

**RAJALAKSHMI ENGINEERING COLLEGE  
DEPARTMENT OF BIOTECHNOLOGY  
CURRICULUM AND SYLLABUS REGULATIONS – 2023  
B.TECH –BIOTECHNOLOGY  
CHOICE BASED CREDIT SYSTEM**

**RAJALAKSHMI ENGINEERING COLLEGE**  
(An Autonomous Institution Affiliated to Anna University Chennai)  
**DEPARTMENT OF BIOTECHNOLOGY**  
**CURRICULUM AND SYLLABUS REGULATIONS – 2023**  
**B. TECH –BIOTECHNOLOGY**  
**CHOICE BASED CREDIT SYSTEM**

**VISION OF THE INSTITUTION**

To be an institution of excellence in Engineering, Technology and Management Education & Research.

To provide competent and ethical professionals with a concern for society.

**MISSION OF THE INSTITUTION**

To impart quality technical education imbued with proficiency and humane values

To provide right ambience and opportunities for the students to develop into creative, talented and globally competent professionals

To promote research and development in technology and management for the benefit of the society

**VISION OF THE DEPARTMENT**

To be a department of academic excellence focused on education, research and development and to conquer the frontiers of biotechnology, benefitting the society.

**MISSION OF THE DEPARTMENT**

- To impart quality technical education
- To continuously enhance and enrich the teaching / learning process
- To provide an ambience for overall development of the students to be more creative, innovative and globally competent ethical professionals
- To promote research and develop technologies and products for the sustenance and wellbeing of the society

**PROGRAM EDUCATIONAL OBJECTIVES**

**This program enables Biotechnology graduates**

- I.** To apply knowledge across the disciplines and in emerging areas of biotechnology for higher studies, research, employability and product development
- II.** To develop communication skills, sense of responsibility to protect the environment and ethical conduct towards their profession and commitment to serve the society
- III.** To possess academic excellence, managerial skills, leadership qualities and understand the need for lifelong learning for a successful professional career

**PROGRAM OUTCOMES**

1. **Engineering Knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems
2. **Problem Analysis:** Identify, formulate, review research literature, and analyse complex engineering

problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences.

3. **Design and Development of Solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal and environmental considerations.
4. **Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data and synthesis of the information to provide valid conclusions.
5. **Modern Tool Usage:** Create, select and apply appropriate techniques, resources and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **The Engineer and Society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and Sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and the need for sustainable development.
8. **Ethics:** Apply the ethical principles and commit to professional ethics and responsibilities and norms of engineering practices.
9. **Individual and Team Work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication:** Communicate effectively in complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations and give and receive clear instructions.
11. **Project Management and Finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and a leader in a team, to manage projects and in multidisciplinary environments.
12. **Life-long Learning:** Recognise the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

### **PROGRAM SPECIFIC OUTCOMES**

1. To apply the knowledge and solve problems through clinical research and improve health related issues of the society
2. To design, develop processes and bioproducts for health care
3. Apply basic skills in Engineering to promote interdisciplinary research in Biotechnology

**CURRICULUM****SEMESTER – I**

Sl. No	COURSE CODE	COURSE TITLE	L	T	P	Total Hours	Total Credits	Category
<b>THEORY &amp; PRACTICALS</b>								
1	HS23111	Technical Communication I	2	0	0	2	2	HS
2	MA23112	Algebra and Calculus	3	1	0	4	4	BS
3	CY23132	Chemistry for Technologists	3	0	2	5	4	BS
4	GE23111	Engineering Graphics	2	0	4	6	4	ES
5	GE23121	Engineering Practices - Civil and Mechanical	0	0	2	2	1	ES
6	BT23131	Microbiology	2	0	4	6	4	PC
7	MC23112	Environmental Science and Engineering	3	0	0	3	0	MC
8	GE23117	தமிழர்மரபு /Heritage of Tamils	1	0	0	1	1	HS
<b>TOTAL</b>			<b>16</b>	<b>3</b>	<b>12</b>	<b>31</b>	<b>20</b>	

**SEMESTER – II**

Sl. No	COURSE CODE	COURSE TITLE	L	T	P	Total Hours	Total Credits	Category
<b>THEORY &amp; PRACTICALS</b>								
1	HS23221	Technical Communication II	0	0	2	2	1	HS
	HS23222	English for Professional Competence						
2	MA23212	Differential Equations and Complex Variables	3	1	0	4	4	BS
3	PH23231	Physics for Bioscience	3	0	2	5	4	BS
4	GE23231	Programming using Python	1	0	4	5	3	ES
	GE23212	Basic Civil and Mechanical Engineering	3	0	0	3	3	ES
5	BT23211	Biochemistry	3	0	0	3	3	PC
6	MC23111	Indian Constitution and Freedom Movement	3	0	0	3	0	MC
7	GE23217	தமிழரும் தொழில்நுட்பமும் /Tamils and Technology	1	0	0	1	1	HS
8	BT23221	Biochemistry Laboratory	0	0	4	4	2	PC
<b>TOTAL</b>			<b>17</b>	<b>1</b>	<b>12</b>	<b>30</b>	<b>21</b>	

