NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

CURRICULUM AND SYLLABUSOF BTECH DEGREE IN BIOTECHNOLOGY PROGRAM

2023 ONWARD ADMISSION BATCH

V0:

First Year Curriculum Recommended by members of UGAC	19.08.2023
First Year Curriculum Approved by the Chairman, Senate	19.08.2023
First Year Curriculum & Syllabus ratified in the 71st Senate meeting (Item No. 71.5(b))	18.12.2023
Entire Curriculum and Syllabus Recommended by UGAC	09.12.2024
Entire Curriculum and Syllabus Approved by the 73rd Senate (Item No. 73.8)	23.03.2025

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	BTS851	Project - II	0	0	18	6
2	BTS852	Comprehensive Viva	0	0	0	1
		TOTAL	0	0	18	**7**

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

<table>
<tr><td colspan="7">Department of Chemistry</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>CYC01</td><td>Engineering Chemistry</td><td>PCR</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="4">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="3">None</td><td colspan="4">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="6">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.</td></tr>
<tr><td>Topics Covered</td><td colspan="6">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</td></tr>
</table>

	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							
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	
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 $Fe(acac)_3$, cis-bis(glycinato)copper (II) monohydrate and their characterization m. p. , FTIR 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 prese in 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)

<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>MAC02</td><td>MATHEMATICS - II</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), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="2">Basic concepts of set theory, differential equations, and probability.</td><td colspan="6">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">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.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">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)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">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</td></tr>
</table>

	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="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">None</td><td colspan="6">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 reference</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>

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)

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	
BTC301	**BIOCHEMISTRY AND ENZYME TECHNOLOGY**	PCR	3	1	0	4	4
Pre-requisites							
Course Outcomes	**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.						

Topics Covered	**Module 1:** Biomolecules, Vitamins, Principles of Bioenergetics[6] **Module2: 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 andPhotophosphorylation**: 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 aminogroups, 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.
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 ofthecourse	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:**Todeveloptheconceptofdimensionandunitconversiontocheck dimensional consistency of balanced equation **CO2:**Learnbasiclawsaboutthebehaviorofgases,liquidsandsolidsand some basic mathematical tools. **CO3:**ToEstablishmathematicalmethodologiesforthecomputationof material balances and energy balances with and without chemical reaction **CO4:**Toapply knowledgeof thelawsof thermodynamicstosolvephysical and chemical problems encountered in chemical, biochemical industries and biological processes. **CO5:**Toanalyzeandinterpretdata,toidentify,formulate,andsolve 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, conceptandestimationofentropy,thirdlawofthermodynamics, Clausius in equality, Gibb's and Helmholtz free energy. Free energy and Chemical Equilibrium. [8] **Module4: 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:Todevelopknowledgeondifferent typesofmicroorganisms includingviruses and microscopyforthe visualizationof microorganisms, their characteristic features as well as internal and external structures and their functions.

CO2: To impart an understanding on microbial classification and taxonomy, microbialcommunityand interactions, microbial nutrition, nutritional types, growth media, growthin different systems, and control of microorganisms using various physical and chemical treatments including antimicrobial drugs.

CO3:Todevelopknowledgeonmicrobialmetabolism,energytransduction 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:Toillustrate theupstream anddownstream processingforproductrecovery and purification.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">PARTA: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,bacterialandarchaebacterialcell walls and cell membranes, Viruses – types, structures, multiplications[4]</td></tr>
</table>

Microbial classification and taxonomy: Domainsoflife, 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]**

Microbialnutrition,growthandcontrol: Commonnutrientrequirements,nutritionaltypes,uptakeofnutrientsbycell,culturemedia,pureculture,microbial growth – batch culture and continuous culture, growth curve, measurement of growth, influence ofenvironmentalfactorsongrowth, controlofmicroorganisms by physicalandchemicalagents, Antimicrobialdrugs –generalcharacteristics, narrow-spectrum and broad-spectrum drugs, inhibitors of cell wall synthesis, nucleic acid synthesisandproteinsynthesis,metabolicantagonists,Drugresistance.[**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) Introductionto FermentationTechnology:MicrobialCulturesystems;Media for Industrial fermentations; Media Optimization; Sterilization of Industrial Media; The development of Inoculum for Industrial fermentations; Starter Cultures; Downstream Processing and fermentationeconomics**[4]**

B) Commercial Strain Development & Microbial Processes: Sources of industrial cultures and maintenance. Alcoholic fermentation: Production of Industrial Alcohol – Fermentation mechanism. Recent developments, brewing andmalting, 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 of5'IMPand5'GMPbyfermentation.**[3]**

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

E) Lectures Microbial Production of Antibiotics : Organism used, production processandrecoveryof-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,StreptomycinandTetracyclines)anditsnewDevelopments **[2]**

TextBooks, and/or reference material	**TextBooks:** 1. Prescott, Harley and Klein's Microbiology – McGraw Hill 2. MicrobiologybyPelczar,ChanandKrieg,TataMcGrawHill 3. L.E.Casida.Jr,IndustrialMicrobiology,NewAgeInternationalPublisher 4. W.Crueger,AnneliseCrueger,Biotechnology:ATextbookofIndustrial 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.3rded.Taylorand Francis. **Referencebooks:** 1. Microbiology: An Introduction Tortora,FunkeandCase 2. GeneralMicrobiologybyHansGSchlegel,Cambridge 3. Atkinson.BandMarituna.F,BiochemicalEngineeringandBiotechnology Handbok, The Nature Press, Macmillan Publ.Ltd.4 4. JamesEBailey,DavidF.,Ollis,Biochemicalengineeringfundamentals,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:**Understandthebasicconceptsandappreciatetheapplicationsofdatabase systems **CO2:**Comprehendthefundamentalsofdesignprinciplesforlogicaldesignofrelational databases **CO3:**Applythequerywritingskill **CO4:**Discussthebasicissuesoftransactionprocessingandconcurrencycontrol
Topics Covered	1.IntroductionofDBMS. [5] 2.Concept of E-R diagram, Extended E-R diagram. [5] 3.Relational Algebra [4] 4.Queries with various operations [4] 5.SQLQueries [4] 6.Indexstructuredesign [5] 7.Normalization(Differentnormalforms) [5] 8.Basicconceptsontransactionprocessing [5] 9.Variousconcurrency-controlprotocols(2phaselocking,timestampprotocol) [5]
TextBooks, 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,"FundamentalsofDBMSSystems",Pearson education. Sixth Edition. c. A. Kahate,"IntroductiontoDatabaseManagementSystems",PearsonEducation , New Delhi, 2006. **ReferenceBooks:** a. C.J.Date,A.KannanandS.Swamynathan,"AnIntroductiontoDatabase 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)

<table>
<tr><th colspan="7">Department of Biotechnology</th></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>BTS351</td><td>Microbiology Laboratory</td><td>PCR</td><td>0</td><td>0</td><td>3</td><td>3</td><td>2</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">Microbiology and Bioprocess Technology (BTC303)</td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="6">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</td></tr>
<tr><td>Topics Covered</td><td colspan="6">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</td></tr>
<tr><td>Books, and/or reference material</td><td colspan="6">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</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
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:**Todevelopskillstoperformexperimentsandhavehandsontraining. **CO3:**Toapplytheresultsanddatatosolveproblemsindailyactivitiesandindustry.						
Topics Covered	1. To prepareTris-HClBufferwithaspecific pH(eg.pH 8.8) 2. Qualitativeandquantitativeestimationofcarbohydrates 3. Qualitativeandquantitativeestimationofaminoacidsanddeterminationof the unknown concentration ofprotein concentration by plotting a standard curve of BSA using Bradford reagent 4. Ammoniumsulphateprecipitationanddialysisforaprotein 5. SeparationandIdentificationofAmino acidsbyPaperChromatographyand Thin Layer Chromatography 6. Analysis of Protein purity and determination of molecular weight of pure proteinbySDSPAGEandCoomassieBrilliant bluestainingofproteinson SDS gel 7. ExtractionofEnzymeTyrosinase fromcommerciallyavailable mushrooms and AssayofEnzyme Tyrosinase withdeterminationofspecific activityof Enzyme Tyrosinase 8. Effect ofsubstrateconcentrationontheactivityofEnzymeTyrosinaseand determination of MichelesMenton parameters of Enzyme Tyrosinase 9. EffectofinhibitorconcentrationontheactivityofEnzyme Tyrosinase						
TextBooks, and/or reference material	**TextBooks:** PracticalBiochemistrybyDavidTPlummer **ReferenceBooks:** BiochemistrybyVoetandVoet						

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		Computerfundamentals,Datastructures Fundamentalsofanycomputer programminglanguages					
CourseAssessmentmethods		Continuous(CT)andend assessment (EA: Class test, Viva, Assignments, Lab test)					
Course Outcomes		CO1:Understand,appreciateandeffectivelyexplaintheunderlyingconceptsof database technologies CO2. Design and implement a database schema for a given problem CO3.PopulateandqueryadatabaseusingSQLDML/DDLcommands					
Topics Covered		1. SQL Queries 2. PL/SQL assignments					
TextBooks, and/or reference material		**TextBooks:** SQLandPL/SQLbyEvanBayross.					

