NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

CURRICULUM AND SYLLABUS OF BTECH-MTECH DUAL DEGREE IN BIOTECHNOLOGY PROGRAM

2023 ONWARD ADMISSION BATCH

CURRICULUM
GROUP – 1
FIRST SEMESTER

		Semester - I					
Sl. No	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	MAC01	Mathematics I	3	1	0	4	4
2	CSC01	Computer Programming	2	1	0	3	3
3	XEC01	Engineering Mechanics	2	1	0	3	3
4	XEC02	Basic Electrical and Electronics Engineering	3	0	0	3	3
5	ESC01	Ecology and Environment	2	0	0	2	2
6	CYC01	Engineering Chemistry	3	0	0	3	3
7	CSS51	Computer Programming Laboratory	0	0	3	2	3
8	XES53	Basic Electrical and Electronics Engineering Laboratory	0	0	3	2	3
9	CYS51	Engineering Chemistry Laboratory	0	0	2	1	2
		TOTAL	**15**	**3**	**8**	**23**	**26**

SECOND SEMESTER

		Semester - II					
Sl. No	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	MAC02	Mathematics - II	3	1	0	4	4
2	CSC02	Data Structure and Algorithms	2	1	0	3	3
3	PHC01	Engineering Physics	2	1	0	3	3
4	HSC01	Professional Communication	2	0	2	3	4
5	CSS52	Data Structure and Algorithms Laboratory	0	0	3	2	3
6	XES51	Engineering Graphics	0	1	3	3	4
7	PHS51	Engineering Physics Laboratory	0	0	2	1	2
8	XXS51	Extra Academic Activities	0	0	2	1	2
		TOTAL	9	4	12	20	25

GROUP – 2

FIRST SEMESTER

		Semester - I					
Sl. No	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	MAC01	Mathematics - I	3	1	0	4	4
2	CSC01	Computer Programming	2	1	0	3	3
3	XEC01	Engineering Mechanics	2	1	0	3	3
4	PHC01	Engineering Physics	2	1	0	3	3
5	HSC01	Professional Communication	2	0	2	3	4
6	CSS51	Computer Programming Laboratory	0	0	3	2	3
7	XES51	Engineering Graphics	0	1	3	3	4
8	PHS51	Engineering Physics Laboratory	0	0	2	1	2
9	XXS51	Extra Academic Activities	0	0	2	1	2
		TOTAL	**11**	**5**	**12**	**23**	**28**

SECOND SEMESTER

		Semester - II					
Sl. No	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	MAC02	Mathematics - II	3	1	0	4	4
2	CSC02	Data Structure and Algorithms	2	1	0	3	3
3	XEC02	Basic Electrical and Electronics Engineering	3	0	0	3	3
4	ESC01	Ecology and Environment	2	0	0	2	2
5	CYC01	Engineering Chemistry	3	0	0	3	3
6	CYS51	Engineering Chemistry Laboratory	0	0	2	1	2
7	CSS52	Data Structure and Algorithms Laboratory	0	0	3	2	3
8	XES52	Basic Electrical and Electronics Engineering Laboratory	0	0	3	2	3
		TOTAL	13	2	8	20	23

THIRD SEMESTER

		Semester - III				
Sl. No	**Code**	**Subject**	**L**	**T**	**S**	**C**
1	MAC331	Mathematics III	3	1	0	4
2	BTC301	Biochemistry & Enzyme Technology	3	1	0	4
3	BTC302	Process Calculations and Thermodynamics	3	0	0	3
4	BTC303	Microbiology & Bioprocess Technology	3	1	0	4
5	CSC331	Database Management Systems	3	0	0	3
6	BTS351	Microbiology Laboratory	0	0	3	2
7	BTS352	Biochemistry Laboratory	0	0	3	2
8	CSS381	Database Management Systems Laboratory	0	0	3	2
		TOTAL	**15**	**3**	**9**	**24**

FOURTH SEMESTER

		Semester - IV				
Sl. No	**Code**	**Subject**	**L**	**T**	**S**	**C**
1	BTC401	Molecular Biology & Genetic Engineering	3	0	0	3
2	BTC402	Cell Biology & Genetics	3	1	0	4
3	BTC403	Plant & Animal Biotechnology	3	1	0	4
4	BTC404	Immunology	3	0	0	3
5	CHC431	Unit Operations of Chemical Engineering I	3	1	0	4
6	CHS481	Unit Operations of Chemical Engineering Laboratory I	0	0	3	2
7	BTS451	Molecular Biology & Genetic Engineering Laboratory	0	0	3	2
8	BTS452	Cell Biology and Genetics Laboratory	0	0	3	2
		TOTAL	**15**	**3**	**9**	**24**

FIFTH SEMESTER

		Semester - V				
Sl. No	**Code**	**Subject**	**L**	**T**	**S**	**C**
1	BTC501	Bioreactor Design & Analysis	3	1	0	4
2	BTC502	Bioseparation Engineering	3	1	0	4
3	BTC503	Bioinformatics	3	0	0	3
4	CHC531	Unit Operations of Chemical Engineering II	3	1	0	4
5	BTE510-512	Depth Elective - 1	3	0	0	3
6	BTS551	Immunology Laboratory	0	0	3	2
7	BTS552	Bioinformatics Laboratory	0	0	3	2
8	CHS581	Unit Operations of Chemical Engineering Laboratory II	0	0	3	2
		TOTAL	**15**	**3**	**9**	**24**

SIXTH SEMESTER

		Semester - VI				
Sl. No	**Code**	**Subject**	**L**	**T**	**S**	**C**
1	CHC631	Process Control & Instrumentation	3	1	0	4
2	HSC631	Economics and Management Accountancy	3	0	0	3
3	CSC631	Artificial Intelligence & Machine Learning	3	0	2	4
4	BTE610-622	Depth Elective - 2	3	0	0	3
5	BTE610 -622	Depth Elective - 3	3	0	0	3
6	BTS651	Plant and Animal Biotechnology Laboratory	0	0	3	2
7	BTS652	Bioseparation Engineering Laboratory	0	0	3	2
		TOTAL	**15**	**1**	**8**	**21**

SEVENTH SEMESTER

		Semester - VII				
Sl. No	**Code**	**Subject**	**L**	**T**	**S**	**C**
1	MSC731	Principles of Management	3	0	0	3
2	BTC701	Data Analytics in Biotechnology	3	1	0	4
3	BTE710-717	Depth Elective - 4	3	0	0	3
4	BTE710-717	Depth Elective - 5	3	0	0	3
5	YYO-74*	Open Elective - 1	3	0	0	3
6	BTS751	Bioprocess Engineering Laboratory	0	0	3	2
7	BTS752	Summer Internship	0	0	2	1
8	BTS753	Project - 1	0	0	3	1
		TOTAL	**15**	**1**	**8**	**20**

EIGHTH SEMESTER

		Semester - VIII				
Sl. No	**Code**	**Subject**	**L**	**T**	**S**	**C**
1	BT2001	Genomics, Proteomics and Bioinformatics	3	1	0	4
2	BT9036	Biopharmaceutical Technology	3	0	0	3
3	BT9043	Immunotechnology	3	0	0	3
4	BT90XX	Depth Elective - 6	3	0	0	3
5	BT90XX	Depth Elective - 7	3	0	0	3
6	BTS851	Analytical Instrumentation Laboratory	0	0	3	2
7	BTS852	Omics & Bioinformatics Laboratory	0	0	3	2
8	BTS853	Project - 2	0	0	6	2

9	BTS854	Comprehensive Viva	0	0	0	1
		TOTAL	**15**	**1**	**12**	**23**

NINTH SEMESTER

		Semester - IX				
Sl. No	**Code**	**Subject**	**L**	**T**	**S**	**C**
1	BT90XX	Depth Elective - 8	3	0	0	3
2	BT90XX	Depth Elective - 9	3	0	0	3
3	BT3055	Major Project - I	0	0	30	10
		TOTAL	**6**	**0**	**30**	**16**

TENTH SEMESTER

		Semester - X				
Sl. No	**Code**	**Subject**	**L**	**T**	**S**	**C**
1	BT90XX	Depth Elective - 10	3	0	0	3
2	BT4055	Major Project - II	0	0	30	10
		TOTAL	**3**	**0**	**30**	**13**

DETAILED SYLLABUS

<table>
<tr><td colspan="8">Department of Mathematics</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td>Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td><td></td></tr>
<tr><td>MAC01</td><td>MATHEMATICS - I</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="3">Basic concepts of function, limit, differentiation and integration.</td><td colspan="5">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: learn the fundamentals of differential calculus of single and several variables.
CO2: learn the basic concepts of convergence of infinite series.
CO3: understand the basic concepts of integral calculus along with its various applications.
CO4: acquire the theoretical knowledge of vector calculus and its engineering applications.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Functions of Single Variable: Review of limit, continuity and differentiability. Mean value theorems: Rolle’s Theorem, Lagrange’s Mean Value Theorem (MVT), Cauchy's MVT, Taylor’s theorem, Taylor’s and Maclaurin’s series. (8)
Functions of several variables: Limit, continuity and differentiability of functions of several variables, partial derivatives and their geometrical interpretation, derivatives of composite and implicit functions, derivatives of higher order and their commutativity, Homogeneous function, Euler’s theorem and its converse, Exact differential, Jacobian, Taylor's & Maclaurin's series, Maxima and Minima, Necessary and sufficient condition for maxima and minima (no proof). (11)
Sequences and Series: Real sequences and their convergence, Series of positive terms, Necessary and sufficient condition for convergence, p-series, geometric series, Comparison test, D Alembert’s ratio test, Cauchy’s root test, Alternating series, Leibnitz’s rule, Absolute and conditional convergence. (6)
Integral Calculus: Review of the idea of integration as a limit of a sum, Mean value theorems of integral calculus, Area and length in Cartesian and polar co-ordinates, Volume and surface area of solids of revolution in Cartesian and polar forms, Improper integrals and their convergence, Beta and Gamma functions. (12)
Multiple Integrals: Evaluation of double and triple integrals, Change of order of integration, Change to better coordinates, Area and volume by double integration, Volume by triple integration. (10)
Vector Calculus: Vector valued functions and its differentiability, Line integral, Surface integral, Volume integral, Gradient, Curl, Divergence, Green’s theorem in the plane (including vector form), Stokes’ theorem, Gauss’s divergence theorem and their engineering applications. (9)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
Kreyszig, E., Advanced Engineering Mathematics: 10th edition, Wiley India Edition, 2010.
Murray, D.A., Differential and Integral Calculus, FB & C Limited, 2018.
Marsden, J. E; Tromba, A. J.; Weinstein: Basic Multivariable Calculus, Springer, 2014.
Murray Spiegel, Schaum's Outline of Vector Analysis, Tata McGraw Hill Education , 1980.</td></tr>
</table>

	Reference Books: Tom Apostal, Calculus-Vol-I & II, Wiley Student Edition, 2011. Thomas and Finny: Calculus and Analytic Geometry, 11th Edition, Addison Wesley.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
MAC01	CO1	2	3	2	3	1	1	-	-	1	1	1	2
	CO2	2	3	2	3	-	1	-	-	1	1	2	2
	CO3	2	3	2	3	-	1	1	-	-	2	2	2
	CO4	3	3	2	3	1	1	-	1	-	2	1	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSC01	**COMPUTER PROGRAMMING**	PCR	2	1	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
Basic knowledge of computer.		CT+MT+EA					
Course Outcomes	**CO1:**To understand basics of computer programming, program flow, and programming constructs. **CO2:** Develop concepts on basic and complex data types, conditional and iterative statements. **CO3:** Exercise the concepts of user defined functions to solve real time problems. **CO4:** Inscribe C programs that use Pointers to access arrays, strings and functions. **CO5:** Exercise user defined data types including structures and unions to solve problems.						
Topics Covered	**Introduction to C**: Phases of developing a running computer program in C. (2L) Data types, size and values. Char, Unsigned and Signed data types. Number systems and representations. Constants, Overflow. (3L) Data concepts in C: Constants, Variables, Expressions, Operators, and operator precedence in C. (2L) Statements: Declarations, Input-Output Statements, Compound statements, Selection Statements. (2L) Conditions, Logical operators, Precedences. Repetitive statements, While construct, Do-while Construct, For construct. (3L) Arrays. Strings. Multidimensional arrays and matrices. (3L) **Pointers:** Pointer variables. Declaring and dereferencing pointer variables. Pointer Arithmetic. Examples. Accessing arrays through pointers. Pointer types, Pointers and strings. String operations in C. (6L) Dynamic memory allocation. (2L) **Modular Programming:** Functions: The prototype declaration, Function definition. (3L) Function call: Passing arguments to a function, by value, by reference. Scope of variable names. Recursive function calls, Tail recursion. (4L)						

	Sorting problem: Sorting in arrays with an example of Bubble sort. Sorting in strings. (3L) Search problem: Linear search and binary search. (2L) **More Data-types in C:** Structures in C: Motivation, examples, declaration, and use. Operations on structures. Passing structures as function arguments. type defining structures. (4L) File input-output in C. Streams. Input, output and error streams. Opening, closing and reading from files. Programming for command line arguments. (3L)
Text Books, and/or reference material	**Text Books:** 1. P. Deitel, H. Deitel. C How to Program. Pearson Education India, 7th Ed. 2. B. W. Kernighan, Dennis M. Ritchie. The C Programming. Prentice Hall Software Series, 2nd Ed. **Reference Books:** 1. P. Dey and M. Ghosh. Computer fundamentals and programming in C. Oxford press, 2013. 1. Y. Kanetkar. Let Us C. BPB Publications, Sixteenth edition, 2017.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CSC01	CO1	3	1	2	1	-	-	-	-	-	-	-	-
	CO2	-	2	1	2	1	-	-	-	-	-	-	-
	CO3	1	2	-	-	3	-	-	-	-	-	-	-
	CO4	1	3	1	2	3	-	-	-	-	-	-	1
	CO5	2	1	-	-	3	-	-	-	-	-	-	-
	CO6	2	-	3	-	1	-	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
XEC01	**ENGINEERING MECHANICS**	PCR	2	1	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
NIL		CT+MT+EA					
Course Outcomes		**CO1:** Acquire knowledge of mechanics and ability to draw free body diagrams. **CO2:** Apply knowledge of mechanics for solving special problems like truss and frame analysis. **CO3:** Ability to calculate centroid, moments of inertia for various shapes. **CO4:** Learn momentum and energy principles. **CO5:** Knowledge on virtual Work Principle and its application					
Topics Covered		Engineering Mechanics; measurement and SI units. [1] Vectors and force as a vector; Resultant of a system of forces on a particle; free body diagram and conditions of equilibrium of a particle; problems on particles; equilibrium of particles in space. [2] Resultant of a system of forces and couples on a rigid body; conditions of equilibrium of a rigid body; free body diagrams of rigid bodies subjected to different types of constraints; simple space problems of rigid bodies. [4]					

	Coefficients of static and kinetic friction; problems involving friction; theories of friction on square threaded power screw and flat belt. [5] Simple trusses; analysis of trusses by method of joints and method of sections. [5] Centre of gravity and centre of mass; centroids of lines, curves and areas; first moment of area; second moment of area; polar moment of inertia; radius of gyration of an area; parallel axis theorem; mass moment of inertia. [4] Path, velocity, acceleration; rectilinear and curvilinear motion; motion of system of particles; introduction to the concept of plane kinematics of rigid bodies. [6] Newton's second law of motion; dynamic equilibrium and D'Alembert's principle; linear momentum; angular momentum; rectilinear and curvilinear motion; principles of work–energy and impulse–momentum; impact of system of particles; introduction to the concept of plane kinetics of rigid bodies. [12] Principle of Virtual Work, Solution of Problems on Mechanics using Principle of Virtual Work [3]
Text Books, and/or reference material	1) S P Timoshenko and D H Young, Engineering Mechanics, 5th Edition 2) J L Meriam and L G Kraige, Engineering Mechanics, 5th Edition, Wiley India 3) F P Beer and E R Johnston, Vector Mechanics for Engineers 4) I H Shames, Engineering Mechanics

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
XEC01	CO1	1	-	-	-	-	-	-	-	-	-	-	1
	CO2	1	1	1	1	-	-	-	-	-	-	-	1
	CO3	1	1	-	-	-	-	-	-	-	-	-	1
	CO4	1	2	-	-	-	-	-	-	-	-	-	1
	CO5	-	2	2	2	2	1	-	-	-	1	-	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electrical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
XEC02	**Basic Electrical and Electronics Engineering**	PCR	3	0	0	3	3
Pre-requisites			Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))				
(10+2) level mathematics and physics			CT+MT+EA				
Course Outcomes	**CO1:** Learn the fundamentals of electric circuits and analyze the circuits using laws and network theorems. **CO2:** Gain the knowledge about magnetic circuits, electromagnetism and the basics of generation of alternating voltage. **CO3:** Understand the behaviour of single phase and poly-phase AC circuits. **CO4:** Understand the fundamentals of semiconductor devices. **CO5:** Analyze the design and characteristics of transistor-based electronic circuits. **CO6:** Evaluate operational amplifier-based circuits and logic gates.						
Topics Covered	1. Introduction to Electrical systems, Fundamentals of Electric Circuits: Ohm's laws, Kirchhoff's laws, Independent and Dependent sources, Analysis of simple circuits. (4)						

	2. Network theorems (DC): Superposition Theorem, Thevenin's Theorem, Norton's Theorem, Maximum Power Transfer Theorem. (5) 3. Magnetic circuits: Review of fundamental laws of electromagnetic induction, Self and mutual inductances, Solution of magnetic circuits. (3) 4. Generation of alternating voltage and current, E.M.F. equation, Average and R.M.S. value, Phase and phase difference, Phasor representation of alternating quantity, Behaviour of AC circuits, Resonance in series and parallel R-L-C circuits. (6) 5. Poly-phase system, Advantages of 3-phase system, Generation of 3-phase voltages, Voltage, current and power in a star and delta connected systems, 3-phase balanced and unbalanced circuits. (3) 6. Semiconductor Devices: Construction, working and V-I characteristics of diode, Zener diode, Zener diode as a voltage regulator, LED. (6) 7. Transistors: Introduction to BJT, FET, MOSFET; CMOS, working principle, and V-I characteristics of Transistors, biasing of BJT circuits-fixed bias, emitter bias, feedback bias, voltage divider bias, transistor as an amplifier. (8) 8. Operational amplifier: Introduction, applications: inverting, non-inverting amplifier, unity follower, integrator, differentiator, summing circuit .(4) 9. Introduction of logic gates, memory: ROM, RAM. (3)
Text Books, and/or reference material	**TEXT BOOKS** 1. Electrical & Electronic Technology by Hughes, Pearson Education India. 2. Introduction Electronic Devices & Circuit Theory, 11/e, 2012, Pearson: Boylestad & Nashelsky. 3. Electronics: Fundamentals and Applications By D. Chattopadhyay, P. C. Rakshit; New Age Int. Publication. **REFERENCE BOOKS** 1. Advanced Electrical Technology by H. Cotton, Reem Publication Pvt. Ltd. 2. Electrical Engineering fundamentals by Vincent Deltoro, Pearson Education India. 3. The Art of Electronics 3e, by Paul Horowitz, Winfield Hill. 4. Electronics - Circuits and Systems, Fourth Edition by Owen Bishop. 5. Electronics Fundamentals: Circuits, Devices & Applications (8e) by Thomas L. Floyd & David M. Buchla.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
XEC02	CO1	3	3	3	3	3	1	1	1	1	1	1	1
	CO2	3	3	3	3	2	1	2	1	1	1	1	1
	CO3	3	3	3	3	3	2	2	1	1	1	1	1
	CO4	2	3	2	2	-	1	-	-	-	-	-	1
	CO5	3	2	1	2	2	1	-	-	2	-	-	1
	CO6	3	2	2	2	3	-	-	-	2	-	-	1

Correlation levels 1, 2 or 3 as defined below:

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

<table>
<tr><td colspan="8">Department of Earth and Environmental Studies</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)#</td><td>Total Hours</td></tr>
<tr><td>ESC01</td><td>Ecology and Environment</td><td>PCR</td><td>2</td><td>0</td><td>0</td><td>2</td><td>2</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="2">NIL</td><td colspan="6">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Understand the importance of environment and ecosystem.
CO2:Understand the fundamental aspect of pollutant tracking and its implementation in natural and anthropogenic pollution of air and water system.
CO3: Understand the scientific basis of local and as well as global issues.
CO4: Apply of knowledge to develop sustainable solution.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">UNIT – I: INTRODUCTION (2)
Multidisciplinary nature of Environmental Studies: Definition, Scope, and Importance.

UNIT–II: FUNDAMENTALS OF ECOLOGY (9)
Definition, Components of Environment; Fundamentals of Ecology and Ecosystem; Components and Classification of Ecosystem; Energy flow in Ecosystem: Tropic level, Food Chain, Food Web, Ecological Pyramid; Biogeochemical cycles: Carbon, Nitrogen, Sulphur, Phosphorus, and Water Cycle; Biosphere and Biodiversity; Conservation.

UNIT–III: FUNDAMENTALS OF ENVIRONMENT (10)
Environmental Pollution: Air pollution, Water pollution, Soil pollution, Marine pollution, Noise pollution, Thermal pollution, Solid Wastes, and Natural hazards: Floods, earthquakes, cyclones, and landslides.
Environmental Issues: Climate change and global warming; acid rain; and ozone layer depletion.
Environment Quality: Ambient air quality standards, Water quality parameters and standards: pH, Turbidity, Hardness, Sulphate, Phosphates, Iron, Dissolved Oxygen, BOD, and COD.

UNIT– IV: NATURAL RESOURCES (3)
Mineral Resources, Energy Resources: Conventional and Non-Conventional.

UNIT- V- GREEN TECHNOLOGY & ENVIRONMENTAL ETHICS (4)
Sustainability: Carbon Sequestration, Green building practices, Green computing; Carrying capacity; and Environment Protection Acts/laws.</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">1. A Basic Course in Environmental Studies. Deswal & Deswal. Pub. Dhanpat Rai & Sons
2. Ecology. Odum. Pub. Oxford & IBH
3. Environmental Engineering. Peany et.al. Pub. McGraw Hill
4. A Text Book of Environmental Engg. Venugpal Rao. Pub. PHI
5. A Basic Course in Environmental Studies. Deswal & Deswal. Pub. Dhanpat Rai & Sons</td></tr>
</table>

	6. Environmental Studies. Bharucha. Pub. University of Press 7. Environmental Chemistry and Pollution, S. S. Dara & D. D. Mishra, S. Chand Publishing

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
ESC01	CO1	3	-	-	-	-	-	2	-	-	-	-	-
	CO2	1	-	-	-	-	-	2	-	-	-	-	-
	CO3	2	-	-	-	-	-	2	-	-	-	-	-
	CO4	1	-	3	-	-	2	1	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium)3: Substantial (High)

Department of Chemistry							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CYC01	**Engineering Chemistry**	PCR	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
None		CT+MT+EA					
Course Outcomes	**CO1:** Students will get the knowledge of fundamentals as well industrial applications of polymer, petroleum products, organometallic compounds and others. **CO2:** Students will be able to elucidate the structure of different organic compounds and to analyze the structure-property correlation. **CO3:** Students will be aware on the role played by different metals in biological systems and also the ecological impact of metals. **CO4:** Students will be able to understand and analyze thermodynamical, kinetic as well as electrochemical aspects of chemical systems and apply the understanding in the technical field.						
Topics Covered	**ORGANIC CHEMISTRY** i. **Polymer chemistry and polymer engineering:** Fundamental concept on polymer chemistry; synthesis and application of important polymers, Rubber and plastic materials; vulcanization, structure-property correlation: Concept of Molecular weight of polymer, Glass transition temperature. Engineered polymer: Thermally stable, flame retardant, Conducting polymer. (5L) ii. **Petroleum Engineering and oil refinery:** Origin of petroleum, separation principle and techniques of distillation of crude oil, thermal and catalytic cracking of petroleum, uses of different fractions, knocking, anti-knock compounds, octane number and cetane number. High octane and Aviation fuel. Bio-diesel. (3L) iii. **Structure elucidation of organic compounds by modern spectroscopic methods:** Application of UV-Visible (Lambert-Beers law), concept of chromophore, auxochrome, hypso-, hyper-, bathochromic, red shift. FT-IR spectroscopy and Mass spectroscopy (including instrumentation). (4L) **INORGANIC CHEMISTRY** i. **Coordination Chemistry:** Crystal Field Theory of octahedral and tetrahedral complexes, colour and magnetic properties, LMCT, MLCT, IVCT. Isomerism and stereochemistry.(5L) ii. **Bioinorganic Chemistry:** Metal ions in biological systems: Fe, Cu (2L)						

	iii. **Industrial applicationof Organometallic complexes:** π-acid ligands, stabilization of metal low oxidation state and 18 electron rules, metal carbonyls and nitrosyls, metal-alkene complexes, Various catalytic cycles of industrial importance. (4L) iv. **Environmental Chemistry:** Metal toxicity (As, Hg, Pb and Cd) and its remediation (1L) **PHYSICAL CHEMISTRY** i. **Chemical Thermodynamics:** 2nd law of thermodynamics: Concept of thermodynamic engine (Carnotand reverse Carnot cycle), entropy, free energy. Temperature and pressure dependence of entropy and free energy. Change in phase: phase diagram of single component system. Cryogenics: Joule Thomson experiment. (5L) ii. **Chemical Kinetics:**Rate expression of Reversible reaction, parallel reaction,and Consecutive reaction with proper examples. Temp effect on reaction rate.(3L) iii. **Catalysis:** Types of catalysis, Rate expression for Catalysed reaction, Acid-base and Enzyme catalysis.(2L) iv. **Electrochemistry:**EMF, Nernst Equation, Application of electrochemistry in chemical processes. Electrochemical cell, Fuel cell, Li-ion battery(3L).
Text Books, and/or reference material	Suggested Text Books: (i) Physical Chemistry by P. Atkins, Oxford (ii) A guidebook to mechanism in Organic chemistry: Peter Sykes; Pearson Edu. (iii) Inorganic Chemistry Part-I & II, R. L. Dutta, The new book stall Suggested Reference Books: **Organic Chemistry**: (i) Basic stereochemistry of organic molecules: S. Sengupta; Oxford University press (ii) Engineering Chemistry: Wiley (iii) Elementary Organic Spectroscopy: William Kemp, ELBS with Macmillan **Inorganic Chemistry:** (i) Inorganic Chemistry: Principle structure and reactivity, J. E. Huheey, E. A. Keiter and R. L. Keiter, Pearson Education (ii) Bioinorganic Chemistry -- Inorganic Elements in the Chemistry of Life: An Introductionand Guide, 2nd Edition, Wolfgang Kaim, Brigitte Schwederski, Axel Klein. (iii) Inorganic Chemistry Fourth Edition, Shriver & Atkins, Oxford **Physical Chemistry:** (i) Physical Chemistry by G.W Castellan (ii) Physical Chemistry by P. C. Rakshit

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CYC 01	CO1	1	2	-	-	-	-	-	-	-	-	-	-
	CO2	1	-	-	-	-	-	2	-	-	-	-	-
	CO3	1	2	1	1	1	-	-	-	-	-	-	-
	CO4	-	1	-	-	2	-	1	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	

CSS51	**COMPUTER PROGRAMMING LABORATORY**	PCR	0	0	3	3	2
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					
Course Outcomes	**CO1:** To understand the principle of operators, loops and branching statements. **CO2:** Implementation of function, recursion, arrays, and pointers based several types of assignments. **CO3:** To detail out the operations of strings. **CO4:** To understand structure and union. **CO5:** Application of C-programming to solve various types of problems.						
Topics Covered	**List of Experiments:** 1. Programs on expression evaluation. 2. Programs on conditional statements and branching 3. Programs on iterations/loops. 4. Applications of Arrays 5. Programs on basics of functions and pointers. 6. Programs on string using array and pointers. 7. Programs on recursion. 8. Programs on structures, union. 9. Programs on File Operations. 10. Case Studies.						
Text Books, and/or reference material	**Text Books:** 1. Y. Kanetkar, "Let Us C", BPB Publications, Sixteenth edition, 2017. 2. B. S. Gottfried, "Programming with C", McGraw Hill Education, Fourth edition, 2018. 3. E. Balagurusamy, "Computing Fundamentals and C Programming", McGraw Hill Education; Second edition, 2017. **Reference Books:** 1. P. Dey and M. Ghosh, “Computer fundamentals and programming in C”, Oxford press, 2013. 2. R. Thareja, “Computer fundamentals and programming in C”, Oxford press, 2013. 3. Schaum’s Outline, Programming with C.						

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CSS51	CO1	3	-	1	-	-	-	-	-	-	-	-	-
	CO2	-	2	1	3	-	-	-	-	-	-	-	-
	CO3	-	1	-	2	1	-	-	-	-	-	-	-
	CO4	-	-	3	2	-	-	1	-	-	-	2	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium)3: Substantial (High)

Department of Electrical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	

XES52	**Basic Electrical and Electronics Laboratory**	PCR	0	0	3	3	2

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
NIL	CT+EA

Course Outcomes	**CO1:** Learn to analyse the electric circuits using network theorems. **CO2:** Understand the characteristics of fluorescent lamp and compact fluorescent lamp. **CO3:** Analyze the behaviour of single phase and three phase AC circuits. **CO4:** Understand the application of electronics components, diode circuits as rectifier circuits and voltage regulators. **CO5:** Evaluate and study the performance of the transistor as a switch. **CO6:** Create inverting and non-inverting amplifier circuits using Op-Amp.
Labs Conducted	1. Verification of the network theorems (DC). 2. Study of the characteristics of fluorescent and compact fluorescent lamp. 3. Analysis of the three phase system for star and delta connected load. 4. Study of the series and parallel R-L-C circuit. 5. Identify and understand the use of different electronic and electrical instruments, various electronic components. 6. Study of half-wave and full-wave (bridge) rectifier with and without capacitor filter circuit. Zener diode as a voltage regulator. 7. Study the performance of a transistor as a switch through NOT gate. 8. Realization of Inverting and Non-inverting amplifier using Op-Amp.
Text Books, and/or reference material	**TEXT BOOK** 1. Handbook of Laboratory Experiments in Electronics and Electrical Engineering by A M Zungeru , J M Chuma, H U Ezea. 2. Experiments Manual for use with Electronic Principles (Engineering Technologies and the Trades) by Albert Paul Malvino Dr., David J. Bates, et al. **REFERENCE BOOKS** 1. Laboratory Courses in Electrical Engineering (5th Edition) by S. G. Tarnekar, P. K. Kharbanda, S. B. Bodhke, S. D. Naik, D. J. Dahigaonkar (S. Chand Publications). 2. The Art of Electronics 3e, by Paul Horowitz, Winfield Hill. 3. Electronic Principles, by Albert Paul Malvino Dr. and David J. Bate.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
XES52	CO1	3	3	3	3	3	1	1	1	2	2	2	3
	CO2	3	3	2	3	3	3	1	1	2	2	2	3
	CO3	3	3	2	3	3	2	1	1	2	2	2	3
	CO4	3	3	3	3	3	1	1	1	2	2	2	3
	CO5	3	2	1	2	2	1	-	-	2	-	-	-
	CO6	3	2	2	2	3	-	-	-	2	-	-	-
	CO7	3	3	2	2	-	-	-	-	2	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium)3: Substantial (High)

Department of Chemistry				
	Title of the course		Total Number of contact hours	Credit

Course Code		Program Core (PCR) / Electives (PEL)	Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CYS51	**CHEMISTRY LABORATORY**	PCR	0	0	2	2	1
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
None		CT+EA					
Course Outcomes	**CO1:** To learn basic analytical techniques useful for engg applications. **CO2:** Synthesis and characterization methods of few organic, inorganic and polymer compounds of industrial importance. **CO3:** Learn chromatographic separation methods. **CO4:** Applications of spectroscopic measurements.						
Topics Covered	1. Experiments based on pH metry: Determination of dissociation constant of we acids by pH meter. 2. Experiments based on conductivity measurement: Determination of amount HCl by conductometric titration with NaOH. 3. Estimation of metal ion: Estimation of Fe^{2+} by permangnomentry 4. Estimation of metal ion: Determ. of total hardness of water by EDTA titration. 5. Synthesis and characterization of inorganic complexes: e. g. $Mn(acac)_3$, Fe(acac cis-bis(glycinato)copper (II) monohydrate and their characterization by m. p. , FT etc. 6. Synthesis and charact. of organic compounds: e.g.Dibenzylideneacetone. 7. Synthesis of polymer: polymethylmethacrylate 8. Verification of Beer-Lamberts law and determination of amount of iron present a supplied solution. 9. Chromatography: Separation of two amino acids by paper chromatography 10. Determination of saponification value of fat/ vegetable oil						
	Suggested Text Books: 1. Vogel's Quantitative Chemical Analysis (6th Edition) Prentice Hall 2. Advanced Physical Chemistry Experiments: By Gurtu&Gurtu 3. Comprehensive Practical Organic Chemistry: Qualitative Analysis By V. K. Ahluwalia and S. Dhingra Suggested Reference Books: 1. Practical Chemistry By R.C. Bhattacharya 2. Selected experiments in Physical Chemistry By N. G. Mukherjee						

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CYS51	CO1	2	1	-	1	-	-	-	-	-	-	-	-
	CO2	-	1	-	1	1	2	-	-	-	-	-	-
	CO3	2	-	-	1	1	-	-	-	-	-	-	-
	CO4	-	1	-	1	1	-	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium)3: Substantial (High)

Department of Mathematics							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	

MAC02	**MATHEMATICS - II**	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
Basic concepts of set theory, differential equations, and probability.		CT+MT+EA					
Course Outcomes	**CO1:** learn the basic concepts of linear algebra and be able to apply the same to solve various engineering problems. **CO2:** Understand fundamentals of ordinary differential equations and their applications. **CO3:** Acquire the theoretical knowledge of Fourier Series, Fourier & Laplace transforms, and learn about their applications. **CO4:** Learn the basic concepts of probability theory.						
Topics Covered	**Introduction to Algebraic structures:** Group, subgroup, ring, subring, integral domain, and field. (3) **Linear Algebra:** Vector spaces over field, linear dependence and independence of vectors, linear span of a set of vectors, basis and dimension of finite dimensional vector space, elementary row/column operations, rank of a matrix, solutions of system of linear (homogeneous and non-homogeneous) equations, eigenvalues and eigenvectors, characteristic polynomials, Cayley-Hamilton theorem (without proof), Diagonalization of matrices. (15) **Ordinary Differential Equations (ODE):** Review of first order ODE, Picard's theorem (Statement Only), ODE of first order and of the first degree (exact ODE, rules for finding integrating factors), ODE of first order and of the higher degree (ODE solvable for x, solvable for y; Clairaut's equation, singular solution), homogeneous and non-homogeneous linear ODE with constant coefficients and variable coefficients (Euler–Cauchy type), linear dependence of solutions, Wronskian determinant, Solution of simultaneous ODEs $(dx/P = dy/Q = dz/R;\ dx/dt = ax + by,\ dy/dt = cx + dy)$, properties of nonlinear ODEs, phase plane analysis. (18) **Fourier series:** Piecewise smooth and periodic functions, Fourier series of a function in an interval, Dirichlet conditions, Convergence of Fourier series, Fourier sine and cosine series, Complex form of Fourier series. (4) **Fourier Transforms:** Fourier Integral Theorem (statement only), Different forms of Fourier Integrals, Fourier Transform and its inversion formula, Properties of Fourier Transform, Convolution. (7) **Laplace Transforms:** Laplace transforms and its Properties, Inverse Laplace transforms, Convolution theorem, Applications to ODE. (4) **Probability:** Random variables and probability distributions (discrete and continuous), Binomial, Poisson, Uniform and Normal distributions. (5)						
Text Books, and/or reference material	**Text Books:** 1. Kreyszig, E., Advanced Engineering Mathematics: 10th edition, Wiley India Edition (2010). 2. Strang, G., Linear algebra and its applications (4th Edition), Thomson (2006). 3. Murray, D.A., Introductory Course in Differential Equations, Khosla Publishing House (2021). 4. Debnath, L., Integral Transforms and Their Applications, CRC Press (1995). 5. Baisnab, A.P., Jas, M., Elements of Probability and Statistics, McGraw Hill Education (2017). **Reference Books:** 1. Kumaresan, S., Linear algebra - A Geometric approach, Chaukhamba Auriyantaliya (2017). 2. Ross, S.L., Differential Equations, 3rd Edition, Wiley Student Edition (2017). 3. Shivamoggi, A., Integral Transforms for Engineers, PHI (2003).						