**SEMESTER –III**

Sl. No	COURSE CODE	COURSE TITLE	L	T	P	Total Hours	Total Credits	Category
<b>THEORY &amp; PRACTICALS</b>								
1	MA23311	Transforms and Applied Partial Differential Equations	3	1	0	4	4	BS
2	BT23311	Enzyme Technology and Biotransformations	3	0	0	3	3	PC
3	BT23312	Stoichiometry and Fluid Mechanics	3	1	0	4	3	ES
4	BT23313	Molecular Genetics	3	0	0	3	3	PC
5	BT23314	Cell Biology	3	0	0	3	3	PC
6	BT23321	Basic Food and Enzyme Technology Laboratory	0	0	2	2	1	ES
7	BT23331	Analytical Techniques in Biotechnology	2	0	2	4	3	ES
<b>TOTAL</b>			<b>17</b>	<b>2</b>	<b>4</b>	<b>23</b>	<b>20</b>	

**SEMESTER –IV**

Sl. No	COURSE CODE	COURSE TITLE	L	T	P	Total Hours	Total Credits	Category
<b>THEORY</b>								
1	MA23431	Probability, Statistics and Reliability	3	0	2	5	4	BS
2	BT23411	Food Biotechnology	3	0	0	3	3	ES
3	BT23412	Genetic Engineering	3	0	0	3	3	PC
4	BT23413	Thermodynamics and Heat transfer	3	1	0	4	3	ES
5	BT23414	Basic Industrial Biotechnology	3	0	0	3	3	PC
<b>PRACTICALS</b>								
6	CS23422	Python Programming for Machine Learning	0	0	4	4	2	ES
7	BT23421	Chemical Engineering Laboratory for Biotechnologists	0	0	4	4	2	ES
8	BT23422	Molecular Biology and Genetic Engineering Laboratory	0	0	4	4	2	PC
9	GE23421	Soft skills - I	0	0	2	2	1	EEC
<b>TOTAL</b>			<b>15</b>	<b>1</b>	<b>16</b>	<b>32</b>	<b>23</b>	

**SEMESTER – V**

Sl. No	COURSE CODE	COURSE TITLE	L	T	P	Total Hours	Total Credits	Category
<b>THEORY</b>								
1	BT23511	Bioprocess Principles	3	0	0	3	3	PC
2	BT23512	Bioinformatics	3	0	0	3	3	PC
3	BT23513	Separation Process Principles	3	1	0	4	3	ES
4	BT23514	Immunology	3	0	0	3	3	PC
5		Professional Elective I	3	0	0	3	3	PE
<b>PRACTICALS</b>								
6	BT23521	Bioprocess Laboratory- I	0	0	4	4	2	PC
7	BT23522	Bioinformatics Laboratory	0	0	4	4	2	PC
8	BT23523	Immunology Laboratory	0	0	4	4	2	PC
9	GE23521	Soft Skills-II	0	0	2	2	1	EEC
<b>TOTAL</b>			<b>15</b>	<b>1</b>	<b>14</b>	<b>30</b>	<b>22</b>	

**SEMESTER – VI**

Sl. No	COURSE CODE	COURSE TITLE	L	T	P	Total Hours	Total Credits	Category
<b>THEORY</b>								
1	BT23611	Bioprocess Technology	3	0	0	3	3	PC
2	BT23612	Chemical Reaction Engineering	3	0	0	3	3	ES
3		Professional Elective II	3	0	0	3	3	PE
4		Professional Elective III	3	0	0	3	3	PE
5		Professional Elective IV	3	0	0	3	3	PE
6		Open Elective I	3	0	0	3	3	OE
<b>PRACTICALS</b>								
7	BT23621	Bioprocess Laboratory II	0	0	4	4	2	PC
8	BT23622	Numerical Programming for Biotechnologists	0	0	2	2	1	PC
9	GE23621	Problem Solving Techniques	0	0	2	2	1	EEC
10	GE23627	Design Thinking and Innovation	0	0	4	4	2	EEC
<b>TOTAL</b>			<b>18</b>	<b>0</b>	<b>12</b>	<b>30</b>	<b>24</b>	

