D, 2D, 1D and zero dimensional structures -Size effect and properties of nanostructures- Top down and Bottom up approach.	
UNIT – II : SYNTHESIS OF NANOMATERIALS	**(9 Periods)**
Sol-Gel Process - Self-assembly – Electrodeposition - Spray Pyrolysis - Flame Pyrolysis – Metal nano-crystals by Reduction – Solvo-thermal Synthesis - Chemical Vapor Deposition (CVD) – Metal Orgonic Chemical Vapor Deposition (MOCVD).Ball Milling - Inert Gas Condensation Technique (IGCT) – Thermal evaporation – Pulsed Laser Deposition (PLD) – DC/RF Magnetron Sputtering - Molecular Beam Epitaxy (MBE) – Melt Spinning process – Applications	
UNIT – III : MECHANICAL AND ELECTRICAL PROPERTIES	**(9 Periods)**
Nanoscale Mechanics - Introduction – Mechanical properties – The Elasticity of Nanomaterials – Elasticity of Bulk Nanomaterials –Plastic Deformation of Nanomaterials – Crystals and Crystal Plasticity – From Crystal Plasticity to Polycrystal Plasticity. Introduction - Energy Storage Basics - Electrical Energy Storage Devices and Impact of Nanomaterials - Electrochemical Properties of Nanoscale Materials - Aerogels and Structure-Directed Mesoporous and Macroporous Solids - Nanoparticles - Nanotubes, Nanowires, and Nanorolls	
UNIT – IV : FUNDAMENTALS OF SURFACE ENGINEERING	**(9 Periods)**
Surface engineering - classification, definition, scope and general principles, Conventional surface engineering - Surface engineering by material removal: Cleaning, pickling, etching, grinding, polishing, buffing / puffing, Surface engineering by material addition - From liquid bath, hot dipping, Electro-deposition / plating.	
UNIT – V : SURFACE MODIFICATION	**(9 Periods)**
Surface modification of steel and ferrous components - Pack carburizing, Aluminizing, calorizing, diffusional coatings (principle and scope of application), Surface modification using liquid/molten bath: Cyaniding, liquid carburizing (diffusion from liquid state), Surface modification using gaseous medium: Nitriding, Carbo-nitriding (diffusion from gaseous state).	

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

TEXT BOOKS:

1. *Kelsall Robert W, Ian Hamley and Mark Geoghegan, —**"Nanoscale Science and Technology"**, Wiley Eastern, 2004.*
2. *N John Dinardo, **"Nanoscale Charecterisation of Surfaces & Interfaces**", 2nd edition, Weinheim Cambridge, Wiley-VCH, 2000.*
3. *ASM Metals Hand Book –Vol. 5, **"Surface Engineering"**, 1996.*

REFERENCE BOOKS:

1. *G. Timp. Editor, **"Nanotechnology"** AIP press, Springer-Verlag, New York, 1999*
2. *Hari Singh Nalwa, Editor, **"Nanostructured materials and Nanotechnology''**, Concise Edition, Academic Press, USA (2002).*
3. *GuozhongGao,**"Nanostructures & Nanomaterials: Synthesis, Properties & Applications**", Imperial College Press (2004).*
4. *K.G. Budinski, **"Surface Engineering for Wear Resistances",** Prentice Hall, Englewood Cliffs, 1988.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Analyze the particle size, particle shape, particle density, Size effect and properties of Nanostructures.

CO2: Acquire knowledge in various methods of synthesis of Nanomaterials.

CO3: Analyze the Elasticity of Nanomaterials, Electrical Energy Storage Devices and Aerogels.

CO4: Apply various Nanomaterials to the LED, Transistor Applications.

CO5: Apply various surface engineering techniques

COURSE ARTICULATION MATRIX

CO/ PO	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	M	M	L	L	M	L	M	M	M	L	M	M	M	M	M
CO2	H	H	M	H	H	L	L	M	M	M	L	H	M	H	M
CO3	H	H	L	H	M	M	L	L	M	M	M	M	M	H	M
CO4	L	H	M	H	M	M	L	L	M	M	M	M	M	H	M
CO5	M	M	L	M	M	L	M	M	M	L	M	M	M	H	M
18MOE$04	H	H	L	M	H	M	H	H	M	H	M	M	M	M	M

L-Low, M-Moderate (Medium), H-High

18MOE$05	MECHATRONICS *(Common to All Branches)*

Category : OE

L	T	P	C
3	0	0	3

PRE-REQUISITES: NIL

COURSE OBJECTIVES:

- To study the mechatronics system and understanding the concepts of integration and design of mechatronics system.

UNIT – I : SYSTEM MODELS	**(9 Periods)**
Introduction - Definition of Mechanical Systems, Philosophy and approach. Systems and Design - Mechatronic approach, Integrated Product Design - Modeling- Analysis and Simulation, Man-Machine Interface.	
UNIT – II : SENSORS AND TRANSDUCERS	**(9 Periods)**
Sensors and transducers - classification, Development in Transducer technology, Optoelectronics - Shaft encoders, CD Sensors, Vision System.	
UNIT – III : DRIVES AND ACTUATORS	**(9 Periods)**
Drives and Actuators - Hydraulic and Pneumatic drives - Electrical Actuators - servo motor and Stepper motor, Drive circuits, open and closed loop control - Embedded Systems - Hardware Structure, Software Design and Communication, Programmable Logic Devices, Automatic Control and Real Time Control Systems.	
UNIT – IV : SMART MATERIALS	**(9 Periods)**
Smart materials - Shape Memory Alloy, Piezoelectric and Magnetostrictive Actuators - Materials, Static and dynamic characteristics, illustrative examples for positioning, vibration isolation.	
UNIT – V : MICROMECHATRONIC SYSTEMS	**(9 Periods)**
Micromechatronic systems - Microsensors, Microactuators - Micro-fabrication techniques - LIGA Process- Lithography, etching, Micro-joining. Application examples - Case studies Examples of Mechatronic Systems from Robotics Manufacturing, Machine Diagnostics, Road vehicles and Medical Technology.	

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

TEXT BOOKS:

*1. W.Bolton, **"Mechatronics"**, Longman,2nd Edition,1999*

REFERENCE BOOKS:

1. *Michael B. Histand and David G.Alciatore,* ***"Introduction to Mechatronics and Measurement Systems"****, Tata McGraw Hill, 2nd Edition,2003*
2. *D.A.Bradley, D.Dawson, N.C.Buru and A.J.Loader****, "Mechatronics"*** *Chapman and Hall,1993*
3. *Dan S Necsulescu,* ***"Mechatronics"****, Pearson Education Asia,2005*
4. *Devdas Shetty, Richard A. Kolk,* ***"Mechatronics System Design"****, Thomson, PWS publishing, 2007.*
5. *Smaili.A and Mrad.F,* ***"Mechatronics: Integrated Technologies for Intelligent Machines",*** *Oxford university press, 2008*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Identify the key elements of mechatronics system and models.

CO2: Select appropriate sensors and transducers for industrial application.

CO3: Integrate mechanical, electrical, electronics, control systems in the mechatronics system design

CO4: Select the proper smart material for mechatronics system.

CO5: Apply the principles of mechatronics in industrial needs.

COURSE ARTICULATION MATRIX

CO/ PO	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	H	H	H	M	L	H	L	L	H	L	M	L	M	H	L
CO2	H	H	H	L	L	H	L	L	M	L	M	L	M	H	L
CO3	H	H	H	L	L	H	L	L	M	L	M	L	M	H	L
CO4	H	H	H	M	H	H	L	L	M	M	L	L	H	H	L
CO5	H	H	H	M	L	H	L	L	H	M	M	M	H	H	L
18MOE$05	H	H	H	H	L	H	L	L	M	L	M	L	M	H	L

L-Low, M-Moderate (Medium), H-High

18MOE$06	RENEWABLE ENERGY SOURCES *(Common to All Branches)*

Category : OE

L	T	P	C
3	0	0	3

PRE-REQUISITES: NIL

COURSE OBJECTIVES:

- To elucidate the technologies used for generation and utilization of power from renewable energy resources.

UNIT – I: SOLAR ENERGY	**(9 Periods)**
Solar radiation, solar spectra-latitude and longitude, Declination angle, solar window, cosine law, seasonal variations, hour angle, calculation of angle of incidence, angstroms equation and constants, Photo voltaic: p-n junctions. Solar cells, PV systems, Standalone, Grid connected solar power - Types of solar thermal collectors – Flat and concentrating collectors, solar thermal applications -water heaters, dryers, stills, refrigeration, air-conditioning, solar pond, central receiver power generation.	
UNIT – II: WIND ENERGY	**(9 Periods)**
Wind energy - Basic principle of wind energy conversion system, wind data and energy estimation, site selection, components of wind energy conversion systems, design consideration of horizontal axis wind mill- merits and limitations- application.	
UNIT – III: BIOMASS ENERGY	**(9 Periods)**
Biomass, sources of biomass, thermo-chemical and bio-chemical conversion of biomass - Pyrolysis, gasification, combustion and fermentation. Gasifiers – Up draft, downdraft and fluidized bed gasifier. Digesters- Fixed and floating digester biogas plants, economics of biomass power generation.	
UNIT – IV: OCEAN AND GEOTHERMAL ENERGY	**(9 Periods)**
Ocean energy resources - Principles of ocean thermal energy conversion systems - ocean thermal power plants - Principles of ocean wave energy conversion and tidal energy conversion - Difference between tidal and wave power generation, Economics of OTEC. Definition and classification of Geothermal resources, Utilization for electricity generation and direct heating, Wellhead power generating units. Overview of micro and mini hydel power generation.	
UNIT – V: RENEWABLE ENERGY POLICIES	**(9 Periods)**
Renewable energy policies - Feed-in tariffs, portfolio standards, policy targets, tax incentives, and biofuels mandates. International policies for climate change and energy security. Economic analysis and comparisons, Life cycle analysis, financial analysis, cost of conserved energy, and externalities. Cost assessment of supply technologies versus energy- Efficiency.	