	4. Grinstead, C.M., Snell, J.L., Introduction to probability, American Mathematical Society (2012).

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
MAC02	CO1	3	3	2	1	2	-	2	-	-	-	1	2
	CO2	3	3	2	2	2	-	2	-	-	1	-	2
	CO3	3	3	2	2	3	1	1	-	1	1	1	2
	CO4	3	2	1	3	2	1	1	1	1	-	-	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium)3: Substantial (High)

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSC02	Data Structure and Algorithms	PCR	2	1	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
CSC01 (Computer Programming)		CA+ MT + ET **[**CA: 15%, MT: 25%, ET: 60%**]**					
Course Outcomes	**CO1:** Understanding the fundamental concepts of abstract data types, data structures, algorithms and time complexity analysis of algorithms. **CO2:** Implementation of different abstract data types (array, linked list, stack, queue, tree, graph). **CO3:** Implementation of different sorting and searching techniques along with their performance evaluation. **CO4:** Analysis of the suitability/compatibility of different data structures based on the types of applications. **CO5:** Design and development of algorithms for real-life applications.						
Topics Covered	**Introduction:** Abstract Data Type (ADT), Data Structures, Concept of static and dynamic memory allocation, Algorithm, Analysis of time and space complexity of algorithms, Asymptotic notations: Big Oh, Big Omega and Big Theta notations, Impact of data structure on the performance of an algorithm. (6L) **Array:** Array as an ADT, Single and multi-dimensional array, Memory representation (row major and column major) of array, Address calculation for array elements. (2L) **Linked list:** Linked list as an ADT, Memory allocation and deallocation for a linked list, Linked list versus array, Types of linked lists: singly linked list, doubly linked list and circular linked list, Operations on linked list: creation, display, insertion and deletion (in different positions), Concatenation, Searching, Sorting, Applications of linked list: Representations and operations on polynomials, sparse matrices, etc., Array vs. Linked List. (6L)						

	Stack: Stack as an ADT, Push and pop operations on stacks, Array implementation of stack, Linked list implementation of stack, Applications of stack: Recursion, Function call, Evaluation of postfix expression using stack, Conversion of infix to postfix using stack. (5L) **Queue:** Queue as an ADT, Enqueue and dequeue operations, Array implementation of queue, Limitation of array implementation, Circular queue, Linked list implementation of queue, Priority queue. (4L) **Binary Tree:** Binary Tree, Definition and properties, Representation of binary tree in memory: linked representation, array representation, Binary tree traversal (Preorder, Inorder and Postorder), Binary search tree, Heap (8L) **Searching Algorithms:** Linear search and binary search. (2L) Sorting Algorithms: Selection sort, Insertion sort, Quick sort, and Merge sort. (5L) **Graphs Algorithms:** Graph representation using Adjacency matrix and Adjacency list, Breadth First Search and Depth First Search algorithms. (4L)
Text Books, and/or reference material	**Text Books:** 1. R. F. Gilberg and B. A. Forouzan, "Data Structures: A pseudocode approach with C", 2nd Edition, CENGAGE Learning. 2. A. V. Aho, J. D. Ullman and J. E. Hopcroft, “Data Structures and Algorithms”, Addition Wesley. 3. Lipschutz, “Data Structures (Schaum’s Outline Series)”, Tata Mcgraw Hill. 4. E. Horowitz, S. Sahni, S. Anderson-Freed, “Fundamentals of Data Structures in C”, Universities Press; Second edition (2008). **Reference Books:** 1. Y. Langsam, M. J. Augenstein and A. N. Tanenbaum, "Data Structures using C and C++", Pearson, 2006. 2. Knuth, Donald E. The Art of Computer Programming. 3rd ed. Vols 1&2. Reading, MA: Addison-Wesley, 1997. ISBN: 0201896834. ISBN: 0201896842. ISBN: 0201896850. 3. Kleinberg and Eva Tardos. Algorithm Design. Addison-Wesley 2005 ISBN-13: 978-0321295354.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CSC02	CO1	2	1	-	1	-	-	-	-	1	1	-	3
	CO2	2	3	3	1	-	-	-	1	2	2	1	2
	CO3	2	3	3	3	1	1	-	1	2	2	2	3
	CO4	3	3	3	3	2	2	2	2	3	3	3	3
	CO5	3	3	3	3	2	2	1	1	3	3	3	3

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium)3: Substantial (High)

Department of Physics							
Course Code	**Title of the course**	**Program Core (PCR) / Electives (PEL)**	**Total Number of contact hours**				Credit
			Lecture (L)	**Tutorial (T)**	**Practical (P)**	**Total Hours**	
PHC01	**Engineering Physics**	PCR	2	1	0	3	3
Pre-requisites:		Course Assessment methods: (Continuous (CT), mid-term (MT) and end assessment (EA))					
NIL		CT+MT+EA					
Course Outcomes	**CO1:** To realize and apply the fundamental concepts of physics such as superposition principle, simple harmonic motion to real world problems.						

	CO2: Learn about the quantum phenomenon of subatomic particles and its applications to the practical field. **CO3:** Gain an integrative overview and applications of fundamental optical phenomena such as interference, diffraction and polarization. **CO4:** Acquire basic knowledge related to the working mechanism of lasers and signal propagation through optical fibers.
Topics Covered	**Harmonic Oscillations** - Linear superposition principle, Superposition of two perpendicular oscillations having same and different frequencies and phases, Free, Damped and Forced vibrations, Equation of motion, Amplitude resonance, Velocity resonance, Quality factor, sharpness of resonance, [8] **Wave Motion**: Longitudinal waves, Transverse waves, Wave equation, phase velocity and group velocity, Maxwell's equations, Electro-magnetic waves in free space. [3] **Introductory Quantum Mechanics** - Inadequacy of classical mechanics, Blackbody radiation, Planck's quantum hypothesis, de Broglie's hypothesis, Heisenberg's uncertainty principle and applications, Schrodinger's wave equation and applications to simple problems: Particle in a one-dimensional box, Simple harmonic oscillator, Tunnelling effect. [8] **Interference & Diffraction** - Huygens' principle, Young's experiment, Superposition of waves, Conditions of sustained Interference, Concepts of coherent sources, Interference by division of wavefront, Interference by division of amplitude with examples, The Michelson interferometer and some problems; Fraunhofer diffraction, Single slit, Multiple slits, Resolving power of grating. [13] **Polarisation** - Polarisation, Qualitative discussion on Plane, Circularly and elliptically polarized light, Malus law, Brewster's law, Double refraction (birefringence) - Ordinary and extra-ordinary rays, Optic axis etc.; Polaroid, Nicol prism, Retardation plates and analysis of polarized lights. [5] **Laser and Optical Fiber** - Spontaneous and stimulated emission of radiation, Population inversion, Einstein's A & B co-efficient, Optical resonator and pumping methods, He-Ne laser. Optical Fibre– Core and cladding, Total internal reflection, Calculation of numerical aperture and acceptance angle, Applications. [5]
Text Books, and/or reference material	**TEXT BOOKS**: 1. The Physics of Vibrations and Waves, H. John Pain, Willy and Sons 2. A Text Book of Oscillations and Waves, M. Goswami and S. Sahoo, Scitech Publications 3. Engineering Physics, H. K. Malik and A. K. Singh, McGraw-Hill. **REFERENCE BOOKS**: 1. Vibrations and Waves in Physics, Iain G. Main, Cambridge University Press 2. Quantum Physics, R. Eisberg and R. Resnick, John Wiley and Sons 3. Fundamental of Optics, Jankins and White, McGraw-Hill 4. Optics, A. K. Ghatak, Tata McGraw-Hill 5. Waves and Oscillations, N. K. Bajaj, Tata McGraw-Hill 6. Lasers and Non-linear Optics, B. B. Laud, New Age International Pvt Lt

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
PHC01	CO1	3	2	1	1	1	-	-	1	-	-	-	1
	CO2	3	2	-	2	-	-	-	-	-	-	-	1
	CO3	3	2	2	2	1	1	1	1	1	-	1	1
	CO4	3	2	2	2	1	1	1	-	1	-	1	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium)3: Substantial (High)

<table>
<tr><td colspan="8">Department of Humanities and Social Sciences</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>HSC01</td><td>Professional Communication</td><td>PCR</td><td>2</td><td>0</td><td>2</td><td>4</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3">None</td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Learners will acquire linguistic proficiency in terms of improvement in their listening, speaking, reading, and writing skills.
CO2: Learners will acquire better communicative ability.
CO3: The course will help learners improve their social connectivity skill.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Vocabulary
1. Word Formation, Use of Prefixes and Suffixes (1)
2. Synonyms, Antonyms (1)
3. Prefixes and Suffixes from Foreign Languages, Words from Foreign Languages (1)
4. Abbreviations and Acronyms (1)
5. Technical Vocabulary (1)
Grammar
1. Identifying Common Errors in Articles and Prepositions (1)
2. Common Errors in Noun-Pronoun Agreement and Subject-Verb Agreement (1)
3. Misplaced Modifiers and Tenses (1)
4. Redundancies and Clichés (1)
Reading
1. Reading and Its Importance, Techniques of Effective Reading (1)
2. Improving Comprehension Skills, Techniques for Good Comprehension (1)
3. Skimming and Scanning (1)
4. Comprehension, Intensive and Extensive Reading (2)
Writing
1. Sentence Structures, Phrases and Clauses, Punctuation (2)
2. Organising Principles of Paragraphs (2)
3. Formal Letters, Letters of Complaint, Requisition Letters, Job Application, and Résumé (2)
4. Nature and Style of Sensible Writing, Defining, Describing, Classifying, Providing Examples and Evidence (2)
5. Essay Writing (2)
6. Précis Writing (2)
7. Report Writing (2)
Oral Communication
1. Listening Comprehension (4)
2. Pronunciation, Intonation, Stress, and Rhythm (4)
3. Communication at the Workplace (4)
4. Everyday Conversation (4)
5. Group Discussion (4)
6. Interviews (4)
7. Formal Presentations (4)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Book:
1. English for Engineers –Sudharshana & Savitha (Cambridge UP)
Reference Books:
2. English—Kulbhushan Kumar (Khanna Book Publishing)
3. Remedial English Grammar—F. T. Wood (Macmillan)</td></tr>
</table>

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
HSC01	CO1	1	-	-	1	-	1	-	1	2	3	1	-
	CO2	1	-	-	1	-	2	-	2	2	3	2	-
	CO3	-	-	-	1	-	3	-	3	3	3	2	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSS52	**DATA STRUCTURES AND ALGORITHMS LABORATORY**	PCR	0	0	3	3	2
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					

Course Outcomes	CO1: Understanding the suitability and compatibility of array and linked list implementations for different application problems. CO2: Understanding the concept of abstract data types from real-life scenarios and their implementation in computing system. CO3: Identify, design and implementation of stack, queue, binary tree, and graph as applicable for given problem. CO4: Implementation of different searching and sorting techniques using appropriate data structures and perform efficiency analysis. CO5: Create efficient algorithms for real-life applications.
Topics Covered	**List of Experiments:** 1. Application of arrays using dynamic memory allocation. 2. Implementation and Applications of linked lists. 3. Implementation of stack, and applications of stack. 4. Implementation of queue, applications of queue: Priority queue. 5. Implementation of Binary tree, Binary tree traversal: Preorder, Inorder and Postorder traversal. 6. Implementation of binary search tree and operations on it. 7. Implementation of linear search, binary search (recursive, non-recursive). 8. Implementation of different sorting algorithms. 9. Implementation of graph algorithms: Breadth first search, Depth first search. 10. Case Studies.
Text Books, and/or reference material	**Text Books:** 1. S. Lipschutz, “Data Structures (Schaum’s Outline Series)”, McGraw Hill Education; First edition (2017). 2. E. Horowitz, S. Sahni, S. Anderson-Freed, “Fundamentals of Data Structures in C”, Universities Press; Second edition (2008). 3. E. Balagurusamy, "Programming in ANSI C", McGraw Hill Education India Private Limited, Seventh edition (2017). **Reference Books:** 1. B. S. Gottfried, "Programming with C", McGraw Hill Education, 4th Ed. (2018).

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CSS52	CO1	2	1	-	1	-	-	-	-	1	1	-	3
	CO2	2	3	3	1	-	-	-	1	2	2	1	2
	CO3	2	3	3	3	1	1	-	1	2	2	2	3
	CO4	3	3	3	3	2	2	2	2	3	3	3	3
	CO5	3	3	3	3	2	2	1	1	3	3	3	3

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
XES51	**ENGINEERING GRAPHICS**	PCR	1	0	3	4	2.5
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					
Course Outcomes	**CO1:** Ability of mental visualization of different objects **CO2:** Theoretical knowledge of orthographic projection to solve problems on one/two/three dimensional objects **CO3:** Able to read/interpret industrial drawing and to communicate with relevant people						
Topics Covered	Graphics as language of communication; technical drawing tools and their up-keep; types of lines; construction of geometrical figures; lettering and dimensioning. [6] Construction and use of scales; construction of curves of engineering importance such as curves of conic section; spirals, cycloids, involutes and different loci of points; use of equations for drawing some curves. [9] Descriptive geometry: necessity and importance of orthographic projection; horizontal and vertical reference planes; coordinate of points; orthographic projection of points and lines situated in different quadrants, viz. 1st, 2nd, 3rd and 4th quadrants; traces of lines. First angle and third angle projection of lines and planes; views from top, front and left (or right); true length and true inclination of lines with planes of projections; primary auxiliary projection of points, lines and planes; auxiliary plan and auxiliary elevation. [9] Projection of simple regular solids, viz. prisms, cubes, cylinders, pyramids, cones, tetrahedrons, spheres, hemi-spheres etc. [6] Section of solids; section by perpendicular planes; sectional views; true shapes of sections. [6] Dimensional techniques; international and national standards (ISO and BIS). [3] Freehand graphics. [3]						
Text and/or reference material	1) Engineering Drawing and Graphics – K Venugopal 2) Engineering Drawing – N D Bhat 3) Practical Geometry and Engineering Graphics – W Abbott						

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
XES51	CO1	1	-	-	-	-	-	-	-	-	-	-	-
	CO2	1	1	-	-	-	-	-	-	-	-	-	-
	CO3	1	-	1	-	-	-	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:

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

Department of Physics							
Course Code	**Title of the course**	Program Core (PCR) / Electives (PEL)	**Total Number of contact hours**				**Credit**
			Lecture (L)	**Tutorial (T)**	**Practical (P)**	**Total Hours**	
PHS51	**Engineering Physics Laboratory**	PCR	0	0	2	2	1
Pre-requisites		Course Assessment methods: (Continuous evaluation (CE) and end assessment (EA))					
NIL		CE+EA					
Course Outcomes	**CO1:** To realize and apply different techniques for measuring refractive indices of different materials. **CO2:** To realize different types of waveforms in electrical signals using CRO. **CO3:** To understand charging and discharging mechanism of a capacitor. **CO4**: To understand interference, diffraction and polarization related optical phenomena. **CO5:** To acquire basic knowledge of light propagation through fibers.						
Topics Covered	1. Find the refractive index of a liquid by a travelling microscope. 2. Determine the refractive index of the material of prism using spectrometer. 3. Determination of amplitude and frequency of electrical signals by oscilloscope. 4. To study the characteristics of RC circuits. 5. To study Brewster's law/Malus' law using laser light. 6. To study the diffraction of light by a grating. 7. To study the interference of light by Newton's ring apparatus. 8. To determine numerical aperture of optical fiber. 9. Determination of Planck constant.						
Text and/or reference material	**SUGGESTED BOOKS**: 1) A Text Book on Practical Physics – K. G. Mazumdar and B. Ghosh 2) Practical Physics – Worsnop and Flint						

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
PHS51	CO1	3	2	1	-	-	-	-	-	2	1	-	1
	CO2	3	2	1	-	-	1	-	-	2	1	-	1
	CO3	3	1	-	-	-	-	-	-	2	1	-	1
	CO4	3	2	-	1	-	1	1	-	2	1	-	1
	CO5	3	2	1	-	1	1	1	-	2	1	-	1

Correlation levels 1, 2 or 3 as defined below:

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

Course Code	**Title of the course**	Program Core (PCR) / Electives (PEL)	**Total Number of contact hours**				**Credit**
			Lecture (L)	**Tutorial (T)**	**Practical (P)**	**Total Hours**	

XXS51	**Extra Academic Activities**	PCR	0	0	2	2	1

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
NIL	CT+EA

Course Outcomes	CO1: Social Interaction through the medium of sports CO3: Self-directed and Life-long Learning: Acquire the ability to engage in independent and life-long learning in the broadest context socio-technological changes. CO4: Personality development through community engagement CO5: Exposure to social service
Topics Covered	**YOGA** • Introduction of Yoga. • Sitting Posture/Asanas- Padmasana, Vajrasana, Ardhakurmasana, Ustrasana, Bakrasana, Sasankasana, Janusirshasana, Suryanamaskar. • Mudra- Gyana mudra, Chin mudra, Shuni mudra, Prana mudra, Adi mudra, Anjali mudra. • Laying Posture/Asanas- PavanaMuktasana, UttanaPadasana, Sarpasana, Bhujangasana (Cobra Pose), Eka Pada Śalabhāsana, Dhanurasana, Chakrasana, Viparitkarani. • Meditation- Yognidra, Om chant, Pray chant. • Standing Posture/Asanas- Tadasana (Mountain Pose), Vrikshasana (Tree Pose), Ardhachandrasana, Trikonasana, Utkatasana, Padahastasana. • Pranayama- Deep breathing, AnulomVilom, Suryabhedi, Chandrabhedi. • Kriya- Kapalbhati, Trataka. **NSS** • Swachha Bharat Mission • Free Medical Camp • Sanitation drive in and around the campus. • Unnat Bharat Abhiyaan • MatribhashaSaptah celebration

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
XXS51	CO1	-	-	-	-	-	2	-	-	3	-	-	-
	CO2	-	-	-	-	-	-	-	2	-	-	-	-
	CO3	-	-	-	-	-	-	1	-	-	-	-	3
	CO4	-	-	-	-	-	-	-	-	2	2	-	-
	CO5	-	-	-	-	-	3	1	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="8">Department of Mathematics</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td>Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td><td></td></tr>
<tr><td>MAC331</td><td>MATHEMATICS-III</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Basic knowledge of topics included in MAC01 & MAC02</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Acquire the idea about mathematical formulations of phenomena in physics and engineering.
CO2: To understand the common numerical methods to obtain the approximate solutions for the intractable mathematical problems.
CO3: To understand the basics of complex analysis and its role in modern mathematics and applied contexts.
CO4: To understand the optimization methods and algorithms developed for solving various types of optimization problems.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Partial Differential Equations (PDE): Formation of PDEs; Lagrange method for solution of first order quasilinear PDE; Charpit method for first order nonlinear PDE; Homogenous and Nonhomogeneous linear PDE with constant coefficients: Complimentary Function, Particular integral; Classification of second order linear PDE and canonical forms; Initial & Boundary Value Problems involving one dimensional wave equation, one dimensional heat equation and two dimensional Laplace equation. [14]

Numerical Methods: Significant digits, Errors; Difference operators; Newton's Forward, Backward and Lagrange’s interpolation formulae; Numerical solutions of nonlinear algebraic/transcendental equations by Bisection and Newton-Raphson methods; Trapezoidal and Simpson’s 1/3 rule for numerical integration; Euler’s method and modified Eular's methods for solving first order differential equations. [14]

Complex Analysis: Functions of complex variable, Limit, Continuity and Derivative; Analytic function; Harmonic function; Conformal transformation and Bilinear transformation; Complex integration; Cauchy’s integral theorem; Cauchy’s integral formula; Taylor’s theorem, Laurent’s theorem (Statement only); Singular points and residues; Cauchy’s residue theorem. [17]

Optimization:
Mathematical Preliminaries: Hyperplanes and Linear Varieties; Convex Sets, Polytopes and Polyhedra. [2]

Linear Programming Problem (LPP): Introduction; Formulation of linear programming problem (LPP); Graphical method for its solution; Standard form of LPP; Basic feasible solutions; Simplex Method for solving LPP. [9]</td></tr>
<tr><td>Text Books, and/or</td><td colspan="7">Text Books:
1. An Elementary Course in Partial Differential Equations-T. Amarnath
2. Numerical Methods for scientific & Engineering Computation- M.K.Jain, S.R.K. Iyengar & R.K. Jain.</td></tr>
</table>

reference material	3. Foundations of Complex Analysis- S. Ponnuswami 4. Operations Research Principles and Practices- Ravindran, Phillips, Solberg 5. Advanced Engineering Mathematics- E. Kreyszig **Reference Books:** 1. Complex Analysis-L. V. Ahfors 2. Elements of partial differential equations- I. N. Sneddon 3. Operations Research- H. A. Taha

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
MAC331	CO1	3	2	-	-	2	-	2	-	-	2	2	3
	CO2	1	2	1	1	-	-	3	-	2	1	-	3
	CO3	3	-	-	2	-	1	2	-	2	-	-	3
	CO4	3	3	3	2	-	-	1	2	1	-	2	3

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="8">Department of Biotechnology</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td>Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td><td></td></tr>
<tr><td>BTC301</td><td>BIOCHEMISTRY AND ENZYME TECHNOLOGY</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6"></td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: To understand the principles of bioenergetics and to correlate them with the metabolic pathway.
CO2: To impart an understanding on the fates of macromolecules during metabolism.
CO3: To provide an understanding on the importance and synthesis of energy currency molecule, ATP.
CO4: To interpret the regulation in the metabolic pathway and to study the role of hormones in the metabolic pathway.
CO 5: To understand mechanism and kinetics of enzyme action and their regulation for application of enzymes in living system and for industrial purpose.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Module 1: Biomolecules, Vitamins, Principles of Bioenergetics [6]

Module 2: Carbohydrate and its metabolism: Carbohydrate Biosynthesis: Gluconeogenesis, Biosynthesis of glycogen, starch, Sucrose, Photosynthetic Carbohydrate Synthesis. Glycolysis and catabolism of hexoses: Glycolysis, pentose phosphate pathway of glucose oxidation, Citric acid cycle, regulation of citric acid cycle, glyoxylate cycle. Role of hormones in metabolism Oxidative Phosphorylation and Photophosphorylation: Oxidative Phosphorylation, Regulation of Oxidative Phosphorylation, Photosynthesis [7]

Module 3: Lipid and its metabolism, Oxidation of Fatty acids - Transport of fatty acid, beta-oxidation, Ketone bodies, Lipid Biosynthesis - Biosynthesis of fatty acids [5]

Module 4: Protein and its metabolism, Amino acid oxidation and production of Urea - Metabolic fates of amino groups, Nitrogen excretion and the urea cycle, Pathways of amino acid degradation Nitrogen metabolism, Biosynthesis of amino acids. [4]

Module 5: Nucleic acid and its metabolism, Biosynthesis and degradation of Nucleotides. [4]

Module 6: Enzyme Technology and Vitamins, Enzymes: Nomenclature of enzymes, Enzyme kinetics, Mechanism of enzymatic, Catalysis, Active site, Activators and inhibitors, Coenzymes, Isoenzymes, Michaelis-Menten equation, Km and Vmax value, Regulation of enzyme activity (single-substrate and multi-substrate reactions). Vitamin’s as coenzyme, Production of enzymes and immobilisation : Production of industrial enzymes such as proteases, amylases, lipases, cellulases, whole cell biocatalysis. Enzyme immobilization: Methods of immobilization of enzymes-physical & chemical techniques, Kinetics of immobilized enzyme, Effect of external mass transfer & intra-particle diffusion, limitation & applications of immobilized enzymes, Bioreactors using immobilized enzyme. Engineering of Enzymes, Application of enzyme in leather industry, detergent industry, dairy industry; Lignocellulose degrading enzymes.</td></tr>
</table>

Text Books, and/or reference material	**Text Books:** 1. Biochemistry by LubertStryer. W. H. Freeman & Company, NY 2. Biochemistry by Lehninger. McMillan publishers **Reference:** 1. Biochemistry, Voet & Voet 2. Fundamental of Enzymology by Price and Stevens (2002): Oxford University Press 3. Enzyme technology by Chaplin and Bucke. Cambridge University Press

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
BTC301	CO1	3	3	3	2	3	3	2	2	1	1	1	3
	CO2	3	3	3	3	3	2	2	3	1	1	1	3
	CO3	3	3	3	3	2	3	1	1	1	1	1	3
	CO4	3	3	2	3	3	3	1	1	1	1	1	3
	CO5	3	3	3	3	3	3	3	3	3	3	1	3

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTC302	**PROCESS CALCULATIONS AND THERMODYNAMICS**	PCR	3	0	0	3	3
Prerequisite		Course Assessment methods (Continuous (CT) and end assessment (EA))					
		CT+EA					
Course Outcomes	**CO1:** To develop the concept of dimension and unit conversion to check dimensional consistency of balanced equation **CO2:** Learn basic laws about the behavior of gases, liquids and solids and some basic mathematical tools. **CO3:** To Establish mathematical methodologies for the computation of material balances and energy balances with and without chemical reaction **CO4:** To apply knowledge of the laws of thermodynamics to solve physical and chemical problems encountered in chemical, biochemical industries and biological processes. **CO5:** To analyze and interpret data, to identify, formulate, and solve engineering problems.						
Topics Covered	**Module 1: Significance of Units and Dimensions:** Conversion of Equations, Systems of Units, Dimensional Homogeneity and Dimensionless Quantities, Buckingham Pi-theorem for Dimensional Analysis Mathematical Requisites: Use of log-log and semi-log graph paper, Triangular Diagram, **Introduction to Chemical Engineering Calculations:** Basis, Mole Fraction and Mole Percent, Mass Fraction and Mass Percent, Concentration of different forms, Conversion from one form to another, Ideal gas laws and its significance, Molar concept, Concept of partial pressure & partial						

	volume, Dalton's law and Amagat's law and Numerical problems on their applications, Fundamental concept of vapor pressure & boiling point, Clausius-Clapeyron equation, Antoine equation and numerical problems on their applications ,Ideal & non-ideal solutions, Raoult's law, Henry's law and their applications in numerical problems. [9] **Module 2: Material Balances with and without chemical reaction:** Material balances in crystallizers, gas - liquid absorbers, evaporators, distillation plant. Systems with recycle,drying, extraction. Energy Balance: Enthalpy calculation for systems without Chemical Reaction, Estimation of Heat Capacities of solids, liquids and gases. Heat of fusion and vaporization, Enthalpy calculation for systems with Chemical Reaction, Thermo-chemistry, Calculations of heat of reaction, heat of combustions, heat of formation and heat of neutralization, Effect of Temperature and Pressure on Heat of Reaction, Hess's Law, Adiabatic Flame Temperature, Theoretical Flame Temperature. [9] **Module 3: Scope of thermodynamics,** Terminology and fundamental concepts. Microscopic and macroscopic view. State and path functions, thermodynamics processes, Zeroth and First law of thermodynamics: Applications of first law to close and open system. Limitations of first law, Heat pump, heat engine, Second law of thermodynamics: Reversibility and irreversibility, Carnot cycle, concept and estimation of entropy, third law of thermodynamics, Clausius in equality, Gibb's and Helmholtz free energy. Free energy and Chemical Equilibrium. [8] **Module 4: PVT behavior of pure substance**, Equations of state for ideal and real gases, cubic and virial equation of state, problems, Compressibility factor, thermodynamic properties of pure substances, **Refrigeration of gases:** Refrigerator, Co-efficient of performance, capacity of refrigerator, Vapor compression cycle, Choice of refrigerants. [7] **Module 5: Thermodynamics in Biology:** Thermodynamics of protein ligand binding, Dissociation constant and Scatchard analysis, Drug binding by proteins, Isothermal Titration Calorimetry, Affinity and specificity in biomolecular interactions, Allosteric regulation. [7].
Text Books, and/or reference material	1. Unit Operations–Chemical Process Principles – Part-I - Haugen, Wartson&Ragatz (CBS) 2. Basic Principles and Calculations in Chemical Engineering – Himmelblau ((Prentice Hall of India) 3. Stoichiometry, Bhatt and Vora, Tata McGraw Hill Companies. 4. Chemical Engineering Thermodynamics – J. M. Smith & H. C. Van Ness and M. M. Abbott (Tata McGraw Hill) 5. Chemical & Engineering Thermodynamics – S. I. Sandler (Wiley)

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
BTC302	CO1	3	3	2	1	1	-	-	1	3	1	1	3
	CO2	3	3	2	1	1	-	-	1	3	1	1	3
	CO3	3	3	3	1	1	-	-	1	3	1	3	3
	CO4	3	3	3	2	1	-	1	2	3	1	3	3
	CO5	3	3	3	2	1	-	1	2	3	1	3	3

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="8">Department of Biotechnology</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td>Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td><td></td></tr>
<tr><td>BTC 303</td><td>MICROBIOLOGY AND BIOPROCESS TECHNOLOGY</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">NIL</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: To develop knowledge on different types of microorganisms including viruses and microscopy for the visualization of microorganisms, their characteristic features as well as internal and external structures and their functions.
CO2: To impart an understanding on microbial classification and taxonomy, microbial community and interactions, microbial nutrition, nutritional types, growth media, growthin different systems, and control of microorganisms using various physical and chemical treatments including antimicrobial drugs.
CO3: To develop knowledge on microbial metabolism, energy transduction mechanisms, and microbial genetics
CO4: To acquire experimental know how of microbial production of various industrial products such as alcohol, antibiotics, amino acids, vitamins exopolysaccharides, enzymes, etc. from industrial strains.
CO5: To illustrate the upstream and downstream processing for product recovery and purification.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">PART A: Microbiology

Introduction to microbiology: History and scope of microbiology, major contribution and events in microbiology, different types of microorganisms – characteristic features, microbes and diseases, microbes in human welfare.[2]
Microbial structures: Different types of microscopy, preparation and staining of specimens, microbial shape, size, arrangements, overview of procaryotic and eucaryotic cell – internal and external structures, cytoplasmic matrix, nucleoid, plasmids, ribosomes, flagella, pilli, fimbrie, spores, bacterial and archaebacterial cell walls and cell membranes, Viruses – types, structures, multiplications [4]</td></tr>
</table>

Microbial classification and taxonomy: Domains of life, classification, taxonomic ranks, techniques for determining microbial taxonomy and phylogeny, prokaryotic phylogeny and diversity, microbial community and interactions – Mutualism, Cooperation, Commensalism, Predation, Parasitism, Amenalism, Competition. Normal microbiota of human body. [**3]**

Microbial nutrition, growth and control: Common nutrient requirements, nutritional types, uptake of nutrients by cell, culture media, pure culture, microbial growth – batch culture and continuous culture, growth curve, measurement of growth, influence of environmental factors on growth, control of microorganisms by physical and chemical agents, Antimicrobial drugs – general characteristics, narrow- spectrum and broad-spectrum drugs, inhibitors of cell wall synthesis, nucleic acid synthesis and protein synthesis, metabolic antagonists, Drug resistance. [**5]**

Microbial metabolism: Energy release and conservation, chemoorganotrophic fueling processes, aerobic respiration, glycolysis, TCA cycle, electron transport and oxidative phosphorylation, anaerobic respiration - nitrate and sulphate reduction, fermentations, chemolithotrophy, phototrophy [3**]**

Microbial genetics: Conjugation, Transduction, Transformation[**4]**

PART B: BIOPROCESS Technology

A) Introduction to Fermentation Technology: Microbial Culture systems; Media for Industrial fermentations; Media Optimization; Sterilization of Industrial Media; The development of Inoculum for Industrial fermentations; Starter Cultures; Downstream Processing and fermentation economics **[4]**

B) Commercial Strain Development & Microbial Processes: Sources of industrial cultures and maintenance. Alcoholic fermentation: Production of Industrial Alcohol – Fermentation mechanism. Recent developments, brewing and malting, manufacture of wine and other distilled liquors. Cellular control regulating production of microbial metabolites – Primary and Secondary metabolite – Induced mutation technique – Analogue resistant mutant – Catabolic derepressed mutants – Genetically engineered strain – Protoplast fusion technique. Basic idea on fermentation process, submerged, stationary, solid and semi-solid – with their merits and demerits. **[5]**

C) Microbial production of nucleosides and nucleotides: i) Introduction ii) Classification of methods for production of 5' IMP and 5'GMP iii) Production of 5'IMP and 5'GMP by fermentation. **[3]**

D) Microbial production of Vitamins: 1) Vitamin B12 - Organisms used, production method- process, recovery and assay. 2) Vitamin C - Organisms used, production method, process, recovery and assay. **[3]**

E) Lectures Microbial Production of Antibiotics : Organism used, production process and recovery of-1) Bacitracin & 2) Chloramphenicol **[2**]

F) Lectures Microbial Production of acids, viz., citric, lactic, Acetic acid, vinegar and gluconic acid. Mechanism of each fermentation, their uses. its spoilage and prevention **[2]**

G) Production of Amino acids (Lysine and glutamic acid) and Antibiotics (Pencillin, Streptomycin and Tetracyclines) and its new Developments **[2]**

Text Books, and/or reference material	**Text Books:** 1. Prescott, Harley and Klein's Microbiology – McGraw Hill 2. Microbiology by Pelczar, Chan and Krieg, Tata Mc Graw Hill 3. L.E. Casida. Jr, Industrial Microbiology, New Age International Publisher 4. W. Crueger, Annelise Crueger, Biotechnology: A Textbook of Industrial Microbiology, Pnima Publishing Corporation 5. Fermentation microbiology and biotechnology. Ed. E.M.T. El-Mansi , C.F.A. Bryce, B. Dahhou, S. Sanchez, A.L. Demain, A.R. Allman. 3rd ed. Taylor and Francis. **Reference books:** 1. Microbiology: An Introduction Tortora, Funke and Case 2. General Microbiology by Hans G Schlegel, Cambridge 3. Atkinson. B and Marituna. F, Biochemical Engineering and Biotechnology Handbok, The Nature Press, Macmillan Publ.Ltd.4 4. James E Bailey, David F., Ollis, Biochemical engineering fundamentals, second edition. McGraw Hill

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
BTC303	CO1	1	2	2	2	1	-	-	-	-	-	-	3
	CO2	2	2	1	2	2	2	2	1	-	-	1	2
	CO3	2	2	2	2	2	1	2	2	2	1	-	3
	CO4	3	2	2	2	2	2	2	1	2	-	1	2
	CO5	3	3	2	2	2	2	2	2	2	1	2	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSC331	**DATABASE MANAGEMENT SYSTEM**	PCR	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
1. Computer fundamentals, Data structures. 2. Fundamentals of any computer programming languages.		[CA: 15%, MT: 25%, ET: 60%]					

Course Outcomes	**CO1:** Understand the basic concepts and appreciate the applications of database systems **CO2:** Comprehend the fundamentals of design principles for logical design of relational databases **CO3:** Apply the query writing skill **CO4:** Discuss the basic issues of transaction processing and concurrency control
Topics Covered	1. Introduction of DBMS. [5] 2. Concept of E-R diagram, Extended E-R diagram. [5] 3. Relational Algebra [4] 4. Queries with various operations [4] 5. SQL Queries [4] 6. Index structure design [5] 7. Normalization (Different normal forms) [5] 8. Basic concepts on transaction processing [5] 9. Various concurrency-control protocols (2 phase locking, time stamp protocol) [5]
Text Books, and/or reference material	**Text Books:** a. A. Silberschatz, H. F. Korth and S. Sudharshan, "Database System Concepts", Sixth Edition, Tata McGraw Hill, 2011. b. R. Elmasri, S. B. Navathe, "Fundamentals of DBMS Systems", Pearson education. Sixth Edition. c. A. Kahate, "Introduction to Database Management Systems", Pearson Education, New Delhi, 2006. **Reference Books:** a. C.J.Date, A.Kannan and S.Swamynathan, "An Introduction to Database Systems", Eighth Edition, Pearson Education, 2006.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CSC331	CO1	3	1	-	-	-	3	1	3	-	1	2	3
	CO2	3	3	3	2	-	2	2	1	3	2	2	3
	CO3	3	2	3	-	3	2	2	1	3	2	2	3
	CO4	3	1	1	-	-	1	1	1	1	2	1	3