**SEMESTER – VII**

Sl. No	COURSE CODE	COURSE TITLE	L	T	P	Total Hours	Total Credits	Category
<b>THEORY</b>								
1	BT23711	Downstream Processing	3	0	0	3	3	PC
2	BT23712	Protein Engineering	3	0	0	3	3	PC
3	BT23713	Comprehension in Biotechnology	2	0	0	2	2	PC
4		Professional Elective V	3	0	0	3	3	PE
5		Professional Elective VI	3	0	0	3	3	PE
6		Open Elective II	3	0	0	3	3	OE
<b>PRACTICALS</b>								
7	BT23721	Downstream Processing Laboratory	0	0	4	4	2	PC
8	BT23722	Artificial Intelligence and Machine Learning for Biotechnologist	0	0	4	4	2	PC
9	BT23723	Internship	0	0	0	0	1	EEC
10	EC23527	Microfluidics Laboratory	0	0	2	2	1	ES
<b>TOTAL</b>			<b>17</b>	<b>0</b>	<b>10</b>	<b>27</b>	<b>23</b>	

**SEMESTER – VIII**

Sl. No	COURSE CODE	COURSE TITLE	L	T	P	Total Hours	Total Credits	Category
<b>PRACTICALS</b>								
1	BT23821	Project Work	0	0	24	24	12	EEC
<b>TOTAL</b>					<b>24</b>	<b>24</b>	<b>12</b>	

**TOTAL CREDITS: 165**

**PROFESSIONAL ELECTIVE VERTICAL LIST**

<b>VERTICAL I</b>	<b>VERTICAL II</b>	<b>VERTICAL III</b>	<b>VERTICAL IV</b>	<b>VERTICAL V</b>	<b>VERTICAL VI</b>
Bioprocess & Biochemical Technology	Biosciences	Medical Biotechnology	Animal Biotechnology	Computational Biotechnology	Plant and Marine Biotechnology
BT23A11 Bioprocess Control and Instrumentation	BT23B11 Bioentrepreneurship and Patent Design	BT23C11 Human Genetics	BT23D11 Fundamentals and Applications of Animal Cell Culture	BT23E11 R for Bioinformatics Applications	BT23F11 Fundamentals of Plant Biotechnology
BT23A12 Bioprocess Economics and Plant Design	BT23B12 Fundamentals of Nano Biotechnology	BT23C12 Cancer Biology	BT23D12 Advanced Animal Cell Culture and Industrial Biotechnology	BT23E12 Computer Aided Drug Design	BT23F12 Therapeutic Applications of Phytochemicals
BT23A13 Bioreactor Consideration for Recombinant products	BT23B13 Biomaterial Engineering	BT23C13 Biopharmaceutical Technology	BT23D13 Techniques in Animal Disease Management and Transgenic Technology	BT23E13 Molecular Modeling	BT23F13 Marine Biotechnology
BT23A14 Advances in Bioenergy and Biofuels	BT23B14 Genome Editing	BT23C14 Clinical Biochemistry	BT23D14 Molecular Pathogenesis	BT23E14 Fundamentals of Algorithms for Bioinformatics	BT23F14 Biofertilizer Production and Mushroom Cultivation
BT23A15 Biosensor Technology	BT23B15 GlycoBiology	BT23C15 Free Radicals in Health and Diseases	BT23D15 Immunotechnology	BT23E15 Metabolomics and Metabolic Engineering	BT23F15 Plant Tissue Culture and Transformation Techniques
BT23A16 Environmental Biotechnology	BT23B16 Neurobiology and Cognitive Sciences	BT23C16 Medical Microbiology	BT23D16 Stem Cell and Regenerative Medicine	BT23E16 Data Mining and Machine Learning Techniques for Bioinformatics	<b>ME23712</b> Total Quality Management



## SUMMARY

S.NO.	SUBJECT AREA	CREDITS PER SEMESTER								CREDITS TOTAL
		I	II	III	IV	V	VI	VII	VIII	
1.	HS	3	2							5
2.	BS	8	8	4	4					24
3.	ES	5	6	7	10	3	3	1		35
4.	PC	4	5	9	8	15	6	12		59
5.	PE					3	9	6		18
6.	OE						3	3		6
7.	EEC				1	1	3	1	12	18
8	MC	*	*							
<b>Total</b>		<b>20</b>	<b>21</b>	<b>20</b>	<b>23</b>	<b>22</b>	<b>24</b>	<b>23</b>	<b>12</b>	<b>165</b>

Subject Code	Subject Name (Theory course)	Category	L	T	P	C
HS23111	TECHNICAL COMMUNICATION I	Theory	2	0	0	2
<b>Common to all branches of B.E/B. Tech programmes – First Semester</b>						

Objectives:
<ul style="list-style-type: none"> <li>• To facilitate students, develop their comprehension skills</li> <li>• To enable students to improve their receptive skills</li> <li>• To equip learners with better vocabulary and enhance their writing skills</li> <li>• To aid students speak effectively in all kinds of communicative contexts.</li> <li>• To improve the learners' basic proficiency in workplace communication</li> </ul>