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)

<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>BTC401</td><td>MOLECULAR BIOLOGY AND GENETIC ENGINEERING</td><td>PCR</td><td>3</td><td>0</td><td>0</td><td>3</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">BTC303 Biochemistry and Enzyme Technology</td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">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.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">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]</td></tr>
</table>

	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 BiologyofCellbyAlbertet.al.JohnWiley&Sons 2. TheCellbyCooper.ASMPress 3. M.W.Strickberger:Genetics,Pearson. 4. InIntroductiontogeneticanalysis, Griffiths,Miller,Suzuki,Lewontinand Gelbart, Freeman and Company. Reference Books 5. CellandMolecular BiologybyKarp.JohnWiley&Sons 6. Brown,T.A.,GeneticsaMolecularApproach,4thEd.ChapmanandHall, 1992 7. Stratchan&Read:HumanMolecular Genetics 8. DavidFreifelder:MicrobialGenetics,JonesandBartlettPublisherInc. 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)

<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>BTC403</td><td>Plant and Animal Biotechnology</td><td>PEL</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) and end assessment (EA))</td></tr>
<tr><td colspan="3">Biochemistry, Cell Biology, Genetics</td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">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.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">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)</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., 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.</td></tr>
</table>

	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)

<table>
<tr><td colspan="8">Department of Chemical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title ofthecourse</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>CHC431</td><td>UNIT OPERATIONS OF CHEMICAL ENGINEERINGI</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: Mathematics</td><td colspan="5">Course Assessment methods (Continuous(CT)and end assessment(EA))</td></tr>
<tr><td colspan="3"></td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1:ToUnderstand fundamentalsoffluiddynamicsand mechanics
CO2:Understandingthefundamentalsofheattransferoperations
CO3:Tolearndesignofheattransferequipmentand calculations
CO4:Todevelopknowledgeofdifferent mechanicaloperationsandtheir applications
CO5:Tosolverelatedproblemsofdifferentdifficultylevelsthroughtutorials</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Module –I(14hrs)

FundamentalConcepts:DefinitionofFluid,Terminologiesoffluidflow,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.</td></tr>
</table>

	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.
TextBooks, and/or reference material	1. ProcessHeatTransfer:D.Q.Kern,MGH 2. HeatTransferPrinciplesand Application,B.K.Dutta,PHI. 3. UnitsOperationsofChemicalEngineering: McCabe&SmithandHarriot,MGH 4. Coulson,J.M.,Richardson,J.F.,"ChemicalEngineering",Volume2,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 ofthecourse	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 LABORATORYI**	PCR	0	0	3	3	2
CHC431:Unitoperationsof chemical engineering-I.		Course Assessment methods (Continuous(CT)and end assessment (EA))					

	CT+EA
Course Outcomes	**CO1:**To recordobservationssystematicallyandarriveatrequiredresultsbasedon experiments conducted **CO2:**Understandtheprinciples, lawsandmechanismofdifferentcomminuting methods like sieve analysis crushers, and grinders, ball mill **CO3:**Acquiretheknowledgeofacycloneseparator andits efficiency **CO4:**Acquiretheknowledgeofdifferentflowregimemeasuringinstruments. **CO5:** Study and design different flow measuring instruments.
Topics Covered	1. Tofindoutthereductionratio and capacityandtoverifythe lawsofcrushingby Jaw Crusher. 2. Todeterminetheoptimumspeed formaximumnewsurfaceareacreatedforthe given feed size and also determines the critical speed of the ball mill. 3. Demonstrationoftheoperationofacycloneseparatoranddeterminationofits overall efficiency 4. ExperimentsonReynoldsApparatusfordeterminationofflowregimeand construction of Fanning friction factor vs. Reynolds No. plot. 5. Determinationofco efficientofDischarge forOrifice meterandDischarge for Venturi meter. 6. Determinationofco-efficientofPitottubeandconstructionofvelocityprofileacross the cross section of pipe. 7. Experiment toproveBernoulli'sequationforfluidflow 8. To analyze a given powder for its particle size distribution. / Cumulative and Differentialmethodsofparticlesizedistributionsandto findoutscreenefficiency.
Text Books, and/or reference material	1. UnitsOperationsofChemicalEngineering: McCabe&Smithand Harriot,MGH 2. Coulson,J.M.,Richardson,J.F.,"ChemicalEngineering",Volume2,Third Edition,Pergamon Press, 1977 3. PrinciplesofUnit OperationsbyAlanSFoust,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)

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	
BTS451	**MOLECULAR BIOLOGYAND GENETIC ENGINEERING LABORATORY**	PCR	0	0	3	3	2
Pre-requisites		Course Assessment methods (Continuous (CT)and end assessment (EA))					
NIL		EA					
Course Outcomes	**CO1:** To understand the principle of isolation of nucleic acids through different techniques. **CO2:**Tounderstandthetechniquesusedinmanipulationofnucleic acids. **CO3:** To develop expertise to apply the toolsof 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.						
Topics Covered	1. Isolationofgenomic DNA 2. QuantificationofDNA 3. AgaroseGelElectrophoresisofDNA 4. IsolationofRNA 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						
Text Books, and/or reference material	Sambrooketal.,“MolecularCloning”ALaboratoryManual						

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	**CELLBIOLOGY 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 Moleculargenetics and interpretation of data obtained by the lab experiments. **CO2:** To develop skillsto performexperimentsrelatedto cellbiologyand Molecular genetics and have hands on training on the related area. **CO3:**Tolearntointerpretdata,drawconclusionanddevelop trouble-shootingskills.					
Topics Covered		1. IsolationofchromosomalDNA frommammaliancells. 2. GenotypingPCRofageneticallymodified cell. 3. IsolationofmRNAandRT-PCRtodeterminethe leveloftranscriptionofthe gene. 4. Studyingtodetectvariationslikesinglenucleotide polymorphism. 5. Studyingbacterialconjugation. 6. Toexaminethemorphologyofcells 7. Identificationofcellularorganellesbystainingmethod 8. Cellproliferationassay 9. Celladhesion assay Cellmigrationassay					
TextBooks, and/or reference material		**REFERENCEBOOKS:** Molecular BiologyofCellby Albertet.al.JohnWiley&Sons TheCellbyCooper.ASMPress 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 ofthecourse	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					
CourseOutcomes	**CO1:**TogainknowledgeaboutChemicalandBiochemicalprocesses,orderof reactions, effectofvarious parametersonrateconstantofa reaction. Tostudyabout different reactionsinbatchreactors,kineticsofenzyme catalyzed reactions **CO2:** Toacquireknowledgeabout different idealandnon-idealreactors,reaction kinetics, microbial growth kinetics **CO3:** To learnabout varioustypesofBioreactors,theirdesignconsiderationsand applications in the field of Biochemical Engineering **CO4:**Tostudyaboutmasstransfer inbioprocesssystems,scaleup,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 orderreactions, Pseudo-first orderreaction, Determinationof 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 ofkinetic constants, Lineweaver-burk and Eadie-Hofstee plot, principles of enzyme inhibition – Competitive, noncompetitive and uncompetitive. [5] Fundamentalsofhomogeneousreactionsforbatch,plugflowandmixedflow reactors. [5] Concept of ideal and non ideal reactors, Residence time distribution, Models for non ideal reactors (Dispersion model, tanks-in-series model). [5] Stoichiometryofcellular reactions. Microbialgrowthkinetics(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] Designoffermenter.Fermenterutilities–boilerandrefrigerationsystem. [5] Immobilized cell bioreactor system. Mass transfer in bioprocess system. Two film theory, $K_La$determination. Scale up concepts. Bioreactor considerations for plant and animal cell culture with special emphasis to single-use bioreactors. [7]						
Text Books, and/or	TEXT 1. BioprocessEngineering:BasicConcepts(2ndEdition),ShulerandKargi, Prentice						

reference material	Hall International. 2. BioprocessEngineeringPrinciples–PaulineMDoran.Academicpress 3. ChemicalReactionEngineering,OLevenspiel,Wiley 4. PrinciplesofFermentationTechnology,StanburyandWhitaker,Pergamon press REFERENCE BiochemicalEngineering.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)

Department of Biotechnology							
Course Code	Title ofthecourse	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTC502	**BIOSEPARATION ENGINEERING**	PCR	3	1	0	4	4
Pre-requisites		CourseAssessmentmethods(Continuousassessment(CA) and end-termexamination(ET))					
Basic Physics, Mathematics includingbasicsofDifferential & Integral Calculus, Basic conceptsofChemistry&Biochemistry		CA+ET					
Course Outcomes	**CO1:**Tolearntheconceptsofseparation includingpurification sequence and its monitoring and the properties of proteins underlying bioseparations. **CO2:**Tolearntechniquesofbiochemicalanalysisofbiomolecules. **CO3:**Tolearnandanalyze,mathematicallywhereverapplicable,the various unit operations in bioseparation. **CO4:** To understand the design aspectsof unit operations in bioseparation. **CO5:**Tosolveproblemsofbioseparationsincludingindustrialbioseparations.						
Topics Covered	**Basic Concepts** **[3]** BasicconceptsofBio-separationTechnology **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 Industrial Application with an example [2]
TextBooks, and/or reference material	Textbooks: PracticalBiochemistryPrinciples and techniques (5th ed)/ Principles and Techniques of Biochemistry and Molecular Biology (7th ed): Editor Wilson and Walker, Cambridge University Press 2. Geankoplis,TransportProcesses&Unitoperations, PHI. Reference books: D.Holme&H.Peck,AnalyticalBiochemistry, 3rd ed,Longman, 1998 Shuler&Kargi,Bio-processEngg.PHI Bailey&Olis,BiochemicalEngg.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:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<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>BTC503</td><td>BIOINFORMATICS</td><td>PCR</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">Computer Programming (CSC01), Biochemistry and Enzyme Technology (BTC301), Cell Biology and Genetics (BTC402)</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">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</td></tr>
<tr><td>Topics Covered</td><td colspan="7">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)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">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</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