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Biotechnology

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTS351	**Microbiology Laboratory**	PCR	0	0	3	3	2

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
Microbiology and Bioprocess Technology (BTC303)	CT+EA
Course Outcomes	**CO1:** Learn preparation of liquid and solid media and media sterilization by autoclaving. Learn subculturing of bacterial strain in liquid and solid media **CO2:** Learn different techniques (serial dilution, spread plate, quadrant streaking, etc.) for isolation of bacterial single colony to obtain pure culture. Learn Gram staining and endospore staining techniques and observation of microbes through microscope **CO3:** Learn bacterial growth pattern, calculation of generation time and specific growth rate **CO4:** Learn to assay different antibiotic sensitivity of bacteria and to determine Minimum Inhibitory Concentration (MIC) of antibiotic **CO5:** Learn about biochemical characterization of microorganism by different sugar utilization (glucose, fructose, inositol, salicin, maltose, mannose, lactose, galactose, etc.) and IMVIC (Indole production, Methylated, Voges-Proskaeur and Citrate utilization) tests **CO6:** Learn to determine Most Probale Number (MPN) of Coliform bacteria in drinking water
Topics Covered	1. Study of autoclaving and sterilization of media. 2. Preparation of solid basal medium, dilution plating with a known microbial strain; isolation of microorganisms from single colonies. 3. Study of a compound microscope, Gram staining of bacteria. 4. Cell wall staining, endospore staining. 5. Subculturing and maintenance of a bacterial strain. 6. Study of bacterial growth (E.Coli), calculation of generation time and specific growth rate. 7. Assay of an antibiotic by disc method 8. Determination of Minimum Inhibitory Concentration (MIC) of antibiotic. 9. Biochemical characterization of microorganism using some standard tests like hydrolysis of starch, hydrolysis of casein, IMVIC test (Indole production test, Methylated test, Voges-Proskaeur and Citrate utilization test). 10. Determination of MPN of Coliform bacteria in drinking water
Books, and/or reference material	1. Brock Biology of Microorganisms- Madigan, Martinko, Bender, Buckley and Stahl- Pearson publisher. 2. Prescott, Harley and Klein's Microbiology – McGraw Hill 3. Microbiology : A laboratory manual , by James G. Cappuccino and Natalie Sherman, Pearson Education

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
BTS351	CO1	1	2	2	2	2	1	-	-	1	2	3	1
	CO2	1	2	2	2	2	1	-	-	2	2	3	1
	CO3	2	2	2	2	2	1	-	-	1	2	2	1
	CO4	2	2	2	2	2	2	-	-	1	1	3	1
	CO5	2	2	2	2	2	2	-	-	1	1	2	1
	CO6	2	2	2	2	2	2	-	-	1	1	2	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTS352	**BIOCHEMISTRY LABOARTORY**	PCR		0	3	3	2
Pre-requisites		BTC303					
Course Outcomes	**CO1:** To design , analyze and solve problems and learn to plot graph and interpret data **CO2:** To develop skills to perform experiments and have hands on training. **CO3:** To apply the results and data to solve problems in daily activities and industry.						
Topics Covered	1. To prepare Tris-HCl Buffer with a specific pH (eg. pH 8.8) 2. Qualitative and quantitative estimation of carbohydrates 3. Qualitative and quantitative estimation of aminoacids and determination of the unknown concentration of protein concentration by plotting a standard curve of BSA using Bradford reagent 4. Ammonium sulphate precipitation and dialysis for a protein 5. Separation and Identification of Amino acids by Paper Chromatography and Thin Layer Chromatography 6. Analysis of Protein purity and determination of molecular weight of pure protein by SDS PAGE and Coomassie Brilliant blue staining of proteins on SDS gel 7. Extraction of Enzyme Tyrosinase from commercially available mushrooms and Assay of Enzyme Tyrosinase with determination of specific activity of Enzyme Tyrosinase 8. Effect of substrate concentration on the activity of Enzyme Tyrosinase and determination of MichelesMenton parameters of Enzyme Tyrosinase 9. Effect of inhibitor concentration on the activity of Enzyme Tyrosinase						
Text Books, and/or reference material	**Text Books:** Practical Biochemistry by David T Plummer **Reference Books:** Biochemistry by Voet and Voet						

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
BTS352	CO1	3	3	2	3	3	3	3	3	3	3	2	3
	CO2	3	3	2	3	2	3	3	3	3	3	2	3
	CO3	3	3	2	3	3	3	3	3	3	3	2	3

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSS381	**DATABASE MANAGEMENT SYSTEM LABORATORY**	PCR		0	3	3	2
Pre-requisites		Computer fundamentals, Data structures Fundamentals of any computer programming languages					
Course Assessment methods		Continuous (CT) and end assessment (EA: Class test, Viva, Assignments, Lab test)					
Course Outcomes		CO1: Understand, appreciate and effectively explain the underlying concepts of database technologies CO2. Design and implement a database schema for a given problem CO3. Populate and query a database using SQL DML/DDL commands					
Topics Covered		1. SQL Queries 2. PL/SQL assignments					
Text Books, and/or reference material		**Text Books:** SQL and PL/SQL by Evan Bayross.					

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CSS381	CO1	3	3	-	3	2	1	2	-	1	2	2	3
	CO2	3	3	-	3	1	1	2	-	2	2	2	2
	CO3	3	3	-	3	2	1	2	-	2	2	2	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTC401	**MOLECULAR BIOLOGY AND GENETIC ENGINEERING**	PCR	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
BTC303 Biochemistry and Enzyme Technology		CT+EA					

Course Outcomes	**CO1:** To acquire basic understanding of the structure, organization and chemistry of nucleic acids and genome as well as understanding the fundamentals of the central dogma **CO2:** To acquire knowledge of recombinant DNA techniques and manipulation of nucleic acid and DNA sequence as well as analysis of genome sequence and variations. **CO3:** To apply the basic understanding of molecular biology in analyzing and solving problems related to recombinant DNA technology. **CO4:** To design strategies to solve problems related to recombinant DNA technology.
Topics Covered	1. Nucleic acid structure: Nucleotides and nucleic acids, DNA structure, different forms of DNA, unusual DNA structure, different types of RNA, RNA structure. [3] 2. Nucleic acid chemistry: Denaturation and renaturation, hybridization, nonenzymatic transformation (Mutation) – spontaneous and induced. DNA sequencing. [4] 3. Chromosome organization: Chromosomal elements – genes and intergenic regions, regulatory sequences; Chromosome structure: Histones, Non-histones, Nucleosome, Chromatin. Chromosome structure in prokaryotes & eukaryotes. [4] 4. DNA replication and repair: Central dogma, DNA replication in prokaryots and eukaryots – set of fundamental rules, DNA polymerases, proteins and enzymes involved in replication, process, accuracy. [4] 5. Transcription and post-transcriptional processing: DNA-dependent RNA synthesis in prokaryotes and eukaryotes, RNA polymerases, transcription process, termination, selective inhibition, RNA processing – capping, splicing of introns, differential RNA processing; RNA-dependent synthesis of RNA and DNA. [4] 6. Protein synthesis – translation: Genetic code, ribosome, transfer RNA, protein biosynthesis stages – attachment of amino acid to specific tRNA, initiation, elongation, termination, folding and processing; inhibition of protein synthesis. [4] 7. Regulation of gene expression: Regulation of gene expression in bacteria - operon concept; Regulation of gene expression in eukaryotes, hormonal control of gene expression in eukaryotes. [3] 8. Introduction to recombinant DNA and Gene Cloning Tools of recombinant DNA: Vectors; plasmid, bacteriophage viral vectors, cosmids, yeast artificial chromosome. Expression vectors, and selection of suitable Host. [5] 9. Restriction endonucleases and other enzymes use and mechanism of action and analysis, Genomic DNA and cDNA library preparation. [5] 10. Screening and selection of clone with desired gene and protein of interest: Colony and plaque hybridization. antibody based assay, Protein activity. Application of gene cloning and DNA Analysis. [3] 11. MOLECULAR TECHNIQES: Polymerase chain reaction, different types and their use. Antisense RNA technology, Site directed mutagenesis, Use of RFLP, SNP and Microarray. [4]
Text Books, and/or reference material	Text Books: 1. Gene IX by B. Lewin, Pearson 2. Molecular biology of the cell by Alberts et. al., Garland science Reference Books 1. Molecular Biology of the Gene, 7th edition 2013. Watson et. al. Published by Pearson.

	2. Cell and molecular Biology, Concepts and experiments Gerald Karp, John Wiley and Sons. 3. The Cell - A molecular approach, GM Cooper ASM Press 4. Genomes, T. A. Brown, John Wiley and Sons PTE Ltd

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
BTC401	CO1	2	-	-	1	-	-	1	-	-	-	-	1
	CO2	2	-	-	-	-	-	1	1	-	-	-	1
	CO3	1	2	2	-	-	2	-	-	-	-	-	1
	CO4	1	2	2	1	-	2	-	-	-	-	-	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTC402	**CELL BIOLOGY AND GENETICS**	PCR	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
BTC303 Biochemistry and Enzyme Technology		CT+EA					
Course Outcomes		**CO1:** To understand the basic organization of cells and organisms and the tools needed to study them **CO2:** To understand the basic processes of the cell machinery, cell-cell interaction and the eukaryotic cell cycle. **CO3:** To apply the knowledge of cell process regulation and cell cycle in understanding the use of a cell as a biological tool for manufacturing biomolecules. **CO4:** To learn the fundamentals of Genetics and its applications. **CO5:** To solve problems associated with genetic diseases and their transmission from one generation to the next					
Topics Covered		**Classical Genetics:** Mendelian inheritance; Euploidy and aneuploidy (4) Genetic interactions (2) **Molecular Genetics**-Split and Overlapping genes; Transposons & Retrotransposons; Mutation (6) DNA Repair and human diseases (4) Recombination (2) **Internal Organization of the cell:** Cells as experimental models, Cells and cellular organelles, Tools of cell biology- Microscopy and cell Architecture, Purification of cells, Membrane structure, Membrane Transport of small molecules and electrical properties of membranes (8) **Cytoskeleton and cell movement:** Structure and organization of actin filaments, Actin myosin and cell movement, intermediate filaments, microtubules, microtubule motors and movements, cell-cell interactions (6)					

	Cell signalling: Signaling molecules and their receptors, function of cell surface receptors, pathways of intracellular signal transduction, signal transduction and the cytoskeleton, signalling in development and differentiation (6) **Cell cycle and cancer:** Eukaryotic cell cycle, meiosis and fertilization, stem cells, Development and causes of cancer, oncogenes, tumor suppressor genes (4)
Text Books, and/or reference material	Text Books: 1. Molecular Biology of Cell by Albert et.al. John Wiley & Sons 2. The Cell by Cooper. ASM Press 3. M.W.Strickberger: Genetics, Pearson. 4. In Introduction to genetic analysis, Griffiths, Miller, Suzuki, Lewontin and Gelbart, Freeman and Company. Reference Books 5. Cell and Molecular Biology by Karp. John Wiley & Sons 6. Brown, T.A., Genetics a Molecular Approach, 4th Ed. Chapman and Hall, 1992 7. Stratchan& Read: Human Molecular Genetics 8. David Freifelder: Microbial Genetics, Jones and Bartlett Publisher Inc. 1987

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
BTC402	CO1	-	2	-	-	-	-	-	-	-	-	-	2
	CO2	-	2	-	2	-	-	-	-	-	-	-	-
	CO3	2	2	3	2	1	-	3	-	-	-	-	2
	CO4	1	2	-	2	-	-	-	-	-	-	-	1
	CO5	-	2	2	-	-	-	-	-	-	-	-	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTC403	**Plant and Animal Biotechnology**	PEL	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Biochemistry, Cell Biology, Genetics		CT+EA					
Course Outcomes	**CO1:** To understand the concepts and techniques of plant tissue culture and molecular mapping. **CO2:** To learn the basic methods of genetic transformation of plants and advanced plant genetic engineering. **CO3:** To learn animal cell and tissue growth conditions and cell culture techniques. **CO4:** To learn application of animal cell culture techniques. **CO5:** To learn basic techniques of animal cloning and transgenic animal generation.						

Topics Covered	Introduction to Plant Tissue Culture, Culture media and general techniques, different types of plant tissue culture (5) Molecular markers, Molecular mapping, Map-based cloning, marker-assisted selection, marker-aided breeding (5) Introduction to genetic transformation of plants in relation to biotic and abiotic stress, various methods of transformation, relevant recombinant DNA technologies, strategies for genetic transformation of plants, chloroplast engineering, GM crops (6) Some advanced methods of gene cloning such activation tagging, transposon tagging, plasmid rescue etc. & genetic engineering tools such as gene silencing, RNA interference, genome editing in plants (5) Animal Cell Culture: Historical Background. Importance of and progress in Animal Cell Culture Technology (2) Biology of Animal Cell; Cellular Interactions. (4) Separation and isolation of cells. Culturing and Sub-Culturing of Animal Cells. Importance of Serum and Serum Free Media. (5) In Vitro Transformation of Animal Cells. Chromosome Spreading and Karyotype Analysis. (2) Animal cloning and transgenic animal development. Gene therapy. (2) Cell Line Preservation. (1) Detection and Control of cell culture contamination. (1) Monoclonal Antibody Production. (2) Stem cell culture and differentiation. (2)
Text Books, and/or reference material	**Text Books:** H. S. Chawla, Introduction to Plant Biotechnology, Oxford &IBH Publishing co. Pvt. Ltd. Slater. A., Nigel W.S, Flower. R. Mark, Plant Biotechnology: The Genetic Manipulation of Plants, 2003, Oxford University Press. Buchaman, Gursam, Jones, Biochemistry and Molecular Biology of Plants, 1ed, 2000, L.K. International. Bhojwani and Razdan –Plant Tissue Culture: Theory and Practice 1996 Elsevier. Culture of Animal Cells: A manual of basic technique, 4th Edition Author(s)/Editor(s): Freshney RI. Publisher: WIELY-LISS ISBN:0-471-34889-9. Biotechnology, David Clark and Nanette Pazdernik. Elsevier Publications. ISBN: 9780123850157. **Reference Books:** Butterworth & Heineman, Invitro Cultivation of Plant Cells, Biotol Series. H.E Street(ed): Tissue culture and Plant science, Academic press, London, 1974 Gamborg O.L. Phillips G.C, Plant Cell, Tissue and Organ Culture, Narosa Publishing House

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
BTC403	CO1	1	-	-	1	-	1	-	-	-	-	-	1
	CO2	2	1	2	2	1	1	1	1	-	-	-	1
	CO3	1	-	-	1	-	1	-	-	-	-	-	1
	CO4	2	1	2	2	1	1	-	-	-	-	-	1

	CO5	2	1	2	2	1	1	1	1	-	-	-	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTC404	**IMMUNOLOGY**	PCR	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
		CT+EA					
Course Outcomes	**CO1:** To understand the role of the components of the immune system and its classification **CO2:** To understand the role of the immune cells and their immunological response in the context of human diseases including infectious diseases, autoimmunity, and cancer. **CO3:** To learn the fundamentals and principles of immunological techniques and their application. **CO4:** To understand methods of generations of Polyclonal and Monoclonal Antibody and the use of custom made genetically engineered antibodies. **CO5:** To solve problems associated with drugs and their toxic response based on the knowledge of immunological response.						
Topics Covered	**Immunology basics-** fundamental concepts and anatomy of the immune system, Components of innate and acquired immunity; Phagocytosis; Complement and Inflammatory responses; Hematopoiesis; Organs and cells of the immune system-primary and secondary lymphoid organs (6) **Immune responses generated by B and T lymphocytes:** Immunoglobulins-basic structure, classes & subclasses of immunoglobulins, antigenic determinants (2), Multigene organization of immunoglobulin genes; B-cell receptor (4), Kinetics of Active and Passive Immunity, Basis of self –non-self-discrimination (4) B cell maturation, activation and differentiation; T-cell maturation, activation and differentiation and T-cell receptors; Cell-mediated immune responses (6) Antibody Dependent Cell Cytotoxicity; Antigen processing and presentation; Adjuvant-Hapten (4) **Antigen – Antibody Interaction based Techniques:** ELISA, Western blotting, ELISPOT assay, Immuno-electron microscopy; Immunofluorescence techniques etc (6) **Clinical Immunology:** Preparation and clinical uses of Monoclonal and Polyclonal antibody (3), Transplantation; Autoimmunity; Introduction to Cancer immunology and vaccines (7)						

Text Books, and/or reference material	Textbook: 1. Kuby J, Thomas J. Kindt, Barbara, A. Osborne Immunology, 6th Edition, Freeman, 2002. 2. Janeway et al., Immunobiology, 4th Edition, Current Biology publications. 1999 Reference Books: 1. Brostoff J, Seaddin JK, Male D, Roitt IM., Clinical Immunology, 6th Edition, Gower Medical Publishing, 2002. 2. Paul, Fundamental of Immunology, 4th edition, Lippencott Raven, 1999. 3. Goding, Monoclonal antibodies, Academic Press. 1985.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
BTC403	CO1	2	-	-	-	-	-	-	-	-	-	-	-
	CO2	2	2	-	-	-	-	-	-	-	-	-	-
	CO3	2	2	-	-	-	2	-	-	-	-	-	2
	CO4	-	3	3	2	1	2	-	-	-	-	-	3
	CO5	-	3	3	3	1	2	-	-	-	-	-	3

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Chemical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHC431	**UNIT OPERATIONS OF CHEMICAL ENGINEERING I**	PCR	3	1	0	4	4
Pre-requisites: Mathematics		Course Assessment methods (Continuous (CT) and end assessment (EA))					
		CT+EA					
Course Outcomes	CO1:To Understand fundamentals of fluid dynamics and mechanics CO2:Understanding the fundamentals of heat transfer operations CO3:To learn design of heat transfer equipment and calculations CO4:To develop knowledge of different mechanical operations and their applications CO5:To solve related problems of different difficulty levels through tutorials						
Topics Covered	Module – I (14 hrs) Fundamental Concepts: Definition of Fluid, Terminologies of fluid flow, velocity – local, average, maximum, flow rate – mass, volumetric, velocity field; flow visualization – streamline, path line, streak line, viscosity; Newtonian fluid; Non-Newtonian fluid; Reynold's number—its significance, laminar, transition and turbulent flows. Fluid Statics: Basic equation of fluid statics; pressure variation in a static field; pressure measuring devices– manometer, U-tube, inclined tube. Introduction to rotational and irrotational flow. Introduction; flow of incompressible fluid in circular						

	pipe; laminar flow for Newtonian fluid; Hagen-Poiseullie equation; introduction to turbulent flow in a pipe-Prandtl mixing length; energy consideration in pipe flow, relation between average and maximum velocity, Bernoulli's equation–kinetic energy correction factor. Fluid moving machines: Introduction; Basic classification of pumps: Mechanical pump: Centrifugal pumps- cavitation, NPSH, Positive displacement pumps (rotary, piston, plunger, diaphragm pumps); Peristaltic pump; Pump specification; Basic characteristics curves for centrifugal pumps Module – II (14 hrs) Basic modes of heat transfer; Heat transfer by conduction: One dimensional steady state heat conduction, Fourier's Law, Thermal conductivity, Compound resistance in series; Steady state heat transfer analysis through extended surface; Unsteady state heat conduction with and without heat generation, Concept of thermal diffusivity; Concept of heat transfer coefficient in convective-conductive system, Critical thickness of insulation. Heat transfer by convection: Convection heat transfer mechanism; Forced convection in systems of simple geometrics (plate, cylinder etc.), Thermal boundary layer; Co-relation for heat transfer coefficient: internal flow & external flow, Momentum & heat transfer analogies. Evaporation: Classification; Capacity, Steam economy; Boiling point elevation (Duhring rule); Material and energy balance of single effect evaporator; Introduction to multiple effect evaporator: Forward feed, Backward feed, Mixed feed, Parallel feed Module – III (12 hrs) Particulate solids: Characterization of solid particles, particle shape, particle size, mixed particle sizes and size analysis, specific surface of mixture, average particle size. Screen analysis: Type of screens, ideal screen, real screen, screen effective ness, differential and cumulative analysis, screen capacity.Screening equipment: stationary screens and grizzlies, gyrating screens, vibrating screens and other industrial screens like trammels etc. Comminution of solids (Size Reduction): Factors affecting comminution, comminution laws: Kick's law, Rittinger's law and Bond's law and Their limitations. Crushing efficiency & power consumption.
Text Books, and/or reference material	1. Process Heat Transfer: D. Q. Kern, MGH 2. Heat Transfer Principles and Application, B. K. Dutta, PHI. 3. Units Operations of Chemical Engineering: McCabe & Smith and Harriot, MGH 4. Coulson, J.M., Richardson, J.F., "Chemical Engineering", Volume 2, Third Edition, Pergamon Press, 1977

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
BTC403	CO1	1	3	3	3	2	1	1	-	3	3	1	3
	CO2	1	3	3	3	2	1	1	-	3	3	1	3
	CO3	1	3	3	3	2	1	1	-	3	3	1	2
	CO4	3	3	3	3	2	1	1	-	3	3	1	3

	CO5	1	2	2	3	2	1	1	-	3	3	1	3

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Chemical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHS481	**UNIT OPERATIONS OF CHEMICAL ENGINEERING LABORATORY I**	PCR	0	0	3	3	2
CHC431: Unit operations of chemical engineering-I.		Course Assessment methods (Continuous (CT) and end assessment (EA))					
		CT+EA					
Course Outcomes	**CO1:** To record observations systematically and arrive at required results based on experiments conducted **CO2:** Understand the principles, laws and mechanism of different comminuting methods like sieve analysis crushers, and grinders, ball mill **CO3:** Acquire the knowledge of a cyclone separator and its efficiency **CO4:** Acquire the knowledge of different flow regime measuring instruments. **CO5:** Study and design different flow measuring instruments.						
Topics Covered	1. To find out the reduction ratio and capacity and to verify the laws of crushing by Jaw Crusher. 2. To determine the optimum speed for maximum new surface area created for the given feed size and also determines the critical speed of the ball mill. 3. Demonstration of the operation of a cyclone separator and determination of its overall efficiency 4. Experiments on Reynolds Apparatus for determination of flow regime and construction of Fanning friction factor vs. Reynolds No. plot. 5. Determination of co efficient of Discharge for Orifice meter and Discharge for Venturi meter. 6. Determination of co-efficient of Pitot tube and construction of velocity profile across the cross section of pipe. 7. Experiment to prove Bernoulli's equation for fluid flow 8. To analyze a given powder for its particle size distribution. / Cumulative and Differential methods of particle size distributions and to find out screen efficiency.						
Text Books, and/or reference material	1. Units Operations of Chemical Engineering: McCabe & Smith and Harriot, MGH 2. Coulson, J.M., Richardson, J.F., "Chemical Engineering", Volume 2, Third Edition, Pergamon Press, 1977 3. Principles of Unit Operations by Alan S Foust, L.A. Wenzel, C.W. Clump, L. Maus, and L.B.						

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CHS481	CO1	3	3	3	3	3	-	1	-	3	1	3	2
	CO2	3	3	3	3	3	-	2	-	3	1	3	2
	CO3	3	3	3	3	3	-	2	-	3	1	3	2
	CO4	3	3	3	3	3	1	2	-	3	1	3	2
	CO5	3	3	3	3	3	1	2	-	3	1	3	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="8">Department of Biotechnology</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>BTS451</td><td>MOLECULAR BIOLOGY AND GENETIC ENGINEERING LABORATORY</td><td>PCR</td><td>0</td><td>0</td><td>3</td><td>3</td><td>2</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3">NIL</td><td colspan="5">EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: To understand the principle of isolation of nucleic acids through different techniques.
CO2: To understand the techniques used in manipulation of nucleic acids.
CO3: To develop expertise to apply the tools of gene cloning and solve the problems associated with production of recombinant protein from genetically modified microorganisms.
CO4: To develop an idea for proper documentation of the work including laboratory procedures, experimental conditions, materials used, equipment used and the results
CO5: To understand the basic hazards of working with nucleic acids and safety measures.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">1. Isolation of genomic DNA
2. Quantification of DNA
3. Agarose Gel Electrophoresis of DNA
4. Isolation of RNA
5. Agarose Gel Electrophoresis of RNA
6. Isolation of plasmid – agarose gel electrophoresis (quantitation and purity test)
7. Restriction digestion of plasmid – agarose gel electrophoresis
8. Bacterial transformation using plasmid having antibiotic resistant marker and some other genetic markers.
9. Southern Blotting
10. PCR technique</td></tr>
</table>

Text Books, and/or reference material	Sambrook et al., “Molecular Cloning” A Laboratory Manual

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
BTS451	CO1	2	-	-	2	-	-	-	-	2	-	1	2
	CO2	-	-	1	2	-	-	-	-	2	-	1	2
	CO3	-	2	2	2	-	-	-	-	2	-	1	2
	CO4	-	1	-	-	-	-	-	-	-	3	-	2
	CO5	-	-	-	-	-	2	-	2	-	-	-	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTS452	**CELL BIOLOGY AND GENETICS LABORATORY**	PCR	0	0	3	3	2
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Cell Biology and Genetics (BTC304)		EA					
Course Outcomes		**CO1:** To design, analyze and solve problems related to cell biology and Molecular genetics and interpretation of data obtained by the lab experiments. **CO2:** To develop skills to perform experiments related to cell biology and Molecular genetics and have hands on training on the related area. **CO3:** To learn to interpret data, draw conclusion and develop trouble-shooting skills.					
Topics Covered		1. Isolation of chromosomal DNA from mammalian cells. 2. Genotyping PCR of a genetically modified cell. 3. Isolation of mRNA and RT-PCR to determine the level of transcription of the gene. 4. Studying to detect variations like single nucleotide polymorphism. 5. Studying bacterial conjugation. 6. To examine the morphology of cells 7. Identification of cellular organelles by staining method 8. Cell proliferation assay 9. Cell adhesion assay					

	Cell migration assay
Text Books, and/or reference material	**REFERENCE BOOKS:** Molecular Biology of Cell by Albert et.al. John Wiley & Sons The Cell by Cooper. ASM Press M.W.Strickberger: Genetics, Pearson.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
BTS452	CO1	3	3	3	3	2	2	1	2	2	2	1	3
	CO2	3	2	2	3	3	3	1	2	3	1	1	3
	CO3	3	3	2	2	2	3	1	3	2	3	1	3

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTC 501	**BIOREACTOR DESIGN AND ANALYSIS**	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					
Course Outcomes	**CO1:** To gain knowledge about Chemical and Biochemical processes, order of reactions, effect of various parameters on rate constant of a reaction. To study about different reactions in batch reactors, kinetics of enzyme catalyzed reactions **CO2:** To acquire knowledge about different ideal and non-ideal reactors, reaction kinetics, microbial growth kinetics **CO3:** To learn about various types of Bioreactors, their design considerations and applications in the field of Biochemical Engineering **CO4:** To study about mass transfer in bioprocess systems, scale up, instrumentation and control, bioreactor considerations in plant and animal cell culture.						
Topics Covered	Rate of chemical reaction; Effect of Temperature on Rate Constant, Arrehnius equation, Order and Molecularity of a Chemical reaction, Elementary Reactions, First, Second and Third order reactions, Pseudo-first order reaction, Determination of rate constant and order of reaction. [5] Interpretation of batch reactor data for simple and complex reactions. Kinetics of Enzyme catalyzed reactions for free and immobilized enzymes.–derivation of Michaelis-Menten equation, Briggs-Haldane relationship, the determination and significance of kinetic constants, Lineweaver-burk and Eadie-Hofstee plot, principles of enzyme inhibition – Competitive, noncompetitive and uncompetitive. [5] Fundamentals of homogeneous reactions for batch, plug flow and mixed flow reactors. [5]						

	Concept of ideal and non ideal reactors, Residence time distribution, Models for non ideal reactors (Dispersion model, tanks-in-series model). [5] Stoichiometry of cellular reactions. Microbial growth kinetics (Batch, continuous, fed batch). Monod model and other kinetic models. Growth kinetics with plasmid instability. [6] Bioreactor design: Packed bed bioreactor, Fluidized bed bioreactor, Bubble column bioreactor, Air lift bioreactor, Tower bioreactor. Hollow fiber bioreactor, Membrane bioreactor.[4] Design of fermenter. Fermenter utilities – boiler and refrigeration system. [5] Immobilized cell bioreactor system. Mass transfer in bioprocess system. Two film theory, $K_{l}a$ determination. Scale up concepts. Bioreactor considerations for plant and animal cell culture with special emphasis to single-use bioreactors. [7]
Text Books, and/or reference material	TEXT 1. Bioprocess Engineering: Basic Concepts (2nd Edition), Shuler and Kargi, Prentice Hall International. 2. Bioprocess Engineering Principles – Pauline M Doran. Academic press 3. Chemical Reaction Engineering ,O Levenspiel, Wiley 4. Principles of Fermentation Technology, Stanbury and Whitaker, Pergamon press REFERENCE Biochemical Engineering. Fundamentals, Bailey &Olis, McGraw-Hill Biochemical Engineering, Humphrey and Aiba. Academic Press

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
BTC501	CO1	3	2	2	1	1	1	1	1	1	1	-	2
	CO2	3	2	2	1	1	1	1	1	1	1	-	2
	CO3	3	2	2	1	1	1	1	1	1	1	-	2
	CO4	3	2	2	1	1	1	1	1	1	1	-	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="8">Department of Biotechnology</td></tr>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>BTC502</td><td>BIOSEPARATION ENGINEERING</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous assessment (CA) and end-term examination (ET))</td></tr>
<tr><td colspan="2">Basic Physics, Mathematics including basics of Differential & Integral Calculus, Basic concepts of Chemistry & Biochemistry</td><td colspan="6">CA+ET</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: To learn the concepts of separation including purification sequence and its monitoring and the properties of proteins underlying bioseparations.
CO2: To learn techniques of biochemical analysis of biomolecules.
CO3: To learn and analyze, mathematically wherever applicable, the various unit operations in bioseparation.
CO4: To understand the design aspects of unit operations in bioseparation.
CO5: To solve problems of bioseparations including industrial bioseparations.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Basic Concepts [3]
Basic concepts of Bio-separation Technology

Basic Analytical Tehniques: [10]
Introduction to Biomolecules, Buffers
Estimation of carbohydrate, protein, and lipid, and enzyme assay Quantitation of DNA and RNA
Methods of cell disintegration

Removal of Insolubles [9]
Flocculation and conditioning of broth. Filtration at constant pressure and at constant rate; equations for batch and continuous filtration, centrifugal and cross-flow filtration. Centrifugation: basic principles, design characteristics; ultracentrifuges: principles and applications.

Techniques Involved in Separation Processes for Solutes [9]
Foam-fractionation; Solvent extraction, aqueous two-phase extraction, adsorption & desorption processes; Salt precipitationMembrane based separation processes:Micro-filtration, Dialysis, Reverse osmosis, Ultrafiltration and affinity ultrafiltration, n, concentration polarization, rejection, flux expression, membrane modules, dead-end and cross-flow modes.

Advanced Techniques for Bioseparation: [9]
Chromatography: paper chromatography, TLC, gel filtration, ion exchange, hydrophobic interaction chromatography, affinity chromatography, HPLC. Electrophoresis: Theory and application of Polyacrylamide and Agarose gel electrophoresis; 2D-Gel electrophoresis</td></tr>
</table>

	Industrial Application with an example [2]
Text Books, and/or reference material	Textbooks : Practical Biochemistry Principles and techniques (5th ed)/ Principles and Techniques of Biochemistry and Molecular Biology (7th ed): Editor Wilson and Walker, Cambridge University Press 2. Geankoplis, Transport Processes & Unit operations, PHI. Reference books: D. Holme & H. Peck, Analytical Biochemistry, 3rd ed, Longman, 1998 Shuler & Kargi, Bio-process Engg. PHI Bailey & Olis, Biochemical Engg. Fundamentals, McGraw-Hill

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
BTC502	CO1	1	1	-	-	-	1	1	1	-	2	-	-
	CO2	1	2	-	2	1	1	-	1	1	2	-	1
	CO3	2	3	1	-	-	-	-	-	1	2	-	-
	CO4	1	-	2	-	1	-	1	-	2	2	1	-
	CO5	3	2	3	1	-	1	1	1	2	2	1	2

Correlation levels 1, 2 or 3 as defined below:
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Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTC503	**BIOINFORMATICS**	PCR	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Computer Programming (CSC01), Biochemistry and Enzyme Technology (BTC301), Cell Biology and Genetics (BTC402)		CT+EA					
Course Outcomes	**CO1:** To learn how to integrate both biological and computer skills for addressing important biological questions. **CO2:** To acquire knowledge of existing biological databases and understand the methods for storing, organizing, retrieving and analyzing biological data in an efficient way. **CO3:** To learn and implement computational algorithms and tools (webservers and standalone programs) for processing biological data						
Topics Covered	1. Introduction to Bioinformatics and its applications (2) 2. Linux and Bash programming for bioinformatics (3) 3. Major Information Resources & biological databases (4) 4. Sequence Alignment: Sequence similarity, Sequence identity, Sequence homology, Gap Penalty, local and global alignment, pairwise and multiple alignments, sequence alignment algorithm, Dynamic programming, BLAST and PSI-BLAST, Application of BLAST tool, Concept of Scoring matrix (12)						

	5. Molecular phylogeny and evolution: Phylogenetics basics and methods for phylogenetic tree constructions (5) 6. Structural Bioinformatics: (10) A. Protein Structure and its visualization, structural alignment, B. Protein secondary Structure Prediction, C. Protein tertiary Structure Prediction, D. RNA Structure Prediction 7. Molecular Docking, Drug designing and performance measures of classifiers (6)
Text Books, and/or reference material	Text Books: 1. Bioinformatics: Sequence and Genome Analysis by David W Mount, Cold Spring Harbor Laboratory Press 2. Introduction to Bioinformatics by Arthur M Lesk Reference Books: 1. Introduction to Bioinformatics computer Skills by Cynthia Gibas and Per Jambeck 2. Protein bioinformatics: an algorithmic approach to sequence and structure analysis by Ingvar Eidhammer, Inge Jonassen and William R. Taylor. 3. Essentials of Bioinformatics by Jin Xiong

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
BTC503	CO1	3	2	1	1	1	-	-	-	-	-	-	3
	CO2	3	2	1	1	1	-	-	-	-	-	-	3
	CO3	3	3	2	2	2	2	-	-	1	-	1	3

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Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHC531	**UNIT OPERATIONS OF CHEMICAL ENGINEERING- II**	PCR	3	1	0	4	4
CHC431: Unit operations of chemical engineering-I.		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					
Course Outcomes	**CO1:** To learn different types of mass transfer phenomena **CO2:** Understanding the fundamentals of mass transfer operations **CO3:** To learn design parameters, their effects and calculations **CO4:** To compare different types of mass transfer operations and their applications **CO5:** To solve related problems of different difficulty levels through tutorials						

Topics Covered	**Module I:** Principles of mass transfer: Introduction, diffusion, classification of diffusion, Inter-phase mass transfer. [8 hr] **Module II:** Evaporation: Introduction, types of evaporators, design calculation and processes [8 hr] **Module III:** Drying: Principles of drying, drying characteristics, methods, equipment. Humidification and Dehumidification: Definitions, adiabatic saturation temperature, wet bulb temperature, processes [8 hr] **Module IV:** Absorption: Principle, operation and design calculation [8 hr] **Module V:** Distillation: Flash distillation, differential distillation, fractionation and design calculations [8 hr] **Module VI:** Extraction and Adsorption: Principles and Operations. [8 hr]
Text Books, and/or reference material	Text Books: 1. B.K.Dutta, Principles of Mass Transfer and Separation Processes, Prentice Hall India Private Limited 2. N Anantharaman and K.M.M.S. Begum, Mass Transfer theory and practice. Prentice Hall India Private Limited Robert E. Treybal, Mass Transfer Operations, McGraw Hill limited

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CHC531	CO1	1	3	3	3	2	1	1	-	3	3	1	3
	CO2	1	3	3	3	2	1	1	-	3	3	1	3
	CO3	1	3	3	3	2	1	1	-	3	3	1	2
	CO4	3	3	3	3	2	1	1	-	3	3	1	3
	CO5	1	2	2	3	2	1	1	-	3	3	1	3

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>BTE510</td><td>Biophysics & Structural Biology</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">NA</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: To acquire structural understanding of the basic building blocks of life
CO2: To understand biophysical parameter governing structure of biomolecules.
CO3: To learn how to determine biophysical and structural properties of protein</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Biophysical aspects of interactions between molecules. Introduction to the structure of protein, nucleic acids, lipids and membranes. (10)
Hierarchical organization of protein structure: Primary, secondary, tertiary and quaternary structure of protein, Domains and motifs, DNA-protein interactions, Membrane proteins. (12)
Conformation of biomolecules, Ramachandran plot, Protein folding, Folding in vivo: molecular chaperones, Method of conformational analysis and prediction of conformation. Thermodynamics and kinetics of conformational transition of proteins. (10)
Methods in structural biophysics: Fluorescence spectroscopy, Circular dichroism spectroscopy, FTIR, Calorimetry. Structure determination techniques: NMR, X-ray spectroscopy, Cryo-Electron Microscope. (10)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. Biophysical Chemistry by Cantor & P. Schimmel. Vol. I & II
2. Introduction to Protein structure by Branden and Tooze
3. Proteins: Structures and Molecular Properties by Thomas E. Creighton.
2. The Molecules of Life Physical and Chemical Principles by John Kuriyan, Boyana Konforti and David Wemmer
5. Principles of Physical Biochemistry by Kensal E Van Holde, Curtis Johnson and Pui Shing Ho.