<b>UNIT-I</b>	<b>DEVELOPING COMPREHENSION SKILLS</b>	6
<b>Listening:</b> Introduction to Informational listening – Listening to Podcasts, News <b>Reading:</b> Intentional Reading - Short Narratives and Passages. <b>Speaking:</b> Introducing Oneself, Narrating a Story / Incident. <b>Writing:</b> Sequential Writing – connecting ideas using transitional words (Jumbled Sentences), Process Description <b>Grammar:</b> Verbs – Main & Auxiliary: Simple Tenses – Form, Function and Meaning. <b>Vocabulary:</b> Word formation – Prefix, Suffix, Compound Words.		
<b>UNIT-II</b>	<b>LISTENING AND EXTENDED READING</b>	6
<b>Listening:</b> Deep Listening – Listening to Talk Shows and Debates <b>Reading:</b> In-depth Reading - Scanning Passages <b>Speaking:</b> Describing Current Issues, Happenings, etc., <b>Writing:</b> Note Making, Note Taking – Paragraph Writing <b>Grammar:</b> Continuous Tenses, Prepositions, Articles <b>Vocabulary:</b> One Word Substitutes, Phrasal Verbs.		
<b>UNIT-III</b>	<b>FORMAL WRITING AND VERBAL ABILITY</b>	6
<b>Listening:</b> Listening to Lectures and Taking Notes <b>Reading:</b> Interpretation of Tables, Charts and Graphs <b>Speaking:</b> SWOT Analysis on Oneself <b>Writing:</b> Formal Letter Writing and Email Writing <b>Grammar:</b> Perfect Tenses, Phrases and Clauses, Discourse Markers <b>Vocabulary:</b> Verbal Analogy / Cloze Exercise		
<b>UNIT-IV</b>	<b>ENHANCING SPEAKING ABILITY</b>	6
<b>Listening:</b> Listening to eminent voices of one's interest (Martin Luther King, APJ Abdul Kalam, etc.) <b>Reading:</b> Timed Reading, Filling KWL Chart. <b>Speaking:</b> Just a Minute, Impromptu <b>Writing:</b> Check-list, Instructions.		

<b>Grammar:</b> 'Wh' Questions / 'Yes' or 'No' Questions, Imperatives	
<b>Vocabulary:</b> Synonyms, Antonyms, Different forms of the same words.	
<b>UNIT-V</b>	<b>LANGUAGE FOR WORKPLACE</b>
6	
<b>Listening:</b> Extensive Listening (Audio books, rendering of poems, etc.)	
<b>Reading:</b> Extensive reading (Jigsaw Reading, Short Stories, Novels)	
<b>Speaking:</b> Short Presentations on Technical Topics	
<b>Writing:</b> Recommendations, Essay Writing	
<b>Grammar:</b> Impersonal Passive, Reported Speech, Concord	
<b>Vocabulary:</b> Informal Vocabulary and Formal Substitutes	
<b>Total Contact Hours: 30</b>	

<b>Course Outcomes: On completion of the course students will be able to</b>
<ul style="list-style-type: none"> <li>● Apply their comprehension skills and interpret different contents effortlessly</li> <li>● Read and comprehend various texts and audio-visual contents</li> <li>● Infer data from graphs and charts and communicate it efficiently in varied contexts</li> <li>● Participate effectively in diverse speaking situations</li> <li>● To present, discuss and coordinate with their peers in workplace using their language skills</li> </ul>

<b>SUGGESTED ACTIVITIES</b>
<ul style="list-style-type: none"> <li>● Ice breaker</li> <li>● Just A Minute</li> <li>● Ship wreck</li> <li>● Hot seat</li> <li>● Vocabulary building</li> <li>● Chinese whispers</li> <li>● Case study</li> </ul>
<b>SUGGESTED EVALUATION METHODS</b>
<ul style="list-style-type: none"> <li>● Assignment topics</li> <li>● Quizzes</li> <li>● Class Presentation/Discussion</li> <li>● Continuous Assessment Tests</li> </ul>

<b>Text Book(s):</b>
1. Effective Technical Communication by M. Ashraf Rizvi (Author) 2nd Edition Paperback 2017
2. Sylvan Barnet and Hugo Bedau, 'Critical Thinking Reading and Writing', Bedford/St. Martin's: Fifth Edition (June 28, 2004)
3. Meenakshi Upadhyay, Arun Sharma – Verbal Ability and Reading Comprehension.
4. Teaching Speaking: A Holistic Approach, Book by Anne Burns and Christine ChuenMeng Goh, Cambridge University Press

<b>Reference Books(s) / Web links:</b>
1. Basic Vocabulary in Use: 60 Units of Vocabulary Practice in North American English with Answers 2nd Edition by Michael McCarthy (Author), Felicity O'Dell (Author), John D. Bunting (Contributor)
2. Reading Development and Difficulties By Kate Cain
3. The 7 Habits of Highly Effective People by Stephen Covey, Simon and Schuster, UK
4. Everybody Writes: Your Go-To Guide to Creating Ridiculously Good Content Hardcover by Ann Handley (Author)