Contact Periods:

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

TEXT BOOKS:

1. Sunil S. Rao and Dr. B.B. Parulekar, ***"Energy Technology",*** *Khanna Publishers, Second Ed. 1997*
2. Pai and Ramaprasad, ***"Power Generation through Renewal sources",*** *Tata McGraw Hill – 1991*

REFERENCE BOOKS:

1. Rai , G.D., ***"NonConventional sources of Energy"****, Khanna Publishers , IV Ed.,2009*
2. Bansal NK, Kleeman and Meliss, M ***"Renewable Energy Sources and Conversion Techniques"****, Tata McGraw Hill, 1996*
3. Roland Wengenmayr, Thomas Buhrke, ***"Renewable energy: Sustainable energy concepts for the future"****, Wiley-VCH, 1st edition, 2008.*

COURSE OUTCOMES:

On completion of the course students will be able to
CO1: Realize the need for utilizing the energy from clean and Sustainable energy resources.
CO2: Describe the principles of operation of the broad spectrum of renewable energy Technologies
CO3: Analyze energy technologies from a systems perspective.
CO4: Articulate the technical challenges for each of the renewable sources
CO5: Create solutions for alternate energy issues
CO6: Discuss economic, technical and sustainability issues involved in the integration of renewable energy systems

COURSE ARTICULATION MATRIX

CO/ PO	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	H	M	M	M	M	M	M			L	L	L	H	M	M
CO2	H	H	M	M	M	M	M	L		L	L	L	H	H	H
CO3	H	M	M	M	M	M	M	M			L	L	M	H	H
CO4	M	H	M	L	M	H	M	M		L	L	L	H	H	H
CO5	M	H	H	H	M	M	M	M		L	L	L	M	H	M
CO6	H	M	M	M	M	M	M		H	H	L	L	M	H	M
18MOE$06	H	H	M	M	M	M	M	L	L	L	L	L	H	H	H

L-Low, M-Moderate (Medium), H-High

18EOE$07	RENEWABLE POWER GENERATION SYSTEMS *(Common to All Branches)*

PRE-REQUISITES: NIL

Category: OE

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- To elucidate the technologies used for generation and utilization of power from renewable energy resources.

UNIT-I : SOLAR ENERGY	**(9 Periods)**
Solar radiation, solar spectra-latitude and longitude, Declination angle, solar window, cosine law, seasonal variations, hour angle, calculation of angle of incidence, angstroms equation and constants, Photo voltaic: p-n junctions. Solar cells, PV systems, Standalone, Grid connected solar power - Types of solar thermal collectors – Flat and concentrating collectors, solar thermal applications -water heaters, dryers, stills, refrigeration, air-conditioning, solar pond, central receiver power generation.	
UNIT-II : WIND ENERGY	**(9 Periods)**
Wind energy - Basic principle of wind energy conversion system, wind data and energy estimation, site selection, components of wind energy conversion systems, design consideration of horizontal axis wind mill- merits and limitations- application.	
UNIT-III : BIOMASS ENERGY	**(9 Periods)**
Biomass, sources of biomass, thermo-chemical and bio-chemical conversion of biomass - Pyrolysis, gasification, combustion and fermentation. Gasifiers – Up draft, downdraft and fluidized bed gasifier. Digesters - Fixed and floating digester biogas plants, economics of biomass power generation.	
UNIT-IV : OCEAN AND GEOTHERMAL ENERGY	**(9 Periods)**
Ocean energy resources - Principles of ocean thermal energy conversion systems - ocean thermal power plants - Principles of ocean wave energy conversion and tidal energy conversion - Difference between tidal and wave power generation, Economics of OTEC. Definition and classification of Geothermal resources, Utilization for electricity generation and direct heating, Wellhead power generating units. Overview of micro and mini hydel power generation.	
UNIT-V : RENEWABLE ENERGY POLICIES	**(9 Periods)**
Renewable energy policies - Feed-in tariffs, portfolio standards, policy targets, tax incentives, and biofuels mandates. International policies for climate change and energy security. Economic analysis and comparisons, Life cycle analysis, financial analysis, cost of conserved energy, and externalities. Cost assessment of supply technologies versus energy - Efficiency.	

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

TEXT BOOKS:

1. *Rao. S. and Dr. Pamlekar B.B "**Energy Technology**" Khanna Publishers, Second Ed. 2016*
2. *Rai , G.D., "**Non-Conventional sources of Energy**", Khanna Publishers , V Ed.,2016*

REFERENCE BOOKS:

1. *Khan. B.H, "Non-Conventional Energy Resources", The McGraw Hills, Second edition, 2016.*
2. *Bansal NK, Kleeman and Meliss, M "**Renewable Energy Sources and Conversion Techniques**", Tata McGraw Hill, 1996*
3. *Roland Wengenmayr, Thomas Buhrke," Renewable energy: Sustainable energy concepts for the future", Wiley-VCH, 1st edition, 2008.*

COURSE OUTCOMES:

CO1: Understand the concept of various Non-Conventional energy resources
CO2: Familiarize the principles of operation of renewable energy technologies
CO3: Realize the need for utilizing the energy from clean and Sustainable energy resources.
CO4: Interpret advantages and disadvantages of different renewable sources of energy
CO5: Comprehend the environmental aspects and the correlation between different operational parameters
CO6: Evaluate the options and estimate the energy generation through renewable sources

COURSE ARTICULATION MATRIX:

CO	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	H	M	M	M	-	M	H	-	-	-	-	-	H	M	M
CO2	H	H	M	L	M	M	M	L	-	-	-	-	H	H	H
CO3	H	M	M	M	M	M	M	-	-	-	-	-	M	H	H
CO4	M	H	M	L	M	H	M	-	-	-	-	-	H	H	H
CO5	M	H	L	H	M	M	M	-	-	-	L	-	M	H	M
CO6	H	M	M	L	M	M	M	-	L	-	L	-	M	H	M
18EOE $07	H	H	M	M	-	M	M	L	L	-	L	-	H	H	H

L - Low, M - Moderate (Medium), H – High

18EOE$08	ELECTRIC VEHICLES *(Common to All Branches)*

Category : OE

PRE-REQUISITES: NIL

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- To understand the technology of Electric and Hybrid Electric Vehicles and their business perspective

UNIT-I : INTRODUCTION	**(9 Periods)**
Conventional Vehicles: Basics of vehicle performance, vehicle power source characterization, transmission characteristics, and mathematical models to describe vehicle performance. Introduction to Hybrid Electric Vehicles: History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies. Hybrid Electric Drive-trains: Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis.	
UNIT-II : ELECTRIC TRAINS	**(9 Periods)**
Electric Drive-trains: Basic concept of electric traction, introduction to various electric drive train topologies, power flow control in electric drive-train topologies, fuel efficiency analysis. Electric Propulsion unit: Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Induction Motor drives, Permanent Magnet Motor drives, Switch Reluctance Motor drives- drive system efficiency.	
UNIT-III : ANALYSIS OF ENERGY STORAGE	**(9 Periods)**
Energy Storage: Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery based energy storage and its analysis, Fuel Cell based energy storage and its analysis, Super Capacitor based energy storage and its analysis, Flywheel based energy storage and its analysis, Hybridization of different energy storage devices. Sizing the drive system: Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics, selecting the energy storage technology, Communications, supporting subsystems.	
UNIT-IV : ENERGY MANAGEMENT STRATEGIES	**(9 Periods)**
Introduction to energy management strategies used in hybrid and electric vehicles, classification of different energy management strategies, comparison of different energy management strategies, implementation issues of energy management strategies.	
UNIT-V : BUSINESS PERSPECTIVE OF ELECTRIC VEHICLE	**(9 Periods)**
Design of a Hybrid Electric Vehicle (HEV) - Design of a Battery Electric Vehicle (BEV) Hybrid Electric Heavy Duty Vehicles, Fuel Cell Heavy Duty Vehicles. Business: E-mobility business, electrification challenges, Connected mobility and Autonomous mobility- case study: E-mobility Indian Roadmap Perspective. Policy: EVs in infrastructure system, integration of EVs in smart grid, social dimensions of EVs.	

Contact Periods:

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

TEXT BOOKS:

1. *Mehrdad Ehsani, Yimin Gao, Sebatien Gay and Ali Emadi, "**Modern Electric, Hybrid Electric and Fuel cell vehicles: Fundamentals, Theory and Design**", CRC press, 2004.*
2. *C. Mi, M. A. Masrur and D. W. Gao, "**Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives**", John Wiley & Sons, 2011.*
3. *S. Onori, L. Serrao and G. Rizzoni, "**Hybrid Electric Vehicles: Energy Management Strategies**", Springer, 2015.*

REFERENCE BOOKS:

1. *James Larminie and John Loury, "**Electric Vehicle Technology – Explained**", John Wiley & Sons Ltd, 2003.*
2. *Sandeep Dhameja, "**Electric Vehicle Battery Systems**", Butterworth – Heinemann, 2002.*
3. *Ronald K Jurgen, "**Electric and Hybrid – Electric Vehicles**", SAE, 2002.*
4. *Ron Hodkinson and John Fenton, "**Light Weight Electric/ Hybrid Vehicle Design**", Butterworth – Heinemann, 2001.*
5. *T. Denton, **"Electric and Hybrid Vehicles"**, Routledge, 2016.*

COURSE OUTCOMES:

CO1: Understand the basics of electric vehicle components and configuration.
CO2: Analyze suitable drive scheme for developing an electric vehicle.
CO3: Able to opt a proper energy management system.
CO4: Analyze the performance of practical HEV and EV.
CO5: Understand the infrastructure for Electric Vehicles and business potential.