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

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">Titleofthe 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>CHC531</td><td>UNIT OPERATIONS OF CHEMICAL ENGINEERING- II</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="2">CHC431:Unitoperationsof chemical engineering-I.</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:Tolearndifferenttypesofmasstransfer phenomena
CO2:Understandingthefundamentalsofmasstransfer operations
CO3:Tolearndesignparameters,their effectsandcalculations
CO4:Tocomparedifferenttypesofmasstransferoperationsandtheir applications
CO5:Tosolverelatedproblemsofdifferentdifficultylevelsthroughtutorials</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Module I: Principles of mass transfer: Introduction, diffusion, classification of diffusion, Inter-phase mass transfer. [8 hr]
Module II: Evaporation: Introduction, typesofevaporators,designcalculationand 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]
ModuleIV:Absorption:Principle,operationanddesigncalculation[8hr]
Module V:Distillation: Flashdistillation, differentialdistillation, fractionationand design calculations [8 hr]
ModuleVI:Extractionand Adsorption:PrinciplesandOperations.[8hr]</td></tr>
<tr><td>TextBooks, and/or reference material</td><td colspan="7">Text Books:
1. B.K.Dutta,PrinciplesofMassTransferandSeparationProcesses,Prentice Hall India Private Limited
2. NAnantharamanandK.M.M.S.Begum,MassTransfertheoryandpractice. Prentice Hall India Private Limited
RobertE.Treybal,MassTransferOperations,McGrawHilllimited</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
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)

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	
BTE510	**Biophysics & Structural Biology**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NA		CT+EA					
Course Outcomes	**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						
Topics Covered	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)						
Text Books, and/or reference material	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,						

	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	Title of the course	Program	Total Number of contact hours	Credit

Code		Core (PCR) / Electives (PEL)	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:**Tolearnaboutthebioprocessengineeringaspectsofmarineproductsin commercial production **CO2:** To learn about the industrial applications of variousmarine products and theirproduction **CO3:**To study the specific applications in energy, pharmaceutical and environmental sector.					
Topics Covered		**Bioprocess engineering of marine products:** Marine microbiology,Photobioreactors–lightregimemasstransferandscaleup,downstream processingof marine products, ManagementofMarineproduction,Storageand transport, Marinenatural products,valuablechemicals,bioactive compounds from micro-algae. **Specializedaspects**:Cultivationofmarinemicroorganism, marinebiomedicalandbioactivecompoundsfrom marine organisms, commercial bio-products from marine organisms biohydrogenproductioninphotobioreactor,marine enzymes, Marine bio-filmandbio-remediation, marinebio-sensorandtransgenicmarineorganisms. **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		MarineBioprocessEngineering, J.G.BurgessR.OsingaR.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)

Course Code	Title ofthecourse	Program Core(PCR) /Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTS551	**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:**Tolearnthefundamentalsofimmunologicaltechniques **CO2:**To be able to perform techniques routinely used in immunology, particularly the use of specific antibody in biomolecular applications. **CO2:**Tobeabletoisolate,countandidentifydifferenttypesofbloodcells. **CO4:**To developanidea forproperdocumentationofthework including laboratory procedures,experimentalconditions, materials used, equipment used and the results. **CO5:** To understand the basic hazards ofworking with human samples and antigens and safety measures to be taken
Topics Covered	1. CellcountwithHaemocytometer 2. Determinationofviabilityofthecells 3. Serology:Preparationoftheblood smear 4. Bloodcellidentification 5. Bloodgrouping byAgglutinationassay 6. QuantitativeWIDALtest(Bytubetestandslidetest) 7. Precipitationtest:Immunodiffusion 8. EnzymelinkedImmunosorbentAssay(ELISA) 9. Proteindetection byWesternblot technique. 10. LymphocytesisolationusingFicollHypaquetechnique
TextBooks, and/or reference material	1. ImmunologyLaboratorymanual. 2. ArtiNigam,ArchanaAyyagari,"LabManualinBiochemistry,Immunologyand Biotechnology", McGrawHillEducation,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)

Course Code	Title ofthecourse	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CHS581	**UNIT OPERATIONS OFCHEMICAL ENGINEERING LABORATORY II**	PCR	0	0	3	3	2
Pre-requisites		CourseAssessmentmethods(Continuousevaluation(CE) and endassessment(EA))					
UnitoperationofChemical EngineeringIandII		CE+EA					
Course Outcomes	**CO1:** Applythe knowledge offundamentalsofheat and masstransfer equipment on laboratory **CO2:**Experimentationand dataanalysis **CO3:**Toapplyprinciplesofmasstransfer phenomenatochemicalprocessindustries **CO4:**Handlingvariousinstrumentsandsolve variousdifficultylevels **CO5:**Learn industrialapplicationsofheat transferequipment **CO6:**Completeprocessdesignthroughassignment / grouptask						
Topics Covered	1. Determinationofthermalconductivityof metalrod 2. Determinationofoverallheattransfercoefficientinacounter-current&parallel flow double pipe heat exchanger. 3. Determinationofoverallheattransfer coefficientinashellandtubeheatexchanger. 4. Experimentaltestrigondrop-wiseandfilm-wisecondensationforassessingthe performance. 5. Studies on estimation of hold-up volume under steady state condition and evaluate the overall performance of a rotary dryer. 6. Determinationofoverallefficiencyofcoolingtower 7. Estimationof rate of dryingof specificbiomassundersteady stateconditioninan atmospheric tray dryer 8. Performancestudiesoncontinuousfractionatingdistillationcolumnintermsof distillate,bottomproductandrefluxquantities,%loss,%recovery,energy consumptionetc. (36hr)						
Text Books, and/or reference material	SuggestedText Books: 1) TransportProcessesandUnitOperations -C.J.Geankoplis 2) HeatTransfer:Principlesand Applications:B.KDutta						

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	Title of the course	Program	Total Number of contact hours	Credit

Code		Core (PCR) / Electives (PEL)	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:**Analyzeopen-loop system **CO2:**Analyzeandapplytheknowledgeoflinearclosed-loop systems. **CO3:**Develop workingknowledgeofcontrolsystemby frequencyresponse **CO4:**Analyzetheresponseofinstrumentsandabilitytointegrateknowledge about instrument **CO5:**Explaintheimportanceandapplicationofinstruments
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,Finalcontrolelement,Controlvalvecharacteristics,TransportationLag, Routh-HurwitzCriteriaandstability (12) frequency response of closed-loop, frequency response technique, Bode Diagram andstabilitycriteria (8) Staticanddynamicresponses, Measurementoftemperatureand pressure (5) instrumentsforprocessplanttomeasureflow,levelandconcentrationoffluid (5)
TextBooks, and/or reference material	1. ProcessSystemsAnalysisandControl,DonaldCoughanowrMcGraw-Hill Science/Engineering/Math; 2 edition (March 1, 1991) 2. ChemicalProcesscontrol,G.Stephanopoulos,PHI, 2008 3. EssentialsofProcessControl,Luybenet al.McGraw-HillCompanies(August 1, 1996) 4. Processcontrol,ThomasMarlin,McGraw-HillEducation;2ndInternational edition (July 1, 2000) 5. Jone'sInstrumentationTechnology(allthevolumes) 6. Instrumentationand DevicesbyRangan &Sharma 7. Considine'sHandbookon Instrumentation 8. AtomicabsorptionandEmissionSpectrophotometers,EdMetcalfe 9. IndustrialInstrumentation,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 ofthecourse	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		CourseAssessmentmethods(Continuousevaluation(CE)andend assessment(EA))					
NIL		CE+EA					
Course Outcomes	**CO1:**Toreviewbasiceconomicprincipleswithstudents; **CO2:**Tointroducestudentsbasiccapital appraisal methodsusedforcarryingout economic analysis of different alternatives of engineering projects or works; **CO3:**Toeducatethestudentsonhowtoevaluatesystematicallythevariouscost elementsofatypicalmanufactured product, anengineering project orservice, withaviewtodeterminingthepriceoffer.						

Topics Covered

PART1:Economics

GroupA: Microeconomics

Sl.No.	Name	L	T	P	Cr	H
Unit1:	Economics:BasicConcepts	2	0	0	2	2
Unit2:	TheoryofConsumerBehaviour	3	0	0	3	3
Unit3:	TheoryofProduction,CostandFirms	3	0	0	3	3
Unit4:	AnalysesofMarketStructures:PerfectCompetition	3	0	0	3	3
Unit5:	MonopolyMarket	1	0	0	1	1
Unit6:	GeneralEquilibrium&WelfareEconomics	2	0	0	2	2
TOTAL	**14001414**					

GroupB: Macroeconomics

Sl.No.	Name	L	T	P	Cr	H
Unit1:	IntroductiontoMacroeconomicTheory	2	0	0	2	2
Unit2:	NationalIncome Accounting	3	0	0	3	3
Unit3:	DeterminationofEquilibriumLevelofIncome	4	0	0	4	4
Unit4:	Money,Interest andIncome	2	0	0	2	2
Unit5:	Inflationand Unemployment	2	0	0	2	2
Unit6:	Output,PriceandEmployment	2	0	0	2	2
	TOTAL	**15**	**0**	**0**	**15**	**15**

PART2:Accountancy

Sl.No.	Name	L	T	P	Cr	H
Unit1:	IntroductiontoAccounting	2	0	0	2	2
Unit2:	PrimaryBooksofAccounts(Journal)	1	0	0	1	1
Unit3:	SecondaryBooksofAccounts(Ledger)	3	0	0	3	3
Unit4:	CashBook 2	0	0	2	2	
Unit5:	BankReconciliationStatement	1	0	0	1	1
Unit6:	TrialBalance	2	0	0	2	2
Unit7:	FinalAccounts	2	0	0	2	2
	TOTAL	**13**	**0**	**0**	**13**	**13**

TextBooks, and/or reference material	**PART1:Economics** **GroupA: Microeconomics** 1. Koutsoyiannis:ModernMicroeconomics 2. MaddalaandMiller:Microeconomics 3. AnindyaSen:Microeconomics:Theoryand Applications 4. Pindyck&Rubenfeld:Microeconomics **GroupB: Microeconomics** 1. W. H. Branson:Macroeconomics–TheoryandPolicy(2nd ed) 2. N.G.Mankiw:Macroeconomics,WorthPublishers 3. DornbushandFisher:MacroeconomicTheory 4. SoumyenSikder:PrinciplesofMacroeconomics **PART2:Accountancy** 1. Gupta,R. L.andRadhaswamy, M:FinancialAccounting;S. Chand&Sons 2. AshokeBanerjee:FinancialAccounting;ExcelBooks 3. Maheshwari:IntroductiontoAccounting;VikasPublishing 4.Shukla, MC, GrewalTSandGupta, SC:AdvancedAccounts;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 Biotechnology							
Course Code	Titleofthe 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		CourseAssessmentmethods(Continuous(CT)andendassessment (EA))					
CellBiology, Molecular Biology, and Immunology		CT+EA					

Course Outcomes	**CO1:**Acquireanunderstandingofvirus lifecycleandhost-virusinteractions. **CO2:**Acquireanideaaboutdetection,preventionandtreatmentofvirus infections. **CO3:**Tolearnaboutuseofvirusin biotechnology.