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
HS23111.1	-	-	-	1	-	-	-	-	-	3	-	-	-	-	-
HS23111.2	-	-	-	1	-	-	-	-	-	3	-	-	-	-	-
HS23111.3	-	1	-	1	-	-	-	-	-	3	-	-	-	-	-
HS23111.4	-	-	-	2	-	-	-	-	1	3	-	-	-	-	-
HS23111.5	-	-	-	1	-	-	-	-	1	3	-	-	-	-	-
Average	-	1	-	1.2	-	-	-	-	1	3	-	-	-	-	-

Course Code	Course Title	Category	L	T	P	C
MA23112	ALGEBRA AND CALCULUS	BS	3	1	0	4
Common to I sem. B.E. - AERO, AUTO, MECH, MCT, R&A, CIVIL and B.Tech. - BT, FT & CHEM						

### Objectives:

- To introduce the matrix techniques and to illustrate the nature of the matrix.
- To address data and synthesis of the information to provide valid conclusions.
- To explain techniques of calculus which are applied in the solutions of engineering problems.
- To analyse special types of integrals by analytical methods and numerical techniques.
- To practice the techniques of Integration in finding area and volumes.

<b>UNIT-I</b>	<b>MATRICES</b>	12
Matrices - Eigenvalues and eigenvectors - Diagonalization of matrices using orthogonal transformation - Cayley-Hamilton Theorem (without proof) -Quadratic forms- Reduction to canonical form using orthogonal transformation- Numerical computation of Eigen value using Power method		
<b>UNIT-II</b>	<b>FUNCTIONS OF SEVERAL VARIABLES</b>	12
Partial differentiation–Total derivative–Change of variables–Jacobians–Partial differentiation of implicit functions– Taylor’s series for functions of two variables–Maxima and minima of functions of two variables–Lagrange’s method of undetermined multipliers.		
<b>UNIT-III</b>	<b>INTEGRAL CALCULUS</b>	12
Integral Calculus: Definite Integrals as a limit of sums - Applications of integration to area, volume - Improper integrals: Beta and Gamma integrals - Numerical computation of integrals: Trapezoidal rule - Gaussian Two point quadrature		
<b>UNIT-IV</b>	<b>MULTIPLE INTEGRALS</b>	12
Double integrals – Change of order of integration – Area enclosed by plane curves–Triple integrals–Volume of solids– Numerical computation of double integrals: Trapezoidal rule.		
<b>UNIT-V</b>	<b>REGRESSION</b>	12
Scatter diagram - Karl Pearson coefficient of correlation for raw data –Spearman rank correlation coefficient - Lines of regression - Regression equation X on Y and Y on X- Curve fitting by Principle of least squares - Fitting a straight-line $y = ax+b$ and a parabola $y = ax^2 + bx + c$ .		
<b>Total Contact Hours:60</b>		

### Course Outcomes:

On completion of the course students will be able to

- Demonstrate the matrix techniques in solving the related problems in engineering and technology.
- Analyse and interpret data, and synthesize information to provide valid conclusions.
- Interpret the problems in Engineering and Technology using the principles of mathematical calculus.
- Apply the analytical methods and numerical techniques to solve the related engineering problems.
- Evaluate multiple integrals to conduct investigations of complex problems.

### SUGGESTED ACTIVITIES

- Problem solving sessions
- Activity Based Learning
- Implementation of small module

### SUGGESTED EVALUATION METHODS

- Problem solving in Tutorial sessions
- Assignment problems
- Quizzes and class test
- Discussion in classroom

### Text Book(s):

1.	Grewal B.S., “Higher Engineering Mathematics”, Khanna Publishers, New Delhi, 43rd Edition, 2014.
2.	Gupta S.C. and Kapoor V.K.”Fundamentals of Mathematical Statistics”, Sultan and Sons 10 <sup>th</sup> Edition,2000.
3.	T Veerarajan, Engineering Mathematics –I, Mc Graw Hill Education, 2018.
4.	I.R. Miller, J.E. Freund and R. Johnson, ”Probability and Statistics for Engineers “,4th Edition, Pearson,

	2018.
5.	A. Goon, M. Gupta and B.Dasgupta , ”Fundamentals of Statistics “,Vol. I & Vol. II, World Press, 2019.