COURSE ARTICULATION MATRIX:

CO	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	-	M	M	M	-	M	M	-	-	-	-	L	M	M	-
CO2	-	M	M	M	-	M	M	-	-	-	-	L	M	M	-
CO3	-	M	M	M	-	M	M	-	-	-	-	L	M	M	-
CO4	-	M	M	M	-	M	M	-	-	-	-	L	M	M	-
CO5	-	M	M	M	-	M	M	-	-	-	-	L	M	M	-
18EOE $08	-	M	M	M	-	M	M	-	-	-	-	L	M	M	-

L - Low, M - Moderate (Medium), H – High

18EOE$09	SMART GRID SYSTEMS *(Common to All Branches)*

Category : OE

PRE-REQUISITES: NIL

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- To comprehend the underlying techniques applied to Smart Grid

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 BOOKS:

*1. Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage "**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.*

REFERENCE BOOKS:

*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.*

COURSE OUTCOMES:

CO1: Demonstrate the various aspects of the smart grid, including Technologies, Components, Architectures and applications
CO2: Creating a framework to operate the grid more effectively.
CO3: Evaluate the existing grid with respect to smart grid
CO4: Upgrade the existing grid to smart grid environment

COURSE ARTICULATION MATRIX:

CO	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	-	-	-	L	L	M	H	L	M	M	M	H	M	H	M
CO2	L	L	M	M	M	M	M	L	M	M	M	M	M	M	H
CO3	-	-	-	M	M	M	M	M	M	M	M	H	M	M	M
CO4	L	-	-	M	M	M	H	-	M	M	M	H	M	H	H
18EOE $09	L	L	M	M	M	M	H	L	M	M	M	H	M	H	H

L - Low, M - Moderate (Medium), H - High

18LOE$10	MOBILE COMMUNICATION *(Common to All Branches)*

PRE-REQUISITES: NIL **Category: OE**

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- To study the concept of Mobile radio propagation, cellular system design
- To understand mobile technologies like GSM and CDMA.
- To know the mobile communication evolution of 2G, 3G and 3 GPP in detail.
- To have overview of immerging technologies application.

UNIT I WIRELESS COMMUNICATION	**(9 Periods)**
Cellular systems- Frequency Management and Channel Assignment- types of handoff and their characteristics, dropped call rates & their evaluation -MAC – SDMA – FDMA – TDMA – CDMA – Cellular Wireless Networks.	
UNIT II WIRELESS NETWORKS	**(9 Periods)**
Wireless LAN – IEEE 802.11 Standards – Architecture – Services – Mobile Ad hoc Networks- WiFi and WiMAX - Wireless Local Loop.	
UNIT III MOBILE COMMUNICATION SYSTEMS	**(9 Periods)**
GSM-architecture-Location tracking and call setup- Mobility management- Handover-Security-GSM SMS – International roaming for GSM- call recording functions-subscriber and service data mgt – Mobile Number portability -VoIP service for Mobile Networks – GPRS – Architecture-GPRS procedures-attach and detach procedures-PDP context procedure-combined RA/LA update procedures-Billing	
UNIT IV MOBILE NETWORK AND TRANSPORT LAYERS	**9 Periods)**
Mobile IP – Dynamic Host Configuration Protocol-Mobile Ad Hoc Routing Protocols– Multicast routing-TCP over Wireless Networks – Indirect TCP – Snooping TCP – Mobile TCP – Fast Retransmit / Fast Recovery – Transmission/Timeout Freezing-Selective Retransmission – Transaction Oriented TCP- TCP over 2.5 / 3G wireless Networks.	
UNIT V APPLICATION LAYER	**(9 Periods)**
WAP Model- Mobile Location based services -WAP Gateway –WAP protocols – WAP user agent profile- caching model-wireless bearers for WAP - WML – WMLScripts - WTA - iMode - SyncML.	

Contact periods:

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

TEXT BOOKS:

1. *John Schiller, "**Mobile Communications**", Second Edition, Pearson Education, 2003.*
2. *William Stallings, "**Wireless Communications and Networks**", Pearson Education, 2002.*

REFERENCES BOOKS:

1. *Kaveh Pahlavan, Prasanth Krishnamoorthy, "**Principles of Wireless Networks**", First Edition, Pearson Education, 2003.*
2. *Uwe Hansmann, Lothar Merk, Martin S. Nicklons and Thomas Stober, "**Principles of Mobile Computing**", Springer, 2003.*
3. *C.K.Toh, "**AdHoc Mobile Wireless Networks**", First Edition, Pearson Education, 2002.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Understand GSM, CDMA concepts and architecture, frame structure, system capacity, services provided.

CO2: Study of evolution of mobile communication generations 2G, 2.5G, 3G with their characteristics and limitations.

COURSE ARTICULATION MATRIX:

CO	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	M	M	M	-	-	-	-	-	-	-	-	L	M	L	-
CO2	M	M	M	-	-	-	-	-	-	-	-	L	M	L	-
18LOE $10	M	M	M	-	-	-	-	-	-	-	-	L	M	L	-

L - Low, M - Moderate (Medium), H - High

18LOE$11	INTRODUCTION TO VLSI SYSTEM DESIGN *(Common to All Branches)*

Category: OE

PRE-REQUISITES: NIL

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- To introduce various aspects of CMOS logic design in combinational and sequential circuit to design CMOS VLSI system components

UNIT I: CMOS LOGIC DESIGN	**(9 Periods)**
Inverter- CMOS Logic Gates: Compound Gates – Pass Transistors and Transmission Gates – Tristated – Multiplexers –CMOS Fabrication and Layout: Fabrication Process – Layout Design rule – Gate Layouts – Stick Diagrams – Design Partitioning	
UNIT II: MOS TRANSISTOR THEORY	**(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 - Dynamic Power – Static Power.	
UNIT III: COMBINATIONAL CIRCUIT DESIGN	**(9 Periods)**
Circuit Families: Static CMOS – Ratioed Circuits – Cascode Voltage Switch Logic – Dynamic Circuits – Pass Transistor Circuits. Silicon-on-Insulator Circuit Design – Subthreshold Cirucit Design	
UNIT IV: SEQUENTIAL CIRCUIT DESIGN	**(9 Periods)**
Sequential static circuits – Circuit design of latched and flip-flops – Sequencing dynamic circuits – Synchronizers – Wave pipelining - VLSI clocking: CMOS clocking styles - Pipelined systems - Clock generation and distribution.	
UNIT V: DESIGN OF VLSI SYSTEMS	**(9 Periods)**
System Specifications – Structural Gate Level Modeling – Switch Level Modeling – Behavioral and RTL Modeling - Addition/subtraction – Comparators –counters —Multiplexers - Binary Decoders – 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, Pearson Education,2011.*
2. *Uyemura, John P, "**Introduction to VLSI Circuits and Systems**", Wiley & Sons, 8th Reprint 2009*

REFERENCE BOOKS:

1. *Jan M. Rabaey, "**Digital Integrated Circuits: A Design Perspective**", PHI, Second Edition, 2012.*
2. *R. Jacob Baker, "**CMOS: Circuit Design, Layout, and Simulation**", Wiley-IEEE, Revised Second Edition, 2008.*
3. *Pucknell, "**Basic VLSI Design**", Prentice Hall, 2006.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Realize the CMOS logic design

CO2: Acquire knowledge on combinational and sequential circuit design of CMOS logic

CO3: Use VLSI clocking styles and realize CMOS VLSI system components

COURSE ARTICULATION MATRIX:

CO	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	M	M	M	-	-	-	-	-	-	-	-	L	H	L	L
CO2	M	M	M	-	-	-	-	-	-	-	-	L	M	L	L
CO3	M	M	M	-	-	-	-	-	-	-	-	L	H	L	L
18LOE $11	M	M	M	-	-	-	-	-	-	-	-	L	H	L	L

L - Low, M - Moderate (Medium), H - High

18LOE$12	MICROCONTROLLER AND APPLICATIONS *(Common to All Branches)*

Category: OE

PRE-REQUISITES: NIL

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- Describe the architecture of 8051 microcontroller.
- Develop assembly program for 8051.
- Apply the instruction set of 8051 to get effective programs.
- Design system in block level using microcontroller, memory devices, buses and other peripheral devices.
- Solve real life problem using microcontroller based systems.

UNIT I: MICROCONTROLLER	**(9 Periods)**
Microcontroller Features – On chip oscillator, List of Special Function Registers (SFRs), On chip program memory, on chip data memory, I/O Ports, Watch Dog Timer, Architecture of 8051, Instruction set - Addressing modes.	
UNIT II: ASSEMBLY LANGUAGE PROGRAMMING	**(9 Periods)**
8051 Assembly Language Programming, Branch Instruction Programming -I/O Port Programming – Arithmetic and Logic Instruction Programming-code conversion programming	
UNIT III: PROGRAMMING IN C AND INTERFACING-I	**(9 Periods)**
Timers & Counters programming - Serial Port Programming - Interrupts Programming .8255 Interfacing and Programming- External Memory Interfacing - LCD interfacing, LED Interfacing	
UNIT IV: INTERFACING-II	**(9 Periods)**
Keyboard Interfacing - ADC, DAC interfacing –Temperature Transducer-Pressure and Displacement Transducer-Light Sensor - Optocoupler - Relays.	
UNIT V: APPLICATIONS OF MICROCONTROLLERS	**(9 Periods)**
Stepper Motor interface-Temperature Monitoring and Control System-Speed Control of a DC Motor - Digital Thermometer-Digital Frequency Meter.	

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

TEXT BOOKS:

1.Mohammad Ali Mazidi, Janice Gillispie Mazidi ***"The 8051 Microcontroller and Embedded Systems (Using assembly and C)"*** *Pearson education/ Prentice Hall of India Pvt. Ltd., 2007.*
2. Ajit Pal, ***"Microcontrollers : Principles and Applications"****, Prentice-Hall of India Pvt.Ltd; 1 edition (August 2011).*

REFERENCE BOOKS:

1. *Krishna Kanth,* ***"Microprocessor and Microcontroller Archotecture,Programming and System Design using 8085, 8086, 8051"****, Prentice Hall of India, 2011.*
2. *Kenneth J.Ayala,* ***"The 8051 Microcontroller"*** *3rd edition,Thompson Delmar Learning,2007, New Delhi.*
3. *Jacob Fraden,* ***"Handbook of Modern Sensors: Physics, Design and Applications"****, 3rd ed, Springer, 2010.*
4. *Michael J. Pont,* ***"Embedded C"*** *Pearson Education India, 1st edition (*2007*);*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Describe the architectures of controller

CO2: Develop Assembly program applying Digital logic and mathematics using 8051 instruction set

CO3: Design microcontroller based system within realistic constraint like user specification, availability of components etc

CO4: Interface real world sensors

CO5: Solve real life problem and construct a complete system as a solution

COURSE ARTICULATION MATRIX:

CO	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	M	M	M	-	-	-	-	-	-	-	-	L	H	L	L
CO2	M	M	M	-	-	-	-	-	-	-	-	L	M	L	L
CO3	M	M	M	-	-	-	-	-	-	-	-	L	H	L	L
CO4	M	M	M	-	-	-	-	-	-	-	-	L	H	L	L
CO5	M	M	M	-	-	-	-	-	-	-	-	L	M	L	L
18LOE $12	M	M	M	-	-	-	-	-	-	-	-	L	H	L	L

L - Low, M - Moderate (Medium), H - High

18POE$13	RAPID PROTOTYPING *(Common to All Branches)*

Category: OE

L	T	P	C
3	0	0	3

PRE-REQUISITES: NIL

COURSE OBJECTIVES:

* To educate students with fundamental and advanced knowledge in the field of Rapid Prototyping technology and the associated Aerospace, Architecture, Art, Medical and Industrial applications.