Topics Covered	Briefhistoryandprinciplesofvirology.(1) Principles of virus classification. (2) Generalstructureofviruses;Viroids,Virusoids,Satellite viruses,andPrions.(2) Genome of plant and animal viruses. Mobile genetic elements. (4) ReplicationsofRNAviruses.(5) Replication of DNA viruses. (5) Virus-cellinteractions:cytopathology;virusentryandegress;host cellshutoffand IRES;viral persistence and latency.(6) Methodstodiagnosevirusinfections.(3) Antiviral vaccines. (3) Antivirals:interferonsanditsmechanismsofaction.(2) Gene silencing. (2) Cultureandpurificationofviruses.(2) Viralvectorsandgenetherapy.(2) New and emerging viruses (3)
TextBooks, and/or reference material	Text Books: 1. PrinciplesofVirology:4thEdition.ByS.JaneFlint,Vincent R.Racaniello, Glenn F. Rall, Anna Marie Skalka, and Lynn W. Enquist. ReferenceBooks: 2. FieldsVirologybyLippincottWilliamsandWilkins.

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 ofthecourse	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		CourseAssessmentmethods(Continuous(CT)andendassessment (EA))					
		CT+EA					
Course Outcomes		**CO1:**Learnaboutenergycrisis,problemsoffossilfueluse,globalwarming **CO2:**Learnaboutproductionofbiologicalsolidfuel. **CO3:**Learnaboutgaseousbiofuelproductionlikemethaneandhydrogenindetail. **CO4:**Learnaboutliquidbiofuels **CO5:**Learnaboutbenefitsanddeficienciesofbiofuels,lifecycleanalysis					
Topics covered		Energyand fossil fueluse – fossil fueluse, fossil fuelreserves, sustainable fuelsources [4] Consequences of burning fossil fuel – effects of industrial (anthropogenic) activity ongreenhouse gases, sources of greenhouse gases[3] Mitigation of global warming – Kyoto protocol, reduction in global greenhouse gases, fuelcells,sequestrationofcarbondioxide,alternativeenergysources,energystorage.[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 – methanolproduction. Large scale ethanolproduction 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] Jatrophacultivation,Nationalhydrogenenergyroadmap. [3]
TextBooks, and/or reference material	Books. 1.Biofuelsproduction,applicationanddevelopment.AlanScragg, 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 ofthecourse	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		CourseAssessment methods(Continuous(CT)andendassessment (EA))					
BTC401(MolecularBiology & rDNA Technology)		CT+EA					
Course Outcomes	**CO1:**Tounderstandthefundamentalsofmolecularcloning. **CO2:** To learn the basic methods of molecular cloning. **CO3:**Togainknowledgeaboutthepotentialapplicationaspectsofmolecularcloning. **CO4:**Tobuild-upabridgingconceptforextensionoftheoreticalknowledgeto practical applications of molecular cloning.						

Topics Covered	**Module1:Basicprinciplesofmolecularcloning** - WhygenecloningandDNAanalysisareimportant (2) - Vectorsforgenecloning(2) - PurificationofDNAfromlivingcells(2) - ManipulationofpurifiedDNA (3) - IntroductionofDNAintolivingcells(3) - Cloning vectorsfor prokaryotes(3) - Cloning vectorsfor eukaryotes(3) - Howtoobtaina clone ofa specific gene (2) - Othermoleculartechniques(2) **Module2: Applicationsof molecularcloninginresearch** - Sequencinggenes&genomes(3) - Studyinggeneexpression&function(3) - Studyinggenomes(4) **Module3: Applicationsofmolecularcloninginbiotechnology** - Productionofproteinfromclonedgenes(2) - Genecloning&DNAanalysisinmedicine(3) - Genecloning&DNAanalysis inagriculture(3) - Genecloning&DNAanalysisin forensicscience &environment(2)
TextBooks, and/or reference material	**TextBooks:**T.A.Brown,GeneCloningandDNAAnalysis:AnIntroduction,Seventh Edition, Wiley Blackwell. Sandy B. Primrose, Richard Twyman & Bob Old, Principles of gene manipulationprimrose:Anintroductiontogeneticengineering,SixthEdition, BlackwellScience

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 ofthecourse	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		CourseAssessmentmethods(Continuous(CT)andend assessment(EA))					
		CT+EA					
Course Outcomes	**CO1:** Tounderstandtheroleofthesmall moleculesinthedrugdeliverysystem. **CO2:** Tolearn thefundamentals and principles of nanotechnologiesin drug release system. **CO3:**Tounderstandmethodsofnanotechnologyinpoint ofcarediagnosis. **CO4:** To understand the basic mechanism of Nano therapeutics oftumors.						

Topics Covered	**UNIT -INANOPHARMACEUTICALS: Nano-biotechnology for Drug Discovery** - Gold Nanoparticles for Drug Discovery - Use of Quantum Dots for Drug Discovery - Nanolasers for Drug Discovery -Cells TargetingbyNanoparticles with attached small molecues. 5, Dendrimers,Nanobodies, Nanospheres-Nanotubes, Nano-cochleates, Nano- moleculerValvesforControlledDrugRelease–Nano-motorsforDrugDelivery.6 **UNIT-IIROLEOFNANOTECHNOLOGYINBIOLOGICAL THERAPIES: Development of nano medicines:** Nano Shells, Nano pores, Tectodendrimers, Nanoparticle drug system. Biomedical nanoparticles, Liposome's Different types of drugloading, Drugrelease, Biodegradablepolymers. 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
TextBooks, and/or reference material	**References:** 1. KewalK.Jain,TheHandbookofNano-medicine HumanaPress,(2008). 2. Zhang,Nanomedicine:A SystemsEngineeringApproach"1stEd.,Pan Stanford Publishing, (2005). RobertA.FreitasJr.,—Nano-medicineVolumeIIA: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 andprocess 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)

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	
BTE615	**Industrial 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 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						

Topics Covered	**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.
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)

<table>
<tr><th colspan="8">Department of Biotechnology</th></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title ofthecourse</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>BTE616</td><td>ENVIRONMENTAL MICROBIOME</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">CourseAssessmentmethods(Continuous(CT)andend assessment(EA))</td></tr>
<tr><td colspan="3">Microbiology and Bioprocess Technology(BTC302);Molecular Biology and Genetic Engineering (BTC401); Bioinformatics(BTC601)</td><td colspan="5">CT+EA</td></tr>
<tr><td colspan="3">Course Outcomes</td><td colspan="5">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 Systembiologyapproachtoassessthe interactionand functionof 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.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Introduction-Significance,developmentsandchallengesofenvironmental microbiome study. (4)

MicrobialDiversityandecology-Environmentsand 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,Deepsea,Hydrothermalvents,Subsurfaces,Permafrostregionetc.Earth microbiome and Human microbiome Project. (7)
Microbiome of the built environment- Microbial interactions with environment, microbialinfluencedcorrosion, microbialenhancedoilrecovery, mineralrecovery, bioremediation of heavy metals and organic pollutants, methane production and consumption (7)
Microbiome characterization- Metagenomics, metaproteomics and metatranscriptomics,culturedependentandcultureindependenttechniques, conventionalandmolecularanalyses, assessmentofmicrobialmetabolicdiversityand activities. (8)
System Biology and Microbial interaction- Approach of system biology in bioremediation, bioremediation with genomics, interaction between community memberswithinmicrobiome,commensalism,syntrophism,interspecieshydrogen transfer etc. Strategies ofbioremediation, Microbialperformance assessment. (9)</td></tr>
<tr><td>TextBooks, and/or reference material</td><td colspan="7">TextBook
BrockBiologyofMicroorganisms-Madigan,Martinko,Bender,BuckleyandStahl- Pearson publisher.
BioremediationandNaturalAttenuation:ProcessFundamentalsandMathematical models- P J J Alvarez and W A Illman- Wiley Interscience.</td></tr>
</table>

	ReferenceBooks EnvironmentalMicrobiology: fromgenomestobiogeochemistry-EugeneL.Madsen-Blackwell Publishing. EnvironmentalMicrobiologyforEngineers- V.Ivanov-CRCPress. EnvironmentalMicrobiology-Maier,PepperandGerba-Elsevier(AcademicPress).