Reference books:

5.Textbook of structural biology by Liljas Anders,
6. Principles of Protein structure by G E Schulz and Schirmer,
7. Fundamentals of Protein Structure and function by Engelbert Buxbaum,
8. Protein structure: A practical approach by Creighton,</td></tr>
</table>

	9. Proteins: Structure and function by James J L'Italien, 10. Biomolecular Crystallography: Principles, Practice and application to structural Biology by Bernhard Rupp, 11. Introduction to Protein Architecture: The structural Biology of proteins by A M Lesk, 12. The physics of proteins:.... by Robert H Austin and Charles E Schulz, 13. Structure and mechanism in protein science by Alan R Fersht

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
BTE510	CO1	1	3	3	3	-	1	1	-	1	2	-	1
	CO2	1	3	3	3	-	1	1	-	1	2	-	1
	CO3	3	3	3	3	3	0	0	-	1	2	-	3

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE511	**Bioentrepreneurship**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Basic understanding of Biosafety guidelines		CT+EA					
Course Outcomes	**CO1.** Basics of legal requirements, intellectual property rights and societal issues in biotechnology. **CO 2**. To educate about entrepreneurial profiling, market survey, product licensing and challenges. **CO 3.** To address the ethical implications and safety rules in biopharma and GMO production management.						
Topics Covered	**Introduction to Bioentrepreneurship**: Current trends in global bio-business opportunities and knowledge-based bio-economy concept. Definition and Profiling of bioentrepreneur. Characteristics of Biotechnology Industry. Basics of legal requirements, intellectual property rights, regulatory environment, funding opportunities to establish star-ups will be introduced. (5) **Commercialization Process & Strategy:** Biotechnology Product Value Chain, Business Models in Biotechnology Commercialization, Technological Innovation vis-à-vis Business Models. (6) **Fundamentals of Marketing**: Growth of entrepreneurship, the marketing and selling of Biotechnology, Creating, and marketing the image of the biotechnology company, Effective advertising and marketing of biotechnological products, patent rules regarding product protection and licensing. International marketing (7) **Entrepreneurial development:** Training, institution in aid of entrepreneur, Power, and importance of Positioning of a company name and product. Definition of MSME Enterprises. Setting of a small industry, location of an enterprise, steps of starting small industry, Incentive & subsidies for industry, Problems of entrepreneurship, The Art of Negotiation, (6)						

	Capacity building: Regulatory systems for health products in India. Regulatory authority India central (federal) and state (provincial) authorities. Central Licensing Authority. International collaboration of India with South East Asia Regulatory Network (SEARN). Quality management system (QMS). (6) **Ethical issues and Biosafety guidelines:** Food safety and environmental safety evaluation of genetically modified microbes, crops, animals (GMO & LMOs); Roles of Institutional Biosafety Committee, WHO, DBT guideline for institutional biosafety. (6) **Entrepreneurship opportunity in industrial biotechnology:** Business opportunities and challenges in Pollution monitoring and Bioremediation for Industrial pollutants, Pesticides, Herbicides etc. Integrated compost production-microbe enriched compost. Bio pesticide/insecticide production. Fermented products-probiotic and prebiotics. Production of monoclonal/polyclonal antibodies, Stem cell production, stem cell bank , contact research in microbial genomics.(6)
Text Books, and/or reference material	Text Book: 1. Dynamics of Entrepreneurial development & management; Vasant Desai, Himalay Publications. 2. Entrepreneurship reflection & investigation; M.S. Bisht & R.C. Mishra, Chugh Publication. 3. Entrepreneurship development in India; Samiuddin, Mittal Publication References: 1. Innovation, Product Development and Commercialization: Case Studies and Key Practices for Market 2. Science Business: The Promise, the Reality, and the Future of Biotech by Gary P. Pisano Harvard Business School Press: 2006. 3. Design and Marketing of New Products by Urban and Hauser,ISBN 0-13-201567-6 4. Putting Biotechnology to Work: Bioprocess Engineering (1992) Commission on Life Sciences The national academy press

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
BTE511	CO1	1	1	2	1	1	2	3	2	3	3	3	3
	CO2	2	2	2	3	3	2	1	2	3	3	3	2
	CO3	1	2	1	1	1	3	3	3	2	2	2	3

Correlation levels 1, 2 or 3 as defined below:

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

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE512	**MARINE BIOTECHNOLOGY**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
		CT+EA					
Course Outcomes	**CO1:** To learn about the bioprocess engineering aspects of marine products in commercial production **CO2:** To learn about the industrial applications of various marine products and their production **CO3:**To study the specific applications in energy, pharmaceutical and environmental sector.						
Topics Covered	**Bioprocess engineering of marine products:** Marine microbiology, Photobioreactors – light regime mass transfer and scale up, downstream processing of marine products, Management of Marine production, Storage and transport, Marine natural products, valuable chemicals, bioactive compounds from micro-algae. **Specialized aspects**:Cultivation of marine microorganism, marine biomedical and bioactive compounds from marine organisms, commercial bio-products from marine organisms biohydrogen production in photobioreactor, marine enzymes, Marine bio-film and bio-remediation, marine bio-sensor and transgenic marine organisms. **Marine Pharmacology:** Potentialities in the Treatment, of Infectious Diseases, Osteoporosis and Alzheimer´s Disease, Molecular biodiversity, marine products as biomarkers, Economic and Regulatory Aspects of Marine Biotechnology.						
Text Books, and/or reference material	Marine Bioprocess Engineering, J.G. Burgess R. Osinga R.H. Wijffels, Elsevier, 1999 Handbook of Marine Biotechnology, **Kim**Se-Kwon , Springer, 2015						

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
BTE512	CO1	3	2	1	1	-	1	-	1	1	1	-	2
	CO2	1	1	1	1	-	1	1	1	1	2	-	2
	CO3	1	1	1	1	-	1	3	1	1	2	-	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTS 551	**IMMUNOLOGY LABORATORY**	PCR	0	0	3	3	2
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					
Course Outcomes	**CO1:** To learn the fundamentals of immunological techniques **CO2:** To be able to perform techniques routinely used in immunology, particularly the use of specific antibody in biomolecular applications. **CO2:** To be able to isolate, count and identify different types of blood cells. **CO4:** To develop an idea for proper documentation of the work including laboratory procedures, experimental conditions, materials used, equipment used and the results. **CO5:** To understand the basic hazards of working with human samples and antigens and safety measures to be taken						
Topics Covered	1. Cell count with Haemocytometer 2. Determination of viability of the cells 3. Serology: Preparation of the blood smear 4. Blood cell identification 5. Blood grouping by Agglutination assay 6. Quantitative WIDAL test (By tube test and slide test) 7. Precipitation test: Immunodiffusion 8. Enzyme linked Immunosorbent Assay (ELISA) 9. Protein detection by Western blot technique. 10. Lymphocytes isolation using FicollHypaque technique						
Text Books, and/or reference material	1. Immunology Laboratory manual. 2. ArtiNigam,ArchanaAyyagari,"Lab Manual in Biochemistry, Immunology and Biotechnology", Mc Graw Hill Education, India, 2007						

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
BTS551	CO1	2	-	-	2	-	1	-	-	-	-	-	2
	CO2	2	-	2	1	-	-	-	-	1	-	-	2
	CO3	2	1	1	2	-	-	-	-	1	-	-	1
	CO4	-	1	-	-	-	-	-	-	-	3	-	2
	CO5	-	-	-	-	-	2	-	2	-	-	-	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTS552	Bioinformatics Lab	PCR	0	0	3	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Computer Programming (CSC01)		CT+EA					
Course Outcomes	**CO1:** To acquire programming knowledge to analyze biological data **CO2:** To learn about different biological databases and retrieval of biological data in different file formats. **CO3:** To learn different bioinformatics softwares related to sequence, structure and phylogeny						
Topics Covered	1. Bash programming (Linux commands) for data mining (3) 2. Handling Biological databases and sequence and structure retrieval (3) 3. Open reading frame finder (1) 4. Pairwise Sequence Alignment: BLAST tool and interpreting the results (1) 5. Multiple Sequence Alignment: Clustal, Muscle (1) 6. Phylogenetics methods for phylogenetic tree constructions: Mega, Phylip (1) 7. Protein Structure and its visualization, structural alignment softwares: PyMOL, Rasmol, VMD (1) 8. Protein Structure prediction softwares: I-Tasser, Psipred , Modeller (2) 9. RNA related softwares: Vienna Package (1)						
Text Books, and/or reference material	Text Books: 4. The Linux Command Line: A Complete Introduction 1st Edition by William E. Shotts Jr. 5. Python Crash Course by Eric Matthews Reference Books: 1. Bioinformatics: Sequence and Genome Analysis by David W Mount, Cold Spring Harbor Laboratory Press 2. A Practical Guide to Linux Commands, Editors and Shell Programming 3rd Edition by Mark G. Sobell						

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
BTS552	CO1	3	3	1	3	3	2	-	-	-	-	-	3
	CO2	3	2	1	3	2	3	-	-	-	-	-	3
	CO3	3	2	2	3	3	3	-	-	3	1	2	3

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Chemical Engineering						
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours			Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHS581	**UNIT OPERATIONS OF CHEMICAL ENGINEERING LABORATORY II**	PCR	0	0	3	3	2
Pre-requisites		Course Assessment methods (Continuous evaluation (CE) and end assessment (EA))					
Unit operation of Chemical Engineering I and II		CE+EA					
Course Outcomes	**CO1:** Apply the knowledge of fundamentals of heat and mass transfer equipment on laboratory **CO2:** Experimentation and data analysis **CO3:**To apply principles of mass transfer phenomena to chemical process industries **CO4:** Handling various instruments and solve various difficulty levels **CO5:** Learn industrial applications of heat transfer equipment **CO6:** Complete process design through assignment / group task						
Topics Covered	1. Determination of thermal conductivity of metal rod 2. Determination of overall heat transfer coefficient in a counter-current & parallel flow double pipe heat exchanger. 3. Determination of overall heat transfer coefficient in a shell and tube heat exchanger. 4. Experimental test rig on drop-wise and film-wise condensation for assessing the performance. 5. Studies on estimation of hold-up volume under steady state condition and evaluate the overall performance of a rotary dryer. 6. Determination of overall efficiency of cooling tower 7. Estimation of rate of drying of specific biomass under steady state condition in an atmospheric tray dryer 8. Performance studies on continuous fractionating distillation column in terms of distillate, bottom product and reflux quantities, % loss, % recovery, energy consumption etc. (36 hr)						
Text Books, and/or reference material	Suggested Text Books: 1) Transport Processes and Unit Operations - C. J. Geankoplis 2) Heat Transfer: Principles and Applications: B. K Dutta						

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CHS581	CO1	3	3	3	3	3	-	1	-	3	1	3	2
	CO2	3	3	3	3	3	-	2	-	3	1	3	2
	CO3	3	3	3	3	3	-	2	-	3	1	3	2
	CO4	3	3	3	3	3	1	2	-	3	1	3	2
	CO5	3	3	3	3	3	1	2	-	3	1	3	2
	CO6	3	3	3	3	3	-	1	-	3	1	3	2

Correlation levels 1, 2 or 3 as defined below:

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

Department of Chemical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHC631	Process Control & Instrumentation	PCR	3	1	0	4	4
Mathematics, Unit Operations		Course Assessment methods (Continuous (CT) and end assessment (EA))					
		CT+EA					

Course Outcomes	**CO1:** Analyze open-loop system **CO2:** Analyze and apply the knowledge of linear closed-loop systems. **CO3:** Develop working knowledge of control system by frequency response **CO4:** Analyze the response of instruments and ability to integrate knowledge about instrument **CO5:**Explain the importance and application of instruments
Topics Covered	Laplace Transform, 1st order response, 1st order in series, linearization, 2nd order Dynamics (12) Feedback control system, Servo and regulator problem, Transfer function of Controller, Final control element, Control valve characteristics, Transportation Lag, Routh-Hurwitz Criteria and stability (12) frequency response of closed-loop, frequency response technique, Bode Diagram and stability criteria (8) Static and dynamic responses, Measurement of temperature and pressure (5) instruments for process plant to measure flow, level and concentration of fluid (5)
Text Books, and/or reference material	1. Process Systems Analysis and Control, Donald Coughanowr McGraw-Hill Science/Engineering/Math; 2 edition (March 1, 1991) 2. Chemical Process control, G. Stephanopoulos, PHI, 2008 3. Essentials of Process Control, Luyben et al. McGraw-Hill Companies (August 1, 1996) 4. Process control, Thomas Marlin, McGraw-Hill Education; 2nd International edition (July 1, 2000) 5. Jone's Instrumentation Technology (all the volumes) 6. Instrumentation and Devices by Rangan & Sharma 7. Considine's Handbook on Instrumentation 8. Atomic absorption and Emission Spectrophotometers, Ed Metcalfe 9. Industrial Instrumentation, D.P.Eckman

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CHC631	CO1	3	3	3	-	3	-	-	1	3	1	2	3
	CO2	3	3	3	-	3	-	-	1	3	1	2	3
	CO3	3	3	3	-	3	-	-	1	2	1	2	3
	CO4	2	2	3	2	3	-	-	1	2	1	3	3
	CO5	2	2	3	2	3	-	-	1	3	1	3	3

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Humanities and Social Sciences							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
HSC631	**ECONOMICS AND MANAGEMENT ACCOUNTANCY**	PCR	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous evaluation (CE) and end assessment (EA))					
NIL		CE+EA					
Course Outcomes	**CO1:** To review basic economic principles with students; **CO2:** To introduce students basic capital appraisal methods used for carrying out economic analysis of different alternatives of engineering projects or works; **CO3:** To educate the students on how to evaluate systematically the various cost elements of a typical manufactured product, an engineering project or service, with a view to determining the price offer.						

Topics Covered

PART 1: Economics

Group A: Microeconomics

Sl. No.	Name	L	T	P	Cr	H
Unit 1:	Economics: Basic Concepts	2	0	0	2	2
Unit 2:	Theory of Consumer Behaviour	3	0	0	3	3
Unit 3:	Theory of Production, Cost and Firms	3	0	0	3	3
Unit 4:	Analyses of Market Structures: Perfect Competition	3	0	0	3	3
Unit 5:	Monopoly Market	1	0	0	1	1
Unit 6:	General Equilibrium &Welfare Economics	2	0	0	2	2
TOTAL		**14**	**0**	**0**	**14**	**14**

Group B: Macroeconomics

Sl. No.	Name	L	T	P	Cr	H
Unit 1:	Introduction to Macroeconomic Theory	2	0	0	2	2
Unit 2:	National Income Accounting	3	0	0	3	3
Unit 3:	Determination of Equilibrium Level of Income	4	0	0	4	4
Unit 4:	Money, Interest and Income	2	0	0	2	2
Unit 5:	Inflation and Unemployment	2	0	0	2	2
Unit 6:	Output, Price and Employment	2	0	0	2	2
	TOTAL	**15**	**0**	**0**	**15**	**15**

PART 2: Accountancy

Sl. No.	Name	L	T	P	Cr	H
Unit 1:	Introduction to Accounting	2	0	0	2	2
Unit 2:	Primary Books of Accounts (Journal)	1	0	0	1	1
Unit 3:	Secondary Books of Accounts (Ledger)	3	0	0	3	3
Unit 4:	Cash Book	2	0	0	2	2
Unit 5:	Bank Reconciliation Statement	1	0	0	1	1
Unit 6:	Trial Balance	2	0	0	2	2
Unit 7:	Final Accounts	2	0	0	2	2

	TOTAL 13 0 0 13 13
Text Books, and/or reference material	**PART 1: Economics** **Group A: Microeconomics** 1. Koutsoyiannis: Modern Microeconomics 2. Maddala and Miller: Microeconomics 3. Anindya Sen: Microeconomics: Theory and Applications 4. Pindyck & Rubenfeld: Microeconomics **Group B: Microeconomics** 1. W. H. Branson: Macroeconomics – Theory and Policy (2nd ed) 2. N. G. Mankiw: Macroeconomics, Worth Publishers 3. Dornbush and Fisher: Macroeconomic Theory 4. SoumyenSikder: Principles of Macroeconomics **PART 2: Accountancy** 1. Gupta, R. L. and Radhaswamy, M: Financial Accounting; S. Chand & Sons 2. Ashoke Banerjee: Financial Accounting; Excel Books 3. Maheshwari: Introduction to Accounting; Vikas Publishing 4. Shukla, MC, Grewal TS and Gupta, SC: Advanced Accounts; S. Chand & Co.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
HSC631	CO1	-	-	1	-	-	3	-	-	3	2	1	-
	CO2	3	2	-	1	-	2	-	2	-	-	3	1
	CO3	-	-	-	-	1	-	3	-	-	-	2	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSC631	**Artificial Intelligence and Machine Learning**	PCR	3	0	2	5	4
Pre-requisites		Course Assessment methods (Continuous evaluation (CE) and end assessment (EA))					
Basic Concepts of Probability and Statistics, Knowledge of Algorithm analysis		CE+EA					
Course Outcomes	**CO1:** Identify problems where artificial intelligence (AI) techniques are applicable **CO2:** Understand to apply search strategies to solve the problems. **CO3:** Principal models used in machine learning and Apply them in machine learning to appropriate problems **CO4:** Formulate valid solutions for problems involving uncertain inputs oroutcomes by using decision making techniques. **CO5:** Understanding different supevised and unsupervised learning methods.						

Topics Covered	**Introduction to Artificial Intelligence (AI):** What is Intelligence, Reasoning and Planning, Learning and Adaptation, and interaction with the real world, A brief history of AI, Application areas of AI, State of the art. (2) **Problem solving by search:** Problem types, Illustrative search problems; Search Space, Search tree; BFS, DFS, UCS; Local search; Hill climbing; Heuristics; A* search (6) **Knowledge Representation:** Propositional, predicate logic, first order logic, resolution and unification (5) **Reasoning under Uncertainty:** Conditonal independence representation, exact inference through variable elimination, and approximate inference through sampling. (5) **Introduction to Machine Learning:** Basic concepts, bias-variance trade off, evaluation metrics etc. (2) **Supervised Learning:** Simple linear regression, multiple linear regression, logistic regression, support vector machine, decision trees, Introduction to artificialneural network. (14) **Unsupervised Learning:** Clustering algorithms, k-means/k-medoid, hierarchical clustering (6) **Dimensionality reduction:** Principal component analysis. (2) **Sessional experiments:** Study of PROLOG programming language to implement different search techniques, Implementation of different machine learningtechniques (linear and logistic regression; Decision Trees**;** Support Vector Machine; artificial neural network; Clustering techniques) by programming in Python (10)
Text Books, and/or reference material	**Text Books:** 1. Artificial intelligence : A Modern Approach- Stuart Russell, Peter Norvig, Prentice Hall,Fourth edition, 2020 2. Tom M. Mitchell, “Machine Learning”, McGraw Hill Education, International Edition,2010 **Reference Books:** 1. Elaine Rich, Kevin Knight and Shivashankar B Nair, “Artificial Intelligence”, Tata McGraw Hill, 3rd Edition 2017. 2. Ethem Alpaydin, “Introduction to Machine Learning”, Third Edition, , MIT Press, 2014

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CSC631	CO1	3	3	3	-	3	-	-	1	3	1	2	3
	CO2	3	3	3	-	3	-	-	1	3	1	2	3
	CO3	3	3	3	-	3	-	-	1	2	1	2	3
	CO4	2	2	3	2	3	-	-	1	2	1	3	3
	CO5	2	2	3	2	3	-	-	1	3	1	3	3

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE610	**MOLECULAR VIROLOGY**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Cell Biology, Molecular Biology, and Immunology		CT+EA					

Course Outcomes	**CO1:** Acquire an understanding of virus life cycle and host-virus interactions. **CO2:** Acquire an idea about detection, prevention and treatment of virus infections. **CO3:** To learn about use of virus in biotechnology.
Topics Covered	Brief history and principles of virology. (1) Principles of virus classification. (2) General structure of viruses; Viroids, Virusoids, Satellite viruses, and Prions. (2) Genome of plant and animal viruses. Mobile genetic elements. (4) Replications of RNA viruses. (5) Replication of DNA viruses. (5) Virus-cell interactions: cytopathology; virus entry and egress; host cell shut off and IRES;viral persistence and latency. (6) Methods to diagnose virus infections. (3) Antiviral vaccines. (3) Antivirals: interferons and its mechanisms of action. (2) Gene silencing. (2) Culture and purification of viruses. (2) Viral vectors and gene therapy. (2) New and emerging viruses (3)
Text Books, and/or reference material	Text Books: 1. Principles of Virology: 4th Edition. By S. Jane Flint, Vincent R. Racaniello, Glenn F. Rall, Anna Marie Skalka, and Lynn W. Enquist. Reference Books: 2. Fields Virology by Lippincott Williams and Wilkins.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
BTE610	CO1	2	-	-	-	-	-	1	-	-	-	-	1
	CO2	2	1	-	1	-	-	1	-	-	-	-	1
	CO3	2	1	2	-	-	2	-	1	-	-	-	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE611	**BIOENERGY**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					

NIL	CT+EA
Course Outcomes	**CO1:** Learn about energy crisis, problems of fossil fuel use, global warming **CO2:** Learn about production of biological solid fuel. **CO3:** Learn about gaseous biofuel production like methane and hydrogen in detail. **CO4:** Learn about liquid biofuels **CO5:** Learn about benefits and deficiencies of biofuels, life cycle analysis
Topics covered	Energy and fossil fuel use – fossil fuel use, fossil fuel reserves, sustainable fuel sources [4] Consequences of burning fossil fuel – effects of industrial (anthropogenic) activity on greenhouse gases, sources of greenhouse gases [3] Mitigation of global warming – Kyoto protocol, reduction in global greenhouse gases, fuel cells, sequestration of carbon dioxide, alternative energy sources, energy storage. [4] Biological solid fuels – 1st, 2nd and 3rd generation biofuels, types of biomass available, energy and fuel generation using biomass. [5] Gaseous biofuels – methane production using anaerobic digestion process, sewage sludge and from landfill sites, use of methane as transport fuel. Hydrogen production from biological material, biological production of hydrogen, photosynthetic hydrogen production, hydrogen storage, use as transport fuel. Diethyl ether production. [6] Liquid biofuels to replace petrol – methanol production. Large scale ethanol production from biomass, use of lignocellulosics for ethanol production, ethanol extraction after production, use of ethanol as fuel. Butanol production and use. [6] Liquid biofuel to replace diesel – synthetic diesel (FT synthesis), bio-oil (pyrolysis), microalgal biodiesel, biodiesel from plant oils and animal fats, properties of biodiesel, glycerol utilization. [5] The benefits and deficiencies of biofuels – reduction in fossil fuel use, fuel economy, reduction in carbon dioxide emission from biofuels, improvement in biodiesel quantity and quality, life cycle analysis of biofuels. [6] Jatropha cultivation, National hydrogen energy road map. [3]
Text Books, and/or reference material	Books. 1. Biofuels production, application and development. Alan Scragg, CABI.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
BTE611	CO1	1	1	-	-	-	2	3	1	1	1	-	2
	CO2	2	2	2	-	-	2	3	1	1	1	-	2
	CO3	2	2	2	-	-	2	3	1	1	1	-	2
	CO4	2	2	2	-	-	2	3	1	1	1	-	2
	CO5	1	1	-	-	-	2	3	1	1	1	-	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE612	**APPLICATIONS OF MOLECULAR CLONING**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
BTC401 (Molecular Biology & rDNA Technology)		CT+EA					
Course Outcomes	**CO1:** To understand the fundamentals of molecular cloning. **CO2:** To learn the basic methods of molecular cloning. **CO3:**To gain knowledge about the potential application aspects of molecular cloning. **CO4:**To build-up a bridging concept for extension of theoretical knowledge to practical applications of molecular cloning.						
Topics Covered	**Module 1: Basic principles of molecular cloning** - Why gene cloning and DNA analysis are important (2) - Vectors for gene cloning (2) - Purification of DNA from living cells (2) - Manipulation of purified DNA (3) - Introduction of DNA into living cells (3) - Cloning vectors for prokaryotes (3) - Cloning vectors for eukaryotes (3) - How to obtain a clone of a specific gene (2) - Other molecular techniques (2) **Module 2: Applications of molecular cloning in research** - Sequencing genes & genomes (3) - Studying gene expression & function (3) - Studying genomes (4) **Module 3: Applications of molecular cloning in biotechnology** - Production of protein from cloned genes (2) - Gene cloning & DNA analysis in medicine (3) - Gene cloning & DNA analysis in agriculture (3) - Gene cloning & DNA analysis in forensic science &environment (2)						
Text Books, and/or reference material	**Text Books:** T. A. Brown, Gene Cloning and DNA Analysis: An Introduction, Seventh Edition, Wiley Blackwell. Sandy B. Primrose, Richard Twyman & Bob Old, Principles of gene manipulation primrose: An introduction to genetic engineering, Sixth Edition, Blackwell Science						

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
BTE612	CO1	2	-	-	2	-	-	2	-	2	-	-	1
	CO2	2	-	-	2	-	-	2	-	2	-	-	1
	CO3	2	2	3	-	3	3	2	2	2	-	-	2
	CO4	3	3	2	-	2	2	3	2	2	-	-	3

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE613	**NANOTHERAPEUTICS**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
		CT+EA					

Course Outcomes	**CO1:** To understand the role of the small molecules in the drug delivery system. **CO2:** To learn the fundamentals and principles of nanotechnologies in drug release system. **CO3:** To understand methods of nanotechnology in point of care diagnosis. **CO4:** To understand the basic mechanism of Nano therapeutics of tumors.
Topics Covered	**UNIT -I NANOPHARMACEUTICALS: Nano-biotechnology for Drug Discovery** - Gold Nanoparticles for Drug Discovery - Use of Quantum Dots for Drug Discovery - Nanolasers for Drug Discovery -Cells Targeting by Nanoparticles with attached small molecues. 5, Dendrimers, Nanobodies, Nanospheres-Nanotubes, Nano-cochleates, Nano- molecular Valves for Controlled Drug Release –Nano-motors for Drug Delivery. 6 **UNIT - II ROLE OF NANOTECHNOLOGY IN BIOLOGICAL THERAPIES: Development of nano medicines:** Nano Shells, Nano pores, Tectodendrimers, Nanoparticle drug system. Biomedical nanoparticles, Liposome's Different types of drug loading, Drug release, Biodegradable polymers. 5**,** Applications Nano biotechnologies for Single-Molecule Detection -Protease- Activated Quantum Dot Probes. 3**,** Nanotechnology for Point-of-Care Diagnostics –Nano diagnostics for the Battle Field, Nano diagnostics for Integrating Diagnostics with Therapeutics. 4 **UNIT – III APPLICATION IN CANCER THERAPY & NANOMEDICINE:** Introduction and Rationale for Nanotechnology in Cancer Therapy -- Diagnostic approach by nano-sensing. (3), Passive Targeting of Solid Tumors: Pathophysiological Principles and Physicochemical Aspects of Delivery Systems -Active Targeting Strategies in Cancer with a Focus on\Potential Nanotechnology Applications. 5, Pharmacokinetics of Nano-carrier-Mediated Drug and Gene Delivery. 4
Text Books, and/or reference material	**References:** 1. Kewal K. Jain , The Handbook of Nano-medicine Humana Press, (2008). 2. Zhang, Nanomedicine: A Systems Engineering Approach" 1st Ed., Pan Stanford Publishing, (2005). Robert A. Freitas Jr., —Nano-medicine Volume IIA: Biocompatibility, Landes Bioscience Publishers, (2003).

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
BTE613	CO1	1	2	3	3	3	1	1	2	-	1	2	2
	CO2	2	3	3	3	2	3	3	2	1	1	1	2
	CO3	3	3	3	3	3	1	2	2	2	1	2	1
	CO4	1	2	3	2	3	1	1	3	1	1	1	3

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE614	**Python for Biologists**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Introduction to Computing (CSC01)		CT+EA					
Course Outcomes	**CO1:** To learn the syntax of python programming language **CO2:** To understand functions to facilitate code reuse and process of structuring the data. **CO3:** To learn data visualization using python and biological data analysis						
Topics Covered	1. Applications of Python, Versions of Python, Elements of Python, Type Conversion (6) 2. Control and flow: Conditional statement in Python (if-else, Elif), Loops: Purpose and working of loops, while loop, for Loop, nested loops, break and continue (6) Strings: Length, Concatenation, Indexing and Slicing of Strings. (6) 3. Data Structure: list, Tuples, Sets, Dictionaries (4) 4. Functions: parts, and execution, keyword and default Arguments, (4) 5. File I/O: File input and output operations in Python Programming. (4) 6. Data analysis and visualization: pandas and numpy, matplotlib, plotnine (6) 7. Biopython: parsing biological data files (6)						
Text Books, and/or reference material	Text Books: Martin Jones “Python for biologists”, 2013 ISBN-10: 1492346136 Allen B. Downey and O'Reilly, Think Python: How to Think Like a Computer Scientist (2 ed.), O′Reilly, 2015. ISBN 978-1-491-93936-9 Reference Books: Al Sweigart, “Automate the Boring Stuff with Python”, William Pollock, 2015, ISBN: 978-1593275990. Wesley J Chun, “Core Python Applications Programming”, 3rd Edition, Pearson Education India, 2015. ISBN-13: 978-9332555365.						

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
BTE614	CO1	3	1	-	-	1	1	-	-	1	-	2	-
	CO2	3	3	2	3	2	1	-	-	2	-	2	-
	CO3	3	3	2	2	3	1	-	-	3	1	2	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="8">Department of Biotechnology</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>BTE615</td><td>Industrial Biotechnology</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">NIL</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1:To understand the methods of cell 's bio processing under various conditions, strain improvement methods for better results
CO2: Demonstrate the experimental techniques associated with aseptic processes, media preparation and related upstream processes
CO3: Design and develop medium for cell cultivation for fermentation process Apply the knowledge of sterilization techniques
CO4: Understand needs of various parts of fermenter and their operation and Design bioreactor based on thumb rules for fermentation operation
CO5: Apply the knowledge of Purification Separation and kinetics theory of Enzyme production for industrial fermentation</td></tr>
<tr><td>Topics Covered</td><td colspan="7">UNIT 1 CELL CULTIVATION ,GROWTH KINETICS -- 10 Hrs
Media development for Cell growth and culture for microbes , plant, animal -derived cells and its application. Microbial growth kinetics and Numericals Strain improvement of industrial micro organism. Measurement of cell mass. Cell immobilization.
UNIT 2 MEDIA PREPARATION and STERILIZATION 10 Hrs
Sterilization: basic concepts in sterilization insitu and ex-situ sterilization, Sterilization of medium, air, filters, fermenter. Types of media, Strain preservation , inoculum preparation, Development of inocula for industrial fermentation/ seed fermenter
UNIT 3 BIOREACTOR DESIGN AND ITS OPERATION- 12 Hrs
Purpose and importance of bioreactor, Parts of fermenter and types ; Oxygen requirement, Oxygen transfer in fermenter, , KLa measurement, Measurement of dissolved oxygen concentrations, Estimating Oxygen Solubility ,Operational modes of bioreactor: batch, semi-batch/fedbatch, continuous. Major components of bioreactor and its purpose, classification of Bioreactor – SLF, SSF, animal and plant cell culture. Classification of bioreactors for environmental control and management. Fixed bed bioreactor, airlift reactor, hollow fibre reactor, seed reactor.
UNIT 4 INDUSTRIAL ENZYMES ,PURIFICATION and APPLICATIONS -10H
Enzyme engineered for new reactions-a novel catalyst for organic synthesis. Case studies: thermozymes cold adopted enzymes. Ribozymes, therapeutic enzymes of industrial importance (amylase, glucose isomerase, cellulose, lipase, protease, xylanase, invertase, peroxidases).
Bioseparation: Extraction and purification; F:iltration, Ultra filtration ,high performance tangential flow filtration, Recovery and purification of intracellular products: centrifugation.cell disruption, chromatographic techniques. Analytical assays of purity level of enzymes.</td></tr>
</table>

Text Books, and/or reference material	**TEXT BOOKS:** 1. Pauline M. Doran, “Bioprocess Engineering Principles”, Academic Press, 2 nd Ed., 2012. 2. El-Mansi (Ed.), “Fermentation Microbiology and Biotechnology”, CRC Press, 3rd Ed., 2011. **REFERENCE BOOKS:** 1. Ashok Pandey et al., “Enzyme Technology”, Springer Publisher, 2006. 2. Nielsen et al., “Bioreaction Engineering Principles”, Plenum Publishers, 2nd Ed., 2002. 3. Mohammed A. Desai (Ed.), “Downstream Processing of Proteins: Methods and Protocols”, Humana Press, 2000. 4. Satinder Ahuja, “Handbook of Bioseparations”, Vol 2, Academic Press, 1st Ed., 2000.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
BTE615	CO1	2	3	2	1	1	-	-	-	-	-	-	1
	CO2	2	3	1	3	2	2	-	-	-	-	-	1
	CO3	1	-	1	2	2	2	-	-	-	-	-	2
	CO4	1	2	3	3	-	1	1	-	1	1	-	3
	CO5	1	2	3	3	1	2	1	-	2	1	-	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE616	**ENVIRONMENTAL MICROBIOME**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Microbiology and Bioprocess Technology (BTC302); Molecular Biology and Genetic Engineering (BTC401); Bioinformatics (BTC601)		CT+EA					
Course Outcomes		**CO1:** Develop understanding of Microbial Diversity and Ecology. Understand the Physicochemical and biological factors that define the microbiome in different environments as well as the significance of microbial interaction with environment **CO2:** Learn about the important tools and techniques used to study microbial ecology or microbiome structure. Learn to apply “Omics” approaches to assess the microbial community structure and function. **CO3:** Understand the System biology approach to assess the interaction and function of microbiome members in global scale. **CO4:** Learn to exploit microbial community members for Resource recovery, Environmental clean-up, CH4 production and consumption, CO2 sequestration, etc.					