Reference Books(s) / Web links:	
1.	Ramana. B.V., " Higher Engineering Mathematics ", McGraw Hill Education Pvt. Ltd, New Delhi, 2018.
2.	T Veerarajan, Fundamentals of Mathematical Statistics , yesdee publications, 2017.
3.	Erwin Kreyszig , " Advanced Engineering Mathematics " , John Wiley and Sons, 10th Edition, New Delhi, 2016
4.	Bali, N.P. and Manish Goyal, A Text Book of Engineering Mathematics, Lakshmi Publications Pvt. Ltd., New Delhi, 2006.
5.	N. Draper & H. Smith, ”Applied Regression Analysis” III edition, Wiley, 1998.

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
MA23112.1	3	2	1	-	-	-	-	-	-	-	1	-	-	-	-
MA23112.2	3	2	-	1	-	-	-	-	-	-	1	1	1	-	-
MA23112.3	2	2	-	-	-	-	-	-	-	-	1	1	-	-	-
MA23112.4	3	3	1	-	-	-	-	-	-	-	1	1	1	1	-
MA23112.5	2	2	-	-	-	-	-	-	-	-	-	-	1	1	-
Average	2.6	2.2	1	1	-	-	-	-	-	-	1	1	1	1	-

Subject Code	Subject Name	Category	L	T	P	C
CY23132	CHEMISTRY FOR TECHNOLOGISTS	BS	3	0	2	4
<b>Common to B.TECH. - CHEMICAL ENGG., FT &amp; BT</b>						
<b>Course Objectives:</b>						
● To acquire knowledge on surface chemistry for industrial and domestic uses.						
● To impart the knowledge on principles of electrochemistry for engineering applications.						
● To provide an insight into the latest nanotechnology to pursue further research.						
● To appreciate the need for and importance of polymer materials and heterocyclic compounds.						
● To enhance the knowledge in line with the modern techniques for material analysis.						

<b>UNIT-I</b>	<b>SURFACE CHEMISTRY</b>	<b>9</b>
Introduction – Adsorption- difference between adsorption and absorption - types of adsorptions - Factors influencing adsorption - Adsorption from solutions- Types of adsorption isotherms - Freundlich adsorption isotherm - Langmuir adsorption isotherm - Industrial applications of adsorption – Adsorption Chromatography - Role of adsorption in Catalysis - Enzyme catalysis-Michael’s Menten equation.		
<b>UNIT-II</b>	<b>ELECTROCHEMISTRY</b>	<b>9</b>
Terminology involved in electrochemistry – Types of Cells - Galvanic and concentration cells- Derivation of Nernst equation - Applications of Electrochemical series - Types of Electrodes - Hydrogen, Calomel, ion-selective electrode - Determination of pH using glass electrode - Determination of electrode potentials - Conductometric titrations - Potentiometric Titration-Redox titration.		
<b>UNIT-III</b>	<b>NANO CHEMISTRY</b>	<b>9</b>
Basic Definitions - Distinction between nanoparticles and bulk materials - size-dependent properties - Mechanical, Chemical, Optical, Electrical and Magnetic properties – Nanoparticles - nanoclusters, nanorods, nanotubes and nanowires - Synthesis of nanoparticles - Precipitation method - Hydrothermal synthesis - Solvothermal synthesis - Sonochemical synthesis - Chemical vapor deposition – Electrodeposition - biogenic synthesis - Applications of nanomaterials.		
<b>UNIT-IV</b>	<b>POLYMERS AND HETEROCYCLES</b>	<b>9</b>
Polymers – Introduction - Polymerization - Types of Polymerizations - Condensation, Addition, Coordination, Copolymerization - Mechanism of Polymerization - Free Radical Mechanism - Biopolymers - PLA and PHB -		

Synthesis properties and applications. Heterocyclic compounds - Synthesis and electrophilic and nucleophilic substitution reactions of pyrrole - furan - thiophene- pyridine- quinoline - isoquinoline.	
<b>UNIT-V</b>	<b>ANALYTICAL TECHNIQUES</b>
Electromagnetic spectrum - absorption of radiation - electronic, vibrational and rotational transitions - Thermal methods of analysis - TGA, DTA – Principle, instrumentation and applications - Spectro Analytical methods - Colorimetry, IR, UV-visible spectroscopy - Principles instrumentation and applications.	
<b>Total Contact Hours:45</b>	

<b>Description of the Experiments</b>		<b>Total Contact Hours:30</b>
1.	Construction and determination of EMF of simple electrochemical cells and concentration cells	
2.	Estimation of acids by pH metry	
3.	Determination of corrosion rate on mild steel by weight loss method	
4.	Estimation of mixture of acids by conductometry	
5.	Estimation of extent of corrosion of iron pieces by potentiometry	
6.	Estimation of copper / ferrous ions by spectrophotometry	
7.	Estimation of DO by using sensors	
8.	Estimation of concentration of sulphate/ Chloride ions in the given sample solution.	
9.	Determination of molecular weight of a polymer by viscometry method	
10.	Synthesis of nanomaterials by simple precipitation method	
11.	Verification of adsorption isotherms (acetic acid on charcoal)	
12.	Determination of phase change temperature of a solid.	