UNIT- I	INTRODUCTION	(9 Periods)
Need - Development of RP systems – Applications in Product Development - Virtual Prototyping- Rapid Tooling – Rapid Manufacturing - Classification of RP processes – Benefits - Applications		
UNIT- II	**REVERSE ENGINEERING AND CAD MODELING**	**(9 Periods)**
Basic concept- Digitization techniques – Model reconstruction – Data Processing for Rapid Prototyping: CAD model preparation, Data requirements – Geometric modeling techniques: Wireframe, surface and solid modeling – data formats - Data interfacing, Part orientation and support generation, Support structure design, Model Slicing, Tool path generation-Software for RP- Case studies.		
UNIT- III	**LIQUID BASED AND SOLID BASED RAPID PROTOTYPING SYSTEMS**	**(9 Periods)**
Classification – Liquid based systems - Stereo lithography Apparatus (SLA): Principle, pre-build process, part-building and post-build processes, photo polymerization of SL resins, part quality and process planning, recoating issues, materials, advantages, limitations and applications. Solid Ground Curing (SGC): working principle, process, strengths, weaknesses and applications. Fused deposition Modeling (FDM): Principle, details of processes, process variables, types, products, materials and application. Laminated Object Manufacturing (LOM): Working Principles, details of processes, products, materials, advantages, limitations and applications - Case studies.		
UNIT- IV	**POWDER BASED RAPID PROTOTYPING SYSTEMS**	**(9 Periods)**
Selective Laser Sintering (SLS): Principle, process, indirect and direct SLS- powder structures, materials, post processing, surface deviation and accuracy, Applications. Laser Engineered Net Shaping (LENS): Processes, materials, products, advantages, limitations and applications – case Studies, Selective Laser Melting and Electron Beam Melting		
UNIT- V	**OTHER RAPID PROTOTYPING SYSTEMS**	**(9 Periods)**
Three dimensional Printing (3DP): Principle, basic process, Physics of 3DP, types of printing, process capabilities, material system. Solid based, Liquid based and powder based 3DP systems, Demerits, Applications and case studies. Shape Deposition Manufacturing (SDM), Ballastic Particle Manufacturing (BPM), Bio Additive Manufacturing.		

Contact Periods:

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

TEXT BOOKS:

1. *Chua Chee Kai and Leong Kah Fai* ***"Rapid Prototyping: Principles and Applications in Manufacturing",*** *John Wiley AND Sons, 1997*
2. *Paul F. Jacobs* ***"Stereo-lithography and other RP & M Technologies",*** *from Rapid Prototyping to Rapid Tooling, SME/ASME,1996*

REFERENCE BOOKS:

1. *Gibson, I., Rosen, D.W. and Stucker, B* ***"Additive Manufacturing Methodologies: Rapid Prototyping to Direct Digital Manufacturing",*** *Springer, 2010.*
2. *Chua, C.K., Leong K.F. and Lim C.S* ***"Rapid prototyping: Principles and applications",*** *second edition, World Scientific Publishers, 2010.*
3. *Gebhardt, A* ***"Rapid prototyping",*** *Hanser Gardener Publications, 2003.*
4. *Liou, L.W. and Liou, F.W* ***"Rapid Prototyping and Engineering applications: A tool box for prototype development",*** *CRC Press, 2011.*
5. *Hilton, P.D. and Jacobs, P.F* ***"Rapid Tooling: Technologies and Industrial Applications",*** *CRC press, 2005*

COURSE OUTCOMES:

On completion of this course, students will be able to

CO1: Appreciate the importance of computers and modern tools in manufacturing to reduce cost and matching the societal needs.

CO2: Create and analyze 2D and 3D models using CAD modeling software and integrating with manufacturing systems.

CO3: Understand the variety of Additive Manufacturing (AM) technologies apply to their potential to support design and manufacturing, case studies relevant to mass customized manufacturing.

CO4: Apply knowledge on latest techniques of manufacturing in their field of career

CO5: To monitor and control shop floor with the aid of computers

COURSE ARTICULATION MATRIX

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1			L				M						L	L	
CO2			M											M	L
CO3			L										M	L	
CO4			M		H	M	L						M	H	L
CO5		M				L					M		L	H	
18POE$13		M	M		M	L	L				L		M	M	L

L- Low, M – Moderate (Medium), H – High

18POE$14	MANAGERIAL ECONOMICS *(Common to All Branches)*

Category: OE

L	T	P	C
3	0	0	3

PRE-REQUISITES: NIL

COURSE OBJECTIVES:

- To introduce the fundamental economic principles necessary for production managers.

UNIT- I	FUNDAMENTALS OF MANAGERIAL ECONOMICS	(9 Periods)
Goals and Constraints - The Nature and Importance of Profits - Understanding Incentives - Economic rationality, Scarcity and opportunity cost -Marginal and Incremental Analysis.		
UNIT- II	**DEMAND ANALYSIS**	**(9 Periods)**
Demand and Supply -Market Equilibrium - Price Elasticity of Demand - Price Elasticity, Total Revenue, and Marginal Revenue - Factors Affecting Price Elasticity - Cross Price Elasticity - Income Elasticity of Demand - Other Elasticities, Elasticities for Nonlinear Demand Functions - Elasticity of Supply.		
UNIT- III	**DEMAND THEORIES**	**(9 Periods)**
Choice and Utility Theory - Law of Diminishing marginal utility - 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 - Cost Minimization and Optimal Input Substitution - The Cost Function - Breakeven analysis, Contribution analysis - Long-run Costs and Economies of Scale - Multiple Cost Functions and Economies of Scope - Learning curve.		
UNIT- V	**THEORY OF MARKET AND PRICING**	**(9 Periods)**
The Nature of Industry - Perfect Competition – Monopoly - Monopolistic Competition – Oligopoly - Product pricing.		

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

TEXT BOOKS:

1. *Thomas and Maurice* ***"Managerial Economics: Concept and Applications",*** *McGraw-Hill, 2005*
2. *Maheshwari.Y* ***"Managerial Economics",*** *Prentice Hall of India, 2012*

REFERENCE BOOKS:

1. *D.N. Dwivedi,* ***"Managerial Economics",*** *Vikas Publishing house, 2015*
2. *Christopher R Thomas, S Charles Maurice,* ***"Managerial economics",*** *Mcgraw Hill, 2014*

COURSE OUTCOMES:

On completion of this course, students will be able to

CO1: Explain fundamentals of managerial economics.

CO2: Discuss the dynamics of market forces.

CO3: Explain about various theories of demand.

CO4: Discuss about the cost concepts related to production.

CO5: Describe about the theory of market and pricing method.

COURSE ARTICULATION MATRIX

PO/PSO CO	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	L	L							L	M	M	L			L
CO2	L	L	L							M	M	L			L
CO3	L									L	M	L			L
CO4	L									L	L	L			L
CO5	L	M	M	L						L	M	L			L
18POE$14	L	L	L	L						L	M	L			L

L- Low, M – Moderate (Medium), H - High

18POE$15	HYDRAULICS AND PNEUMATICS *(Common to All Branches)*

PRE-REQUISITES: NIL **Category: OE**

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- To make the students to design the hydraulic and pneumatic circuits for different applications.

UNIT- I	**BASIC PRINCIPLES**	**(9 Periods)**
Hydraulic Principles; Hydraulic Fluids; Hydraulic pumps – Classification, Characteristics, Pump Selection; Hydraulic actuators; Hydraulic valves – Pressure, Flow, Direction Controls, Applications, Symbols.		
UNIT- II	**HYDRAULIC CIRCUITS**	**(9 Periods)**
Hydraulic circuits – Reciprocating, Quick Return, Sequencing, Synchronizing, Regenerative circuit, Double pump hydraulic system; Safety Circuits.		
UNIT- III	**POWER GADGETS IN HYDRAULICS**	**(9 Periods)**
Accumulators – Classification, Circuits; Pressure Intensifier and Circuit; Mechanical-hydraulic servo system; Selection of components. Installation and Maintenance of Hydraulic power pack; Troubleshooting of fluid power circuits.		
UNIT- IV	**PNEUMATIC SYSTEMS**	**(9 Periods)**
Pneumatic Fundamentals; Control Elements; Logic Circuits; Position sensing, Pressure sensing; Electrical controls: Various switches; Electro Pneumatic and Electro Hydraulic Circuits.		
UNIT- V	**DESIGN AND SELECTION OF PNEUMATIC CIRCUITS**	**(9 Periods)**
Design of Pneumatic circuits – Classic, Cascade, Step counter; PLC and Microprocessors – Uses; Selection criteria for Pneumatic components; Installation and Maintenance of Pneumatic power pack; Fault finding; Case studies.		

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

TEXT BOOKS:

1. *Anthony Esposito,* ***"Fluid Power with Applications",*** *Pearson Education India, 7th edition, 2013.*
2. *Andrew Parr,* ***"Hydraulics and Pneumatics:A Technician's and Engineer's Guide",*** *Butterworth-Heinemann, 3rd edition, 2011.*

REFERENCE BOOKS:

1. *DudleyA Pease and John J Pippenger* ***"Basic Fluid Power",*** *Prentice Hall PTR, 2nd edition 1987.*
2. *John J Pippenger and Tyler G Hicks* ***"Industrial Hydraulics",*** *McGraw Hill,2nd edition, 1970.*
3. *J. Michael, Pinches and HohnG.Ashby* ***"Power Hydraulics",*** *Prentice Hall, 1989.*

COURSE OUTCOMES:

On completion of this course, students will be able to

CO1: Describe the principle of fluid power

CO2: Describe the components of hydraulics

CO3: Design the hydraulic circuits for automation

CO4: Describe the components of pneumatics

CO5: Design the pneumatic circuits for automation

COURSE ARTICULATION MATRIX

PO/PSO CO	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	M	H										M			
CO2	M											M			
CO3	M	H										M			
CO4	M											M			
CO5	M											M			
18POE$15	M	H										M			

L- Low, M – Moderate (Medium), H - High

18NOE$16	MEASUREMENT AND CONTROL *(Common to All Branches)*

PRE-REQUISITES: NIL **Category: OE**

L	T	P	C
3	0	0	3

COURSE OBJECTIVE

* To learn about the working of different analog and digital instruments.