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

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

Department of Biotechnology							
Course Code	Title ofthecourse	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE617	**BIOPHARMACEUTICAL PROCESS DESIGN**	PEL	3	0	0	3	3
Pre-requisites		CourseAssessmentmethods(Continuous(CT)andend assessment(EA))					
		CT+EA					
Course Outcomes	CO1:Tolearnaboutthemanufacturingprocessandfacilitydesignfor biopharmaceutical products CO2:To acquireknowledgeofdetaileddesignofGMPcompliant biopharmaplant CO3:To studythedesignandoptimizationofdownstreamprocessesoftherapeutic protein manufacture in a commercial set up CO4:Tolearnabouttechnologytransfer,regulation,validationandquality assurance of biopharma industry						
Topics Covered	**Manufacturingprocess -** Drugsubstance manufacturing, drugproduct 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 cellculture 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 processdesignforbiopharmaceuticalproductrecovery.Productrecoveryofbiopharmaceutical products from transgenic sources – aqueous two phase extraction[12] **Roleof processdevelopmentgroupandmanufacturinggroupin biopharmaceutical process start up.** [3]						

	Making changes toa biopharmaceutical manufacturing process during development and commercial manufacturing – a case study [2] Biosimilarsandnon-innovatorbiotherapeuticsinIndia–anoverviewofcurrent situation[2] **Fundamental of Quality assurance,** Structure of Quality Management Systems, Responsibility of Management and Training of Personnel, Quality Assurance in Development.[5] **Qualityassurance in manufacturing**, GMP, Process validation for cell culture derived pharmaceutical proteins.Regulation [6]

TextBooks, and/or reference material	**Books** Text Process Scale Bioseparations for the Biopharmaceutical Industry, Abhinav A.Shukla,Mark R. Etzel, ShishirGadam, CRC Press 2. ManufacturingofPharmaceuticalProteins,StefanBehme,Wiley-VCH References PharmaceuticalProductionFacilities:DesignandApplications,GrahamCole, Informa Healthcare Large-scaleMammalianCellCultureTechnology,Lubiniecki,CRCPress

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

Department of Biotechnology							
Course Code	Titleofthe 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		CourseAssessmentmethods(Continuous(CT)andendassessment (EA))					
CellBiology,Molecular Biology and Genetic Engineering		CT+EA					
Course Outcomes		**CO1:**Tounderstandthegeneralorganizationofhumannuclear and mitochondrial genome and know about the salient features and characteristics. **CO2:**Toacquireknowledgethehumangenomeproject anditsimplicationon clinical biology in the post genomic era. **CO3:**Tofamiliarizewithdifferentscientifictechniquesusedforstudying different features of genome. **CO4:**Togetanoverviewaboutdifferentapplicationsofthegenomicbased knowledge.					

	1. Patternsofgenomeorganization(10) 2. Structuralgenomics(2) 3. Functionalgenomics(2) 4. Reversegenetics(2) 5. Genepatenting(2) 6. ElectronicPCR(2) 7. Genomemappingandgenomesequencing(2) 8. Specializeddatabaseinmolecularbiology(2) 9. Humangenomeprojectprogress(2) 10. Genesinhealthanddisease(2) 11. Genomicdisordersandmolecular medicine(2) 12. MinimalcellGenome (2) 13. ProspectsofGenetherapyinHuman (2) 14. Pharmacogenomics(2) 15. Genebank(2) 16. Legalstatusofgenebank (2)
TextBooks, and/or reference material	**Textbook:** 1.T.A.Brown,Genomes, JohnWiley&Sons **ReferenceBooks** Singer.M,andBerg.P,Genesandgenomes,BlackwellScientificPublication, Oxford 1991 Beebe.T,andBurke.T,GeneStructureandTranscription,2nd edition,1992,Oxford Univ Press GlickandPasteurneck, Molecular Biotechnology, PrinciplesandApplicationsof Recombinant DNA technology, ASM Press Strachan&Reed, HumanMolecularGenetics, Garland Science. Cantor&Smith,Genomics,JohnWiley& 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:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Biotechnology							
Course Code	Titleofthe 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		CourseAssessment methods(Continuous(CT)andendassessment (EA))					
		CT+EA					

Course Outcomes	**CO1:** To understand the importance, ethical issues and safety regulations in Biotechnology and Biomedical research. **CO2:** TorealizetheimportanceandbasicsofintellectualpropertyRightsandlaws. **CO3:** Tolearnthe process offiling a patentclaim 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: I**ntroduction; 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 ofethics frombiomedicalpractice 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. Contentsofpatentspecificationand procedurefor obtainingpatents,Geographicalindication, 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) **Regulationsonethicalprinciplesinbiomedicalpractices:**The, Nuremberg code, declaration ofHelsinki; 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)
TextBooks, and/or reference material	Textbook: F.H. Erbisch andK.M.Maredis,Intellectual Property Rightsin 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-Acomprehensivetreatise(Vol.12).Legal economicandethical dimensions VCH. EncyclopaediaofBioethics

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

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

Department of Biotechnology							
Course Code	Title ofthecourse	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE620	**MEDICAL &PHARMACEUTICAL BIOTECHNOLOGY**	PEL	3	0	0	3	3
Pre-requisites		CourseAssessmentmethods(Continuous(CT)andend assessment(EA))					
		CT+EA					
Course Outcomes	**CO1:** To understand the growing landscape of pharmaceutical industry and application of cutting edge advancement of Biotechnology for its growth. **CO2:** Tostudy the recent development and applications in drug design and disease diagnosis. **CO3:** Tolearnthe process ofindustrial productions of biopharmaceuticals.						

Topics Covered	**Introduction-**Biopharmaceuticalsandtheirdevelopment,historicalaspects,general stepsindevelopmentofadrug,sourcesandstrategies(includingrandom,non-random,andrational)ofdiscovering leadcompounds 2 **Drugdesigning** MacromoleculesasTargetsofdrugs:(lipids,carbohydrates,proteins,nucleicacids) 2 Drugtargets:carrierproteins,structuralproteins,enzymes,receptors(including mechanisms–ionchannelsand membrane-boundenzymes)4 Conceptsanddesigncriteriaofagonists,antagonists,partialagonists,andinverse agonists.3 Rationaldrugdesigning,Structure–activityrelationshipsandidentificationof pharmacophoreandauxophoreinaleadcompound;drugdesignonthebasisofdrug-targetinteractions.5 **Diseasediagnosis** PCR,LCRimmunologicalassay,Detectionofgenetic,Neurogeneticdisorders involvingMetabolicandMovementdisorders.Treatment-productsfromrecombinant andnon-recombinantorganisms,Interferons,Antisensetherapy,cellpenetrating 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 ofdiseasebyproteomics. 25 **Production ofpharmaceuticals** Productionofpharmaceuticalsbygeneticallyengineeredcells(hormones, interferons). Microbial transformation for production of important pharmaceuticals (steroids and semi-syntheticantibiotics).Techniquesfordevelopmentofnew generation antibiotics. 15, **Drug delivery**
TextBooks, and/or reference material	Textbooks: 1. AnIntroductionto MedicinalChemistry;GrahamL.Patrick,Oxford Reference Books: 1.TheOrganicChemistryofDrugDesignandDrugAction;RichardB. Silverman, Elsevier

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

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

Department of Biotechnology							
Course Code	Title ofthecourse	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE621	**NANOBIOTECHNOLOGY**	PEL	3	0	0	3	3
Pre-requisites		CourseAssessmentmethods(Continuous(CT)andend assessment(EA))					
		CT+EA					
Course Outcomes	**CO1:**Acquireanideaaboutnanoscalephenomenon **CO2:**Tolearnaboutthebasicinvestigationtoolsforthenanobiotechnology **CO3:**Tolearnaboutbottomup andtop downsynthesisofnanosystems **CO4:**toget comprehensiveunderstandingofapplicationsofnanotechnology in biology						
TopicsCovered	Nanotechnology;introductiontominiaturization.(4) Iinvestigationtools:experimentalmethodsandprobes;basicprinciplesof scanning force microscopy; scanning electron microscopy; transmission electron microscopy. Investigation tools: lithography (8) Nanomaterials:organicandinorganicnanoparticles.Synthesis,assembly,and processing of nanostructures: phenomenon of self-assembly. (6) Molecularself-assemblyandbottomupsynthesisofnanomaterials. (6) Nanoparticlesandcancertherapeutics;nanoparticle-baseddrugdelivery.(6) Nanofiber-basedscaffoldsandtissueengineering;nanodiagnosticsand biosensing. (6) Nanotoxicology.(4) FutureConceptsinNanobiotechnology. (2)						
TextBooks, and/or reference material	Text Book: UnderstandingNanomedicine-AnIntroductoryTextbookbyRobBurgess. RefrencesBooks SpringerHandbookofNanotechnology,byBharatBhushanSpringer 2. Nanobiotechnology:Concepts,ApplicationsandPerspectives,byChristofM. Niemeyer, Chad A. Mirkin, John wiley 3. IntroductiontoNanotechnology,byCharlesP.Poole,FrankJ.Owens, Wiley-Interscience 4. NanofabricationandBiosystems:IntegratingMaterialsScience,Engineering, and Biology, byHarvey 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	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:
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">Titleofthe course</td><td rowspan="2">ProgramCore (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>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: ToelucidatethescopeofAnimalBiotechnology.
CO2: To learn the different areas of Animal Biotechnology applications.
CO3:To learnthebasictechnologyineachareaofAnimalBiotechnology.
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 mediaandgrowthconditions.Celltypeandcharacterization,originofanimalcell line,maintenanceandcharacterizationofdifferentcelllines,Markergene characterization(8)
Technology–Presentandfuture :
Hybridomatechnology/Monoclonalantibodytechnology,Vaccineproduction, Organ culture, Transfection of animal cells, Future tissue engineering (4).
InVitroFertilizationandEmbryoTransfer:
Basic knowledge on Fertilization and embryology, Steps involved in IVF, Fertilizationbymeansofmicro insemination,PZD,ICSI,SUZI,MESA(4)
Stemcells:
Classificationandtypes,Sources,Markers,Differentiationsignals,application, IPSC, Cncer stem cells (4).
GeneTherapy:
Ex-vivogenetherapy,Invivogenetherapy, Viralgenedeliverysystem,
Retrovirus vector system, Adenovirus vector system, Adeno-Associated virusvectorsystem,Herpexsimplexvirusvectorsystem,Non-viralgenedeliverysystem, Prodrug activation therapy, Nucleic acid therapeutic agents (4)
TransgenicandKonckoutAnimals:
Methodology,EmbryonicStemCellmethod,Microinjectionmethod,Retroviral vector method, Applications of transgenic animals
Recombinanatproteinexpressionandpurification:
Expressionvectorsformammalianproteins,Cell(Scerevicea,Ppasturisetc.)for large-scale mammalian protein production, Post translational modification and purification.</td></tr>
</table>