**Course Outcomes:** At the end of the course the student will be able to:

- Explore the applications of Surface Chemistry in domestic and industrial uses.
- Employ the basic principles of Electrochemistry in our daily life appliances.
- Synthesize Nano materials for modern engineering applications.
- Recognize the need of advanced polymer and heterocyclic compounds in industrial applications.
- Identify the structure of unknown/new compounds with the help of spectroscopy.

#### **SUGGESTED ACTIVITIES**

- Electroplating process can be done by a group of students.
- Determination of alkali content in the soap.
- Biogenic synthesis of nanomaterials

#### **SUGGESTED EVALUATION METHODS**

- Continuous assessment tests
- Assignments
- Model lab examination
- End semester examination

#### **Text Book(s):**

1. P. C. Jain and Monika Jain, "Engineering Chemistry", DhanpatRai Publishing Company (P) Ltd, New Delhi, 2015
2. O.G.Palanna, "Engineering Chemistry", McGraw Hill Education (India) Pvt, Ltd, New Delhi, 2017
3. Shikha Agarwal "Engineering Chemistry-Fundamentals and applications", Cambridge University Press, New Delhi, 2015

#### **Reference Books(s)**

- A Text Book of Engg. Chemistry, Shashi Chawla, Dhanpat Rai & Co. (P) Ltd.
- B.K. Sharma, "Industrial chemistry", Krishna Prakashan Media (P) Ltd, Meerut, 2016.
- Polymer Science, V R Gowariker, N V Viswanathan, Jayadev, Sreedhar, Newage Int. Publishers, 4th Edition, 2021.
- PradeepT, "A Text Book of Nanoscience and Nanotechnology", Tata McGraw Hill, New Delhi, 2012
- An Introduction to nanomaterials and nanoscience (PB 2020) : Asim K DAS, Mahua Das, CBS publishers and distributors Pvt. Ltd.
- Laboratory Manual Engg. Chemistry, Anupma Rajput, Dhanpat Rai & Co

**Lab equipment required:**

S. No	Name of the Equipment	Quantity Required
1.	pH meter	10
2.	Ion selective electrodes for various ions in solution	10
3	Spectrophotometer	4
4	Magnetic stirrer with hot plate	10
5	Shaker	5

**SUGGESTED EVALUATION METHODS**

- Experiment based viva
- Quizzes

**Weblinks:**

1. NPTEL course Elementary Electrochemistry course url  
[https://onlinecourses.nptel.ac.in/noc23\\_cy19/preview](https://onlinecourses.nptel.ac.in/noc23_cy19/preview)
2. For downloading text/reference books the weblink is given below can be used  
<http://libgen.rs/>
3. <https://nptel.ac.in/courses/104/103/104103019>
4. <https://ndl.iitkgp.ac.in/>

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CY23132.1	2	1	1	-	-	-	1	1	-	-	-	-	-	2	-
CY23132.2	2	2	1	-	-	-	-	-	-	-	-	1	-	1	2
CY23132.3	3	2	2	-	-	-	-	-	-	-	-	-	1	1	1
CY23132.4	2	2	1	-	-	-	1	1	-	-	-	-	2	1	-
CY23132.5	2	1	1	-	-	-	-	-	-	-	-	-	-	1	1
Average	2.2	1.6	1.2	-	-	-	1	1	-	-	-	1	1.5	1.2	1.3

Subject Code	Subject Name	Category	L	T	P	C
GE23111	ENGINEERING GRAPHICS	ES	2	0	4	4

**Objectives:**

- To understand the importance of the drawing in engineering applications
- To develop graphic skills for communication of concepts, ideas and design of engineering products
- To expose them to existing national standards related to technical drawings.
- To improve their visualization skills so that they can apply this skill in developing new products.
- To improve their technical communication skill in the form of communicative drawings

**CONCEPTS AND CONVENTIONS (Not for Examination)****1**

Importance of graphics in engineering applications–Use of drafting instruments– BIS conventions and specifications–Size, layout and folding of drawing sheets– Lettering and dimensioning. Basic Geometrical constructions.

**UNIT-I PLANE CURVES AND PROJECTION OF POINTS****5+12**

Curves used in engineering practices: Conics–Construction of ellipse, parabola and hyperbola by eccentricity method – Cycloidal Curves–Construction of cycloid, epicycloid and hypocycloid – Construction of involutes of square and circle–Drawing of tangents and normal to the above curves.Principles of Projection and Projection of points.

**UNIT-II PROJECTION OF LINES AND PLANE SURFACES****6+12**

Projection of straight lines (First angle projection) inclined to both the principal planes – Determination of true lengths and true inclinations by rotating line method. Projection of planes (polygonal and circular surfaces) inclined to both the principal planes by rotating object method.