UNIT I – INTRODUCTION TO MEASUREMENTS	**(9 Periods)**
Significance of measurements – Methods of measurements – Classification of Instruments – Functions of Instruments and Measurement System – Elements of measurement system – Errors in measurement — Calibration of instruments: Methods & analysis – Introduction to Transducer & types.	
UNIT II – STRAIN AND DISPLACEMENT MEASUREMENT	**(9 Periods)**
Factors affecting strain measurements – Types of strain gauges – theory of operation – strain gauge materials – strain gauge circuits and applications of strain gauges. Resistive potentiometer (Linear, circular and helical) – L.V.D.T., R.V.D.T. and their characteristics – variable inductance and capacitance transducers – Piezo electrical transducers – Hall Effect devices and Proximity sensors.	
UNIT III – PRESSURE AND TEMPERATURE MEASUREMENT	**(9 Periods)**
Mechanical devices like Diaphragm, Bellows, and Bourdon tube for pressure measurement – Variable inductance and capacitance transducers – Piezo electric transducers – L.V.D.T. for measurement of pressure. Resistance type temperature sensors – RTD & Thermistor – Thermocouples & Thermopiles, Laws of thermocouple – Radiation methods of temperature measurement.	
UNIT IV – FLOW AND LEVEL MEASUREMENT	**(9 Periods)**
Differential pressure meters like Orifice plate, Venturi tube, flow nozzle, Pitot tube, Rotameter, Turbine flow meter, Electromagnetic flow meter and Ultrasonic flow meter. Resistive, inductive and capacitive techniques for level measurement – Ultrasonic methods – Air purge system (Bubbler method).	
UNIT V – AUTOMATIC CONTROL SYSTEM	**(9 Periods)**
Elements of control systems – concept of open loop and closed loop systems – Controllers – Brief idea of proportional, derivative and integral – Pneumatic Controller – Hydraulic Controller.	

Contact Periods:

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

TEXT BOOKS

1. *A.K. Sawhney, Puneet Sawhney* ***"A Course in Electronic and Electrical Measurements and Instrumentation"*** *S.K.Kataria & Sons, Delhi, 2014.*
2. *E. D. Doeblin,* ***"Measurement Systems: Application and Design",*** *McGraw – Hill Publication, 6th Edition 2017.*

REFERENCE BOOKS

1. *S. K. Singh,* ***"Industrial Instrumentation & Control"****, 3rd Edition, McGraw Hill, 2016.*
2. *A.K. Sawhney, Puneet Sawhney,* ***"A Course in mechanical measurements and Instrumentation & Control"****, Dhanapat Rai & Co, 2012.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO 1: Explain the construction and working of instruments used for various measurements.
CO 2: Describe the methods of measurement, classification of transducers and to analyze error.
CO 3: Elaborate the basic concept of control system.
CO 4: Analyze the characteristics of various measuring instruments
CO 5: Suggest suitable instruments for a particular application

COURSE ARTICULATION MATRIX:

CO/ PO	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	H	H	M	H	M	H	M	L	H	M	H	H	H	M	H
CO2	H	M	M	M	H	H	H	M	H	L	H	H	H	H	M
CO3	H	H	M	H	M	H	M	L	H	M	H	H	H	H	H
CO4	H	H	M	H	M	H	M	L	H	M	H	H	H	M	H
CO5	H	H	M	H	M	H	M	L	H	M	H	H	H	M	M
18NOE$16	H	H	M	H	M	H	M	L	H	M	H	H	M	H	M

L-Low, M-Moderate(medium), H-High

18NOE$17	INDUSTRIAL AUTOMATION *(Common to All Branches)*

PRE-REQUISITES: NIL **Category: OE**

L	T	P	C
3	0	0	3

COURSE OBJECTIVE

- To elaborate the basic concept of automation and the components required for automation

UNIT I – INTRODUCTION TO AUTOMATION	**(9 Periods)**
Automation overview – requirement of automation systems – architecture of industrial automation system – power supplies and isolators –relays – switches –transducers – sensors –seal-in circuits – industrial bus systems : modbus and profibus.	
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 – 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 (DCS)	**(9 Periods)**
Overview of DCS – DCS hardware – DCS software configuration – DCS communication – DCS supervisory computer tasks – DCS integration with PLC and Computers	
UNIT V – SCADA	**(9 Periods)**
Introduction - Supervisory Control and Data Acquisition Systems (SCADA) – SCADA HMI Essentials – SCADA Components – SCADA Configuration and Software – HMI hardware and software.	

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

TEXT BOOKS:

1. *John.W. Webb Ronald A Reis,* ***"Programmable Logic Controllers - Principles and Applications",*** *Prentice Hall Inc., 5th Edition, 2003.*
2. *M. P. Lukcas,* ***"Distributed Control Systems",*** *Van Nostrand Reinhold Co., 1986.*

REFERENCE BOOKS :

1. *Bela G Liptak,* ***"Process software and digital networks – Volume 3",*** *4th Edition, CRC press, 2012.*
2. *Romily Bowden,* ***"HART application guide and the OSI communication foundation",*** *1999*
3. *Frank D. Petruzella,* ***"Programmable Logic Controllers",*** *5th Edition, McGraw Hill, 2016.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO 1: Elaborate the basic architecture of automation systems

CO 2 : Describe the various sensors and actuators involved in industrial automation

CO 3: Construct ladder logic diagram using PLC basic functions, timer and counter functions for simple applications

CO 4: Illustrate the functionary components and supervisory control of DCS with relevant diagrams

CO 5: Describe the basics of SCADA technology

COURSE ARTICULATION MATRIX:

CO/ PO	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	H	H	M	M	L	L	L	H	L	M	L	L	H	L	L
CO2	H	H	H	H	L	L	L	H	L	M	L	L	H	L	L
CO3	H	H	M	M	L	L	M	H	L	M	L	L	H	L	L
CO4	H	H	H	H	L	L	L	H	L	M	L	L	H	L	L
CO5	H	H	M	M	M	L	L	H	L	M	L	L	H	L	L
18NOE$17	H	H	M	M	L	L	L	H	L	M	L	L	H	L	L

L-Low, M-Moderate(medium), H-High

18NOE$18	VIRTUAL INSTRUMENTATION *(Common to All Branches)*

PRE-REQUISITES: NIL **Category: OE**

L	T	P	C
3	0	0	3

COURSE OBJECTIVE

- To confer applications of virtual instrumentation in various fields.

UNIT I – INTRODUCTION	**(9 Periods)**
Virtual Instrumentation and LabVIEW - Evolution of LabVIEW - Difference between LabVIEW and conventional languages - Sequencing and data flow - Graphical programming.	
UNIT II – LabVIEW ENVIRONMENT	**(9 Periods)**
Front panel - Block diagram - Icon and Connector - Control Palette - Function Palette-Tools Palette - Creating, editing, wiring, debugging and saving VIs - sub-VIs - creating sub-VIs - simple examples - Looping: For loop, while loop-Shift registers - case and sequence; structures, formula nodes.	
UNIT III – PROGRAMMING TECHNIQUES	**(9 Periods)**
Arrays - clusters, charts and graphs, - local and global variables - property node, string and file I/O.	
UNIT IV – DATA ACQUISITION AND INSTRUMENT CONTROL	**(9 Periods)**
DAQ – Components - Buffers: Buffered and non buffered I/O - Triggering - Analog I/O-Digital I/O - Counters and timers-Instrument control: VISA, GPIB, VXI and PXI	
UNIT V – ADVANCED Lab VIEW AND APPLICATIONS	**(9 Periods)**
Connectivity in LabVIEW: an introduction - IVI - Labwindows/CVI. Applications of Lab VIEW: process control, physical, biomedical, Image acquisition and processing.	

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

TEXT BOOKS

1. *Sanjay Gupta and Joseph John,* ***"Virtual Instrumentation using LabVIEW"*** *Tata McGraw-Hill, Second edition 2010*
2. *Gary Johnson, Richard Jennings* ***"Lab view graphical programming",*** *Tata McGraw Hill, 2011.*

REFERENCE BOOKS

1. *Lisa K Wells and Jeffrey Travels,* ***"Labview for everyone",*** *Prentice Hall, 3rd Edition 2009.*
2. *S. Gupta, J.P. Gupta,* ***"PC interfacing for data acquisition and process control",*** *2nd Ed., Instrument Society of America, 2011*
3. *Jovitha Jerome,* ***"Virtual Instrumentation Using LabVIEW"*** *PHI Learning Pvt. Ltd 1st Edition, 2010*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO 1: Recognize the importance and applications of virtual instrumentation.

CO 2: Develop ability for programming in LabVIEW using various data structures, program structures, plotting the graphs and charts for system monitoring, processing and controlling.

CO 3: Realize the basics of interfacing and programming using related hardware.