Topics Covered	**Introduction**- Significance, developments and challenges of environmental microbiome study. (4) **Microbial Diversity and ecology**- Environments and microenvironments, ecosystem services, biogeochemistry and nutrient cycles, carbon-nitrogen-sulfur-and other nutrient cycles. (7) **Survey of microbiome in different habitats-** Microbiomes of Terrestial, Marine, Freshwater, Deep sea, Hydrothermal vents, Subsurfaces, Permafrost region etc. Earth microbiome and Human microbiome Project. (7) **Microbiome of the built environment-** Microbial interactions with environment, microbial influenced corrosion, microbial enhanced oil recovery, mineral recovery, bioremediation of heavy metals and organic pollutants, methane production and consumption (7) **Microbiome characterization**- Metagenomics, metaproteomics and metatranscriptomics, culture dependent and culture independent techniques, conventional and molecular analyses, assessment of microbial metabolic diversity and activities. (8) **System Biology and Microbial interaction**- Approach of system biology in bioremediation, bioremediation with genomics, interaction between community members within microbiome, commensalism, syntrophism, interspecies hydrogen transfer etc. Strategies of bioremediation, Microbial performance assessment. (9)
Text Books, and/or reference material	**Text Book** Brock Biology of Microorganisms- Madigan, Martinko, Bender, Buckley and Stahl- Pearson publisher. Bioremediation and Natural Attenuation: Process Fundamentals and Mathematical models- P J J Alvarez and W A Illman- Wiley Interscience. **Reference Books** Environmental Microbiology: from genomes to biogeochemistry- Eugene L.Madsen- Blackwell Publishing. Environmental Microbiology for Engineers- V.Ivanov- CRC Press. Environmental Microbiology- Maier, Pepper and Gerba- Elsevier (Academic Press).

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
BTE616	CO1	2	2	2	2	2	2	2	2	2	2	3	3
	CO2	3	3	3	3	3	2	2	2	2	3	3	3
	CO3	2	3	3	2	3	3	3	3	3	3	3	3
	CO4	3	3	3	3	3	3	3	3	3	3	3	3

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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>BTE617</td><td>BIOPHARMACEUTICAL PROCESS DESIGN</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2"></td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: To learn about the manufacturing process and facility design for biopharmaceutical products
CO2: To acquire knowledge of detailed design of GMP compliant biopharma plant CO3: To study the design and optimization of downstream processes of therapeutic protein manufacture in a commercial set up
CO4: To learn about technology transfer, regulation, validation and quality assurance of biopharma industry</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Manufacturing process - Drug substance manufacturing, drug product manufacturing, key factors for process evaluation. Manufacturing and storage of cell bank. Comparison of batch and continuous process for fermentation. Difference between suspension fermenters for cell culture and microbial fermentation. [6]
Design and construction of manufacturing facilities for mammalian cell derived pharmaceuticals. Detailed design of a GMP compliant plant with process flow diagram along with utilities, water treatment, waste management and location selection [6]
Downstream processing - Harvest of therapeutic proteins from high cell density fermentation broths – centrifugation and filtration. Expanded bed adsorption for separating the biopharmaceutical product from crude solution. Ultrafiltration process design and implementation for biopharmaceutical product recovery. Virus filtration process design for biopharmaceutical product recovery. Product recovery of biopharmaceutical products from transgenic sources – aqueous two phase extraction [12]
Role of process development group and manufacturing group in biopharmaceutical process start up. [3]
Making changes to a biopharmaceutical manufacturing process during development and commercial manufacturing – a case study [2]
Biosimilars and non-innovator biotherapeutics in India – an overview of current situation [2]
Fundamental of Quality assurance, Structure of Quality Management Systems, Responsibility of Management and Training of Personnel, Quality Assurance in Development. [5]
Quality assurance in manufacturing, GMP, Process validation for cell culture derived pharmaceutical proteins. Regulation [6]</td></tr>
</table>

Text Books, and/or reference material	**Books** Text Process Scale Bioseparations for the Biopharmaceutical Industry, Abhinav A. Shukla, Mark R. Etzel, ShishirGadam, CRC Press 2. Manufacturing of Pharmaceutical Proteins, Stefan Behme, Wiley-VCH References Pharmaceutical Production Facilities: Design and Applications, Graham Cole, Informa Healthcare Large-scale Mammalian Cell Culture Technology, Lubiniecki, CRC Press

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
BTE617	CO1	3	2	3	1	1	1	2	1	1	1	1	2
	CO2	2	2	3	1	1	1	2	1	1	1	1	2
	CO3	2	2	2	1	1	1	1	1	1	1	1	2
	CO4	2	2	2	1	1	1	2	2	1	1	3	2

Correlation levels 1, 2 or 3 as defined below:
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Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE618	**Human Genomics**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Cell Biology, Molecular Biology and Genetic Engineering		CT+EA					
Course Outcomes		**CO1:** To understand the general organization of human nuclear and mitochondrial genome and know about the salient features and characteristics. **CO2:** To acquire knowledge the human genome project and its implication on clinical biology in the post genomic era. **CO3:** To familiarize with different scientific techniques used for studying different features of genome. **CO4:** To get an overview about different applications of the genomic based knowledge.					
		1. Patterns of genome organization (10) 2. Structural genomics (2) 3. Functional genomics (2) 4. Reverse genetics (2) 5. Gene patenting (2) 6. Electronic PCR (2) 7. Genome mapping and genome sequencing (2) 8. Specialized database in molecular biology (2) 9. Human genome project progress (2) 10. Genes in health and disease(2)					

	11. Genomic disorders and molecular medicine (2) 12. Minimal cell Genome (2) 13. Prospects of Gene therapy in Human (2) 14. Pharmacogenomics (2) 15. Genebank (2) 16. Legal status of gene bank (2)
Text Books, and/or reference material	**Textbook:** 1. T. A. Brown, Genomes, John Wiley & Sons **Reference Books** Singer.M, and Berg.P, Genes and genomes, Blackwell Scientific Publication, Oxford 1991 Beebe.T, and Burke.T, Gene Structure and Transcription, 2nd edition,1992, Oxford Univ Press Glick and Pasteurneck, Molecular Biotechnology, Principles and Applications of Recombinant DNA technology, ASM Press Strachan & Reed, Human Molecular Genetics, Garland Science. Cantor & Smith, Genomics, John Wiley & Son

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
BTE618	CO1	3	2	2	1	1	3	1	2	1	2	1	3
	CO2	3	2	3	2	2	3	1	2	1	2	1	2
	CO3	3	3	3	3	3	3	1	2	1	2	1	3
	CO4	2	2	2	2	3	3	1	3	1	2	1	3

Correlation levels 1, 2 or 3 as defined below:
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Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE619	**BIOETHICS AND IPR**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
		CT+EA					
Course Outcomes		**CO1:** To understand the importance, ethical issues and safety regulations in Biotechnology and Biomedical research. **CO2:** To realize the importance and basics of intellectual property Rights and laws. **CO3:** To learn the process of filing a patent claim in India and abroad.					
Topics Covered		**Biotechnology and Society:** Introduction to science, technology and society, biotechnology and social responsibility, public acceptance issues in biotechnology, issues of access, ownership, monopoly, traditional knowledge, biodiversity, benefit sharing, environmental sustainability, public vs. private funding, biotechnology in international relations, globalization and development divide. (4)					

	Biosafety: Introduction; historical background for substances Intended for Use in Human Food or Animal Food Based on the Generally Recognized as Safe (GRAS). Recommended biosafety levels for infectious agents and infected animals; definition of GMOs & LMOs. Laboratory safety measurements like biological safety cabinets; containment zones for biohazards, disposal methods of bio-wastes etc. (8) **Biotechnology and Bioethics:** The expanding scope of ethics from biomedical practice to biotechnology, ethical conflicts in biotechnology. Legality, morality and ethics, the principles of bioethics: autonomy, human rights, beneficence, privacy, justice, equity etc. Introduction, ethical conflicts in biological sciences - interference with nature, bioethics in health care - patient confidentiality, informed consent, euthanasia, prenatal diagnosis, genetic screening, cloning, gene therapy. Bioprospecting and biopiracy. Bioethics vs. business ethics. (10) **IPR:** Jurisprudential definition and concept of intellectual property, types of IP: patents, trademarks, copyright & related rights, industrial design, traditional knowledge, geographical indications, protection of new GMOs; International framework for the protection of IP; IP as a factor in R&D; IPs of relevance to biotechnology and few case studies; introduction to history of GATT, WTO, WIPO and TRIPS. Ethical dimensions of IPR, technology transfer and other global biotech issues. Contents of patent specification and procedure for obtaining patents, Geographical indication, trademark etc. Indian Patent Act 1970; recent amendments; WIPO Treaties; Budapest Treaty; Patent Cooperation Treaty (PCT) and implications; procedure for filing a PCT application. (12) **Regulations on ethical principles in biomedical practices:** The, Nuremberg code, declaration of Helsinki; the Belmont report, imposed voluntary moratorium period in rDNA research. Biosafety guidelines by WHO and DBT (India). Guidelines of an informed consent. Rights/ protection, infringement or violation and remedies against infringement, civil/criminal proceedings. (8)
Text Books, and/or reference material	Textbook: F. H. Erbisch and K. M. Maredis, Intellectual Property Rights in Agricultural Biotechnology, Bios Publishers Text / Reference Books: 1. Thomas, J.A., Fuch, R.L. (2002). Biotechnology and Safety Assessment (3rd Ed). Academic Press. 2. Fleming, D.A., Hunt, D.L., (2000). Biological safety Principles and practices (3rd Ed). ASM Press, Washington. 3. Biotechnology - A comprehensive treatise (Vol. 12). Legal economic and ethical dimensions VCH. Encyclopaedia of Bioethics

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
BTE619	CO1	-	1	2	1	-	2	-	2	1	3	2	2
	CO2	1	-	1	-	2	3	2	2	-	3	1	2
	CO3	2	2	1	-	-	3	-	3	2	3	1	1

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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>BTE620</td><td>MEDICAL & PHARMACEUTICAL BIOTECHNOLOGY</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2"></td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: To understand the growing landscape of pharmaceutical industry and application of cutting edge advancement of Biotechnology for its growth.
CO2: To study the recent development and applications in drug design and disease diagnosis.
CO3: To learn the process of industrial productions of biopharmaceuticals.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Introduction - Biopharmaceuticals and their development, historical aspects, general steps in development of a drug, sources and strategies (including random, non-random, and rational) of discovering lead compounds
2
Drug designing
Macromolecules as Targets of drugs: (lipids, carbohydrates, proteins, nucleic acids) 2
Drug targets: carrier proteins, structural proteins, enzymes, receptors (including mechanisms – ion channels and membrane-bound enzymes) 4
Concepts and design criteria of agonists, antagonists, partial agonists, and inverse agonists. 3
Rational drug designing, Structure –activity relationships and identification of pharmacophore and auxophore in a lead compound; drug design on the basis of drug-target interactions. 5
Disease diagnosis
PCR, LCR immunological assay, Detection of genetic, Neurogenetic disorders involving Metabolic and Movement disorders. Treatment-products from recombinant and non-recombinant organisms, Interferons, Antisense therapy, cell penetrating peptides. Gene therapy, Types of gene therapy, somatic virus germline gene therapy, mechanism of gene therapy, Immunotherapy. Detection of mutations in neoplastic diseases MCC, SSCP, DGGE, PTTC. Use of enzymes in clinical diagnosis. Use of biosensors for rapid clinicalanalysis. Diagnostic kit development for microanalysis, Diagnosis of disease by proteomics. 25
Production of pharmaceuticals
Production of pharmaceuticals by genetically engineered cells (hormones, interferons). Microbial transformation for production of important pharmaceuticals (steroids and semi-synthetic antibiotics). Techniques for development of new generation antibiotics. 15, Drug delivery</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Textbooks:
1. An Introduction to Medicinal Chemistry; Graham L.Patrick, Oxford
Reference Books:
1.The Organic Chemistry of Drug Design and Drug Action; Richard B. Silverman, Elsevier</td></tr>
</table>

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
BTE620	CO1	2	1	2	-	1	-	-	1	-	-	-	-
	CO2	2	1	2	-	1	-	1	-	-	-	-	1
	CO3	2	1	1	-	1	-	1	-	-	-	-	1

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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>BTE621</td><td>NANOBIOTECHNOLOGY</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2"></td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Acquire an idea about nanoscale phenomenon
CO2: To learn about the basic investigation tools for the nanobiotechnology
CO3: To learn about bottom up and top down synthesis of nanosystems
CO4: to get comprehensive understanding of applications of nanotechnology in biology</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Nanotechnology; introduction to miniaturization. (4)
Iinvestigation tools: experimental methods and probes; basic principles of scanning force microscopy; scanning electron microscopy; transmission electron microscopy. Investigation tools: lithography (8)
Nanomaterials: organic and inorganic nanoparticles. Synthesis, assembly, and processing of nanostructures: phenomenon of self-assembly. (6)
Molecular self-assembly and bottom up synthesis of nanomaterials. (6)
Nanoparticles and cancer therapeutics; nanoparticle-based drug delivery. (6)
Nanofiber-based scaffolds and tissue engineering; nanodiagnostics and biosensing. (6)
Nanotoxicology. (4)
Future Concepts in Nanobiotechnology. (2)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Book:
Understanding Nanomedicine - An Introductory Textbook by Rob Burgess.
Refrences Books
Springer Handbook of Nanotechnology, by Bharat Bhushan Springer
2. Nanobiotechnology: Concepts, Applications and Perspectives, by Christof M. Niemeyer, Chad A. Mirkin, John wiley
3. Introduction to Nanotechnology, by Charles P. Poole, Frank J. Owens, Wiley-Interscience
4. Nanofabrication and Biosystems : Integrating Materials Science, Engineering, and Biology, by Harvey C. Hoch, Lynn W. Jelinski, Harold G. Craighead, Cambridge University Press</td></tr>
</table>

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
BTE621	CO1	3	3	1	1	1	1	-	-	-	1	-	2
	CO2	3	3	2	3	3	1	-	-	-	1	-	2
	CO3	3	3	2	3	3	1	0	1	-	1	-	2
	CO4	3	3	2	3	3	3	1	1	-	1	-	2

Correlation levels 1, 2 or 3 as defined below:
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>BTE622</td><td>Animal Genetic Engineering</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2"></td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: To elucidate the scope of Animal Biotechnology.
CO2: To learn the different areas of Animal Biotechnology applications.
CO3: To learn the basic technology in each area of Animal Biotechnology.
CO4: To learn the future prospect of the Animal Biotechnology.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Animl Cell culture:History of animal cell culture and development, Development of primary culture, Development of cell line by enzymatic disaggregation, Culture media and growth conditions. Cell type and characterization, origin of animal cell line, maintenance and characterization of different cell lines, Marker gene characterization (8)
Technology – Present and future :
Hybridoma technology/Monoclonal antibody technology, Vaccine production, Organ culture, Transfection of animal cells, Future tissue engineering (4).
In Vitro Fertilization and Embryo Transfer:
Basic knowledge on Fertilization and embryology, Steps involved in IVF, Fertilization by means of micro insemination, PZD, ICSI, SUZI, MESA (4)
Stem cells:
Classification and types, Sources, Markers, Differentiation signals, application, IPSC, Cncer stem cells (4).
Gene Therapy:
Ex-vivo gene therapy, In vivo gene therapy, Viral gene delivery system, Retrovirus vector system, Adenovirus vector system, Adeno-Associated virus vector system, Herpex simplex virus vector system, Non-viral gene delivery system, Prodrug activation therapy, Nucleic acid therapeutic agents (4)
Transgenic and Konck out Animals:
Methodology, Embryonic Stem Cell method, Microinjectionmethod, Retroviral vector method, Applications of transgenic animals
Recombinanat protein expression and purification:
Expression vectors for mammalian proteins, Cell (S cerevicea, P pasturis etc.) for large-scale mammalian protein production, Post translational modification and</td></tr>
</table>

	purification.
Text Books, and/or reference material	Animal Cell Culture by John R.W. Masters; Oxford University Press 2. Introduction to Cell and Tissue Culture by Jennie P. Mather and Penelope E. Roberts; Plenum Press, New York and London Molecular Biotechnology: Primrose. 4. Animal Cell Biotechnology: R.E. Spier and J.B. Griffiths (1988), Academic press. 5. Balasubramanian, Bryce, Dharmalingam, Green and Jayaraman (Eds.), Concepts in Biotechnology, University Press, 1996 Hood L.E., Weissman I., Wood W.B. and Wilson J.H. Immunology, Benjamin Cummings, 1989 7. Biotol Series – Butterworth and Heineman, Oxford, 1992

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
BTE622	CO1	-	-	1	-	-	1	-	1	-	-	-	2
	CO2	-	-	1	-	-	1	-	1	-	-	-	3
	CO3	-	-	-	-	-	2	1	2	-	-	-	2
	CO4	-	-	-	-	-	-	-	1	1	1	-	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTS651	**PLANT AND ANIMAL BIOTECHNOLOGY LABORATORY**	PCR	0	0	3	3	2
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
BTC01 Life Science BTC301 Cell Biology and Genetics BTC 502 Cell and Tissue Culture		CT+EA					
Course Outcomes		**CO1:** Students will be acquainted with basic plant tissue culture techniques. **CO2:** Students will be acquainted in basic animal cell culture techniques. **CO3:** Students will attain knowledge of application of cell and tissue culture techniques in academic and industrial laboratories. **CO4:** Students will have knowledge of biosafety and ethical issues related to cell and tissue culture.					
Topics Covered		**Plant Tissue Culture** 1. Preparation and sterilization of plant tissue culture media. 2. Preparation of explants. 3. Callus induction in rice. 4. Regeneration of rice callus tissue. 5. Rooting of regnerants in rice.					

	Animal Cell Culture 1. Sterilization Techniques, Preparation of Media & Preparation of Sera 2. Primary Cell Culture 3. Preparation of established Cell lines 4. Cell Counting and Viability **5.** Staining of Animal Cells & Preservation of Cells
Text Books, and/or reference material	1. Laboratory manual.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
BTS651	CO1	2	-	1	1	-	-	-	-	1	-	-	1
	CO2	2	-	1	1	-	-	-	-	1	-	-	1
	CO3	2	-	1	1	-	-	-	-	-	1	-	1
	CO4	-	-	-	-	-	2	1	1	-	-	-	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTS652	**BIOSEPARATION ENGINEERING LABORATORY**	PCR	0	0	3	3	2
Pre-requisites		Course Assessment methods (Continuous assessment (CA) and end-term examination (ET))					
Bioseparation& Biochemical Analysis (BTC 503)		CA+ET					
Course Outcomes		**CO1:** To determine the specific cake resistance & filter medium resistance by constant pressure filtration/pressure-time variation in constant rate filtration **CO2:** To prepare a cell-free extract by sonication/homogenization and identify a specific protein therein by Western Analysis **CO3:** To learn the technique of salt precipitation of a protein and subsequent dialysis for removal of the salt and to get an idea of other equipment for concentrating a protein **CO4:**To construct a binodial diagram and study the extraction of a protein in an aqueous two-phase system **CO5:**To separate out a protein from a mixture by gel filtration/ion exchange chromatography and to concentrate a protein by ultrafiltration **CO6:** To extract and estimate biomolecules such as lipids, DNA, & RNA					
Topics Covered		1. Filtration (constant pressure filtration) 2. Preparation of cell-free extracts from cultured cells 3. Salt precipitation of protein and Dialysis 4. Extraction and estimation of total lipid content 5. Separation/concentration of proteins by Ultrafiltration. 6. Aqueous two phase extraction (binodial diagram) 7. Separation of proteins by gel permeation/ion-exchange					

	chromatography 8. Identification of a specific protein present in the cell-free extract by Western Analysis 9. Determination of DNA and RNA concentration by UV absorption **10.** Demonstration of lyophilization& Rotary vacuum evaporation
Text Books, and/or reference material	Textbooks : 1. Practical Biochemistry Principles and techniques (5th ed)/ Principles and Techniques of Biochemistry and Molecular Biology (7th ed): Editor Wilson and Walker, Cambridge University Press 2. Geankoplis, Transport Processes & Unit operations, PHI. Reference books: 1. D. Holme & H. Peck, Analytical Biochemistry, 3rd ed, Longman, 1998 2. Shuler & Kargi, Bio-process Engg. PHI **3.** Bailey &Olis, Biochemical Engg. Fundamentals, McGraw-Hill

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
BTS652	CO1	2	-	-	-	-	-	-	-	1	2	-	-
	CO2	2	1	-	2	1	1	1	1	2	2	-	1
	CO3	1	-	1	-	1	-	1	-	1	2	1	2
	CO4	1	-	1	-	-	-	-	-	1	2	1	-
	CO5	1	-	2	1	1	-	1	-	2	2	-	1
	CO6	1	-	-	1	1	1	-	1	1	2	-	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Management Studies							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MSC731	**PRINCIPLES OF MANAGEMENT**	PCR	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous assessment (CA) and end-term examination (ET))					
NIL		CA+ET					
Course Outcomes		**CO1:**To make budding engineers aware of various management functions required for any organization **CO2:**To impart knowledge on various tools and techniques applied by the executives of an organization **CO3:**To make potential engineers aware of managerial function so that it would help for their professional career **CO4:**To impart knowledge on organizational activities operational and strategic both in nature **CO5:** To impart knowledge on each functional area of management like Marketing, Finance, Behavioral Science and Quantitative Techniques and decision science					
Topics Covered		**UNIT I:** Management Functions and Business Environment: Business					

	environment- macro, Business environment -micro; Porter's five forces, Management functions –overview, Different levels and roles of management, Planning- Steps, Planning and environmental analysis with SWOT, Application of BCG matrix in organization**(8)** **UNIT II:** Quantitative tools and techniques used in management: Forecasting techniques, Decision analysis, PERT & CPM as controlling technique (7) **UNIT III:** Creating and delivering superior customer value:Basic understanding of marketing, Consumer behavior-fundamentals, Segmentation, Targeting & Positioning, Product Life cycle. (8) **UNIT IV:** Behavioral management of individual: Motivation, Leadership, Perception, Learning. (8) **UNIT V:** Professional ethics: Introduction to Professional ethics, Morals, values and Ethics, Ethics in Business. (2)
Text Books, and/or reference material	Text Books: 1. Marketing Management 15th Edition, Philip Kotler and Kelvin Keller, Pearson India 2. Management Principles, Processes and practice, first edition, Anil Bhatand Arya Kumar, Oxford Higher education 3. Organizational Behavior,13 th edition, Stephen P Robbins, Pearson Prentice hall India 4. Operations Management, 7th edition (Quality control, Forecasting), Buffa & Sarin, Willey

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
MSC731	CO1	-	-	-	-	-	-	-	2	2	1	1	3
	CO2	-	-	-	-	-	-	-	-	-	1	1	3
	CO3	-	-	-	-	-	-	1	2	2	2	2	3
	CO4	-	-	-	-	-	-	1	2	2	1	1	3
	CO5	-	-	-	-	-	-	2	2	2	2	1	3

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="8">Department of Biotechnology</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>BTC 701</td><td>Data Analytics Biotechnology</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">Basic knowledge of topics Data Structure and Algorithm, DBMS and Engineering Mathematics.</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: To understand the fundamentals of concepts, applications, and limitations of commonly used data analysis techniques in medicine and biology.
CO2: visualization and analysis of higher-dimensional data, like clustering, classification, and dimensionality reduction
CO3: To gain hands-on experience with tools and platforms through practical exercises and projects.
CO4: To explore basics of statistical learning and their application in biological data analysis.</td></tr>
<tr><td>Topics covered</td><td colspan="7">Introduction to Data Analysis in Biology: The intersection of AI, Biology, and Medicine, Fundamentals of AI and Machine Learning, Definition and scope of AI in healthcare, Historical perspective and milestones in AI research, Applications of AI in clinical practice and biomedical research. (1)

Descriptive & inferential Statistics: Introduction to Descriptive Statistics, Probability Distributions (Discrete and continuous), Use cases in modelling mutation and inheritance using probability distributions. Moments (mean, variance, covariance) Bayes theorem, likelihood, Use cases with disease diagnosis, population genetics drug discovery and phylogenetics, Inferential Statistics through hypothesis tests, Permutation & Randomization Test, Regression & ANOVA Regression ANOVA(Analysis of Variance), Use cases in biological studies comparing case vs control, Practice session with biological data analysis using R (5).

Linear Algebra for machine learning: Vectors and vector operation, Matrix and matrix operation, Eigen value, Eigen vectors, singular value decomposition (SVD), Using SVD in spectral clustering of gene expression pattern, linear systems of equation (5).

Feature engineering: feature scaling (Normalization and Standardization), Data encoding (ordinal encoding and one-hot encoding), Data transformation, Data binning, handling missing data, Principle component analysis, Use of PCA to interpret gene expression and ecological niche modelling. (5)

Data analysis and visualization: Histogram, box plot, heat map, volcano plot, Network visualization, Familiarization with ggplot2, PCA with R, t-SNE, Use cases of t-SNE in single-cell RNA sequencing (scRNA-seq) studies, t-SNE is widely used for visualizing cell clusters. , Diffusion map. (5)

Fundamentals of statistical Learning : Fundamentals of Machine Learning, instance based and model-based machine leaning, Supervised learning (types of with example</td></tr>
</table>

	of regression: Simple Linear Regression, Multiple Linear Regression, Logistic Regression, Example with in vitro protein-DNA binding data), Ridge Regression, Lasso and Elastic net Regression, Gradient descent, Stochastic and batch gradient descent, Accuracy and confusion matrix, Precision and Recall concepts, and reinforcement learning, Bias-variance tradeoff and model interpretability, Decision tree, Regression tree, Ensemble learning, Voting , bagging, Random Forest Classifier, Ada Boost, XGBoost, Support Vector Machine with use cases in subtype classification in biological samples and cancer subtype, Naïve Bayes Classifier (Text mining for drug discovery), Case studies in biology and medicine in one for each case, Unsupervised Learning, Clustering, K nearest neighbors, Identifying protein families with clustering, self-organizing maps, Supra hex for genomics data analysis with examples with GWAS and gene expression data, Challenges for Big Data Analytics (30)
Text Books, and/or reference material	**Text book:** [1] Hastie, Trevor, et al.;The elements of statistical learning. Vol. 2. No. 1. New York: Springer, 2009. [2] Montgomery, Douglas C., and George C. Runger.; Applied statistics and probability for engineers. John Wiley & Sons, 2010Mesko, B., 2017. [3]A guide to artificial intelligence in healthcare. Budapest, Hungary: The Medical Futurist. leanpub. com. **Reference Book:** Handbook of AI-Based Models in Healthcare and Medicine: Approaches, Theories, and Applications (Artificial Intelligence in Smart Healthcare Systems), CRC Press; 1st edition (21 February 2024). Relevant research papers.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
BTC701	CO1	3	2	-	-	2	-	2	-	-	2	2	3
	CO2	1	2	1	1	-	-	3	-	2	1	-	3
	CO3	3	-	-	2	-	1	2	-	2	-	-	3
	CO4	3	3	3	2	-	-	1	2	1	-	2	3

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE710	**PROTEOMICS AND PROTEIN ENGINEERING**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Biochemistry and Enzyme Technology; Molecular Biology and Genetic Engineering;		CT+EA					
Course Outcomes	**CO1:** Students will acquire knowledge on protein structure and function and will be able to apply the understanding in designing strategies for proteomic analysis and protein engineering. **CO2:** Students will be acquainted with tools and techniques for proteomic analysis and						

	will be able to analyze proteomic data using databases. **CO3:** Students will be acquainted with tools and techniques for protein engineering and will be able to apply them to solve problem related to protein function and efficiency.
Topics covered	1. **Introduction to proteinstructure and function:** Elementary ideas of bonding and structure, stereochemistry; spectroscopic techniques. Amino acid structure and properties to 3D structure of protein. Basic principles of protein folding anddynamics. Protein sequence andevolution. [10] 2. **Proteomics and its application:** Chromatography principles. Analytical protein and peptide Separation, Protein Digestion Techniques, Mass Spectrometers for protein and peptide analysis, protein identification by peptide Mass fingerprinting. Mining proteomes, protein expression profiling, identifying protein-protein interactions and protein complexes, Mapping protein modifications. [16] **3. Protein Engineering:** Proteins design and engineering, Random, site directed mutagenesis; Strategies to alter catalytic efficiency; structure prediction and modeling proteins; Molecular graphics in protein engineering; Dynamics and mechanics; Drug-protein interactions and Design; applications of engineered proteins. [16]
Text Books, and/or reference material	Textbooks: 1. R.M. Twyman; Principles of Proteomics, Bioscientific Publishers. 2. Biotechnology, 2nd Edition 2015. David Clark and Nanette Pazdernik. Academic Cell. Reference Books: 1. B.Alberts,D.Bray, J.Lewis et al, Molecular Biology of the Cell, Garland Pub. N.Y 1983. 2. Richard J. Simpson, Proteins and Proteomics, I.K. International Pvt Ltd. Daniel C. Liebler, Introduction to Proteomics: Tools for the New Biology, Humana Press.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
BTE710	CO1	2	-	-	-	-	-	-	-	-	-	-	1
	CO2	2	2	2	1	1	1	-	-	-	-	-	1
	CO3	2	2	2	1	1	1	1	-	-	-	-	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE711	**ENVIRONMENTAL ENGINEERING**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
		CT+EA					
Course Outcomes	**CO1:** To learn about air pollution monitoring and control **CO2:** To learn about waste water treatment processes along with analytical procedures **CO3:** To study about solid waste management **CO4:** To acquire knowledge on bioremediation of pollutants						

Topics Covered	Air pollution control methods and equipment - Primary and secondary air pollutants, Effect of air pollutants on health, Control of gaseous and particulate pollutants, air pollution control equipment. 6 Water pollution: sampling and analysis - Sampling, BOD and COD analysis, Bacteriological measurements, Numerical problems5 Water and waste- water treatment processes - Overview of treatment principles. Primary treatment – screening, sedimentation, flotation, neutralization etc.4 Secondary treatment - Activated sludge process, extended aeration, Trickling filter, Aerated lagoons, Waste stabilization ponds, Aquatic plant systems, UASB reactors. Design of a complete mix activated sludge process.8 Biomethanation. Nitrification and denitrification operations. Phosphorus removal. Sludge treatment and disposal. Tertiary treatment. Membrane based treatment processes. 8 Solid waste management, Vermiculture, hazardous waste management 5 Specialized aspects - Bioremediation for recovery of metals, Xenobiotics, Degradation of chlorinated hydrocarbons, polyaromatic hydrocarbons, Phytoremediation. Reactors in bioremediation. 6
Text Books, and/or reference material	**Books** Text 1. Introduction to waste water treatment processes, Ramalho, Elsevier. 2. Environmental Engineering: A design Approach, Sincero, Arcadio. P, Sr. &Greogia; PHI 3. Waste water treatment and disposal, Arceivala, Wiley 4. Environmental Biotechnology, Alan Scragg, Oxford University press Reference 1. Waste water Engineering: Treatment, disposal, reuse, by Metcalf & Eddy, Tata Mc Graw Hill Industrial Water Pollution Control, Eckenfelder, McGraw Hill.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
BTE711	CO1	3	2	2	1	1	1	3	1	1	1	-	2
	CO2	3	2	2	1	1	1	3	1	1	1	-	2
	CO3	3	2	2	1	1	1	3	1	1	1	-	2
	CO4	3	2	2	1	1	1	3	1	1	1	-	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE712	**VACCINE TECHNOLOGY**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
BTC403 Immunology		CT+EA					
Course Outcomes		**CO1:** To understand the factors that influence vaccine design and development					

	CO2: To understand how research based discovery has driven vaccine development **CO3:** To know about the different types of vaccines **CO4:** To learn about the quality control and regulation in the vaccine production **CO5:** To understand the importance of vaccination as a public health strategy
Topics Covered	History of vaccine development- Importance of vaccines (2) Immunological response to vaccines (2) Vaccine design and development: Epitope identification; Vaccine efficacy, Adjuvants (6) Different types of vaccines: Inactivated toxins, Inactivated whole bacteria or viruses, Live attenuated bacteria or viruses; Subunit vaccines, Polysaccharide vaccines, Conjugated vaccines ; Recombinant DNA vaccines, Edible vaccines, Virus like particles(8) Next-generation vaccines: Human Immunome project; Human antibodies as vaccines (4) Production techniques used for vaccines (4) Storage and preservation of vaccines (4) Delivery methods: microspheres, nanoparticles; ISCOMS and immunomodulators (6) Regulatory issues in vaccine production: OIE guidelines for production and seed lot management; Manufacturing recommendation; Final product release tests (5) Vaccine safety-the debate (1)
Text Books, and/or reference material	Text Books: New Vaccine Technologies: Ronald W. Ellis (Landes Bioscience), 2001. Vaccines: Stanley A. Plotkin, Walter A. Orenstein, Paul A. Offit(Elsevier), 6th Edition Reference Books: Medical Microbiology : Samuel Baron , 4th Edition (University of Texas) Advances in Vaccine Technology and Delivery: Cheryl Barton, Espicom Business Intelligence. "Vaccine manual: The production and quality control of veterinary vaccines for use in developing countries": Noel Mowat ,Daya books.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
BTE712	CO1	2	-	-	-	1	-	-	-	-	-	-	1
	CO2	2	3	-	2	-	-	-	-	-	-	-	1
	CO3	-	-	2	-	-	2	1	-	-	-	-	2
	CO4	-	-	2	-	-	2	2	1	-	-	1	2
	CO5	-	-	-	-	-	-	1	-	-	2	-	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE 713	**PROTEIN FOLDING, MISFOLDING AND DISEASES**	PEL	3	0	0	3	3
Prerequisite		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Molecular biology & Genetic Engineeering; Biochemistry & Enzyme Technology; Cell biology and genetics		CT+EA					
Course Outcomes		CO1: To acquire an understanding of the protein structure CO2: To learn about the principles of protein folding and misfolding CO3: To obtain a comprehensive idea of different diseases related to protein misfolding CO4: Development of cumulative understanding of protein folding, misfolding and diseases to find much-needed cure for the relevant conditions.					
Topics Covered		Basic of protein misfolding related diseases. The hierarchical structure of the protein. Principles of protein stability and folding. (16) Protein misfolding and aggregation. Protein quality control: molecular chaperones, protein degradation, autophagy and aging. (12) Prion Diseases. Alzheimer's Disease. Parkinson's Disease. Huntington's Disease and other unstable repeat disorders. Amyotrophic lateral sclerosis and frontotemporal lobar degeneration. (14)					
Text Books, and/or reference material		Text Books: 1. Fundamentals of Neurodegeneration and Protein Misfolding Disorders by Martin Beckerman, Springer Introduction to Protein Structure by Carl IV Branden, Routledge Structure and Mechanism in Protein Science: A Guide to Enzyme Catalysis and Protein Folding by Alan Fersht, W. H. Freeman.					