TextBooks, and/or reference material	AnimalCellCulturebyJohnR.W.Masters;OxfordUniversityPress 2. IntroductiontoCellandTissueCulturebyJennieP.MatherandPenelopeE. Roberts; Plenum Press, New York and London MolecularBiotechnology:Primrose. 4. AnimalCellBiotechnology:R.E.SpierandJ.B.Griffiths(1988),Academic press. 5. Balasubramanian, Bryce, Dharmalingam, Green and Jayaraman (Eds.), Concepts in Biotechnology, University Press, 1996 HoodL.E.,WeissmanI.,WoodW.B.andWilsonJ.H.Immunology,Benjamin Cummings,1989 7.BiotolSeries–ButterworthandHeineman,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	Titleofthe 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		CourseAssessment methods(Continuous(CT)andendassessment (EA))					
BTC01 Life Science BTC301CellBiologyand Genetics BTC502CellandTissue Culture		CT+EA					
Course Outcomes		**CO1:**Studentswillbeacquaintedwithbasicplanttissueculturetechniques. **CO2:** Students will be acquainted in basic animal cell culture techniques. **CO3:** Studentswillattainknowledgeofapplicationofcelland tissueculturetechniques in academic and industrial laboratories. **CO4:** Students will have knowledge of biosafety and ethical issues related to cell and tissue culture.					
Topics Covered		**PlantTissueCulture** 1. Preparationandsterilizationofplanttissueculturemedia. 2. Preparationofexplants. 3. Callusinductioninrice. 4. Regenerationofricecallustissue. 5. Rooting ofregnerantsinrice. **AnimalCell Culture** 1. SterilizationTechniques,PreparationofMedia&					

	PreparationofSera 2. PrimaryCellCulture 3. PreparationofestablishedCelllines 4. CellCountingandViability **5.** StainingofAnimalCells&PreservationofCells
TextBooks, and/or reference material	1.Laboratorymanual.

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	Titleofthe 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		CourseAssessment methods(Continuousassessment(CA)andend-term examination (ET))					
Bioseparation&Biochemical Analysis(BTC503)		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 andsubsequent 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 proteinin an aqueous two-phase system **CO5:**To separateout a protein froma mixture bygelfiltration/ion exchange chromatography and to concentrate a protein by ultrafiltration **CO6:**Toextractandestimatebiomoleculessuchaslipids, DNA,&RNA					
Topics Covered		1. Filtration(constantpressurefiltration) 2. Preparationofcell-freeextractsfromculturedcells 3. SaltprecipitationofproteinandDialysis 4. Extractionand estimationoftotallipid content 5. Separation/concentrationofproteinsbyUltrafiltration. 6. Aqueoustwophaseextraction(binodialdiagram) 7. Separationofproteinsbygelpermeation/ion-exchangechromatography 8. Identification of a specific protein presentin the cell-free extract by					

	WesternAnalysis 9. DeterminationofDNAandRNAconcentrationbyUVabsorption **10.** Demonstrationoflyophilization&Rotaryvacuumevaporation
TextBooks, 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,TransportProcesses&Unitoperations,PHI. Reference books: 1. D.Holme&H.Peck,AnalyticalBiochemistry, 3rd ed,Longman, 1998 2. Shuler&Kargi,Bio-processEngg.PHI **3.** Bailey&Olis,BiochemicalEngg.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)

DepartmentofManagement Studies							
Course Code	Titleofthe 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		CourseAssessment methods(Continuousassessment(CA)andend- term examination (ET))					
NIL		CA+ET					
Course Outcomes		**CO1:**Tomakebuddingengineersawareofvariousmanagement functions required for any organization **CO2:**Toimpart knowledgeonvarioustoolsandtechniquesappliedbythe executives of an organization **CO3:**Tomakepotentialengineersawareofmanagerialfunctionsothat it would help for their professional career **CO4:**Toimpartknowledgeonorganizationalactivitiesoperationaland strategic both in nature **CO5:** To impart knowledge on each functional area of management like Marketing,Finance,BehavioralScienceandQuantitativeTechniquesand 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,PlanningandenvironmentalanalysiswithSWOT,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) **UNITIII:**Creatinganddeliveringsuperiorcustomervalue:Basicunderstanding of marketing, Consumer behavior-fundamentals, Segmentation, Targeting & Positioning, Product Life cycle. (8) **UNITIV:**Behavioralmanagementofindividual:Motivation,Leadership, Perception, Learning. (8) **UNIT V:** Professional ethics: Introduction to Professional ethics, Morals, values and Ethics, Ethics in Business. (2)
TextBooks, and/or reference material	Text Books: 1. MarketingManagement 15thEdition,PhilipKotlerandKelvinKeller, Pearson India 3. ManagementPrinciples,Processesandpractice,firstedition,AnilBhatandAryaKumar,OxfordHigher education 4. OrganizationalBehavior,13thedition,StephenPRobbins,Pearson Prentice hall India 5. OperationsManagement,7thedition(Qualitycontrol,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)

Department of Biotechnology							
Course Code	Title ofthecourse	Program Core(PCR)/ Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTC 701	**Data Analytics Biotechnology**	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT)and end assessment (EA))					
Basicknowledgeoftopics Data Structure and Algorithm, DBMS and Engineering Mathematics.		CT+EA					

Course Outcomes	**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.
Topics covered	**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 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)

TextBooks, and/or reference material	**Textbook:** [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. **ReferenceBook:** 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 ofthecourse	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; MolecularBiology and Genetic Engineering;		CT+EA					
Course Outcomes	**CO1:**Students will acquire knowledge on protein structure and function and will beable 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:**Studentswillbeacquaintedwithtoolsandtechniquesforproteinengineeringand 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 proteinand 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]
TextBooks, and/or reference material	Textbooks: 1. R.M.Twyman;PrinciplesofProteomics,BioscientificPublishers. 2. Biotechnology,2ndEdition 2015.DavidClarkandNanette Pazdernik.Academic Cell. ReferenceBooks: 1. B.Alberts,D.Bray, J.Lewis et al, Molecular Biology of the Cell, Garland Pub. N.Y 1983. 2. RichardJ.Simpson,ProteinsandProteomics,I.K.InternationalPvtLtd. 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 ofthecourse	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		CourseAssessmentmethods(Continuous(CT)andend assessment(EA))					
		CT+EA					
Course Outcomes	**CO1:**To learnaboutairpollutionmonitoringandcontrol **CO2:**Tolearnaboutwastewatertreatmentprocessesalongwithanalytical procedures **CO3:**Tostudyaboutsolid wastemanagement **CO4:**Toacquireknowledgeonbioremediationofpollutants						
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 Waterpollution:samplingandanalysis-Sampling,BODandCODanalysis, Bacteriologicalmeasurements,Numericalproblems 5 Waterandwaste- watertreatmentprocesses-Overviewoftreatmentprinciples. Primarytreatment–screening,sedimentation, flotation,neutralizationetc. 4 Secondarytreatment-Activatedsludgeprocess,extendedaeration,Tricklingfilter, Aeratedlagoons,Wastestabilizationponds,Aquaticplantsystems,UASBreactors. Designofacompletemixactivatedsludgeprocess. 8 Biomethanation.Nitrificationanddenitrificationoperations.Phosphorusremoval. Sludgetreatment and disposal.Tertiarytreatment.Membranebasedtreatment						

	processes. 8 Solidwastemanagement,Vermiculture,hazardouswastemanagement 5 Specializedaspects-Bioremediationforrecoveryofmetals,Xenobiotics,Degradation ofchlorinatedhydrocarbons,polyaromatichydrocarbons,Phytoremediation.Reactors inbioremediation. 6
TextBooks, and/or reference material	**Books** Text 1. Introductiontowastewatertreatmentprocesses,Ramalho,Elsevier. 2. EnvironmentalEngineering:AdesignApproach,Sincero,Arcadio.P,Sr. &Greogia; PHI 3. Wastewatertreatmentanddisposal,Arceivala,Wiley 4. EnvironmentalBiotechnology, AlanScragg, OxfordUniversitypress Reference 1. WastewaterEngineering:Treatment,disposal,reuse,byMetcalf& Eddy,Tata Mc Graw Hill IndustrialWaterPollutionControl,Eckenfelder,McGrawHill.