CO 4: condition the acquired signal from the transducer to standard data formats

CO 5: Develop real time applications using LabVIEW

COURSE ARTICULATION MATRIX:

CO/ PO	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	M	H	M	M	L	L	L	H	L	M	M	M	H	M	M
CO2		H	H	H	L	L	L	H	L	M	M	M	H	M	M
CO3		H	M	M	L	L	M	H	L	M	M	M	H	M	M
CO4		H	H	H	L	L	L	H	L	M	M	M	H	M	M
CO5		H	M	M	M	L	L	H	L	M	M	M	H	M	M
18NOE$18	M	H	M	M	L	L	L	H	L	M	M	M	H	M	M

L-Low, M-Moderate(medium), H-High

18SOE$19	PROGRAMMING IN JAVA *(Common to All Branches)*

PRE-REQUISITES: NIL **Category: OE**

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

Upon completion of this course the students will be familiar with:

- Basic programming constructs in java to develop simple object oriented programs.
- Exception handling, multi-threading and I/O programming
- Development of GUI applications
- Manipulation of images.
- Network Programming

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 : APPLETS AND EVENT HANDLING	**(9 Periods)**
Applet class- Event Handling. Introducing the AWT: working with windows- graphics and text- Using AWT controls- Layout Manager - menus.	
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, Eighth Edition, 2011.*

REFERENCE BOOKS:

1. *Deitel .H.M and Deitel.P.J,* ***"Java: How to Program",*** *Pearson Education Asia, Eighth Edition 2010.*
2. *Lay.S & Horstmann Gary Cornell,* ***"Core Java Vol I",*** *Seventh Edition, The Sun Microsystems & press Java Series, 2005.*
3. *Lay.S & Horstmann Gary Cornell,* ***"Core Java Vol II",*** *Eighth Edition, The Sun Microsystems & press Java Series, 2008.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Write simple java programs using fundamental concepts of java like control structures, inheritance, packages, interfaces and exception handling. [**Usage]**

CO2: Write java program using multithreading and string handling. [**Usage]**

CO3: Develop GUI based applications using Applets. [**Usage]**

CO4: Write java programs to display and manipulation of graphical images. [**Usage]**

CO5: Establish database connectivity.[**Familiarity]**

CO6: Develop client server programs using RMI and servlets. [**Usage]**

COURSE ARTICULATION MATRIX:

CO	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	PSO 4
CO1	M	M	H		H	M	M				H	M	M	H	H	H
CO2	M	M	H		H	M	M				H	M	M	H	H	H
CO3	M	M	H		H	M	M				H	M	M	H	H	H
CO4	M	M	H		H	M	M				H	M	M	H	H	H
CO5	M	M	H		H	M	M				H	M	M	H	H	H
CO6	M	M	H		H	M	M				H	M	M	H	H	H
18SOE$19	M	M	H		H	M	M				H	M	M	H	H	H

L - Low, M - Moderate (Medium), H - High

18SOE$20	CYBER SECURITY *(Common to All Branches)*

PRE-REQUISITES: NIL **Category: OE**

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

Upon completion of this course, the students will be familiar with:

- Cybercrime and cyber offenses
- Cybercrime using mobile devices.
- Tools and methods used in cybercrime.
- Legal perspectives of cybercrime.
- Fundamentals of computer forensics.

UNIT – I : INTRODUCTION TO CYBERCRIME AND CYBEROFFENSES	**(9 Periods)**
Cybercrime and Information Security - Classifications of Cybercrimes - The Legal Perspectives - Cybercrime and the Indian ITA 2000 - A Global Perspective on Cybercrimes - Plan of Attacks - Social Engineering – Cyberstalking - Cybercafe and Cybercrimes – Botnets - Attack Vector.	
UNIT – II : CYBERCRIME: MOBILE AND WIRELESS DEVICES	**(9 Periods)**
Proliferation of Mobile and Wireless Devices - Trends in Mobility - Credit Card Frauds in Mobile and Wireless Computing Era – Security challenges posed by mobile devices – registry setting for mobile devices – authentication service security – attacks on mobile/cell phones – Organizational measures for handling mobiles.	
UNIT – III : TOOLS AND METHODS USED IN CYBERCRIME	**(9 Periods)**
Proxy Servers and Anonymizers – Phishing - Password Cracking – Keyloggers – Spywares -Virus and Worms - Trojan Horses and Backdoors – Steganography - DoS and DDoS Attacks - SQL Injection - Attacks on Wireless Networks.	
UNIT – IV : CYBERCRIMES AND CYBERSECURITY: THE LEGAL PERSPECTIVES	**(9 Periods)**
Cyberlaws- The Indian Context - The Indian IT Act - Challenges to Indian Law and Cybercrime Scenario in India - Consequences of Not Addressing the Weakness in Information Technology Act - Digital Signatures and the Indian IT Act - Amendments to the Indian IT Act - Cybercrime and Punishment.	
UNIT – V : UNDERSTANDING COMPUTER FORENSICS	**(9 Periods)**
Digital Forensics - Forensics Analysis of E-Mail - Network Forensics - Forensics and Steganography - Forensics and Social Networking Sites - Challenges in Computer Forensics - Data Privacy Issues – Forensics Auditing – Antiforensics.	

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

TEXT BOOKS:

1. *Nina Godbole and Sunit Belapur,* ***"Cyber Security Understanding Cyber Crimes, Compute Forensics and Legal Perspectives"****, Wiley India Publications, April, 2011.*

REFERENCE BOOKS:

1. *Robert Jones,* ***"Internet Forensics: Using Digital Evidence to Solve Computer Crime",*** *O"Reilly Media, October, 2005.*
2. *Chad Steel, "****Windows Forensics: The field guide for conducting corporate computer investigations****", Wiley India Publications, December, 2006.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Explain the fundamental concepts of cybercrime and cyberoffenses. **[Familiarity]**

CO2: Describe the cybercrimes occurred in mobile and wireless devices. **[Familiarity]**

CO3: Elaborate the methods used in cybercrime. **[Familiarity]**

CO4: Explain the laws for cybercrime and its respective punishments. **[Familiarity]**

CO5: Explain the forensics Analysis of E-Mail, Network and Social Networking Sites **[Familiarity]**

COURSE ARTICULATION MATRIX:

CO	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	PSO 4
CO1	M	M	M	M	L	H	L	M				H	H	L	M	M
CO2	M	M	M	M	M	H	M	M				M	H	H	M	M
CO3	H	L	L	L	L	H	H	L				H	H	H	L	L
CO4	H	M	M	M	M	H	H	H				M	H	H	L	L
CO5	H	M	M	M	M	L	H	L				H	H	H	M	M
18SOE$20	H	M	M	M	M	H	H	M				H	H	H	M	M

L - Low, M - Moderate (Medium), H - High

18SOE$21	NETWORK ESSENTIALS *(Common to All Branches)*

PRE-REQUISITES: NIL **Category: OE**

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

Upon completion of this course, the students will be familiar with,

- Basic taxonomy and terminology of the computer networking
- Wireless networking
- Addressing and Routing
- Routing protocols
- Troubleshooting and security issues.

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 BOOKS:

1. *Jeffrey S.Beasley Piyasat Nilkaew* ***"Network Essentials"*** *3rd Edition, Pearson, 2012*
2. *Larry L. Peterson and Bruce S. Davie* ***"Computer Networks, A Systems Approach"*** *5th edition, Morgan Kaufmann Publishers Inc, 2011.*

REFERENCE BOOKS:

1. *Behrouz A.Ferouzan,* ***"Data Communications and Networking"****, 5th edition, Tata McGraw-Hill, 2012.*
2. *Andrew S. Tanenbaum,* ***"Computer networks"****, PHI, 5th edition 2011.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Identify topologies and types of Computer Networks and enumerate the layers of the OSI model and TCP/IP and Explain the functions of each layer **[Familiarity]**

CO2: Explain the significance of wireless networks and configure a Wireless LAN **[Assessment]**

CO3: Describe basic routing algorithms and network services. **[Familiarity]**

CO4: Troubleshoot the router and switch interface **[Usage]**

CO5: Analyze Campus Network data traffic **[Usage]**

COURSE ARTICULATION MATRIX:

CO	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	PSO 4
CO1	M	M	H	H	H	L	L	H	H	H	H	H	M	H	H	M
CO2	L	L	L	L	H	L	L	H	L	L	L	H	M	H	H	M
CO3	L	H	M	M	H	L	L	H	H	M	L	H	L	H	H	L
CO4	H	H	H	M	H	L	L	H	H	H	M	H	M	H	H	M
CO5	H	H	H	M	H	L	L	H	H	M	L	H	M	H	H	M
18SOE$21	M	H	H	M	H	L	L	H	H	L	M	H	M	H	H	M

L - Low, M - Moderate (Medium), H - High

18IOE$22	PROGRAMMING IN PYTHON *(Common to All Branches)*

PRE-REQUISITES: **Category: OE**

NIL

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

Upon completion of this course, the students will be familiar with,

- Data types and variables declaration.
- Control statements, Functions and the use of basic programming.
- List, dictionary and operations used in python.
- File and Exception handling.
- Object oriented programming and GUI development.

UNIT – I : INTRODUCTION	**(9 Periods)**
Introduction to Python - Setting up Python in OS – Python IDLE(write- edit- run- and save programs) – Strings - Numbers – Variables – simple I/O - Getting user input– Using String method– Converting values.	
UNIT – II : CONTROL STATEMENTS AND FUNCTIONS	**(9 Periods)**
Control statements – Random number generator- Branching and loops – Range functions- Functions –User defined functions- passing parameters- return function- working with global variables and constants.	
UNIT – III : LISTS AND DICTIONARIES	**(9 Periods)**
Lists – create- index- slice a list- Add and delete elements from a list- Append- Sort and reverse a list- nested sequences- Dictionaries – Create- add- delete from a Dictionary- Operations associated with pairs of data.	
UNIT – IV : FILES AND EXCEPTIONS	**(9 Periods)**
Files – Read from text files- Write to text files- Read and write more complex data- Exceptions – Intercept and handle errors during program's execution.	
UNIT – V : OBJECT ORIENTED PROGRAMMING AND GUI	**(9 Periods)**
Object oriented programming – Create objects of different classes in the same program- objects communication- complex object creation- derive new classes- existing class extension- override method- GUI – GUI toolkit- create and fill frames- create buttons- text entries and text boxes- create check buttons and radio buttons - case study – create a web page using GUI functionality.	

Contact Periods:

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

TEXT BOOKS:

1. *Y. Daniel Liang,* ***"Introduction to Programming Using Python",*** *Pearson, 2013.*
2. *David I.Schneider,* ***"Introduction to programming using python",*** *person, 2015.*

REFERENCE BOOKS:

1. *Michael Dawson,* ***"Python Programming for the Absolute Beginner",*** *Premier Press, 2003.*
2. *Charles Dierbach,* ***"Introduction to Computer Science Using Python: A Computational Problem-Solving Focus",*** *Wiley Publications, 2012.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to,

CO1: Use various data types. **[Understand]**

CO2: Use control statements and functions. **[Understand]**

CO3: Analyze the arrangement of data elements in Lists and Dictionary structures. **[Analyze]**

CO4: Handle exceptions and perform file operations**. [Understand]**

CO5: Develop application using object oriented programming and GUI. **[Analyze]**

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	L		L	L		L	L			L		L	L
CO2	M	L		L	L		L	L			L		L	L
CO3	M	M	L	M	L		L	L			L		M	L
CO4	M	M	L	M	L		M	M			L		M	L
CO5	M	M	L	M	L		M	M			M	L	M	L
18IOE $22	M	M	L	M	L		M	M			L	L	M	L

L - Low, M - Moderate (Medium), H – High

18IOE$23	**BIG DATA SCIENCE** *(Common to All Branches)*

PRE-REQUISITES: **Category: OE**

NIL

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

Upon completion of this course, the students will be familiar with,

- Big Data and its characteristics.
- Technologies used for Big Data Storage and Analysis.
- Mining larger data streams.
- Concepts related to Link analysis and handle frequent data sets.