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
BTE713	CO1	1	3	3	3	2	1	1	-	3	3	1	3
	CO2	1	3	3	3	2	1	1	-	3	3	1	3
	CO3	1	3	3	3	2	1	1	-	3	3	1	2
	CO4	3	3	3	3	2	1	1	-	3	3	1	3
	CO5	1	3	3	3	2	1	1	-	3	3	1	3

Correlation levels 1, 2 or 3 as defined below:
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<table>
<tr><td colspan="7">Department of Biotechnology</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>BTE 714</td><td>CANCER BIOLOGY AND CELL SIGNALING</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">BTC301-Cell Biology and Genetics/BT-817- Cancer Biology</td><td colspan="5">CT+EA</td></tr>
<tr><td colspan="2">Course Outcomes</td><td colspan="5">CO1: To understand the basic concepts of cancer biology and related cellular signaling
CO2: To understand the development and causes of cancer.
CO3: To understand the therapeutic aspects of cancer prevention
CO4: To identify the target molecules that are associated with cancer so that the cancer preventive small molecule inhibitors/phytochemicals can be screened.</td></tr>
<tr><td colspan="2">Topics Covered</td><td colspan="5">Cancer Biology
1. Introduction to Cancer and Molecular basis of cancer [2] Mutation and DNA damage repair mechanism [2]
2. Cell cycle [3]
3. Oncogenes (tumor viruses) , Tumor suppressors [3]
4. Epigenetics, non-coding RNAs and genome fluidity in cancer [4] Cancer and Stem Cells, Angiogenesis, Apoptosis [4]
5. Cancer therapy, Future of Cancer research [3]
6. Cell Signaling related to cancer

Cell Signaling

1. Introduction to cellular signaling [3]
2. Signaling molecules – (e.g. Hormones, Interferons and others) [3] Receptor-mediated signaling in cells [3]
3. Role of different transcription factors and kinases (e.g. MAP kinases and other ser/thr kinases) [4]
4. Involvement of different signal transduction pathways during cancer initiation, progression and metastasis [5]
5. Small molecule inhibitors of cancer [3]</td></tr>
<tr><td colspan="2">Text Books, and/or reference material</td><td colspan="5">Text Books:
Weinberg RA. The Biology of Cancer, 2nd Edition. Garland Science, 2013.
Cellular signal processing , 2nd Edition by Friedrich Marks, Ursula Klingmuller and Karin Muller-Decker, Garland Science

Reference: Selected reviews and primary scientific literature</td></tr>
</table>

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
BTE714	CO1	1	-	2	2	-	1	-	-	1	2	1	2
	CO2	1	1	2	2	1	1	1	1	2	2	1	2
	CO3	1	1	1	2	1	-	1	-	1	2	1	2
	CO4	1	1	2	2	1	2	3	-	1	1	1	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE715	**STEM CELL BIOLOGY**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Cell Biology, Biochemistry, Genetics, Molecular Biology		CT+EA					
Course Outcomes	CO1: To understand the basic mechanisms of how cells differentiate into specific tissues in response to a variety of biologic signaling molecules and the use of such factors for tissue production in-vitro. CO2: To acquire knowledge on the molecular basis of cellular and functional changes of different organs that occur in disease and treatments that cause tissue remodeling to correct these changes CO3: To gather insights on how studies of the developmental, cellular and molecular biology of regeneration have led to the discovery of new drugs/therapy for regenerative therapy. CO4: To understand the recent advances on application the regenerative therapy from well characterzied case studies.						
Topics Covered	1. An Introduction to Stem Cells (2) 2. Adult Stem Cells (1) 3. Embryonic Stem Cells (1) 4. Induced Pluripotent Stem Cells (1) 5. Hematopoietic Stem Cells (1) 6. Messenchymal stem cells , cord blood cells, Lessons from Medipost company products like Neurostem, Cardiostem, Cartistem, Pneumostem (4) 7. Molecular and Cellular Bases of Organ Development (6) 8. Cloning of Somatic Cells by Nuclear Transfer, iPSC based cloning, Production of chimera animals (4) 9. Molecular Bases of degenerative disease (1) 10. Therapeutic Uses of Stem Cells with examples (2) 11. In vivo Regeneration of Tissues by Cell Transplantation (2) 12. IPS Cells as Experimental Models of Neurodegenrative Disorders: use of them as disease modelling platform, novel drug testing and tissue renerarative therapy and implantation studies(2) 13. Studies of Patients Treated with Stem Cells, The modalities of treatment, Preperation						

	of cells/tissues/scaffolds and Trnasplantation procedure (3) 14. Tissue Regeneration Driven by Growth Hormones (2) 15. Organ of dish, Orgnoid culture, Tissue Bioprinting to develop transplantation quality organs, Bioartificial Organs (8) 16. Biobanking of stem cells and the ethical considerations in regenerative medicine. (2)
Text Books, and/or reference material	Text Books: 7. Stem Cells, Tissue Engineering And Regenerative Medicine By: David Warburton 1st Edition. 8. Principles of Regenerative Medicine by Anthony Atala Robert Lanza Tony Mikos Robert Nerem , 3rd Edition. 9. Translational Regenerative Medicine by Anthony Atala and Julie G. Allickson Reference Books: 1. The Developping Human by Keith L. Moore/T.V.N. Persaud/ Mark G. Tenth edition. 2. Encyclopedia of Tissue Engineering and Regenerative Medicine by Rui Reis, IstEdtion.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
BTE715	CO1	2	1	1	3	1	1	2	-	-	2	-	1
	CO2	2	1	2	3	2	2	2	-	-	2	-	-
	CO3	2	2	3	2	3	3	3	-	3	2	-	2
	CO4	3	2	3	3	2	2	3	-	3	2	-	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE716	**PROJECT ENGINEERING FOR BIOTECHNOLOGY**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
		CT+EA					
Course Outcomes	CO1: To learn about detailed design of a manufacturing plant CO2: To learn about cleaning, sterilization, waste management and utilities of a biotechnology production plant CO3: To study about Planning, construction and commissioning of a biopharmaceutical manufacturing plant CO4: To learn about project management and financial aspects of the plant						
Topics Covered	Introduction Basic considerations in plant design, project identification, preliminary techno-economic feasibility. Process flow Diagrams and symbols: Symbols of Process Equipments& their concepts, types of flow diagrams, Importance of Laboratory development, pilot plant, scale up methods [6] Piping and valves for biotechnology: design, piping materials, polishing, passivation, sizing of pipes and tubes, connections and cleanability, piping applications, supporting						

	and insulating sanitary tubing, in-line instruments, hoses, valves. [6] Cleaning of process equipment: design and practice, sterilization of process equipment, pharmaceutical water systems: design and validation, utilities for biotechnology production plant, biowaste decontamination systems, Heating, ventilating & air conditioning (HVAC) [6] Programming & facility design, project planning, containment regulations affecting the design and operation of biopharmaceutical facilities. [6] Planning, construction and commissioning of a biopharmaceutical manufacturing plant: planning, construction, commissioning, qualification, validation, project schedules, cost estimates, organization of an engineering project, role & selection of contractors, legal aspects of facility engineering, health, safety and environmental law, building law. [6] Product sales and manufacturing costs: basic principles of cost calculation, fixed cost, variable cost, depreciation, interest, typical costs of biotechnological manufacturing processes, profit and loss calculation. [6] Investments: investment targets, types of investments, investment appraisal, cost comparison, profit comparison, internal rate of return, dynamic payback time. [3] Production concepts: capacity planning, dilemma of in-house manufacturing, aspects of manufacturing out-sourcing, contractual agreements, technology transfer, process optimization after market launch, supply chain management. [3]
Text Books, and/or reference material	Text Books: 1. Bioprocess engineering: system, equipment and facilities, B K Lydersen, NAD'Elia, K M Nelson. Wiley 2. Manufacturing of pharmaceutical proteins, Stefan Behme, wiley Reference Books: 1. Plant design and Economics for chemical engineers, peter M. S. Timmerhaus, K. D. McGraw Hill. Project Engineering with CPM and PERT, Modes J. Philips, Rheinhold publishers.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
BTE716	CO1	3	3	3	2	1	1	2	1	1	1	1	2
	CO2	3	3	3	2	1	1	3	1	1	1	1	2
	CO3	3	3	3	2	1	1	2	1	1	1	1	2
	CO4	3	3	3	2	1	1	2	1	1	1	3	2

Correlation levels 1, 2 or 3 as defined below:

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

<table>
<tr><td colspan="8">Department of Biotechnology</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>BTE717</td><td>FOOD BIOTECHNOLOGY</td><td>PER</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2"></td><td colspan="6">CT+EA</td></tr>
<tr><td colspan="2">Course Outcomes</td><td colspan="6">CO1: To quantitate and identify the spoilage microorganisms present in food.
CO2: To learn the concepts of food fermentation and increase the shelf life of food.
CO3: To learn the concepts in genetically modified food and increase the agricultural yield by using genetic engineering approach.
CO4: To apply the concepts of antioxidant and nutraceutical for health and wellness.
CO5: To follow the regulations and ethical issues of food safety by using good manufacturing practices in industry and genetically modified food.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Food for health and wellness [2]

Food Microbiology: [6]
Detection of microorganism in food – role of PCR, DNA CHIP, rapid methods for identification of microorganism in food, immunological methods, Bioassay, Biosensors- detection of toxin, heavy metal , pesticide and herbicides

Food preservation [10]
Pasteurization, sterilization, Canning, Irradiation, Dehydration, low temperature Food preservation, use of preservatives,

Food fermentation [8]
Role of lactic acid bacteria in fermentation and strain improvement, Fermentation of meat, fish, vegetables, beverages , dairy product, non beverage product , use of genetic engineering techniques for improved quality product.
Genetically modified food [6]

Fruit ripening, improvement of sweetness, flavor, starch, amino acid, vitamin content, Golden rice. Safety aspects of genetically modified food, Single cell protein, single cell oil, Spirulina,

Biotechnology in relation to food product and Food Safety (5+5)

Antioxidant, nutraceutical, Nutrigenomics
Legal status of irradiated food and preservatives, Concept of HACCP, Hazop, codex alimentarius, ISO series</td></tr>
</table>

Text Books, and/or reference material	Text Book Food microbiology by James . M. Jay Food Microbiology by Frazier and Westhoff Plant Biotechnology by Slater Reference Book Fundamentals of Food Biotechnology by Lee

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
BTE717	CO1	3	3	3	3	3	3	3	2	1	1	2	3
	CO2	3	3	3	3	2	2	3	2	1	1	2	3
	CO3	3	3	3	3	3	3	3	3	2	1	2	3
	CO4	3	2	3	3	1	3	3	2	2	1	1	3
	CO5	3	2	2	2	3	3	3	3	3	3	3	3

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTO740	**COMPUTATIONAL BIOLOGY**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
		CT+EA					
Course Outcomes		**CO1:** To impart knowledge of life science and biological data **CO2:** To acquire knowledge of computational and mathematical skills for addressing important biological questions. **CO3:** To learn how to develop and implement computational algorithms and tools for processing biological data					
Topics Covered		1. Introduction to Computational biology and its applications(2) 2. Central dogma and biological macromolecules- DNA, RNA & proteins(2) 3. Major biological databases related to DNA, RNA, proteins &metabolic pathways(3) 4. Basic file formats & sequence representation(2) 5. Computational algorithms for Sequence Alignment: Local and global alignment, Sequence similarity, Sequence identity, Gaps, Scoring matrices, pairwise and multiple alignments, Dynamic programming, BLAST & its application,(7) 6. Algorithms for phylogenetics: Tree constructions(5) 7. StructuralBioinformatics: A. Protein Structure and its visualization(2) B. Protein structural alignment(3) C. Protein secondary Structure Prediction(4) D. Protein tertiary Structure Prediction(4) E. RNA Structure Prediction(3) F. Molecular docking and docking algorithms(3)					

	7. Application of machine learning in biological sciences (Basic concepts) (2)
Text Books, and/or reference material	Text Books: 1. Bioinformatics: Sequence and Genome Analysis by David W Mount, Cold Spring Harbor LaboratoryPress 2. Introduction to Bioinformatics by Arthur M Lesk Reference Books: 1. Protein bioinformatics: an algorithmic approach to sequence and structure analysis by Ingvar Eidhammer, Inge Jonassen and William R.Taylor. Essentials of Bioinformatics by JinXiong

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
BTO740	CO1	3	1	-	-	1	1	-	-	1	-	-	-
	CO2	3	3	2	-	2	1	-	-	2	-	-	-
	CO3	3	3	2	2	3	1	-	1	3	1	2	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTO 741	**FOOD BIOTECHNOLOGY**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					
Course Outcomes	**CO1:** To quantitate and identify the spoilage microorganisms present in food. **CO2:** To learn the concepts of food fermentation and increase the shelf life of food. **CO3:** To learn the concepts in genetically modified food and increase the agricultural yield by using genetic engineering approach. **CO4:** To apply the concepts of antioxidant and nutraceutical for health and wellness. **CO5:**To follow the regulations and ethical issues of food safety by using good manufacturing practices in industry and genetically modified food.						
Topics Covered	**Food Microbiology:** [8] Microorganism in food, Intrinsic and extrinsic parameters of food, rapid methods for identification of microorganism in food, Food borne illness, Biosensors –use and application **Food preservation** [8] : Pasteurization, sterilization, Canning, thermal process of food with numerical, Irradiation, Dehydration, low temperature, use of preservatives **Food fermentation** [10]: Role of lactic acid bacteria in fermentation and strain improvement, Fermentation of meat, fish, vegetables, beverages, dairy product, non-beverage product, use of genetic engineering techniques for improved quality product. **Genetically modified food** [8] : Fruit ripening, amino acid, vitamin content, Golden rice. Safety aspects of genetically modified food, Ethical and regulatory issues **Biotechnology in relation to food product** [4] :Antioxidant, nutraceutical, **Food safety** [6] : Legal status of irradiated food and preservatives, Concept of HACCP, Hazop, codex alimentarius, ISO series, detection of toxin, heavy metal , pesticide and herbicides.						
Text Books, and/or reference material	**Text Book** 1. Food microbiology by James . M. Jay 2. Food Microbiology by Frazier and Westhoff 3. Plant Biotechnology by Slater **Reference Book** Fundamentals of Food Biotechnology by Lee						

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
BTO741	CO1	3	3	3	3	3	3	3	2	1	1	2	3
	CO2	3	3	3	3	2	2	3	2	1	1	2	3
	CO3	3	3	3	3	3	3	3	3	2	1	2	3
	CO4	3	2	3	3	1	3	3	2	2	1	1	3
	CO5	3	2	2	2	3	3	3	3	3	3	3	3

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTO742	**MINERAL BIOTECHNOLOGY**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					
Course Outcomes	**CO1:** To understand the nature and characteristics of different biogeochemical cycles and involvement important micro-organisms. **CO2:** To learn the basic concepts of bioleaching and biobeneficiation along with the microbiological aspects **CO3:** To gain the detail knowledge bioleaching processes with examples. **CO4:** To demonstrate and provide examples on how to use microbes for the environmental pollution control						
Topics Covered	**Module-I :** Introduction to Biotechnology applied to Raw Material processing, Biogeochemical reactions – chemical mechanisms and controlling factors, Microbial interventions, Nature and characteristics of Biogeochemically important micro-organisms. 10 **Module-II:** Kinetics of bioleaching; Applications of biogeochemical process in mining and metallurgy, dump, heap and in-situ leaching. 8 **Module-III:** Reactor modeling for leaching, Beneficiation of ored and process residues: recovery of gold, silver, copper, beneficiation of sulfidic tailings from tin processing; purification of ferroginous sand. 8 **Module-IV :** Beneficiation of bauxite, applications of sulphate reducing bacteria; applications of sulphate reducing bacteria, Environmental pollution control: accumulation of metals by microbial cells. 8						
Text Books, and/or reference material	Books: 1. H.D. Kumar and S.Kumar , Modern Concepts of Microbiology, Vikas Publishing House , 2nd Edition , 2001 2. M.E. Curtin , Microbial mining and metal recovery biotechnology (1) , pp 229-235, 1983 3. Woods D, Rawling D.E., Bacterial bleaching and biomining J.L.(ed), Revolution in biotechnology , Cambridge University Press.						

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
BTO742	CO1	2	1	1	-	2	1	1	-	1	-	-	1
	CO2	2	1	1	-	1	-	2	1	1	1	-	1
	CO3	2	1	1	1	1	-	1	-	1	-	-	1
	CO4	2	1	1	1	1	-	2	1	1	1	1	1

Correlation levels 1, 2 or 3 as defined below:

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

<table>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>BTO743</td><td>MEDICAL BIOTECHNOLOGY</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">NIL</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: To provide an understanding about Inborn errors of metabolism and genetic disorders and their consequence.
CO2: Able to analyze the key features therapeutics and drugs in current scenario.
CO3: Able to apply the knowledge for commercial production of pharmaceuticals and place it in market for marketing approvals.
CO4: Able to understand the ethical issues and the different competent regulatory authorities globally associated with clinical Biotechnology.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Microbial pathogenesis: Definitions - Infection, Invasion, Pathogen,Pathogenicity, Virulence, Carriers and their types, Opportunistic infections, NosocomialInfections, epidemics.
Diagnosis of Infectious diseases: Biology of Nitric oxide implications in diagnosis and therapeutics, Ethical problems around prenatal diagnosis, in vitro fertilization, cloning, gene therapy.
DrugDesign and Drug delivery system: Synthesis of compounds in accordance with the molecular structure and biological activity concept. Various principles/ mode of drug action/ screening of drugs/ drug analysis using various techniques . New generation viral vectors for Gene Therapy and advancement in Drug Delivery system, antibody mediated drug delivery of vaccines, Antibiotics
Molecular Medicine: Antibodies and vaccines-Therapeutic production of antibodies different kind of vaccines and applications of recombinant vaccines.Ribozymes for therapeutic use in viral infection.
Cell and tissue therapy – Gene therapy, tissue engineering, stem cell and cloning. In vivo targeted gene delivery
Clinical Toxicology,Clinical Research Governance and Ethics: Basic concept in toxicology. Types and mechanism of toxin action- Epoxidation& drug toxicity, Overview on regulatory affairs for pharmaceuticals, neutraceuticals and medical devices. International quality standard and related guidelines (ICH-E6). Risk assessment and trial monitoring. Legal and ethical issues on biotechnology, medical research and related clinical practice.</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">1. Recombinant DNA: Genes and Genomes - A Short Course, Third Edition (Watson, Recombinant DNA) by James D. Watson; Cold Spring Harbor Laboratory Press
2. Biopharmaceuticals- Biochemistry and Biotechnology: Gary Walsh; John Wiley & Sons.
3. S. P. Vyas, V. Dixit, Pharmaceutical Biotechnology, CBS Publishers
4. Cedric A and Mim S. et al.: Medical Microbiology, Mosby USA
Reference Books</td></tr>
</table>

	1. Pharmaceutical Biotechnology ; Sambhamurthy&Kar , NewAge Publishers 2. Epenetos A.A.(ed), Monoclonal antibodies: applications in clinical oncology, Chapman and Hall Medical, London 3. V.Venkatesharalu-Biopharmaceutics and Pharmacokinetics-Pharma Books Syndicate 4. Diagnosis: A Symptom-Based Approach in InternalMedicine; C.S.Madgaonkar, Publisher: JPB

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
BTO743	CO1	2	1	1	2	2	1	-	-	-	-	-	2
	CO2	2	1	1	-	1	1	-	1	-	1	-	2
	CO3	2	1	1	1	1	1	-	1	-	1	1	2
	CO4	2	1	1	1	1	2	2	2	1	1	2	2

Correlation levels 1, 2 or 3 as defined below:

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

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTS 751	**BIOPROCESS ENGINEERING LABORATORY**		0	0	3	3	2
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					
Course Outcomes		**CO1:** To learn the experimental protocol of microbial growth and inhibition kinetics in a batch process **CO2:** To study substrate degradation, cell growth and product formation with immobilized cells in plug flow bioreactors. **CO3:** To learn about functions of a fermenter **CO4:** To study non-ideality in a plug flow reactor					
Topics Covered		1. Microbial cell growth kinetics 2. Microbial cell inhibition kinetics 3. Substrate degradation, cell growth and productformation study using immobilized cells in a continuous packed bed reactor. 4. Substrate degradation, cell growth and productformation study using immobilized cells in a continuous fluidized bed reactor. 5. Function of bioreactor- a) calibration of DO electrode. b) Calibration of pH electrode. 6. RTD studies in a packed bed reactor					
Text Books, and/or reference material		NA					

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
BTO743	CO1	2	1	1	-	2	-	1	2	3	2	-	2
	CO2	2	1	1	-	2	-	1	2	3	2	-	2
	CO3	2	1	1	-	2	-	1	2	3	2	-	2
	CO4	2	1	1	-	2	-	1	2	3	2	-	2

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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>BT2001</td><td>Genomics, Proteomics & Bioinformatics</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA)</td></tr>
<tr><td colspan="2">Molecular Biology & rDNA Technology</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: In depth understanding of genomes, transcriptomes and proteomes to address relevant problems.
CO2: Understanding of concepts for functional analysis of genes and proteins.
CO3: Learning bioinformatics to analyse genomes, transcriptomes and proteomes.
CO4: Development of comprehensive understanding of “Omes & Omics” to solve the existing problems of the society.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Introduction to genomics; Importance of genomics; (2)
Sequencing of genomes; Assembly of genome sequences; (2)
The human genome project; (2)
Locating the genes in the genome; (2)
Determination of gene functions; (3)
Structural, comparative and functional genomics; (2)
Lessons from various prokaryotic and eukaryotic genomes; (3)
Comparative genomics in evolution and medicine; Genomic variations. (2)

Introduction to proteomics: (1)
Expression proteomics, Functional proteomics, Structural proteomics; (2)
Two-dimensional gel electrophoresis (2-DGE); Sample Preparation; Isoelectric focusing (IEF); (3)
Equilibration of the IPG strip, the second dimension and detection of proteins on the 2-DGE gel; (2)
Introduction to mass spectrometry; Mass spectrometry (MS) - based methods of protein
identification: (3)
MALDI-MS, ESI-MS; (3)
Analysis of phosphoproteins by MS; Glycobiology and proteomics; (2)
Protein microarrays; Protein 3D structures; (2)
Protein interaction networks; Measuring proteins. (2)

Introduction to bioinformatics; (2)
Data acquisition; Databases and data retrieval; (2)
Searching sequence database; Multiple sequence alignment, (2)
phylogenetics and sequence annotation; (2)
Structural informatics; (2)
Microarray, 2DGE and MS data analysis; (2)</td></tr>
</table>

Text Books, and/or reference material	**Text Books:** 1. S. B. Primrose and R. M. Twyman; *Principles of Genome Analysis* 2. A. *M. Campbell and L. J. Heyer; Discovering Genomics, Proteomics & Bioinformatics; Pearson ducation; Second Edition.* *3. T. A. Brown; Genomes; Wiley-Liss; Third Edition.* 4. Mount "Bioinformatics" Cold Spring Harbour 5. Arthur Lesk "Introduction to Bioinformatics" 6. Bioinformatics Sequences and Genome Analysis,2nd edition 2004 by David W. Mount, CBS Publishers and Distributors . **Reference Books:** 1. Bioinformatics. (A.D.Baxevanis&B.F.F.Ouellette, eds.) Wiley Interscience, 1998.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
BT2001	CO1	3	2	3	3	3	1	1	2	3	2	-	2
	CO2	3	2	3	3	3	1	1	2	3	2	-	2
	CO3	3	2	3	3	3	1	1	2	3	2	-	2
	CO4	3	2	3	3	3	2	1	2	3	2	-	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTS851	**Analytical instrumentation Laboratory**	PCR	0	0	3	3	2
Pre-requisites:		Course Assessment methods (Continuous (CT) and end assessment (EA))					
BTC502 Bio separation Engineering		CT+EA					
Course Outcomes	**CO1:**To acquire knowledge about advanced methods needed to study macromolecular structures and functions. **CO2:**To gain exposure to advanced tools for studying biomolecules						
Topics Covered	1. UV-Vis spectroscopy 2. Fluorescence spectrophotometer 3. Gas Chromatography 4. High performance liquid chromatography 5. 2D gel electrophoresis. 6. Flow cytometry 7. Freeze drying 8. Fluorescence microscopy						
Text Books, and/or reference material	Wilson and Walker's; Principles and Techniques of Biochemistry and Molecular Biology- Edited by by Andreas Hofmann and Samuel Clokie; Cambridge University Press						

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
BTS851	CO1	1	1	1	1	-	1	-	-	1	-	1	1
	CO2	3	1	-	2	-	1	1	1	1	-	1	2

Correlation levels 1, 2 or 3 as defined below:

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

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTS852	**Omics & Bioinformatics Laboratory**	PCR	0	0	4	4	2
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Genomics, Proteomics & Bioinformatics		CT+EA					
Course Outcomes	**CO1:** To acquire knowledge of most important bioinformatics databases and learn text- and sequence-based searches to retrieve biological data in different file formats. **CO2:** Understanding pairwise and multiple sequence alignment using various softwares. **CO3:** Perform phylogenetic analysis to understand evolutionary relationships. **CO4:** To learn prediction of secondary and tertiary structures of protein and RNA sequences						
Topics Covered	1. Introduction and use of various sequence and structure databases. 2. Sequence information resource: Using NCBI, EMBL, Genbank, Entrez, UniProt. 3. Pairwise Sequence Alignment: BLAST tool and interpreting the results 4. Multiple Sequence Alignment: Clustal, Muscle etc 5. Phylogenetic analysis of protein and nucleotide sequences and phylogenetic tree constructions using softwares like Mega, Phylip 6. Use of different protein family databases (SCOP, CATH). 7. Visualization of protein structures using Rasmol and PyMol. 8. Aligning protein structures. 9. Secondary structure prediction of proteins using DSSP, Pispred. 10. Homology modelling of proteins. 11. Using RNA structure prediction tools.						
Text Books, and/or reference material	Text Books: The Linux Command Line: A Complete Introduction 1st Edition by William E. Shotts Jr. Python Crash Course by Eric Matthews Reference Books: A Byte of Python by C.H. Swaroop A Practical Guide to Linux Commands, Editors and Shell Programming 3rd Edition by Mark G. Sobell						

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6
BTS852	CO1	3	1	3	2	2	1
	CO2	3	1	3	3	2	1
	CO3	3	1	3	3	2	2
	CO4	3	1	3	3	3	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="8">Department of Biotechnology</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>BT9031</td><td>Human Molecular Genetics</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">Genetics and Molecular Biology</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Learn about classical human genetics, Mutation and diseases.
CO2: Learn about gene mapping and positional cloning.
CO3: Learn about genetics of behavioural disorders and pharmacogenomics and biochemical genetics.
CO4: Study about animal models in human genetics
CO5: Learn about methods used for diagnosis and detection of gene mutations</td></tr>
<tr><td>Topics Covered</td><td colspan="7">1. Simple Mendelian traits.
2. Loss-of-function mutations; Gain-of-function mutations; Gene interactions; Dynamic mutations.
3. Genetics of neoplasia.
4. Genomic imprinting and human disease.
5. X-inactivation and DNA methylation
6. Gene mapping and positional cloning
7. Genetics of behavioral disorders.
8. Pharmacogenetics and biochemical genetics.
9. Animal models in human genetics.
10. Methods used for diagnosis and detection of gene mutations.</td></tr>
<tr><td>Text/ References</td><td colspan="7">1. Human Molecular Genetics : Tom Strachan and Andrew P Read
2. Thompson and Thompson Genetics in Medicine
3. An Introduction to Human Molecular Genetics: Jack J. Pasternak
4.Molecular Biology of the Gene: James D Watson
5. Genes IX: Benjamin Lewin
6.Concept of Genetics: Klug, Cummings and Spencer
7. Molecular Cell Biology: James E. Darnell
8. Molecular Biology of Cancer: Pecorino</td></tr>
</table>

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6
BT9031	CO1	1	1	2	-	3	-
	CO2	1	1	2	-	3	-
	CO3	1	1	2	-	3	-
	CO4	1	1	2	-	3	2

Correlation levels 1, 2 or 3 as defined below:

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

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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>BT9032</td><td>Cancer Biology</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">Genetics and Molecular Biology</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: To understand the basic concepts of cancer biology and related cellular signaling
CO2: To understand the development and causes of cancer.
CO3: To understand the therapeutic aspects of cancer prevention
CO4: To identify the target molecules that are associated with cancer so that the cancer preventive small molecule inhibitors/phytochemicals can be screened.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">1.Phenotypic characteristics of cancer cells
2. DNA replication and Repair mechanisms
3. Role of differentiation and apoptosis, Biology of metastasis, Carcinogenesis, Cancer genetics
4. Oncogenes ,Tumor suppressor genes
5. Growth factors and signal transduction
6.Cell cycle regulation and check point.
7. Host tumor interactions, Gene rearrangements, detecting oncogene abnormalities in clinical specimens
8. Principles of chemotherapy, Concepts in cancer therapy - Mechanisms of cytotoxic drug action, Cancer Immunotherapy.</td></tr>
<tr><td>Text/ References</td><td colspan="7">1. The Biology of Cancer: Robert Weinberg
2. Principles of Cancer Biology: LJKleinsmith
3. Cancer: A Beginner's Guide (Beginner's Guides): Paul Scotting
4.Molecular Biology of the Gene: James D Watson
5. Genes IX: Benjamin Lewin
6.Concept of Genetics: Klug, Cummings and Spencer
7. Molecular Cell Biology: James E. Darnell
8. Molecular Biology of Cancer: Pecorino</td></tr>
</table>

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6
BT9032	CO1	1	-	2	2	-	1
	CO2	1	1	2	2	1	1
	CO3	1	1	1	2	1	-
	CO4	1	1	2	2	1	2

Correlation levels 1, 2 or 3 as defined below:

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

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<tr><td colspan="8">Department of Biotechnology</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR)/ Elective (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>BT9033</td><td>Signal Transduction</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous assessment (CA) and end-term examination (ET))</td></tr>
<tr><td colspan="2">Molecular Biology, Biochemistry, Cell biology and Genetics</td><td colspan="6">CA+ET</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Acquire an understanding on fundamental components of signal transduction processes.
CO2: Acquire an understanding on various signaling steps in different physiological and developmental processes of bacteria, plants and animals.
CO3: To be able to design experiments to investigate new signaling pathways and regulation of gene expression.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Bacterial two-component regulatory systems (2)
Ligands, Receptors, Second messengers and Effectors (3)
Carriers and channels of membrane (1)
G protein-coupled signal transmission (3)
Protein tyrosine kinase (2)
Ras/MAP Kinase pathways (2)
Transcription factors and regulators (3)
Chromatin remodeling (2)
Ethylene signaling (1)
Light perception and photoreceptors (2)
Signal transducers and master regulators (3)
Photomorphogenesis (2)
Transcriptional networks of seedling development (2)
Light regulated gene expression (2)
Identification of novel signaling molecules (2)
Functional characterization of new components (2)
Cross talks among various signaling pathways (2)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
Lewin’s Genes X by J.E. Krebs, E.S. Goldstein and S.T. Likpatrick
Research Articles on the said topics (usually given to the students)</td></tr>
</table>

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6
BT9033	CO1	2	0	3	1	0	0

CO2	1	0	3	1	2	1
CO3	3	2	3	3	2	2
CO4	2	0	3	1	0	0

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BT9034	**Molecular Cell Signaling**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Cell Biology, Molecular Biology and Biochemistry		CT+EA					
Course Outcomes	**CO1:** To understand the concepts of molecular signaling of cells which regulate its function. **CO2:** To understand the deregulation of these pathways leading to functional defects at cellular and molecular level. **CO3:** To identify the molecules than can be targeted therapeutically for the treatment of human diseases at cellular and molecular level.						
Topics Covered	1. Introduction of cellular signaling [4] 2. Signaling molecules – Interferons, Interleukins and others [4] 3. Receptor-mediated signaling in cells, Receptor associated and non-receptor tyrosine kinases and their involvement in different signal transduction pathways [5] 4. Role of different transcription factors and kinases (MAP kinases and other ser/thr kinases) [7] 5. Activation of various signalling pathways (Jak-Stat, MAPK, PI3K-Akt, NF-kB etc.) in different cells by extracellular stimuli [10] 6. Involvement of signal transduction pathways in many important cellular processes like Cell migration, cancer, angiogenesis etc. [10]						
Text Books, and/or reference material	Text Books: 1. Molecular Biology of the Cellby Bruce Alberts, Alexander Johnson, Julian Lewis, David Morgan, Martin Raff, Keith Roberts, Peter Walter.6th Edition, 2014.Garland Science. 2. Molecular Cell Biologyby Harvey Lodish, Arnold Berk, Chris A. Kaiser, Monty Krieger, Matthew P. Scott, Anthony Bretscher, HiddePloegh, Paul Matsudaira. 8th edition, 2016. Publisher: WH Freeman. Reference Books: 1. Cell and Molecular Biology: Concepts and Experiments by Gerald Karp. 6th Edition, 2010. Wiley. Essential Immunology, Roitt, I.M., 9th Ed. (1997), Blackwell Scientific, Oxford, UK 2. Immunology, Kuby, J. 3rd Ed. (1997), Freeman, W.H,Oxford,UK 3. Weir, Immunology, 8th ed, W.B. Saunders& Co. 4. K.A. Abbas, Immunology, 4th ed, W.B. Saunders& Co. 5. Relevant publications from many peer-reviewed journals.						