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 ofthecourse	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		CourseAssessmentmethods(Continuous(CT)andendassessment (EA))					
BTC403 Immunology		CT+EA					
Course Outcomes		**CO1:**Tounderstandthe factorsthatinfluencevaccine designanddevelopment **CO2:**Tounderstandhowresearchbaseddiscoveryhasdrivenvaccine development **CO3:**To know aboutthe differenttypesofvaccines **CO4:**Tolearnaboutthequalitycontroland regulation inthevaccineproduction **CO5:**Tounderstand the importanceofvaccinationasa publichealthstrategy					
Topics Covered		Historyofvaccinedevelopment-Importanceofvaccines(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) Productiontechniquesusedforvaccines(4) Storage and preservation of vaccines (4) Deliverymethods: microspheres,nanoparticles;ISCOMSandimmunomodulators(6) Regulatory issuesin vaccine production: OIE guidelines for production and seedlot management; Manufacturing recommendation; Final product release tests (5)Vaccinesafety-thedebate(1)
TextBooks, and/or reference material	Text Books: NewVaccineTechnologies:RonaldW.Ellis(LandesBioscience),2001. Vaccines:StanleyA.Plotkin,WalterA.Orenstein,PaulA.Offit(Elsevier),6th Edition ReferenceBooks: MedicalMicrobiology:SamuelBaron,4th Edition(UniversityofTexas) AdvancesinVaccineTechnologyandDelivery:CherylBarton,EspicomBusiness Intelligence. “Vaccine manual:Theproductionandqualitycontrolofveterinaryvaccinesfor 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	Titleofthe 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		CourseAssessment methods(Continuous(CT)andendassessment (EA))					
Molecular biology & Genetic Engineeering; Biochemistry & Enzyme Technology;Cell biologyand genetics		CT+EA					
Course Outcomes		CO1:Toacquireanunderstandingoftheproteinstructure CO2:Tolearnabouttheprinciplesofprotein foldingandmisfolding CO3:Toobtainacomprehensive ideaofdifferent diseasesrelatedtoprotein misfolding CO4:Developmentofcumulativeunderstandingofproteinfolding, misfolding and diseases to find much-needed cure for the relevant conditions.					

Topics Covered	Basicofproteinmisfoldingrelateddiseases.Thehierarchicalstructureofthe protein. Principles of protein stability and folding. (16) Proteinmisfoldingandaggregation.Proteinqualitycontrol:molecularchaperones, protein degradation, autophagy and aging. (12) PrionDiseases.Alzheimer'sDisease.Parkinson'sDisease.Huntington'sDiseaseand other unstable repeat disorders. Amyotrophic lateral sclerosis and frontotemporallobardegeneration. (14)
Text Books, and/or reference material	Text Books: 1. FundamentalsofNeurodegenerationandProteinMisfoldingDisordersbyMartin Beckerman, Springer Introductionto ProteinStructurebyCarlIVBranden,Routledge StructureandMechanisminProteinScience:AGuidetoEnzymeCatalysisand 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:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Biotechnology							
Course Code	Titleofthe course	ProgramCore (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE 714	**CANCER BIOLOGY AND CELL SIGNALING**	PEL	3	0	0	3	3
Pre-requisites		CourseAssessmentmethods(Continuous(CT)andendassessment (EA))					
BTC301-CellBiologyand Genetics/BT-817-Cancer Biology		CT+EA					
Course Outcomes		**CO1:**Tounderstandthebasicconceptsofcancerbiologyandrelatedcellular signaling **CO2:**Tounderstandthedevelopmentandcausesofcancer. **CO3:**To understand thetherapeuticaspectsofcancerprevention **CO4:**Toidentifythetargetmoleculesthat areassociatedwithcancersothatthe cancer preventive small molecule inhibitors/phytochemicalscan be screened.					
Topics Covered		**CancerBiology** 1. IntroductiontoCancerandMolecular basisofcancer[2] Mutation and DNA damage repair mechanism[2] 2. Cellcycle[3] 3. Oncogenes(tumorviruses),Tumorsuppressors[3] 4. Epigenetics,non-codingRNAsandgenomefluidityincancer[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. Involvementofdifferentsignaltransductionpathwaysduringcanceriniti ation, progression and metastasis [5] **5.** Smallmoleculeinhibitorsofcancer [3]
Text Books, and/or reference material	**TextBooks:** WeinbergRA. TheBiologyofCancer,2ndEdition.GarlandScience,2013. Cellularsignalprocessing,2ndEditionbyFriedrichMarks,Ursula Klingmuller and Karin Muller-Decker, Garland Science **Reference:** Selectedreviewsandprimaryscientificliterature

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
	CO5	1	-	2	2	-	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 Biotechnology							
Course Code	Titleofthe course	Program Core(PCR)/ Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE715	**STEMCELL BIOLOGY**	PEL	3	0	0	3	3
Pre-requisites		CourseAssessmentmethods(Continuous(CT)andendassessment (EA))					
Cell Biology, Biochemistry,Genetics, MolecularBiology		CT+EA					
Course Outcomes	CO1:Tounderstandthebasicmechanismsofhowcellsdifferentiateintospecific tissuesinresponsetoavarietyofbiologicsignalingmoleculesandtheuseofsuch factorsfortissueproduction 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. AnIntroductiontoStemCells(2) 2. AdultStemCells(1) 3. EmbryonicStemCells(1) 4. InducedPluripotentStemCells(1) 5. HematopoieticStemCells(1) 6. Messenchymal stem cells , cord blood cells, Lessons from Medipost company products like Neurostem, Cardiostem, Cartistem, Pneumostem (4) 7. MolecularandCellularBasesofOrganDevelopment(6) 8. Cloning ofSomatic Cells by Nuclear Transfer, iPSC based cloning, Production of chimera animals (4) 9. MolecularBasesofdegenerativedisease(1) 10. Therapeutic UsesofStemCells withexamples (2) 11. InvivoRegenerationofTissuesbyCellTransplantation(2) 12. IPS Cells as Experimental Models of Neurodegenrative Disorders: use of them as disease modelling platform, novel drug testing and tissue reneraravetherapy 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. TissueRegenerationDrivenbyGrowthHormones(2) 15. Organ of dish, Orgnoid culture, Tissue Bioprinting to develop transplantation quality organs, Bioartificial Organs (8) 16. Biobankingofstemcellsandtheethicalconsiderationsinregenerative medicine.(2)
TextBooks, and/or reference material	Text Books: 7. StemCells,TissueEngineeringAndRegenerativeMedicineBy:DavidWarburton 1st Edition. 8. PrinciplesofRegenerativeMedicine byAnthonyAtalaRobert LanzaTonyMikos Robert Nerem , 3rd Edition. 9. TranslationalRegenerativeMedicinebyAnthonyAtalaandJulieG.Allickson ReferenceBooks: 1. TheDevelopingHumanbyKeithL.Moore/T.V.N.Persaud/ MarkG.Tenth edition. 2. EncyclopediaofTissueEngineeringandRegenerativeMedicinebyRuiReis, 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)

<table>
<tr><td colspan="8">Department of Biotechnology</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title ofthecourse</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>BTE716</td><td>PROJECT ENGINEERING FOR 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">CourseAssessmentmethods(Continuous(CT)andend 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:Tolearnaboutdetaileddesignofamanufacturing plant
CO2:Tolearnabout cleaning,sterilization,wastemanagement andutilitiesofa biotechnology production plant
CO3:To studyaboutPlanning,constructionandcommissioningofa biopharmaceutical manufacturing plant
CO4:Tolearnaboutprojectmanagementandfinancialaspectsofthe plant</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Introduction Basic considerations in plant design, project identification, preliminary techno-economic feasibility. Process flow Diagrams and symbols: Symbols ofProcess 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 ofpipes and tubes, connections and cleanability, piping applications, supporting and insulating sanitary tubing, in-line instruments, hoses, valves. [6]
Cleaningofprocessequipment:designandpractice, sterilizationofprocessequipment, pharmaceutical water systems: design and validation, utilities for biotechnology production plant, biowaste decontamination systems, Heating, ventilating & air conditioning (HVAC) [6]
Programming&facilitydesign,projectplanning,containmentregulationsaffectingthe design and operation of biopharmaceutical facilities.[6]

Planning, construction and commissioning of a biopharmaceutical manufacturingplant: planning, construction, commissioning, qualification, validation, project schedules, cost estimates, organization of an engineering project, role & selection of contractors, legal aspects of facility engineering, health, safetyand 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, aspectsof manufacturing out-sourcing, contractual agreements, technology transfer, process optimization after market launch, supply chain management. [3]</td></tr>
</table>

TextBooks, and/or reference material	Text Books: 1. Bioprocessengineering:system,equipmentandfacilities,BKLydersen,NAD'Elia, K M Nelson. Wiley 2. Manufacturingofpharmaceuticalproteins,StefanBehme, wiley Reference Books: 1. Plant designandEconomicsforchemicalengineers,peterM.S.Timmerhaus,K.D. McGraw Hill. ProjectEngineeringwithCPMandPERT,ModesJ.Philips,Rheinholdpublishers.

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)

Department of Biotechnology							
Course Code	Title ofthecourse	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE717	**FOOD BIOTECHNOLOGY**	PER	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT)and end assessment (EA))					
		CT+EA					
Course Outcomes		**CO1:** To quantitate and identify the spoilage microorganisms present in food. **CO2:**Tolearnthe conceptsof food fermentationand increase the shelf life of food. **CO3:**Tolearntheconceptsingeneticallymodifiedfoodandincreasethea gricultural yield by using genetic engineering approach. **CO4:**Toapplytheconceptsofantioxidantandnutraceuticalforhealthan dwellness. **CO5:**Tofollow the regulations and ethical issues of food safety by using good manufacturing practices in industry and genetically modified food.					