UNIT – I : THE FUNDAMENTALS OF BIG DATA	**(9 Periods)**
Understanding Big Data-Concepts and Technology-Big Data Characteristics-Types of data-Case Study-Business Motivation and Drivers for Big Data Adoption- Planning Considerations-Enterprise Technologies and Big Data Business Intelligence- OLTP-OLAP-Extract Transform Load-Data Warehouses-Data Mart-Traditional and Big Data BI-Case Study.	
UNIT – II : BIG DATA STORAGE AND PROCESSING	**(9 Periods)**
Big Data Storage Concepts- Clusters-File systems and Distributed File Systems-NoSQL- Sharding - Replication -Sharding and Replication-CAP Theorem-ACID-BASE-Case Study- Big Data Processing Concepts- Parallel Data Processing-Distributed Data Processing-Hadoop-Processing Workloads-Cluster-Processing in Batch mode-Processing in RealTime mode-Case study	
UNIT – III : BIG DATA STORAGE AND ANALYSIS TECHNOLOGY	**(9 Periods)**
Big Data Storage Technology: On-Disk Storage devices-NoSQL Databases-In-Memory Storage Devices-Case study, Big Data Analysis Techniques: Quantitative Analysis-Qualitative Analysis-Data Mining-Statistical Analysis-Machine Learning-Semantic Analysis-Visual Analysis-Case Study.	
UNIT – IV : MINING DATA STREAMS	**(9 Periods)**
The stream data model – Sampling data streams – counting distinct elements in a stream – Estimating moments. Finding similar items – Applications of nearest neighbor search – shingling of documents - similarity preservation – locality sensitive hashing- distance measures – methods for high degree similarity.	
UNIT – V : LINK ANALYSIS AND FREQUENT ITEMSETS	**(9 Periods)**
Link analysis – Page rank – Efficient computation of a page rank – topic sensitive page rank – link spam –Frequent datasets – the market basket model – Apriori algorithm – handling larger datasets in main memory –limited pass algorithm – counting frequent items in a stream.	

Contact Periods:

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

TEXT BOOKS:

1. *Thomas Erl, WajidKhattak, and Paul Buhler,* ***"Big Data Fundamentals Concepts, Drivers & Techniques",*** *Prentice Hall,2015.*
2. *AnandRajaraman and Jeffrey David Ullman,* ***"Mining of Massive Datasets",*** *Cambridge University Press, 2012.*

REFERENCE BOOKS:

1. *Paul Zikopoulos, Chris Eaton, Paul Zikopoulos,* ***"Understanding Big Data: Analytics for Enterprise Class Hadoop and Streaming Data",*** *McGraw Hill, 2011.*
2. *Frank J Ohlhorst,* ***"Big Data Analytics: Turning Big Data into Big Money",*** *Wiley and SAS Business Series, 2012.*
3. *Bill Franks,* ***"Taming the Big Data Tidal Wave: Finding Opportunities in Huge Data Streams with Advanced Analytics",*** *Wiley and SAS Business Series, 2012.*
4. *Paul Zikopoulos, Dirk deRoos, Krishnan Parasuraman, Thomas Deutsch , James Giles, David Corrigan,* ***"Harness the Power of Big data – The big data platform",*** *McGraw Hill, 2012.*
5. *Colleen Mccue,* ***"Data Mining and Predictive Analysis: Intelligence Gathering and Crime Analysis",*** *Elsevier, 2007*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to,

CO1: Understand the Big Data and usage in Enterprise Technologies. **[Understand]**
CO2: Store and Process Big Data using suitable Processing Methods. **[Understand]**
CO3: Handle Big Data using appropriate analysis Techniques. **[Analyze]**
CO4: Mine larger data streams using suitable algorithms. **[Understand]**
CO5: Rank pages and handle large data sets efficiently. **[Analyze]**

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	L	M	L	H	L							M	L
CO2	M				H			L				L	M	L
CO3		H			H							L	M	L
CO4	M	H	M		M							L	M	L
CO5	L	M	H									L	M	L
18IOE $23	M	H	M	L	H	L		L				L	M	L

L - Low, M - Moderate (Medium), H - High

18IOE$24	OBJECT ORIENTED PROGRAMMING USING C++ *(Common to All Branches)*

PRE-REQUISITES: NIL **Category: OE**

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

Upon completion of this course, the students will be familiar with,

- Fundamentals of object oriented programming.
- Classes and objects.
- Concepts of overloading and type conversions.
- Inheritance and Polymorphisms.
- Files, templates and exception handling.

UNIT – I : PRINCIPLES OF OBJECT ORIENTED PROGRAMMING	**(9 Periods)**
Basic concepts- benefits – applications of object oriented programming – beginning with C++ - tokens – expressions and control structures – C++ stream classes – Formatted and Unformatted I/O operations. Managing output with manipulators.	
UNIT – II : CLASSES AND OBJECTS	**(9 Periods)**
Introduction – specifying class – defining member functions – memory allocation constructors and destructors - parameterized, copy, default, dynamic and multiple constructors – destructors.	
UNIT – III : FUNCTIONS AND TYPE CONVERSIONS	**(9 Periods)**
Introduction – function prototyping call by reference – return by reference – inline function – recursion – friend function – function overloading – operator overloading – manipulation of strings using operators – type conversions.	
UNIT – IV : INHERITANCE AND POLYMORPHISM	**(9 Periods)**
Defining derived classes – single, multiple, multilevel, hierarchical and hybrid inheritance – virtual base classes – abstract base classes – nesting of classes - pointers – pointers to objects – this pointer – pointers to derived classes – virtual functions – pure virtual functions virtual constructors and destructors.	
UNIT – V : FILES AND TEMPLATES	**(9 Periods)**
Classes for file stream operations – opening and closing a file – detecting EOF – open file modes – file pointers and their manipulations – sequential I/O operations – updating and error handling of file. Class and function template – template with multiple parameters – overloading, member function and non-type template arguments-Exception handling.	

Contact Periods:

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

TEXT BOOKS:

1. *Lafort Robert,* ***"Object oriented proframming in C++",*** *4th Edition.*
2. *E.Balagurusamy,* ***"Object oriented Programming with C++",*** *McGraw Hill Education Ltd, 7th Edition 2017.*

REFERENCE BOOKS:

1. *R.Rajaram,* ***"Object Oriented Programming and C++",*** *New Age International 2nd edition, 2013.*
2. *K.R. Venugopal, Rajkumar, T. Ravishankar,* ***"Mastering C++",*** *Tata McGraw Hill Education, 2nd edition, 2013.*
3. *Yashavant P. Kanetkar,* ***"Let us C++",*** *BPB Publications, 2nd edition 2003.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to,

CO1: Understand the principles of object oriented programming. **[Understand]**
CO2: Develop programs using classes and objects. **[Analyze]**
CO3: Use functions and type conversions in programs. **[Understand]**
CO4: Apply inheritance and polymorphism to develop applications. **[Analyze]**
CO5: Use files, templates and handle exceptions. **[Understand]**

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	H	H	M			M						M	L
CO2	M	H	H	H			M						H	L
CO3	M	H	H	H			M						H	L
CO4	M	H	H	H			M						H	L
CO5	M	H	H	H			M						H	L
18IOE $24	M	H	H	H			M						H	L

L - Low, M - Moderate (Medium), H - High

18BOE$25	COMPUTATIONAL BIOLOGY *(Common to All Branches)*

Category: OE

PRE-REQUISITES: NIL

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- Understand the basic concepts and role of computation in biological analysis
- Familiarize with sequence alignment methods
- Understand the machine learning tools used for biological analysis

UNIT – I : BASICS OF BIOLOGY	**(9 Periods)**
Biomolecules of life: Structure and Composition of DNA, RNA & Protein. Protein Structure basics-Primary, Secondary and Tertiary Structure of protein.	
UNIT – II : BIOLOGICAL DATABASES	**(9 Periods)**
Concept of Relational database, Data archiving, Data mining, Primary databases-NCBI, EMBL, DDBJ; Structure databases-PDB	
UNIT – III : SEQUENCE ANALYSIS	**(9 Periods)**
Pairwise alignment tools-Dot matrix analysis, Dynamic programming-Smith Waterman and Needleman Wunsch algorithm, Heuristic methods- BLAST,FASTA; Multiple sequence alignment methods-Progressive alignment (Clustal)	
UNIT – IV : STRUCTURE ANALYSIS AND DRUG DESIGN	**(9 Periods)**
Protein secondary prediction-Chou fasman method, GOR method; Tertiary structure prediction-Homology modelling, Introduction to Computer aided drug design.	
UNIT – V : MACHINE LEARNING	**(9 Periods)**
Genetic Algorithm, Neural networks, Artificial Intelligence, Hidden markov model -application in bioinformatics	

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

TEXT BOOKS:

*1.David W. Mount , **"Bioinformatics: Sequence and Genome Analysis"** , Cold Spring Harbor Laboratory Press, Second Edition, 2004*

*2. Arthur M. Lesk, **"Introduction to Bioinformatics"**, Oxford University Press, 2008.*

*3.Pierre Baldi, Soren Brunak. , **"Bioinformatics: The machine learning approach"**, MIT Press, 2001*

REFERENCE BOOKS:

*1. Andreas D. Baxevanis, **"Bioinformatics, A Practical Guide to the Analysis of Genes and Proteins"**, Third edition; Wiley-Interscience, 2004.*

*2. Baxevanis A.D. and Oullette, B.F., **"A Practical Guide to the Analysis of Genes and Proteins"**, 2nd ed., John Wiley, 2002*

*3. David L. Nelson, Michael M. Cox., **"Lehninger: Principles of Biochemistry"**, Sixth edition, Freeman, W. H. & Co. Publisher, 2012.*

COURSE OUTCOMES:

Upon completion of the course the students will be able to

CO1: Understand the basic structure of Biological macromolecules

CO2: Acquire the knowledge of biological databases and its importance.