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6
BT9034	CO1	1	1	3	1	1	0
	CO2	2	1	3	1	2	0
	CO3	3	2	3	2	2	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BT9035	**Food Biotechnology**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Bioseparation Technology		CT+EA					
Course Outcomes	**CO 1:** To understand the concept of metabolic Engineering in food and apply it to increase the quality and productivity of food products **CO-2**: To increase the efficiency of enzyme by protein engineering. **CO-3:** To formulate associations between specific nutrients and genetic factors and to study how a food/food ingredient influence gene expression. **CO-4:** To learn the concept of nutratceuticals and help in the prevention of lifestyle related disorders. **CO-5:** To study the application of nutratceutical in food-based system and to develop delivery strategies for the nutraceutical. **CO-6:** To learn about heat transfer, mass transfer and reaction kinetics in foods **CO-7:** To learn about details of thermal processing of foods, dehydration operations and filtration operations art commercial level **CO-8:** Studies on Food quality management and concept of HACCP **CO-9:** Studies on design of a food processing plant						
Topics Covered	Introduction to Food Biotechnology – Food Microbiology- Metabolic Engineering of Bacteria for food ingredients, Metabolic engineering of Saccharomyces cerevisae (4) Biotechnological Modifications of S. cerevisae and its effect in wine production, genetic Engineering of baker's yeast, [2] Recombinant Lactic Acid Bacteria [1] Plant and Animal Food applications and functional food- Introduction to Nutraceutical and Nutigenomics, Probiotics, Bioavailability and delivery of nutraceuticals using nanotechnology Food and food component preventing cancer, Antiobesity effect of Allenic carotenoid, fucoxanthin, Encapsulation of probiotic bacteria, Antioxidant [10] Improvement in Food Quality- Enzymes & Recombinant lipooxygenases and oxylipin metabolism for food quality [4] Heat transfer in food, microwave operation, ultrasound assisted processing [4] Kinetics of chemical reactions in foods [2] Dehydration of foods, Mass transfer in dehydration, Drying rate curve, Pychrometry [4] Physical separation processes in foods – filtration operation, membrane filtration [5]						

	Food quality management, HACCP [3] Design of food processing plant [3]
Text Books, and/or reference material	Text Books Food Biotechnology by Kalidas Shetty Fundamentals of Food Biotechnology by Lee Fundamentals of Food Process Engineering, Romeo Toledo , Springer Fundamentals of Food Engineering, D G Rao, PHI References: 1. Bioprocesses and Biotechnology for Functional Foods and Nutraceuticals by Jean-Richard Neeser, J. Bruce German, CRC Press

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6
BT9035	CO1	-	-	2	3	3	-
	CO2	-	-	-	3	3	-
	CO3	-	-	3	-	3	1
	CO4	-	-	3	3	3	1
	CO5	-	-	-	3	-	-
	CO6	1	1	2	3	2	2
	CO7	3	2	3	3	3	2
	CO8	3	3	3	3	3	3
	CO9	3	3	3	3	3	3

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BT9036	**Biopharmaceutical Technology**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Bioprocess Engineering, Bioseparation Technology		CT+EA					
Course Outcomes	**CO 1:** To learn about the manufacturing processes of drug substance and drug products **CO 2:** To learn about the detailed design of a GMP compliant plant **CO 3:** To learn about downstream processing of biopharmaceutical products at commercial level **CO 4:** To learn about biopharmaceutical process start up **CO 5:** To learn about quality management in a biopharmaceutical industry						
Topics Covered	Manufacturing process - Drug substance manufacturing, drug product manufacturing, key factors for process evaluation. Manufacturing and storage of cell bank. Comparison of batch and continuous process for fermentation. Difference between suspension fermenters for cell culture and microbial fermentation. [6]						

	Design and construction of manufacturing facilities for mammalian cell derived pharmaceuticals. Detailed design of a GMP compliant plant with process flow diagram along with utilities, water treatment, waste management and location selection [6] Downstream processing - Harvest of therapeutic proteins from high cell density fermentation broths – centrifugation and filtration. Expanded bed adsorption for separating the biopharmaceutical product from crude solution. Ultrafiltration process design and implementation for biopharmaceutical product recovery. Virus filtration process design for biopharmaceutical product recovery. Product recovery of biopharmaceutical products from transgenic sources – aqueous two phase extraction [14] Role of process development group and manufacturing group in biopharmaceutical process start up. [2] Making changes to a biopharmaceutical manufacturing process during development and commercial manufacturing – a case study [2] Biosimilars and non-innovator biotherapeutics in India – an overview of current situation [2] Fundamental of Quality assurance, Structure of Quality Management Systems, Responsibility of Management and Training of Personnel, Quality Assurance in Development. [4] Quality assurance in manufacturing, GMP, Process validation for cell culture derived pharmaceutical proteins. Regulation [4] Concepts of understanding controlling factors regulating cost of production of a biopharmaceutical product. [2]
Text Books, and/or reference material	Text Process Scale Bioseparations for the Biopharmaceutical Industry, Abhinav A. Shukla, Mark R. Etzel, ShishirGadam, CRC Press Manufacturing of Pharmaceutical Proteins, Stefan Behme, Wiley-VCH References Pharmaceutical Production Facilities: Design and Applications, Graham Cole, Informa Healthcare Large-scale Mammalian Cell Culture Technology, Lubiniecki, CRC Press

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6
BT9036	CO1	2	1	2	2	2	2
	CO2	3	3	3	3	3	3
	CO3	3	2	3	3	3	2
	CO4	3	3	3	3	3	3
	CO5	3	3	3	3	3	3

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BT9037	**Biomaterials**	PEL	3	0	0	3	3
Biochemistry, cell biology, Chemistry		Course Assessment methods (Continuous (CT) and end assessment (EA))					

	CT+EA
Course Outcomes	CO1: Classify the biomaterials and recognize their production and properties. CO2: Explain the application areas of biomaterials CO3: To realize the important basic properties and requirements for biomaterials CO4: Recognize the importance of relationships between living tissues and biomaterials
Topics Covered	Definition of biomaterials – biologically derived materials or materials compatible with biology. **(2)** Common biomaterials: some proteins, many carbohydrates and some specializedpolymers. **(4)** Collagen (protein in bone and connective tissues): Structure production and its use. **(3)** Fibroin (protein in silk): Production and its use. **(2)** Production of these proteins by conventional cloning methods. **(3)** Carbohydrates: Modified carbohydrates acting as lubricants for biomedical applications; Polydextrose; Carbohydrates modified by enzymes; **(8)** Biopolymers: Synthesis from a simple biological monomer (eg., hyaluronate polymers); Dextrans (used in chromatography columns); Rubber Like materials produced by bacteria and fungi (Polyhydroxybutyrate PHB), Polycaprolactone(PCL); Production of a copolymer of PHB and PHV(polyhydrovaleric acid), sold as Biopol by fermentation by Alcaligeneseutrophus; Biodegradable polymers **(8)** Industrial biopolymers: Production of polyphenol resins by the enzyme soybean peroxidase; Evaluation of the properties of biopolymers to make good biomaterials; Tensile strength (both elasticity and breaking strength); Hydration, visco – elastic properties; viscosity. **(8)** Biomaterials for Organ Replacement; Tissue Engineering; tissue replacements, cardiovascular; biodegradable and bioactive materials, drug delivery systems.**(4)**
Text Books, and/or reference material	Text Book: 1. Biomaterials: Principles and Applications by J.B. Park and J.D. Bronzino. 2. Biomaterials: SUJATA V. BHATT, Second Edition, Narosa Publishing House,2005. 3. Biomaterials Science: An introduction to Materials in Medicine, Edited by Ratner, Hoffman, Schoet and Lemons, Second Edition: Elsevier Academic Press, 2004. Reference book: 1. Biomaterials Science and Biocompatibility, Fredrick H. Silver and David L. Christiansen, Piscataway, Springer, New Jersey.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6
BT9037	CO1	3	3	3	2	2	-
	CO2	3	3	3	2	2	-
	CO3	3	3	3	3	2	-
	CO4	3	3	3	2	3	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BT9038	**Biometallurgy**	PEL	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
Microbiology, Chemical Kinetics	CT+EA

Course Outcomes	**CO1:** To recapitulate the basics of bioenergetics and to understand the relevant biogeochemistry & microbiology. **CO2:** To learn about the concepts of bioleaching and biobeneficiation along with the microbiological aspects **CO3:** To learn about bioleaching processes with typical examples. **CO4:** To analyze the kinetics of bioleaching **CO5:** To understand the enzymatic mechanism of bioleaching.
Topics Covered	Recapitulation of basics of bioenergetics (ATP as an energy-rich molecule, oxidation-reduction reactions), Biogeochemical cycles – sulphur, iron, and manganese cycles. Nature and characteristics of biogeochemically important micro-organisms. (9) Bioleaching: definition, scope, advantages & disadvantages; Types: direct, indirect, & indirect contact. Types of bioleaching with respect to reaction intermediates (thiosulphate & polysulphide mechanisms). Autotrophs & heterotrophs as candidate microorganisms for bioleaching. Bioleaching by aerobic and anaerobic microorganisms. (9) Bioleaching processes: in situ, heap & dump, & reactor bioleaching. Bioleaching of copper by *Acidithiobacillus* from chalcopyrites, chalcocite, & covellite. Dump & heap and reactor bioleaching of copper. Uranium bioleaching & biobeneficiation of gold. Environmental pollution control in gold recovery processes. (9) Kinetics of pyrite bioleaching – two-subprocess mechanism- ferric leach kinetics & kinetics of bacterial oxidation of ferrous iron. Modelling of continuous tank bioleaching of pyrite – unsegregated and segregated models. (9) Oxidation of iron by Acidithiobacillus – enzymatic mechanism; role of cytochromes & rusticyanin, elements of electron transport pathways in iron & sulphur oxidation. (6)
Text Books, and/or reference material	Text Books: **1.** Pillai Abhilash, B. D. Pandey, K. A. Natarajan. Microbiology for Minerals, Metals, Materials and the Environment, CRC Press, 2018 **2.** Ross W. Smith & Manoranjan Misra, ed. Mineral Bioprocessing, The Minerals, Metals & Materials Society, 1991 **Reference Books:** 1. L. M. Prescott, J.P.Harley, D.A.Klein. Microbiology 5th edn. Mc-Graw Hill, 2002. 2. M.E. Curtin, Microbial mining and metal recovery biotechnology (1), pp 229-235, 1983 Woods D, Rawling D.E., Bacterial leaching and biomining in Marx J.L. (ed), A Revolution in biotechnology, Cambridge University Press

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6
BT9038	CO1	-	1	2	2	2	-
	CO2	1	2	3	2	2	-
	CO3	1	2	3	2	3	1

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

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BT9039	**BioEnergy**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
		CT+EA					
Course Outcomes	**CO1:** To learn about present energy scenario in the world and importance of alternate energy **CO2:** Detailed study on biological solid fuels **CO3:** Detailed study on biological liquid fuels to replace petrol and diesel **CO4:** Detailed study on biological gaseous fuels **CO5:** To learn about Indian scenario and approach to solve the problem						
Topics Covered	Energy and fossil fuel use – fossil fuel use, fossil fuel reserves, sustainable fuel sources [4] Consequences of burning fossil fuel – effects of industrial (anthropogenic) activity on greenhouse gases, sources of greenhouse gases [3] Mitigation of global warming – Kyoto protocol, reduction in global greenhouse gases, fuel cells, sequestration of carbon dioxide, alternative energy sources, energy storage. [4] Biological solid fuels – 1st, 2nd and 3rd generation biofuels, types of biomass available, energy and fuel generation using biomass. [5] Gaseous biofuels – methane production using anaerobic digestion process, sewage sludge and from landfill sites, use of methane as transport fuel.Hydrogen production from biological material, biological production of hydrogen, photosynthetic hydrogen production, hydrogen storage, use as transport fuel. Diethyl ether production [6] Liquid biofuels to replace petrol – methanol production.Large scale ethanol production from biomass, use of lignocellulosics for ethanol production, ethanol extraction after production, use of ethanol as fuel.Butanol production and use. [6] Liquid biofuel to replace diesel – synthetic diesel (FT synthesis), bio-oil (pyrolysis), microalgal biodiesel, biodiesel from plant oils and animal fats, properties of biodiesel, glycerol utilization. [5]						

	The benefits and deficiencies of biofuels – reduction in fossil fuel use, fuel economy, reduction in carbon dioxide emission from biofuels, improvement in biodiesel quantity and quality, life cycle analysis of biofuels. [6] Jatropha cultivation, National hydrogen energy road map. [3]
Text Books, and/or reference material	**Text Books:** 1. Biofuels production, application and development. Alan Scragg, CABI. 2. Research articles

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6
BT9039	CO1	-	-	-	1	-	-
	CO2	-	-	3	3	3	-
	CO3	-	-	3	3	3	-
	CO4	-	-	3	3	3	-
	CO5	3	2	3	3	3	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BT9040	**Bioprocess & Plant Design**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Bioprocess Engineering, Bioseparation Technology		CT+EA					
Course Outcomes	CO1: Learn about mass balance and energy balance in Bioprocess Engineering and Cell growth kinetics CO2: Learn about media sterilization and air sterilization including kinetics, design of batch and continuous media sterilizers and air sterilizer**s.** CO3: Study of bioreactors and their design aspects related to microbial, plant and animal cell culture products CO4: Study of Scale-up, Operation, Instrumentation and control of Bioreactors. CO5: Bioreactor design supporting systems; Pumps, Refrigeration, Boilers and Effluent treatment plants. CO6: plant design aspects						
Topics Covered	**Introduction to Bioprocess Engineering and Systems: (10)** Mass balance and energy balance in Bioprocess Engineering, kinetics of microbial growth, batch, continuous and fed batch systems, components of bioreactors, material of construction, vessel size, Aseptic operations in bioreactors, Mass Transfer and Heat transfer Bioreactors Mechanical fittings in bioreactors ,Project planning in Bioprocess Engineering **Sterilization of Bioreactors: (6)**						

	Media sterilization, kinetics of media sterilization, Arrhenius equation. Design of batch and continuous sterilizers Air sterilization, kinetics of air sterilization, Design of Air Filters **Bioreactors and their Design: (8)** Batch, continuous stirred tank Bioreactors (CSTR), Plug flow Bioreactors (PFR). Enzyme immobilized bioreactors ,Fluidized bed bioreactors, Bubble column bioreactors, Air- lift bioreactors, Hollow- fibre bioreactors, Membrane bioreactors Bioreactors for plant and animal cell culture systems **Scale-up, Operation, Instrumentation and control of Bioreactors: (4)** Scale up criteria, Measurement systems and their control in Bioreactors, Feedback control, Computer control Bioreactors. **Bioreactor design supporting systems: (6)** Reciprocating and Centrifugal Pumps; Boilers for Steam generation-Water Tube and Fire Tube boilers; Refrigeration systems; Effluent treatment systems-Aerobic and Anaerobic. **Plant Design (8)** Plant Location and Site Selection, Site layout, Utilities, Environmental considerations, Equipment cleaning, Culture cell bank, cGMP aspects, Bioprocess validation, Safety Considerations, Process economics.
Text Books, and/or reference material	Text Books: 1. Shuler M.L, Kargi F, '*Bioprocess Engineering-Basic Concepts'*, Prentice Hall of India Ltd. 2. Aiba S, Humphrey A E and Millis N F, '*Biochemical Engineering'* , Academic Press 3. Stanbury P F and Whitaker A, *'Principles of Fermentation Technology'*, Pergamon Press 4. Bailey J E and Ollis D F, *Biochemical Engineering Fundamentals*,' McGraw Hill Reference Books: 1.Doran P M, '*Bioprocess Engineering Principles'*, Academic Press 2. Sinnott, R.K, '*Coulson and Richardson's Chemical EngineeringVol.3& Vol.6*,', Butterworth- Heinemann

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6
BT9040	CO1	3	2	3	2	2	1
	CO2	3	2	3	2	2	1
	CO3	3	2	3	2	2	1
	CO4	3	2	3	2	2	1
	CO5	3	2	3	2	2	1
	CO6	3	3	3	2	2	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	

BT9041	**Advanced rDNA & Cellular Biotechnology**	PCR	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
Cell Biology, Biochemistry, Immunology, Molecular Biology & rDNA Technology, Microbiology	CT+EA
Course Outcomes	**CO1:** Learn the concept about working of Host system, vectors, specific enzymes **CO2 :** Formulate the strategies for r proteins from specific cells, media selection and their modification. **CO3:** By applying knowledge of cellular technologies, purification specific bioreactors can be setup for commercial level production of valuable compounds for humankind.
Topics Covered	**Module 1**: **Tools and general Methodology Recombinant DNA Technology**: Vectors types and their importance. Selection of host and its characteristics, Cloning and screening strategies for gene and gene expression with specific examples. (**6)** **Module 2**: **Manipulation in Gene Expression and Protein Production in Prokaryotes and Eukaryotes**; regulatable promoters role; Vector design for increasing protein, Fusion protein , protein stability ; overcome oxygen limitation ,DNA integration into host chromosome, Metabolic load, Increasing Secretion ;Yeast expression system Cultured insect cell expression systems; Microbial Cell factories for insulin production. Modified microorganisms for waste degradation, Synthesis of commercial from recombinant microorganisms Ascorbic acid , Indigo, amino acids antibiotics, Engineering human interferon, Human growth hormones, DNAse I and Aginate lyase. **(10)** **Module 3: Animal cells as Bioreactor**: Cultivation systems for cell and tissue culture: Animal cell cultures maintenance and modifications. Vector design for mammalian gene expression; CHO cells and its modification to enhance its potential in production of recombinant proteins; Animal cell culture fermenter. Cell immobilization techniques. Large Scale Production of r Protein, Types of Fermenter Two stage fermentation in Tandem air-lift reactor for T4 DNA Ligase. Separation of products**.(10)** **Module 4**: **Plants as bioreactors** for bio Pharmaceuticals production: Plant tissue culture techniques Cell suspension cultures and bioreactor technology, secondary metabolites, plant biosynthesis of alkaloids, flavonoids, terpenes, phenols, regulation and commercial importance, plant and plant cell culture derived therapeutics and its purification**.(10)** **Module 5**: **Recent advanced tools** for Forensic studies, Molecular Diagnostics, Gene therapy. Environment cleaning programme**.(6)**
Text Books, and/or reference material	**Text/ Reference Books :** 1. Principles of Gene Manipulation. Old and Primrose- Blackwell scientific Pub. 2. Recombinant DNA Technology. Watson JD et al., Scientific American Book Series 3. Molecular biotechnology Principles and applications of r DNA technology. Bernard R.Glick.Jack J Pasternak. ASM Press ; Washington DC 4. Culture of Animal Cells: A Manual of Basic Technique. R. Ian Freshney Wiley-Liss. 5. Principles of Gene Manipulation. Sandy B. et al., Blackwell Publishers

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6
BT9041	CO1	3	2	2	3	-	3
	CO2	3	-	2	-	2	2

	CO3	3	2	-	1	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BT9042	**Animal Biotechnology**	PEL	3	0	0	0	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Genetics and Molecular Biology		CT+EA					
Course Outcomes	**CO1:** Learn about animal cell culture technique in laboratory scale. **CO2:** Learn about technique for animal in large scale. **CO3:** Learn about various techniques in animal biotechnology. **CO4:** Learn about transgenic and knock animal techniques and its application. **CO5:** Learn about techniques and importance of gene therapy **CO6**: Learn about IVF technique and its importance. **CO7:** Learn about stem cells and its applications.						
Topics Covered	1.History scope and prospect of animal cell culture: History of animal cell culture and development, Development of primary culture, Development of cell line by enzymatic disaggregation, Culture media and growth conditions.Cell type and characterization, origin of animal cell line, maintenance and characterization of different cell lines, Marker gene characterization. 2. Growth and scale up: Cell growth characteristics and kinetics, Micro-carrier attached growth, Cell culture in continuous, perfusion and hollow fiber reactor, Mass transfer in mammalian cell culture. 3. Technology – Present and future: Hybridoma technology/Monoclonal antibody technology, Vaccine production, Organ culture, Transfection of animal cells, Future tissue engineering. 4. Transgenic and Konck out Animals: Methodology, Embryonic Stem Cell method, Microinjection method, Retroviral vector method, Applications of transgenic animals 5. Gene Therapy: Ex-vivo gene therapy, In vivo gene therapy, Viral gene delivery system,Retrovirus vector system, Adenovirus vector system, Adeno-Associated virus vectorsystem, Herpex simplex virus vector system, Non-viral gene delivery system, Prodrug activation therapy, Nucleic acid therapeutic agents. 6.In Vitro Fertilization and Embryo Transfer:Composition of IVF media, Steps involved in IVF, Fertilization by means of micro insemination, PZD, ICSI, SUZI, MESA. 7.Stem cells: Classification and types, Sources, Markers, Differentiation signals, application, IPSC						

Text/ References	1. Animal Cell Culture by John R.W. Masters; Oxford University Press 2. Introduction to Cell and Tissue Culture by Jennie P. Mather and Penelope E. Roberts Plenum Press, New York and London 3. Molecular Biotechnology: Primrose. 4. Animal Cell Biotechnology: R.E. Spier and J.B. Griffiths (1988), Academic press. 5. Balasubramanian, Bryce, Dharmalingam, Green and Jayaraman (Eds.), Concepts in Biotechnology, University Press, 1996 6. Hood L.E., Weissman I., Wood W.B. and Wilson J.H. Immunology, Benjamin Cummings, 1989 7. Biotol Series – Butterworth and Heineman, Oxford, 1992

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6
BT9042	CO1	1	1	2	1	3	1
	CO2	1	1	2	1	3	1
	CO3	1	1	2	1	3	1
	CO4	1	1	2	1	3	1
	CO5	1	1	2	1	3	1
	CO6	1	1	2	1	3	1
	CO7	1	1	2	1	3	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BT9043	**Immunotechnology**	PEL	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
Immunology, Cell biology	CT+EA

Course Outcomes	**CO1.** The students will gain insight into the immune response to various infectious and non-infectious and autoimmune diseases. **CO2.** In depth understanding of the impact of different receptors cell signaling pathways in immune response will allow their knowledge to apply for future application. **CO3.** The latest technologies used in disease detection and antibody production **CO4.** To apply the concept and strategies for immunotherapeutics production from cell lines at higher scale.
Topics Covered	**Fundamental and cell signaling in immune system:** Components of innate and acquired immunity; major histocompatibility complex and immune responsiveness, molecular basis of antibody diversity, self–non-self discrimination and immunological memory. Immunoglobulin superfamily; B and T cell activation B-cell receptor; T-cell receptor; cytokines, chemokines and their receptors; signal transduction pathways. **(8)** **Host-Pathogen interaction**; Molecular basis of Immune diversity, Immunity and infection to bacteria, virus, protozoa, fungi. tumor. Cancer, Auto immune disease,

	Inflammation. Discussion with examples for each category.Research on progress for immunotherapy **(8)** **Principles and applications of laboratory tests in Immunology:** Principles of antigen-antibody interactions;production and purification of polyclonal antibodies; antibody assays - precipitation, agglutination, immunoelectrophoresis advanced immunological techniques - RIA, ELISA, Western blotting, immunofluorescence, immunoelectron microscopy, flow cytometry and ELISPOT assay, surface plasmon resonance; total and differential counts in human peripheral cells, separation of monocytes from peripheral cells; lymphoproliferation assay, mixed lymphocyte reaction, cell cytotoxicity assays, HLA typing **(6)** **Cellular technologies and animal cell bioreactors** : Large scale production of interferon, therapeutic agents. Generation of monoclonal antibodies through Hybridoma technology,. Use of specific cells and cell lines for therapeutic purpose. Genetic engineering techniques to make human antibodies- chimeric antibodies & humanized antibodies, clinical use of monoclonal antibodies. **(8)** **Vaccinology:** Active and passive immunization; Live, killed, attenuated, sub unit vaccines; Vaccine technology- Role and properties of adjuvants, recombinant DNA and protein based vaccines; mRNA based vaccine, Peptide vaccines; conjugate vaccines, Dendritic cell vaccine; **(4)** **Clinical Immunology**- Hypersensitivity; Types of autoimmune diseases and their treatment; Transplantation and immunosuppressive therapy; Tumor immunology – Tumor antigens; Therapeutic uses of cytokines. **(8)**
Text Books, and/or reference material	**Text Book**: Kuby Immunology By Owen, Punt, & Stranford, 7th, Seventh Edition, 2013, Macmillan press. 2. Abul K. Abbas, Andrew K. Lichtman & Jordan S. Pober (Eds.). Cellular and Molecular Immunology. 3rd Edn. W.B. Saunders Company, 2001 **Reference books:** 2. The Elements of Immunology by FahimHalim Khan, Pearson Education, 2009. 3. Essentials of Immunology: Ivan Riot- Blakswell Scientific Publications, Oxford, 6th Edition. 4. Infection and immunity by John Playfair and Gregory Bancroft, 3rd edition, Oxford Univ.press. 2008. 5. Monoclonal antibodies: Principles and practice by J.W. Goding. 3rd edition, Academic Press.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6
BT9043	CO1	3	3	3	3	2	2
	CO2	3	3	2	2	3	3
	CO3	3	2	3	3	3	3
	CO4	3	2	3	3	2	3

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	

BT9044	**Molecular Modeling & Drug Design**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Biochemistry, Proteomics, Protein Engineering		CT+EA					
Course Outcomes	**CO1:** To understand the physical basis of the structure, the dynamic evolution of the system, and the function of biological macromolecules. **CO2:** To learn the fundamental concepts of structure-activity relationships **CO3:** To elucidate the mechanism of action of drugs (drug-receptor interaction) **CO4:** To learn rational design of novel, biologically active compounds.						
Topics Covered	1. Introduction to molecular Simulation Techniques (5) 2. Quantum chemistry for Modeling of small molecules (5) 3. Molecular Dynamics Methods- Molecular Dynamics of rigid non-linear polyatomic molecules in ensembles, Structural information from M.D. (5) 4. Force fields for molecular modeling: Choice of functional form. Parametrization of a force field, Distributed multipole and polarizable force fields, Hydrophobic effect and solvation energy. Potentials of mean force. (10) 5. Conformational analysis: Geometry optimization using steepest descent and conjugate gradients. Restrained and constrained molecular dynamics. Distance geometry. Case studies: Prediction of protein-protein interactions. DNA conformation. (10) 6. Principles of ligand based drug design: SAR, QSAR and 3D-QSAR. Receptor based drug design: Principles of receptor based de novo ligand design. Rigid body, molecular Docking. (7)						
Text Books, and/or reference material	**Text Books:** **1.** A R Leach-Molecular Modelling. Principles and application 2nd edition–Prentice Hall. **2.** Krogsgaard, L-Text Book of Drug Design and Discovery-2002, Taylor and Francis, London **Reference Books:** 1. G.Walsh-Biopharmaceuticals-Biochemistry and Biotechnology-2003, Wiley 2. Scolnick.J.(2001) Drug Discovery and Design Academic Press, London 3. N. R. Cohen, Editor. *Guidebook on Molecular Modeling in Drug Design.* Academic Press, San Diego, 1996.						

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6
BT9044	CO1	3	2	3	3	3	-
	CO2	3	-	3	3	2	-
	CO3	3	-	3	3	3	2
	CO4	3	-	3	3	3	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	

BT9045	**Regenerative Medicine & Translational Research**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Cell Biology, Biochemistry, Genetics, Molecular Biology		CT+EA					
Course Outcomes	**CO1:** To understand the basic mechanisms of how cells differentiate into specific tissues in response to a variety of biologic signalling molecules and the use of such factors for tissue production in-vitro. **CO2:** To acquire knowledge on the molecular basis of cellular and functional changes of different organs that occur in disease and treatments that cause tissue remodelling to correct these changes **CO3:** To gather insights on how studies of the developmental, cellular and molecular biology of regeneration have led to the discovery of new drugs/therapy for regenerative therapy. **CO4:** To understand the recent advances on application the regenerative therapy from well-characterized case studies.						
Topics Covered	1. An Introduction to Stem Cells(2) 2. Adult Stem Cells (1) 3. Embryonic Stem Cells (1) 4. Induced Pluripotent Stem Cells (1) 5. Hematopoietic Stem Cells (1) 6. Mesenchymal stem cells , cord blood cells, Lessons from Medipost company products like Neurostem, Cardiostem, Cartistem, Pneumostem (4) 7. Molecular and Cellular Bases of Organ Development (6) 8. Cloning of Somatic Cells by Nuclear Transfer, iPSC based cloning, Production of chimera animals(4) 9. Molecular Bases of degenerative disease (1) 10. Therapeutic Uses of Stem Cells with examples (2) 11. In vivo Regeneration of Tissues by Cell Transplantation (2) 12. IPS Cells as Experimental Models of Neurodegenerative Disorders: use of them as disease modelling platform, novel drug testing and tissue regenerative therapy and implantation studies(2) 13. Studies of Patients Treated with Stem Cells, The modalities of treatment, Preparation of cells/tissues/scaffolds and Transplantation procedure(3) 14. Tissue Regeneration Driven by Growth Hormones (2) 15. Organ of dish, Orgnoid culture, Tissue Bioprinting to develop transplantation quality organs, Bioartificial Organs(8) 16. Biobanking of stem cells and the ethical considerations in regenerative medicine. (2)						
Text Books, and/or reference material	**Text Books:** 1. Stem Cells, Tissue Engineering And Regenerative Medicine By: David Warburton 1st Edition. 2. Principles of Regenerative Medicine by Anthony Atala Robert Lanza Tony Mikos Robert Nerem,3rd Edition. 3. Translational Regenerative Medicine by Anthony Atala and Julie G. Allickson **Reference Books:** 1. The Developing Human by Keith L. Moore/T.V.N. Persaud / Mark G.Tenth edition. 2. Encyclopaedia of Tissue Engineering and Regenerative Medicine by Rui Reis, Ist Edtion.						

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6
BT9045	CO1	3	3	3	3	2	1
	CO2	3	1	2	3	3	2
	CO3	3	2	3	2	3	3
	CO4	3	2	3	3	2	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BT9046	**Microbial Biotechnology**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Cell Biology and Genetics Biochemistry and Enzyme Technology, Microbiology and Fermentation Technology		CT+EA					
Course Outcomes	**CO1:** To acquire knowledge on microbial-based products of commercial importance at environmental, industrial and clinical relevance. **CO2:**To Apply knowledge based skills in developing strategies to improve yield and reduce cost of the microbial process and or derived products **CO3:**To generate pilot plant design via understanding in microbial kinetic studies and scale up approaches. **CO4:** Able to impart the knowledge in synthesis and separation of microbial products at highest level of purity as per the required demand.						
Topics Covered	**UNIT 1:** An overview of traditional and modern applications of microbial products. Concept of Overproduction of metabolites. Strain improvement strategies for improved production of valuables via Classical (Random Mutagenesis) and advanced approaches (Genetic engineering, Site directed mutagenesis, Protoplast fusion). Case studies on strategies for enhanced production of Insulin, Penicillin, and enzymes of microbial origin with emphasis on host cell engineering; vector						

	design, optimization of media and process parameters. Concepts on cost analysis for better yield using improved technology (10) **UNIT 2:** Process technology for the production of microbial biomass. , primary metabolites and secondary metabolites. Growth and product kinetics .Fermentation, raw materials for fermentation, submerged, surface and solid-state systems, whole cell and enzyme immobilized systems. Technological processes for industrial manufacture of Yoghurt, acidophilus milk, Koumis, kefir, cheese, bread, alcoholic beverage, vinegar. Lactic acid and oriental fermented food of commercial importance. Equipment involved in the commercially important food processing methods.(10) **UNIT 3:** Different regulatory mechanisms involved in controlling the catabolic and anabolic processes of microbes, Induction, nutritional repression, carbon catabolite repression, Crabtree effect, feedback inhibition and feedback repression, with respect to biomass and valuables production. Case studies on Heterologous gene expression and secretion in Gram-positive bacteria with industrial applications. Biotechnology of protein secretion systems in Escherichia coli.(10) **UNIT4:** Environmental factors and stress in Bacterial community and their response. Microbial waste degradation (Heavy metal, phenolic, and hydrocarbon); Microbes in bioenergy production (bioethanol, bio-butanol, algal biofuel); Application based perspectives of Metagenomics. Plant microbe interaction microbe-mediated enhancement of nitrogen and phosphorus content for crop improvement; Genetic control of the cell cycle and microbial pathogenesis.(10) **UNIT 5**: Primary & secondary separation process for recovery of microbial products -Biomass removal. Biomass disruption, Membrane based techniques. Extraction - solvent, aqueous two phases, super critical, and Adsorption. Chromatography, Precipitation (Ammonium Sulfate, solvent), Electrophoresis, Crystallization, Drying and Freeze drying. (6)
Text/ References	1.Bioprocess Engineering Principles" by Pauline M.Doran, Academic Press 2.A Text book of Industrial Microbiology 2nd Edition. Crueger, W. and Cruger, A. (2000) Panima Publishing Corporation, New Delhi. 4. 3. Manual of Industrial Microbiology and Biotechnology 2nd Edition. Ed. Arnold L. Demain and Julian E. Davies (1999) ASM Press Washington D.C. 4..Bailey J.E. & Ollis, D.F. Biochemical Engineering Fundamentals, 2nd ed., McGraw Hill, 1986 5.Michael Shuler and FikretKargi. “Bioprocess Engineering: Basic Concepts”, 2nd Edition, Prentice Hall, and Englewood Cliffs, NJ, 2002.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6
BT9046	CO1	3	2	3	3	2	-
	CO2	3	-	3	-	-	-
	CO3	3	-	3	3	1	1
	CO4	3	2	3	2	-	2

Correlation levels 1, 2 or 3 as defined below:

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

<table>
<tr><td colspan="8">Department of Biotechnology</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>BT9047</td><td>Environmental Biotechnology</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">Microbiology, Molecular Biology, Biochemistry</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Learn about scope, applications (pollution prevention and abatement) and different parameters in the field of Environmental Biotechnology. Learn about different modes of microbial interaction with inorganic and organic pollutants.
CO2: Learn about aerobic and anaerobic biotransformation mechanisms and about the scope of genetically engineered organisms in bioremediation.
CO3: Learn about role and requirements of microorganisms, Microbial community composition and the interactions between community members for enhanced bioremediation.
CO4: Learn about different strategies of bioremediation – in-situ bioremediation approaches, ex-situ bioremediation approaches, biostimulation, bioaugmentation, monitored natural attenuation, phytoremediation. Learn about different factors regulating bioremediation.
CO5: Learn about waste water characteristics. Learn about effluent treatment processes. Learn about various suspended growth Aerobic effluent treatment processes. Learn about various attached growth Aerobic effluent treatment processes.
CO6: Learn about Anaerobic digestion process. Learn about design of reactors for effluent treatment processes.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Unit 1-Introduction to Environmental Biotechnology: definition, scope of applications; Biotechnology for pollution prevention and pollution abatement (green technologies – bioleaching of metals, microbially enhanced oil recovery, biodegradable polymers, biobleaching, biodesulphurization, biofuel production, biogas, bioremediation, etc.) (3)
Unit 2 -Types of pollutants, sources of pollutants, magnitude of contamination problem, merits and limitations of bioremediation, bioremediation of organic and inorganic pollutants. Microbial interactions with heavy metals/radionuclides – bioaccumulation, biosorption, biotransformation, bioprecipitation, applications of metal-microbe interactions, biomining, engineering microorganisms for metal bioremediation (3)
Unit 3 - Biodegradation principles – microbial processes, biotransformation, mineralization, detoxification, activation, cometabolism and growth associated degradation. Requirements for biodegradation, cooperation between different microbial species for enhanced biodegradation, Implications of recalcitrance, acclimation, biotransformation mechanisms – genes, enzymes, reactions, Biodegradation pathways and metabolites, effect of contaminant structure on biodegradability. (8)
Unit 4 -Bioremediation strategies – microbial community composition and interactions between community members for enhanced bioremediation, natural attenuation and accelerated bioremediation, aerobic, anaerobic, ex-situ bioremediation approaches, in-situ bioremediation approaches, biostimulation, bioaugmentation, Phytoremediation - phytoextraction, rhizofiltration, phytodegradation, phytovolatilization, rhizoremediation, phytostabilization. (8)
Unit 5 -Waste Water & Sludge treatment:Characteristics and analysis of waste water, Treatment of waste water of sewage & Industry. Bio-kinetics coefficient and</td></tr>
</table>

	its application in waste water treatment. Basic design concepts and calculations for waste water treatment of:Preliminary treatment units – screening,grit removal , removal of oil and grease; Primary treatment units- settling tank, flotation.Biological treatment:Aerobic: Activated sludge process, secondary settling tank, trickling filter, waste stabilization pond.Anaerobic : Anaerobic reactors for treatment of waste water- Anaerobic Digesters, Upflow Anaerobic Sludge Blanket Reactor(UASB), Fluidized Bed Biofilm Reactor(FBBR), Treatment and disposal of sludge, Solid waste management , Advanced Waste Water Treatment-Limitations of conventional treatment, pathogen removal, toxic substances removal, phosphorous and nitrogen removal (12) Unit 6 -Industrial Waste:Approach to design, process design parameters - Characteristics, analysis and treatment of wastes from different Industry like: dairy industry, fermentation, slaughter house, tanning, dye, pulp and paper, distillery, petroleum, heavy metal pesticides, food and beverage, antibiotics etc. Treatment of biological industry wastes, Treatment & disposal of radioactive waste.(8)
Text/ References	1. Bioremediation and Natural Attenuation: Process fundamentals and mathematical models by P J J Alvarez and W A Illman, Wiley-Interscience 2. Wastewater treatement: Concepts & design approach, G L Karia, R A Christian, PHI 3. Water supply & waste water engineering, B S N Raju, Tata Mc Graw Hill Publications 4. Industrial wastes, Their disposal & Treatment; Willem Rudolfs, Reinhold Publishing Corporation, American series 5. Soil Microbiology; N S Subba Rao; Oxford & IBH Publishing Co. Pvt Ltd. 6. Waste water Engineering: Treatment, disposal, reuse, by Metcalf & Eddy, Tata Mc Graw Hill 7. Environmental Engineering: A design Approach, Sincero, Arcadio. P, Sr. & Greogia; PHI 8. Water & wastewater Technology; Hammer, Mark J, Mark J Hammer; PHI 9. Biodegradation & Bioremediation (1999), Martin Alexander, Academic press. 10. Bioremediation engineering; design and application 1995 John. T. cookson, Jr. Mc Graw Hill, Inc. 11. Foster C.F., John Ware D.A., Environmental Biotechnology, Ellis Horwood Ltd., 12. Environmental Pollution Control Microbiology by Ross E Mc Kinney, Dekker publisher 13. Environmental Engineer's Mathematics Handbook by Frank R Spellman & Nancy E Whiting. CRC Publication 14. Biology of wastewater treatment by N F Gray; Imperial College Press.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6
BT9047	CO1	1	2	2	1	3	1
	CO2	2	3	3	2	3	-
	CO3	2	3	3	3	3	3
	CO4	-	3	3	3	3	3
	CO5	3	3	3	3	3	-
	CO6	3	3	3	3	3	-

Correlation levels 1, 2 or 3 as defined below:

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

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BT9048	**Protein structure, folding & misfolding**	PEL	3	0	0	3	3
Biochemistry, Cell Biology, Molecular Biology		Course Assessment methods (Continuous (CT) and end assessment (EA))					
		CT+EA					
Course Outcomes	**CO1:** To learn about protein structures and its classification into structural groups. **CO2:** To understand protein-DNA interactions and the origin of selectivity and specificity in this process **CO3:** To learn how to determine protein structure **CO4:** Understanding of protein folding mechanism and how protein misfolding is related to several human diseases.						
Topics Covered	● Basic structural principles - The building blocks, motifs of protein structure, alpha-domain structures, alpha/beta structures, beta structures, fibrous proteins. (10) ● DNA structures. DNA recognition in prokaryotes by helix-turn-helix motifs. (6) ● DNA recognition by eukaryotic transcription factors, specific transcription factors. (6) ● Structural feature of common proteins involved in enzyme catalysis, signal transduction and immunity. (8) ● Protein Structure determination (4) ● Protein folding: thermodynamics, kinetics and chaperones. (4) ● Protein misfolding and Disease. (4)						
Text Books, and/or reference material	**Text Book:** 1. Introduction to Protein Structure: Second Edition by Carl IV Branden, Routledge **Reference book:** 1. Structure and Mechanism in Protein Science A Guide to Enzyme Catalysis and Protein Folding: Alan Fersht						

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6
BT9048	CO1	3	3	3	-	-	-
	CO2	3	2	3	-	-	-
	CO3	3	3	3	3	-	-
	CO4	3	2	3	2	1	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="7">Department of Biotechnology</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>BT9049</td><td>Methods in Computational Biology</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">Biochemistry, Bioinformatics, C programming</td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="6">CO1: Learning computational skills to examine biological information
CO2: Learning and developing computational tools for analysis of large biological data
CO3: To understand the models of biological systems constructed from experimental measurements
CO4: Learn about machine learning and statistical tools to construct models from large existing datasets</td></tr>
<tr><td>Topics Covered</td><td colspan="6">1. Algorithms in Computing: Biological and Computer algorithm, Fibonacci problem, Dynamic Programming, Time and space complexity of algorithms (7)
2. Programming languages- Algorithm, Flowchart, Compiling, Testing and Debugging (7)
3. C programming – C language Introduction, Identifier , Variables, Constants, Operators, Input statement, Output statement, Conditional and Unconditional Control Statement, Looping Statement: while, do-while, for loop, Arrays. Read, write files (biological data) (10)
4. Clustering and Trees: Hierarchical Clustering, k-Means Clustering, Evolutionary Trees, Distance-Based Tree Reconstruction, Reconstructing Trees from Additive Matrices, Character-Based Tree Reconstruction, Small and large Parsimony Problem. (10)
5. Hidden Markov Models: Markov processes and Markov Models, Hidden Markov Models (8)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="6">Text Books:
1. Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins” by A D Baxevanis and B F F Ouellette
2. Protein Bioinformatics: An Algorithmic Approach to Sequence and Structure Analysis by Ingvar Eidhammer, Inge Jonassen, William R. Taylor
Reference Books:
1. Introduction to Computational Biology by Bernhard Haubold
2. Bioinformatics: Genes, Proteins and Computers by Christine Orengo, David Jones, Janet Thornto</td></tr>
</table>

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6
BT9049	CO1	3	2	3	3	3	2
	CO2	3	2	3	3	2	2
	CO3	3	-	3	3	3	1
	CO4	3	-	3	3	3	1

Correlation levels 1, 2 or 3 as defined below:

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

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BT9050	**Nanobiotechnology & Nanomaterials**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Basic understanding of biology, Chemistry and Physics		CT+EA					
Course Outcomes	**CO1:** Acquire advanced idea about nanoscale phenomenon **CO2:** To learn about the different investigation tools for the nanobiotechnology **CO3:** To learn about synthesis of diverse classes of nanomaterials **CO4:** To get comprehensive understanding of applications of nanotechnology in biology						
Topics Covered	1) Nanotechnology; introduction to miniaturization. (4) 2) Investigation tools: experimental methods and probes; basic principles of scanning force microscopy; scanning electron microscopy; transmission electron microscopy. investigation tools: nanoimprint lithography (8) 3) Nanomaterials: organic and inorganic nanoparticles. (6) 4) Molecular self-assembly and bottom up synthesis of nanomaterials. (6) 5) Nanoparticles and cancer therapeutics; nanoparticle-based drug delivery. (6) 6) Nanofiber-based scaffolds and tissue engineering; nanodiagnostics and biosensing. (6) 7) Nanotoxicology. (4) 8) Future Concepts in Nanobiotechnology. (2)						
Text Books, and/or reference material	**Text Book:** 1. Understanding Nanomedicine - An Introductory Textbook by Rob Burgess. **References Books** 1. Springer Handbook of Nanotechnology, by Bharat Bhushan Springer 2. Nanobiotechnology: Concepts, Applications and Perspectives, by Christof M. Niemeyer, Chad A. Mirkin, John wiley 3. Introduction to Nanotechnology, by Charles P. Poole, Frank J. Owens, Wiley-Interscience 4. Nanofabrication and Biosystems : Integrating Materials Science, Engineering, and Biology, by Harvey C. Hoch, Lynn W. Jelinski, Harold G. Craighead, Cambridge University Press						

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6
BT9050	CO1	3	3	2	3	2	-
	CO2	3	1	1	3	-	-
	CO3	3	2	1	3	-	-
	CO4	3	3	2	3	3	1

Correlation levels 1, 2 or 3 as defined below:

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

<table>
<tr><td colspan="8">Department of Biotechnology</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>BT9051</td><td>Plant Biotechnology</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">Biochemistry, Cell Biology, Genetics, Molecular Biology & rDNA Technology</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: To understand the concepts and techniques of plant tissue culture.
CO2: To understand the basic methods of mapping and cloning plant genes.
CO3: To learn the methodologies of genetic transformation of plants.
CO4: To generate the ability to create genetically modified plants by means of plant breeding and genetic engineering with improved quality traits.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">1. History of Plant Tissue Culture (1)
2. Lab requirements and general techniques (1)
3. Tissue Culture Media (1)
4. Hormones in plant tissue culture (4)
5. Cellular Totipotency (1)
6. Somatic embryogenesis (1)
7. Cell Suspension Culture (1)
8. Haploid Production, (1)
9. Somaclonal variation (1)
10. Protoplast Isolation and Culture (1)
11. Micropropagation in plants(1)
12. Morphological Markers, Biochemical Markers, (1)
13. molecular markers (DNA / protein) – RFLP, RAPD,AFLP, SSLPs, ESTs, SNPs etc., (6)
14. Molecular mapping, Map-based cloning, (2)
15. marker-assisted selection, marker-aided breeding, (1)
16. Cloning of plant genes using activation tagging, transposon tagging etc. (2)
17. Direct and indirect methods of genetic transformation of plants, (2)
18. Agrobacterium mediated gene transfer, Ti Plasmid, (3)
19. vectors for plant transformation, selectable and screenable markers, (1)
20. gene constructs, strategies for genetic transformation of plants,(2)
21. gene silencing, RNA interference, (1)
22. genome editing in plants, (1)
23. resistance to biotic stresses, tolerance to abiotic stresses, genetically modified crops (5)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
H.S.Chawla, Introduction to Plant Biotechnology, Oxford &IBH Publishing co.Pvt..Ltd
Slater.A.,NigelW.S,Flower.R.Mark , Plant Biotechnology: The Genetic Manipulation of Plants, 2003, Oxford Univesity Press.</td></tr>
</table>

	Buchaman, Gursam, Jones, Biochemistry and Molecular Biology of Plants, 1ed, 2000, L.K.International. Bhojwani and Razdan –PlantTissue Culture: Theory and Practice 1996 Elsevier **Reference Books:** Butterworth & Heineman, Invitro Cultivation of Plant Cells, Biotol Series. H.E Street(ed): Tissue culture and Plant science, Academic press, London, 1974 GamborgO.L.,.Phillips G.C, Plant Cell, Tissue and Organ Culture, Narosa Publishing House

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6
BT9051	CO1	3	2	3	3	3	2
	CO2	3	2	3	3	3	2
	CO3	3	2	3	3	3	2
	CO4	3	2	3	3	3	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BT9052	**Metabolic Engineering**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Basic concepts of chemical reaction kinetics & stoichiometry; matrices, Biochemistry, recombinant DNA Technology		CT+EA					
Course Outcomes	**CO1:** To learn about the basic concepts of Metabolic Engineering **CO 2:**To learn about the models of cellular reactions and to understand the regulation of metabolic pathways **CO 3:** To understand the manipulation of metabolic pathways to enhance the yield and quality of the products **CO 4:** To learn and understand the models and the concepts required for the purpose of metabolic flux analysis **CO 5:** To study the methods and application of metabolic flux analysis **CO 6:** To analyze metabolic networks						
Topics Covered	1. Importance of metabolic engineering [1] 2. Review of cellular metabolism, Regulation of metabolic pathways, Examples of pathway manipulations: metabolic engineering in practice – enhancement of product yield and productivity [10] 3. Extension of product spectrum and novel products (antibiotics, biopolymers, polyketides, vitamins etc), Improvement of cellular properties [7]						

	4. Metabolic modeling: Introduction to models for cellular reactions- stoichiometry, rates, and yield coefficients of cellular reactions, black box stoichiometries [7] 5. Material balance & data consistency: Black box model; elemental balances, degree of reduction balances, Heat balance [7] 6. Biochemical reaction networks: simple metabolic networks, flux analysis in metabolic networks; Metabolic control analysis [7] 7. Xenobiotic degradation [3].
Text Books, and/or reference material	**Text Books:** Metabolic Engineering: Principles and Methodologies, Gregory N. Stephanopoulos, Aristos A. Aristidou, Jens Nielsen, Academic Press Bioreaction Engineering Principles, Jens Nielsen, John Villadsen, Gunnar Liden, Springer **Reference Books:** Pathway Analysis and Optimization in Metabolic Engineering, Néstor V. Torres, Eberhard O. Voit, Cambridge University Press An Introduction to Metabolic and Cellular Engineering, S. Cortassa, M. A. Aon , A. A. Iglesias, D. Lloyd, World Scientific Publishing Company

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6
BT9052	CO1	-	-	1	2	1	-
	CO2	-	-	2	2	-	-
	CO3	2	2	3	2	3	2
	CO4	3	-	3	2	-	-
	CO5	3	-	3	2	-	-
	CO6	3	-	3	2	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BT9053	**Nutraceuticals & Nutrigenomics**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
		CT+EA					
Course Outcomes	**CO1:** To establish the correlation between nutraceuticals with cell signaling pathway. **CO2:** To target nutraceuticals from different sources. **CO3:** To understand the interaction between gut microbiota with functional food components and nutraceuticals. **CO4:** To formulate the concept of nutrient gene interaction.						
Topics Covered	Nutraceuticals : General concepts of cell apoptosis/proliferation and molecular targets of nutraceuticals. Nutraceutical role in host immune response, in cancer, infection and chronic/acute inflammations. Mechanism of action of Nutraceutical-signaling events, proteomics						

	and transcription factors. Nutraceuticals from food and herbs I: Polyphenols, flavonoids and other phenolic compounds. Nutraceuticals from food and herb -II: Saponins, terpenoids and sulphur compounds, Probiotic food with therapeutic applications, Prebiotics, Genomics of Lactic Acid Bacteria Nutragenomics: An introduction, Nutrient gene interaction- Structure of nuclear receptors with reference to carbohydrate, fat and vitamin A, Type 2 Diabetes Mellitus and nutrigenomics, PPAR-γ and Diabetes Mellitus, Bioactive Peptides and its role in Nutrigenomics
Text Books, and/or reference material	**Books** Nutritional Genomics: Discovering the Path to Personalized Nutrition by James Kaput, Raymond L. Rodriguez, Wiley Functional Food Ingredients and Nutraceuticals by John Shi , CRC Press Nutraceuticals by Lisa Rapport, Brian Lockwood , Pharmaceutical press **References:** Nutragenomics and Proteomics In Health Promotion and Disease Prevention by Mohamed M. Rafi, FereidoonShahidi, CRC Press Nutraceuticals: The Complete Encyclopedia of Supplements, Herbs, Vitamins, and Healing Foods by Arthur J. Roberts, GenelleSubak-Sharpe, Mary E. O'Brien (Designer) , Perigee Trade Regulation of Functional Foods and Nutraceuticals: A Global Perspective by Clare Hasler, Blackwell Publishing Professional

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6
BT9053	CO1	3	1	3	3	3	3
	CO2	3	1	3	3	3	3
	CO3	3	1	3	3	3	3
	CO4	3	1	3	3	3	3

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BT9054	**Molecular Plant Pathogen Interactions**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Molecular Biology & rDNA Technology		CT+EA					
Course Outcomes	**CO1:** Development of basic concept of plant diseases and contribution of environment toward plant disease development. **CO2:** Understanding the genetics of plant pathogen interactions. **CO3:** Learning about mechanisms of host defense & pathogenesis.						

	CO4: Development of knowledge toward developing control measures against phytopathogens.
Topics Covered	1. Introduction to molecular plant pathology, Plant diseases, (4) 2. Plant disease development and environment, (3) 3. Effects of pathogen on plant physiology, (2) 4. Biochemistry of plant defense reactions, (3) 5. Plant-pathogen interactions, (3) 6. Genetic regulation of resistance in host plants, (4) 7. Genetic regulation of virulence in pathogen, (4) 8. Mechanisms of host defense, (3) 9. Mechanisms of pathogenesis, (3) 10. Hormone signaling pathways, (7) 11. Biotechnological approach for plant protection; (3) 12. Genetically modified plants to protect against pathogens. (3)
Text Books, and/or reference material	**Text Books:** Plant Pathology; Fifth Edition, Elsevier; By Geroge N. Agrios. Biochemistry and Molecular Biology of Plants; American Society of Plant Biologists; By Bob Buchanon, Wilhelm Gruissem and Russel Jones. **Reference Books:** Plant Immunity; Methods in Molecular Biology, 2011, 712, Springer. Plant-Pathogen Interactions; Methods in Molecular Biology; By Pamela Ronald, 2007, 354, Springer. Plant-Pathogen Interactions; Annual Plant Reviews; By Nick Talbot, 2004, 11, Blackwell Publishing.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6
BT9054	CO1	3	2	3	3	3	2
	CO2	3	2	3	3	3	2
	CO3	3	2	3	3	3	2
	CO4	3	2	3	3	3	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BT9055	**Cell Biology of Human Diseases**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Cell Biology, Molecular Biology and Biochemistry		CT+EA					
Course Outcomes	**CO1:** To understand the concepts of structure, organization and molecular signaling of cells which govern its function. **CO2:** To understand cellular defects leading to human diseases and apply such understanding to explain any given phenotype at the cellular or organism level. **CO3:** To learn the application of experimental methods and designs to solve cell biology questions in human diseases.						

Topics Covered	1. Overview of cell organizations and functions. (3) 2. Experimentations in cell biology: Microscopy, genetic screens, cell fractionations and biochemical assays. (6) 3. Cytoskeleton and extracellular matrix. Hypertrophic and dilated cardiomyopathies,epidermolysis bullosa simplex (EBS), muscular dystrophy, neurodegeneration, progeria, hearing defects. (4) 4. Cell polarity, cell junctions and changes in cell shape. Neural Tube Defects.(2) 5. Cell transport, endocytosis, exocytosis, membrane channels. Cholera and cystic fibrosis. (3) 6. Cell migration during development and chemotaxis. Developmental defects and cancer.(1) 7. Cilia structure and function and specialized sensory cells. Ciliopathies.(1) 8. Protein processing, trafficking and transport. Microbial immune evasion,lysosomal storage disease, and diabetes.(4) 9. Neurons, astrocytes and oligodendrocytes. Demyelinating diseases.(1) 10. Mitochondrial function andmitochondrial genome. Mitochondrial diseases.(2) 11. Cell cycle, cell proliferation, apoptosis.Cancer.(4) 12. Stem cells and cell differentiation. Cancer.Regenerative medicine. (3) 13. Nuclear organization and gene expression.Cancer.(2) 14. Paper presentations (in group).(4)
Text Books, and/or reference material	**Text Books:** 1. Molecular Biology of the Cellby Bruce Alberts, Alexander Johnson, Julian Lewis, David Morgan, Martin Raff, Keith Roberts, Peter Walter.6th Edition, 2014.Garland Science. **Reference Books:** 1. Molecular Cell Biologyby Harvey Lodish, Arnold Berk, Chris A. Kaiser, Monty Krieger, Matthew P. Scott, Anthony Bretscher, HiddePloegh, Paul Matsudaira. 8th edition, 2016. Publisher: WH Freeman. 2. Cell and Molecular Biology: Concepts and Experiments by Gerald Karp. 6th Edition, 2010. Wiley.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6
BT9055	CO1	1	1	3	1	1	-
	CO2	2	1	3	2	2	-
	CO3	3	1	3	3	2	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="8">Department of Biotechnology</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>BT9056</td><td>Infectious Diseases & Infection Control</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">Cell Biology, Immunology</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: To understand about the spread of infectious diseases, the social impact and means of infection control
CO2: To learn about bacterial infections and ways to tackle different bacterial diseases
CO3: To learn the viral infections, vaccine development and challenges
CO4: To learn about the protozoan and fungal infections and methods to combat them</td></tr>
<tr><td>Topics Covered</td><td colspan="7">1. Origin of Infection; Evolution of infectious diseases; Concept of Infection: Immunity, Immune surveillance, Virulence, Pathogenesis (4)
2. Introduction to pathogenic and non-pathogenic bacteria; Common bacterial diseases in humans; Basic mechanism of Bacterial pathogenesis; Bacterial survival in host cells-Quorum sensing; Bacterial virulence factors: Microbial structures and Toxins; infection; Bacterial immune evasion: Molecular Mimicry; Strategies for antibacterial therapy: Antibiotics, Other antibacterial compounds, and Antibiotic resistance- MDR and XDR strains. Bacterial vaccines. Case study: E. coli infection and diarrhoea (9)
3. History of viral infections; Different viral diseases; Viral pathogenesis; Viral life cycle; Virus genomes and structure; Host –virus interactions; Host Immune reaction against viruses; Viral evasion of host immune surveillance; Antiviral pathways; Mutations in viral genome; Viral diseases and antibody response; Vaccine against viral diseases; Antivirals compounds for viral infections; Challenges in vaccine production against certain virtues; Case study: Influenza (9)
4. Introduction to Protozoan Diseases; Different protozoan diseases, General mode of action of protozoa; Pathogenesis of protozoan diseases; Host response to Protozoans; Molecular signalling against Protozoa; Hypersensitivity and autoimmunity associated with Protozoan infections; Antimalarial drug development ; Case study: Plasmodium (7)
5. General fungal diseases; Mode of action of fungal diseases; Immune response against fungal infection; Case study: Candidiasis; Infection caused by Yeast; Mode of action of Yeast infection; Case study: Ring worm (4) ; Infection and life style- Concepts of Microbiome; Neglected diseases (2)
6. Spread of Infectious diseases; Disease epidemiology, Steps involved in epidemiology and epidemiological case studies; (3) Purpose of infection control, Regulations, policy and practice; Roles and responsibilities in infection control; Risk assessments; Principles of infection control procedures (4).</td></tr>
</table>

Text Books, and/or reference material	Text Books: 1. Mandell, Douglas, and Bennett's Principles and Practice of Infectious Diseases-8thEdition; Volume I and II. By John E. Bennett , Raphael Dolin, Martin J. Blaser. SaudersPublication. 2. Immunology of Infectious Diseases. Edited By Stephan Kaufmann, Alan Sher, and Rafi Ahmed. American Society for Microbiology. Reference Books: 1. Principles of Virology: 4th Edition. By S. Jane Flint, Vincent R. Racaniello, Glenn F. Rall, Anna Marie Skalka, and Lynn W. Enquist. American Society for Microbiology 2. Practical Healthcare Epidemiology, 4th Edition. By Ebbing Lautenbach. Cambridge University press. 3. Principles and practice of clinical bacteriology-2nd Edition. By Stephen Gillespie, Peter M. Hawkey. John Wiley &Sons.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6
BT9056	CO1	1	2	2	3	3	3
	CO2	3	2	3	2	2	1
	CO3	3	2	3	2	2	1
	CO4	3	2	3	2	2	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BT9057	**Project Engineering in Biotechnology**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Bioprocess Engineering, Bioseparation Technology		CT+EA					
Course Outcomes	**CO1:** Learning about process flow diagram and basic concepts of plant design **CO2:** Learning about cleaning of process equipment and design of pipes and valves **CO3:** Learning about facility design and project planning **CO4:** Learning about Planning, construction and commissioning of a biopharmaceutical manufacturing plant **CO5:** Learning about process economics **CO6:** Learning about production concepts						
Topics Covered	1. Introduction Basic considerations in plant design, project identification, preliminary techno-economic feasibility. Process flow Diagrams and symbols: Symbols of Process Equipments& their concepts, types of flow diagrams, Importance of Laboratory development, pilot plant, scale up methods (6) 2. Piping and valves for biotechnology: design, piping materials, polishing, passivation, sizing of pipes and tubes, connections and cleanability, piping applications, supporting and insulating sanitary tubing, in-line instruments, hoses, valves. (5)						

	3. Cleaning of process equipment: design and practice, sterilization of process equipment, pharmaceutical water systems: design and validation, utilities for biotechnology production plant, biowaste decontamination systems, Heating, ventilating & air conditioning (HVAC) (4) 4. Programming & facility design, project planning, containment regulations affecting the design and operation of biopharmaceutical facilities. (4) 5. Planning, construction and commissioning of a biopharmaceutical manufacturing plant: planning, construction, commissioning, qualification, validation, project schedules, cost estimates, organization of an engineering project, role & selection of contractors, legal aspects of facility engineering, health, safety and environmental law, building law. (6) 6. Product sales and manufacturing costs: basic principles of cost calculation, fixed cost, variable cost, depreciation, interest, typical costs of biotechnological manufacturing processes, profit and loss calculation. (6) 7. Investments: investment targets, types of investments, investment appraisal, cost comparison, profit comparison, internal rate of return, dynamic payback time. (5) 8. Production concepts: capacity planning, dilemma of in-house manufacturing, aspects of manufacturing out-sourcing, contractual agreements, technology transfer, process optimization after market launch, supply chain management. (6)
Text Books, and/or reference material	**Text Books:** 1. Bioprocess engineering: system, equipment and facilities, B K Lydersen, N AD'Elia, K M Nelson. Wiley 2. Manufacturing of pharmaceutical proteins, Stefan Behme, Wiley **Reference Books:** 1. Plant design and Economics for chemical engineers, peter M. S. Timmerhaus, K. D. McGraw Hill. 2. Project Engineering with CPM and PERT, Modes J. Philips, Rheinhold publishers.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6
BT9057	CO1	2	2	2	2	2	1
	CO2	2	2	2	2	2	1
	CO3	2	2	2	2	2	2
	CO4	3	3	3	3	3	3
	CO5	3	3	3	3	3	3
	CO6	3	3	3	3	3	3

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BT9058	**Biological Computation**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					

Cell Biology, Biochemistry, Programming and Data Structure	CT+EA
Course Outcomes	**CO1:** Learning about different biological databases and the biological data stored in them **CO2:** To learn UNIX operating system to run bioinformatics resources **CO3:** To acquire knowledge of Bash scripting and programming skills for analyzing biological data **CO4:** To learn how to store and visualize biological data using computational methods
Topics Covered	1. **Biological data and different file formats:** Introduction to biological databases, sources of biological data, genbank, fasta file formats, interchanging of file formats (3) 2. **Introduction to Linux operating system:** What is Linux OS, Kernel system, benefits of Linux for computational biology (3) 3. **Bash programming for bioinformatics:** Shell scripting, working in terminal with different commands, use of important commands such as sed, grep, awk (8) 4. **C programming for bioinformatics:** introduction to C, Identifier , Variables, Constants, Operators, Input statement, Output statement, Conditional and Unconditional Control Statement, Looping Statement: while, do-while, for loop, Arrays. Read, write files (biological data) (10) 5. **Python scripting for bioinformatics:** File handling in python, numpy, pandas etc (8) 6. **Database management:** Designing databases using SQL (5) 7. **HTML and web-designing:** Designing web-pages using HTML and java scripts (5)
Text Books, and/or reference material	**Text Books:** 1. Computational Biology —Unix/Linux, Data Processing and Programming by Röbbe Wünschiers 2. Learning Python, 5th Edition by Mark Lu **Reference Books:** 3. Introduction to Bioinformatics by Arthur M Lesk 4. Introduction to Bioinformatics computer Skills by Cynthia Gibas and Per Jambeck

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6
BT9058	CO1	3	1	3	3	2	1
	CO2	3	1	3	3	2	1
	CO3	3	-	3	3	2	1
	CO4	3	-	3	3	2	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BT9059	**Quality by Design for Biopharmaceuticals**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Bioprocess Engineering, Bioseparation Technology		CT+EA					
Course Outcomes	**CO1**: Learning about the concept of QbD and importance in Biotechnology **CO2:** Learning about QbD for Biopharma production process **CO3:** Learning about QbD for Biopharma purification process **CO4:** Learning about QbD in biologics formulation and product development **CO5:** Learning about PAT tools **CO6:** Learning about integration of PAT with QbD						
Topics Covered	1. QbD: Basic Concepts (2) 2. Considerations for Biotech Product QbD (3) 3. Risk Assessment to determine criticality of product quality attributes (3) 4. Case study on definition of process design space for a microbial fermentation step (4) 5. Application of QbD for Tangential Flow Filtrationprocess (4) 6. Applications of design space for biopharmaceutical purification processes (4) 7. Viral Clearance: A Strategy for QbD and the design Space (4) 8. Application of Quality by Design and risk assessment principles for the development of formulation design space (4) 9. Application of QbD principles to biologics product: formulation and process development (4) 10. QbD for Raw Materials (2) 11. PAT Tools for Biologics (4) 12. Evolution and Integration of QbD and PAT (4)						
Text Books, and/or reference material	**Text Books:** Anurag S Rathore, 2009, Quality by Design for Biopharmaceuticals: Principles and Case Studies, Wiley.						

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6
BT9059	CO1	1	1	2	2	3	2
	CO2	2	2	2	3	3	2
	CO3	2	2	2	3	3	2
	CO4	3	2	3	3	3	3
	CO5	3	3	3	3	3	3
	CO6	3	3	3	3	3	3

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="8">Department of Biotechnology</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>BT9060</td><td>Medical Biotechnology</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">Immunology, Molecular Biology, rDNA technology</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: To provide an understanding about Inborn errors of metabolism and genetic disorders and their consequence.
CO2: Able to analyze the key features therapeutics and drugs in current scenario.
CO3: Able to apply the knowledge for commercial production of pharmaceuticals and place it in market for marketing approvals.
CO4: Able to understand the ethical issues and the different competent regulatory authorities globally associated with clinical Biotechnology.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Module 1: Biochemical diagnostics in Medical Biotechnology 10
Clinical diagnosis of diseases: Inborn errors of metabolism and genetic disorders. Preimplantation diagnosis, pre-natal diagnosis-chorionic villus sampling, Amniocentesis. Molecular techniques for analysis of diseases: DNA polymorphism; ‘disease’ gene vs. ‘susceptibility’ gene; SNP detection: hybridization based assays; Polymerization based assays; Ligation based assays; Polymorphism detection without sequence information: Single nucleotide polymorphism and disease association; High throughput DNA sequencing and diagnosis; and Array based techniques in diagnosis.
Module 2: Drug Discovery and targeting: 10
Overview of inherited and acquired diseases for gene therapy; Identification of disease biomarkers and selection of drug targets; Proteomics and High throughput DNA screening for drug discovery; Gene silencing technology: therapeutic applications in treatment of influenza and HIV/AIDS; Tissue and organ transplantation; Transgenics and their uses. Delivery system development: Intracellular barriers to gene delivery; virus, Liposome and nanoparticles mediated gene delivery.
Module 3: Production of pharmaceuticals: 12
Production of pharmaceuticals by genetically engineered cells. Microbial transformation for production of important pharmaceuticals. Techniques for development of new generation antibiotics; Pharmacogenomics and pharmacogenetics of pharmaceuticals; Cellular and genotoxicity of pharmaceuticals.
Module 4:Clinical research: 10
Introduction and importance of clinical research, Drug development and phases of clinical trials: Designing clinical trials, Protocol designing, Ethical, safety and regulatory issues in clinical research, Drug regulatory concepts and accrediting agencies of the world (USFDA, TGA, ICH, WHO, ISO etc.), ICH-GCP Guidelines,</td></tr>
</table>

	Informed consent process, Role of CRC and CRA in clinical trials, Standard operating procedures, Guidelines to undertake clinical trials in India.
Text Books, and/or reference material	**Books** 1. Lewis, Human Genetics, 7th Edition, WCB & McGraw, 2007. 2. Maroni, Molecular and Genetic Analysis of Human Traits, 1st Edition, Wiley-Blackwell, 2001. 3. Alberts et al, Molecular Biology of The Cell, 2nd Edition , Garland 2007 4. Biopharmaceuticals- Biochemistry and Biotechnology: Gary Walsh; John Wiley & Sons 5. S. P. Vyas, V. Dixit, Pharmaceutical Biotechnology, CBS Publishers 6. Cedric A and Mim S. et al.: Medical Microbiology, Mosby USA 7. An Introduction to Medicinal Chemistry; Graham L.Patrick, Oxford **Reference:** Pharmaceutical Biotechnology ; Sambhamurthy & Kar , New Age Publishers 2. Epenetos A.A.(ed), Monoclonal antibodies: applications in clinical oncology, Chapman and Hall Medical, London 3. V.Venkatesharalu -Biopharmaceutics and Pharmacokinetics-Pharma Books Syndicate 4. Diagnosis: A Symptom-Based Approach in Internal Medicine; C.S.Madgaonkar, Publisher: JPB

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6
BT9060	CO1	3	1	3	3	2	1
	CO2	3	1	3	2	2	1
	CO3	2	2	3	2	1	2
	CO4	3	3	3	3	3	3

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BT9061	**Biological Chemistry**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Basic understanding of biology, chemistry and physics		CT+EA					
Course Outcomes	**CO1:** Understanding of the basic thermodynamic and kinetic aspect of biology. **CO2:** Getting familiarity with common principle of chemistry and chemical bonds **CO3:** To have a deeper understanding of energy flow in biology. **CO4:** To learn about the chemical reactions relevant to biological processes.						
Topics Covered	1. Chemical reactions, reaction stoichiometry, rates of reaction, rate constants, order of reactions, Arrhenious equation, Maxwell Boltzmann distributions, rate determining steps, catalysis, free-energy, entropy and enthalpy changes during						

	reactions; kinetic versus thermodynamic controls of a reaction, reaction equilibrium (equilibrium constant). (8) 2. Chemical and Biological Synthesis-Introduction to synthesis in biology. Chemical synthesis of peptides and proteins. Chemical synthesis of nucleic acids. Chemical synthesis of oligosaccharides. Chemical synthesis of lipids. Biological synthesis of biological macromolecules. Directed biological synthesis of proteins. Biological synthesis of nucleic acids, oligosaccharides and lipids. (6) 3. Advance chemical and physical tools for Biology-Electronic and vibrational spectroscopy in biology, Circular dichroism spectroscopy, Vibrational spectroscopy, Fluorescence spectroscopy, X-ray crystallography, Mass spectrometry for proteomics. (8) 4. Chemical thermodynamics - internal energy, heat and temperature, enthalpy (bond enthalpy and reaction enthalpy), entropy, Gibbs free energy of ATP driven reactions, spontaneity versus driven reactions in biology; redox reactions and electrochemistry - oxidation-reduction reactions, standard cell potentials, Nernst equation, resting membrane potentials, electron transport chains (ETC) in biology, coupling of oxidative phosphorylations to ETC; theories of ATP production and dissipation across biological membranes. (8) 5. Bond rotations and molecular conformations - Newman projections, conformational analysis of alkanes, alkenes and alkynes; functional groups, optically asymmetric carbon centers, amino acids, proteins, rotational freedoms in polypeptide backbone (Ramachandran plot). Types of organic reactions in biology; addition reactions- electrophilic, nucleophilic and free radical. Substitution reactions – electrophilic, nucleophilic and free radical. Elimination and Rearrangement reactions; Chemical insight of enzyme catalyzed reactions – proteases, polymerases, ribosomes. (12)
Text Books, and/or reference material	**Text Book:** 1. Ebbing, D. D., &Wrighton, M. S. (1990). General Chemistry. Boston: Houghton Mifflin. 2. Averill, B., &Eldredge, P. (2007). Chemistry: Principles, Patterns, and Applications. San Francisco: Benjamin Cummings. 3. Cantor, C. R., &Schimmel, P. R. (2004). Biophysical Chemistry. San Francisco: W.H. Freeman.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6
BT9061	CO1	3	3	1	2	-	-
	CO2	3	2	1	2	-	--
	CO3	3	3	1	2	-	-
	CO4	3	2	1	2	-	-

Correlation levels 1, 2 or 3 as defined below:
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>BT9062</td><td>Bioentrepreneurship</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">Basic understanding of Biosafety guidelines</td><td colspan="6">CT+EA</td></tr>
<tr><td colspan="2">Course Outcomes</td><td colspan="6">CO1. To educate about various societal, governance and regulatory issues in biotechnology.
CO 2. To educate about entrepreneurial skill attainment in customer development, customer validation, competitive analysis of the real-world problems and projects and market survey.
CO 3. To build managerial capacity in value creation through company formation, intellectual property licensing of biopharmaceutical products.
CO 4. To raise awareness about the ethical implications and safety rules in biopharma and GMO production management.</td></tr>
<tr><td colspan="2">Topics Covered</td><td colspan="6">Introduction to Bioentrepreneurship: Fundamentals of Marketing of biotechnological products, patent rules regarding product licensing. (4)
Entrepreneurship traits & motivation: Growth of entrepreneurship, The marketing and selling of Biotechnology, Creating and marketing the image of the biotechnology company, Effective advertising and marketing.(8)
Entrepreneurial development: Training, institution in aid of entrepreneur, Power and importance of Positioning of a company name and product. (6)
Capacity building: Regulatory systems for health products in India: Regulatory authority India central (federal) and state (provincial) authorities. Central Licensing Authority. International collaboration of India with South East Asia Regulatory Network (SEARN). Quality management system (QMS). Regulatory functions : Control of clinical trials. Marketing Authorization, Registration Certificate for Import, Manufacturing Licence, Non-Objection Certification (NOC). Licence to manufacture Pre-approval batches, Import Licence, Export NOC for Biological Samples Pharmacovigilance for medicines, vaccines and blood products. (3)
Setting of a small industry, location of an enterprise, steps of starting small industry, Incentive & subsidies for industry, Problems of entrepreneurship, The Art of Negotiation, Workable marketing and the strength of distribution. Opportunities in international marketing. (8)
Risk & benefit assessment: Steps involved in product licensing and technology transfer for commercialization of a biotechnological product. (6)
Ethical issues and Biosafety guidelines: Food safety and environmental safety evaluation of genetically modified microbes, crops, animals (GMO & LMOs); Roles of Institutional Biosafety Committee, WHO, DBT guideline for institutional biosafety . Primary Containment for Biohazards; Biosafety Levels; Biosafety Levels of Specific</td></tr>
</table>

	Microorganisms. Ethical implications of biotechnological products and techniques over human health. (7)
Text Books, and/or reference material	Text Book: 1. Dynamics of Entrepreneurial development & management; Vasant Desai, Himalay Publications. 2. Entrepreneurship reflection & investigation; M.S. Bisht & R.C. Mishra, Chugh Publication. 3. Entrepreneurship development in India; Samiuddin, Mittal Publication References: • Innovation, Product Development and Commercialization: Case Studies and Key Practices for Market • Science Business: The Promise, the Reality, and the Future of Biotech by Gary P. Pisano Harvard Business School Press: 2006. • Design and Marketing of New Products by Urban and Hauser,ISBN 0-13-201567-6 • Putting Biotechnology to Work: Bioprocess Engineering (1992) Commission on Life Sciences The national academy press

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6
BT9062	CO1	3	3	1	2	3	2
	CO2	3	2	2	1	2	2
	CO3	2	2	3	3	2	3
	CO4	3	2	3	3	3	3

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)