Topics Covered	**Foodforhealth and wellness** **[2]** **FoodMicrobiology:** **[6]** Detectionofmicroorganismin food –roleofPCR, DNACHIP,rapid methodsfor identification of microorganism in food,immunological methods, Bioassay, Biosensors-detectionoftoxin,heavymetal,pesticideand herbicides **Foodpreservation** **[10]** Pasteurization,sterilization,Canning,Irradiation,Dehydration,lowtemperature Food preservation, use of preservatives, **Foodfermentation** **[8]** Roleoflacticacidbacteriainfermentationandstrainimprovement,Fermentation ofmeat,fish,vegetables,beverages,dairyproduct,nonbeverageproduct,useof genetic engineering techniques for improved quality product. **Geneticallymodified food** **[6]** Fruitripening,improvementofsweetness,flavor,starch,aminoacid,vitamin content,Goldenrice. Safetyaspects ofgenetically modified food,Single cell protein, single cell oil, Spirulina, **Biotechnologyinrelation to foodproductand FoodSafety** **(5+5)** Antioxidant,nutraceutical,Nutrigenomics Legalstatusofirradiatedfoodandpreservatives,ConceptofHACCP,Hazop, codex alimentarius, ISO series
TextBooks, and/or reference material	TextBook FoodmicrobiologybyJames.M.Jay FoodMicrobiologybyFrazierandWesthoff Plant Biotechnology by Slater ReferenceBook FundamentalsofFoodBiotechnologybyLee

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 ofthecourse	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		CourseAssessmentmethods(Continuous(CT)andend assessment (EA))					
		CT+EA					
Course Outcomes	**CO1:**Toimpartknowledgeoflifescienceand biological data **CO2:**Toacquireknowledgeofcomputationalandmathematicalskills for addressing important biological questions. **CO3:**Tolearnhowtodevelopandimplementcomputationalalgorithms and tools for processing biological data						
Topics Covered	1. IntroductiontoComputationalbiologyanditsapplications(2) 2. Centraldogmaandbiologicalmacromolecules-DNA,RNA&proteins(2) 3. MajorbiologicaldatabasesrelatedtoDNA,RNA,proteins &metabolic pathways(3) 4. Basic fileformats&sequencerepresentation(2) 5. ComputationalalgorithmsforSequenceAlignment:Localandglobal alignment, Sequence similarity, Sequence identity, Gaps, Scoring matrices, pairwise and multiple alignments, Dynamic programming, BLAST & its application,(7) 6. Algorithmsforphylogenetics:Treeconstructions(5) 7. StructuralBioinformatics: A. ProteinStructureandits visualization(2) B. Proteinstructuralalignment(3) C. ProteinsecondaryStructurePrediction(4) D. ProteintertiaryStructurePrediction(4) E. RNAStructurePrediction(3) F. Moleculardockinganddockingalgorithms(3) 7.Applicationofmachinelearninginbiologicalsciences(Basicconcepts)(2)						
TextBooks, and/or reference material	Text Books: 1. Bioinformatics:SequenceandGenomeAnalysisbyDavidWMount, Cold Spring Harbor LaboratoryPress 2. IntroductiontoBioinformaticsbyArthurM Lesk ReferenceBooks: 1. Protein bioinformatics: an algorithmic approach to sequence and structureanalysisbyIngvarEidhammer,IngeJonassenandWilliam R.Taylor. EssentialsofBioinformatics byJinXiong						

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 ofthecourse	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		CourseAssessmentmethods(Continuous(CT)andend assessment (EA))					
NIL		CT+EA					
Course Outcomes	**CO1:** To quantitateand identify the spoilage microorganisms present infood. **CO2:**Tolearn the concepts of food fermentationand increase the shelf life of food. **CO3:**Tolearntheconceptsingeneticallymodifiedfoodandincreasetheagricultural yield by using genetic engineering approach. **CO4:**Toapplytheconceptsofantioxidantandnutraceuticalforhealthandwellness. **CO5:**To follow the regulations and ethical issues of food safetyby using good manufacturing practices in industryandgenetically modified food.						
Topics Covered	**FoodMicrobiology:** [8] Microorganisminfood,Intrinsicandextrinsic parametersoffood,rapid methods for identificationofmicroorganismin food,Foodborne illness, Biosensors –use and application **Foodpreservation**[8] : Pasteurization,sterilization,Canning,thermalprocessoffoodwithnumerical, Irradiation, Dehydration, low temperature,use of preservatives **Foodfermentation**[10]: Role of lactic acid bacteria in fermentation and strain improvement, Fermentationofmeat,fish,vegetables,beverages,dairyproduct,non-beverage product, use of genetic engineering techniques for improved quality product. **Geneticallymodified food** [8] : Fruit ripening, amino acid, vitamincontent,Goldenrice. Safetyaspectsof genetically modified food, Ethical and regulatory issues **Biotechnologyinrelation to foodproduct**[4] :Antioxidant,nutraceutical, **Foodsafety** [6] : Legalstatusofirradiatedfoodandpreservatives,ConceptofHACCP,Hazop, codexalimentarius, ISOseries, detectionoftoxin, heavymetal, pesticideand 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)

<table>
<tr><td colspan="9">Department of Biotechnology</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title ofthecourse</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>BTO742</td><td>MINERAL 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="7">Course Assessment methods (Continuous (CT)and end assessment (EA))</td></tr>
<tr><td colspan="2">NIL</td><td colspan="7">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">CO1: To understand the nature and characteristics of different biogeochemicalcyclesandinvolvementimportantmicro-organisms.
CO2:Tolearnthebasicconceptsofbioleachingand biobeneficiation alongwiththemicrobiologicalaspects
CO3:Togainthedetailknowledgebioleachingprocesseswithexamples.
CO4:Todemonstrateandprovideexamplesonhowto usemicrobesfor the environmental pollution control</td></tr>
<tr><td>Topics Covered</td><td colspan="8">Module-I:Introductionto Biotechnology appliedto Raw Materialprocessing,Biogeochemicalreactions–chemicalmechanismsandcontrollingfactors,Microbialinterventions,NatureandcharacteristicsofBiogeochemicallyimportantmicro-organisms. 10
Module-II: Kineticsofbioleaching;Applicationsofbiogeochemicalprocessinminingand metallurgy,dump,heapand in-situ leaching.8
Module-III:Reactormodelingforleaching,Beneficiationoforedandprocessresidues:recoveryofgold,silver,copper,beneficiationofsulfidictailingsfromtinprocessing;purificationofferroginoussand. 8
Module-IV:Beneficiationofbauxite,applicationsofsulphatereducingbacteria;applicationsofsulphatereducingbacteria,Environmentalpollutioncontrol:accumulationofmetals bymicrobialcells. 8</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="8">Books:
1. H.D.KumarandS.Kumar,ModernConceptsofMicrobiology,Vikas Publishing House , 2nd Edition , 2001
2. M.E. Curtin , Microbial mining and metalrecovery biotechnology(1) , pp 229-235, 1983
3. WoodsD,RawlingD.E.,BacterialbleachingandbiominingJ.L.(ed),Revolution inbiotechnology, CambridgeUniversityPress.</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
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:
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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">CourseAssessmentmethods(Continuous(CT)andend 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 provideanunderstandingaboutInbornerrorsofmetabolismand genetic disorders and their consequence.
CO2:Abletoanalyzethekeyfeaturestherapeuticsanddrugsincurrent scenario.
CO3:Ableto applytheknowledgeforcommercialproductionof pharmaceuticals and place it in market for marketing approvals.
CO4:Abletounderstandtheethicalissuesandthedifferentcompetent regulatoryauthorities globallyassociated with clinicalBiotechnology.</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.
DiagnosisofInfectiousdiseases: BiologyofNitricoxide implicationsindiagnosis and therapeutics, Ethicalproblems around prenatal diagnosis, in vitro fertilization, cloning, gene therapy.
DrugDesign and Drug delivery system: Synthesis of compounds in accordance withthemolecularstructureandbiologicalactivityconcept.Variousprinciples/mode of drug action/ screening of drugs/ drug analysis using various techniques . New generationviralvectorsforGeneTherapyandadvancement inDrugDeliverysystem, antibody mediated drug delivery of vaccines, Antibiotics
MolecularMedicine:Antibodiesandvaccines-Therapeuticproductionofantibodies different kind of vaccines and applications of recombinant vaccines.Ribozymes for therapeutic use in viral infection.
Cellandtissuetherapy–Genetherapy,tissueengineering,stemcellandcloning.
Invivotargetedgenedelivery
ClinicalToxicology,ClinicalResearchGovernanceandEthics:Basic concept in toxicology. Types and mechanism of toxin action- Epoxidation& drugtoxicity,Overviewonregulatoryaffairsforpharmaceuticals, neutraceuticalsand medical devices. International quality standard and related guidelines (ICH-</td></tr>
</table>

	E6).Riskassessment andtrialmonitoring.Legalandethicalissuesonbiotechnology, medical research and related clinical practice.
TextBooks, and/or reference material	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,PharmaceuticalBiotechnology,CBSPublishers 4. CedricAandMimS. etal.:MedicalMicrobiology, MosbyUSA **ReferenceBooks** 1. PharmaceuticalBiotechnology;Sambhamurthy&Kar,NewAge Publishers 2. Epenetos A.A.(ed), Monoclonal antibodies: applications in clinical oncology, Chapman and Hall Medical, London 3. V.Venkatesharalu-BiopharmaceuticsandPharmacokinetics-PharmaBooks 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 ofthecourse	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		CourseAssessment methods(Continuous(CT)andendassessment (EA))					
NIL		CT+EA					
Course Outcomes		**CO1:**To learn the experimental protocol of microbial growth and inhibition kinetics in a batch process **CO2:**Tostudysubstratedegradation,cellgrowthandproduct formationwith immobilized cells in plug flow bioreactors. **CO3:**To learnabout functionsofafermenter **CO4:**Tostudynon-idealityinaplugflowreactor					

Topics Covered	1. Microbialcellgrowthkinetics 2. Microbialcellinhibitionkinetics 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. Functionofbioreactor-a)calibrationofDOelectrode.b)CalibrationofpH electrode. 6. RTDstudiesinapackedbed 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

Correlation levels 1, 2 or 3 as defined below:

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