CO3: Perform pair wise and multiple sequence alignment

CO4: Predict the secondary and tertiary structure of proteins.

CO5: Understand the Machine learning approaches in computational biology

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	M	L	L		L			M				L	
CO2	M	L	L	L					L			L	L	L
CO3	L		L			M			L			L	L	
CO4	M	M	L	M	M								M	
CO5		M		H	H	M	L		M				H	H
18BOE $25	M	M	L	M	M	M	L		M			L	M	H

L - Low, M-Moderate (Medium), H- High

18BOE$26	FUNDAMENTAL CONCEPTS OF BIOLOGY FOR ENGINEERS *(Common to All Branches)*

Category: OE

PRE-REQUISITES: NIL

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- To understand the basic functions of the cell and their mechanisms in transport process.
- To get familiarize human anatomy and physiology.
- To learn about microbes, immune system and biomolecules.
- To know the concepts of applied biology.

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

TEXT BOOKS:

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.*

REFERENCE BOOKS:

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:

Upon completion of the course, the student will be able to

CO1: Understand the functions of cell and their structural organization

CO2: Describe the mechanisms and role of cell in immune system

CO3: Get familiarized biomolecules and human anatomy system

CO4: Illustrate the applications of microbes in industrial process

CO5: Apply the engineering concepts in biology

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	L	L	L	-	-	-	-	-	-	-	-	-	H	M
CO2	L	M	-	L	-	-	L	M	-	-	-	-	M	M
CO3	L	M	L	L	-	-	-	L	M	-	-	L	H	H
CO4	L	L	L	L	M	-	-	-	L	-	-	-	M	H
CO5	-	-	-	-	-	-	-	-	-	-	-	-	H	H
18BOE $26	L	M	L	L	M	-	L	M	M	-	-	L	H	H

L - Low, M-Moderate (Medium), H- High

18BOE$27	FUNDAMENTALS OF BIOENGINEERING *(Common to All Branches)*

Category: OE

PRE-REQUISITES: NIL

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- To make the students aware of the overall industrial bioprocess.
- To understand the basic configuration and parts of a fermentor.
- To study the production of primary and secondary metabolites.
- To understand the production of modern biotechnology products.

UNIT I: INTRODUCTION TO INDUSTRIAL BIOPROCESS	**(9 Periods)**
Fermentation - Bacterial, Fungal and Yeast, Biochemistry of fermentation. Traditional and Modern Biotechnology - A brief survey of organisms, processes, products. Basic concepts of Upstream and Downstream processing in Bioprocess.	
UNIT II : FERMENTATION INDUSTRY	**(9 Periods)**
Overview of fermentation industry, Basic configuration of Fermentor and ancillaries, main parameters to be monitored and controlled in fermentation processes. Types of fermentation – Solid state, submerged, batch, continuous, fed batch fermentation methods.	
UNIT III : PRODUCTION OF PRIMARY METABOLITES	**(9 Periods)**
A brief outline of processes for the production of some commercially important organic acids - Citric acid, lactic acid ,acetic acid; amino acids - glutamic acid, phenylalanine; ethanol.	
UNIT IV: PRODUCTION OF SECONDARY METABOLITES	**(9 Periods)**
Study of production processes for various classes of secondary metabolites: Antibiotics: beta lactams – penicillin and cephalosporin; aminoglycosides – streptomycin; macrolides - erythromycin, vitamin - B9, B12.	
UNIT V: PRODUCTS THROUGH MODERN BIOTECHNIQUES	**(9 Periods)**
Production of industrial enzymes - proteases, amylases, lipases; Production of single cell protein from wastes; biopreservatives – Bacterosin; biopolymers - xanthan gum and PHA. Industrial uses of enzymes in detergents, beverage and food.	

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

TEXT BOOKS

1. *Peter F. Stanbur., Stephen J. Hall., A. Whitake.,* ***"Principles of Fermentation Technology"****, Science & Technology Books. 2007.*
2. *Presscott, S.C., Cecil G., Dun,* ***"Industrial Microbiology"****, Agrobios (India), 2005.*
3. *Casida, L.E.,* ***"Industrial Microbiology"****, New Age International (P) Ltd, 1968.*

REFERENCE BOOK

1. *Crueger, W., Anneliese Cruege.,* ***"Biotechnology: A Textbook of Industrial Microbiology"****, Panima Publishing Corporation, Edition 2, 2003.*
2. *Sathyanarayana, U.,* ***"Biotechnology"****, Books and Allied (P) Ltd. Kolkata, 2005.*
3. *Ratledge C., Kristiansen B.,* ***"Basic Biotechnology"****, Cambridge University Press, second Edition, 2001.*
4. *Michael J. Waites.,* ***"Industrial Microbiology: An Introduction"****, Blackwell Publishing,2001.*

COURSE OUTCOMES:

Upon completion of the course in Bioprocess Principles graduates will be able to
CO1: Understand the basics of industrial bioprocess.
CO2: Explain the principle of a fermentation process and the chronological development of fermentation industry.
CO3: Understand the basic configuration of a fermentor and its ancillaries.
CO4: Learn the production of various primary and secondary metabolites.
CO5: Understand the production of biotechnological products.

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	H	H	-	-	-	-	-	-	-	-	-	M	-
CO2	H	M	-	-	-	-	-	-	-	-	-	-	-	-
CO3	H	H	H	M	M	M	-	L	H	-	-	-	-	H
CO4	H	L	L	-	-	L	-	L	-	-	-	-	-	H
CO5	H	M	H	L	M	-	-	L	-	-	-	-	-	H
18BOE $27	H	M	H	M	M	M	-	L	H	-	-	-	M	H

L- Low , M-Moderate(Medium), H- High

18BVA$01	INTRODUCTION TO FOOD SAFETY AND PRESERVATION

PRE-REQUISITES: NIL **Category: VA**

L	T	P	C
1	0	0	1

COURSE OBJECTIVES:

- To impart students with basic knowledge relating to food safety and principles of preservation.
- To introduce them to the concept of processing and preservation of fruits and vegetables.

UNIT I: PURPOSE AND SCOPE OF PRESERVATION	**(3 Periods)**
Objectives of preservation and processing - Scope of preservation industry in India.	
UNIT II: POST-HARVEST CHANGES AND SPOILAGE	**(3 Periods)**
Physical, chemical and microbiological changes in fruits and vegetables - Factors affecting growth of microorganisms and the control measures.	
UNIT III: FOOD SAFETY	**(3 Periods)**
Key terms, factors affecting food safety, recent concerns Food laws, standards and regulations, Food additives and contaminants, Hygiene and sanitation, HACCP.	
UNIT IV: PRINCIPLES AND METHODS OF PRESERVATION	**(3 Periods)**
Asepsis - Use of low temperature, Use of high temperature-Removal of moisture, Removal of air, Use of chemical preservatives, Fermentation- Irradiation, Gas preservation, Newer methods.	
UNIT V: FRUIT AND VEGETABLE PROCESSING – SAUCES AND BEVERAGES	**(3 Periods)**
Chutney and sauces- definition, method of preservation, steps in preparation of chutney and sauces. Fruit beverages- definition and classification, method of preservation (with special emphasis on pasteurization, use of chemical preservatives, sugar), role of various ingredients.	

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

REFERENCES:

*1. Fellows P.J, **"Food Processing Technology: Principles and Practices"**, Woodhead Publishing 4th edition, 2016.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Explain various preservation and post harvest changes and spoilage of food products

CO2: Describe the operation principles involved in food preservation.

CO3: Sketch food quality, safety and regulations.

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	L	-	-	-	-	-	-	-	-	-	L	H	L
CO2	H	L	-	-	-	L	-	-	-	-	-	L	H	L
CO3	-	H	-	-	L	-	-	-	-	-	-	L	H	H
18BVA $01	-	-	-	-	-	H	L	M	-	-	L	L	M	H

L - Low, M-Moderate (Medium), H- High

18BVA$02	SAFETY PRACTICES AND MANAGEMENT IN PROCESS INDUSTRIES

PRE-REQUISITES: NIL **Category: VA**

L	T	P	C
1	0	0	1

UNIT I: SAFETY AND HEALTH MANAGEMENT SYSTEM	**(5 Periods)**
Key elements of a safety and Health Management System- Policy & commitment, Planning, Implementation and Operation, Measuring Performance, Auditing and Reviewing performance Initial Safety and health Management System Review, Safety and health Management System model, safety and Health policy	
UNIT II: RISK ASSESSMENT AND CONTROL	**(5 Periods)**
Legal Basis for risk Assessment, key stages of Risk assessment and control- use trained Risk assessors, preparation and Inventory, Identify the hazards, assess the risk , identify Appropriate Action , Risk assessment records and control . A simple Risk estimation example – Hazards, remedial measures, Motivation of employees, Insurance coverage of Industrial plant & personnel.	
UNIT III: RULES AND REGULATION OF SAFETY DEPARTMENT	**(5 Periods)**
Stages in plant life and unsafe condition in factories, maintenance & safety, basics safety programming, safety department, Rules and regulation of safety department, Responsibility of management for safety in plant, safe guarding the public, Responsibility of government, social organization and public authorities. Safety activities of the ILO (International Labour Organization)	

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

REFERENCES

1. *S.P.Mahajan, "**Pollution control in process industries**", 1st Edition, Tata McGraw Hill Publishing Company, New Delhi, 1993.*
2. *Krishnan N.V. **"Safety Management in Industry"**, 1st Edition, Jaico Publishing House, Bombay, 1997.*

COURSE OUTCOME

Upon completion of the course, the students will be able to
CO1: Evaluate the safety performance of an organization
CO2: Gain the knowledge about the risk assessment and control
CO3: Familiarize the rules and regulations of safety department

COURSE ARTICULATION MATRIX:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	L	M	L	L	-	-	-	L	M	-	-	L	L	L
CO2	L	L	L	L	M	-	-	-	L	-	-	-	L	L
CO3	-	-	-	-	-	-	-	-	-	-	-	-	L	H
18BVA $02	L	M	L	L	-	-	-	M	L	-	-	L	L	L

L - Low, M-Moderate (Medium), H- High