**UNIT-III PROJECTION OF SOLIDS AND PROJECTION OF SECTIONED SOLIDS****6+12**

Projection of simple solids like prisms, pyramids, cylinder and cone when the axis is inclined to one of the principal planes by rotating object method. Sectioning of solids in simple vertical position when the cutting

plane is inclined to HP and perpendicular to VP – obtaining true shape of the section. Practicing three-dimensional modeling of simple objects by CAD software (Not for examination)			
<b>UNIT-IV</b>	<b>DEVELOPMENT OF SURFACE AND ISOMETRIC PROJECTIONS</b>	<b>6+12</b>	
Development of lateral surfaces of simple and sectioned solids – Prisms, pyramids cylinders and cones.Principles of isometric projection–isometric scale–Isometric projections of simple solids and truncated solids - Prisms, pyramids, cylinders and cones. Model making of isometric projection of combination of solids as assignment (Not for End semester)			
<b>UNIT-V</b>	<b>FREE HAND SKETCHING AND PERSPECTIVE PROJECTIONS</b>	<b>6+12</b>	
Free Hand sketching: Freehand sketching of multiple views from pictorial views of objects - Freehand sketching of pictorial views of object from multiple views. Perspective projection of simple solids-Prisms, pyramids, cylinder and cone by visual ray method.			
<b>Total Contact Hours:</b>		(L=30; P=60) 90 Periods	<b>90</b>

<b>Course Outcomes:</b> The students will be able to	
•	To construct different plane curves and to comprehend the theory of projection
•	To draw the basic views related to projection of lines and planes
•	To draw the projection of simple solids and to draw the projection of development of surfaces of Sectioned solids in simple vertical position
•	To draw the orthographic projection from pictorial objects and Isometric projections of simple solids
•	To visualize Perspective view of simple solids

<b>Text Book(s):</b>	
1	Bhatt N.D. and Panchal V.M., “Engineering Drawing”, Charotar Publishing House, 50th Edition, 2010.
2	Natarajan K.V., “A text book of Engineering Graphics”, Dhanalakshmi Publishers, Chennai, 2017.

<b>Reference Book(s):</b>	
1	Varghese P I., “Engineering Graphics”, McGraw Hill Education (I) Pvt.Ltd., 2013.
2	V.B Sikka “Civil Engineering Drawing”, S.K Kataria & Sons, New Delhi.
3	Venugopal K. and PrabhuRaja V., “Engineering Graphics”, New Age International(P)Limited, 2008.
4	Gopalakrishna K.R., “Engineering Drawing” (Vol. I&II combined), Subhas Stores,Bangalore, 2017.
5	Basant Agarwal and Agarwal C.M., “Engineering Drawing”, McGraw Hill Publishing Company Limited, New Delhi, 2018

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
GE23111.1	3	2	2	1	-	1	-	2	2	2	-	2	-	-	-
GE23111.2	3	2	2	1	-	1	-	2	2	2	-	2	-	-	-
GE23111.3	3	2	2	1	-	1	-	2	2	2	-	2	-	-	-
GE23111.4	3	2	2	1	-	1	-	2	2	2	-	2	-	-	-
GE23111.5	3	2	2	1	-	1	-	2	2	2	-	2	-	-	-

Subject Code	Subject Name (Laboratory Course)	Category	L	T	P	C
GE23121	ENGINEERING PRACTICES – Civil and Mechanical	ES	0	0	2	1

<b>Objectives:</b>	
•	To provide exposure to the students with hands on experience on various basic engineering practices in Civil and Mechanical Engineering

List of Experiments	
CIVIL ENGINEERING PRACTICE	
1.	Study of pipeline joints, its location and functions: valves, taps, couplings, unions, reducers, and elbows in household fittings.
2.	Preparation of basic plumbing line sketches for wash basins, water heaters, etc.
3.	Hands-on-exercise: Basic pipe connections – Pipe connections with different joining components.

<b>Carpentry Works:</b>			
4.	Study of joints in roofs, doors, windows and furniture.		
5.	Hands-on-exercise: Woodwork, joints by sawing, planning and chiselling.		
<b>MECHANICAL ENGINEERING PRACTICE</b>			
6.	Preparation of butt joints, lap joints and T- joints by Shielded metal arc welding.		
7	Gas welding practice.		
<b>Basic Machining:</b>			
8	Simple Turning and Taper turning		
9	Drilling Practice		
<b>Sheet Metal Work:</b>			
10	Forming & Bending:		
11	Model making – Trays and funnels		
12	Different type of joints.		
<b>Machine Assembly Practice:</b>			
13	Study of centrifugal pump		
14	Study of air conditioner		
			<b>Total Contact Hours : 30</b>

<b>Course Outcomes:</b>	
•	Able to perform plumbing activities for residential and industrial buildings considering safety aspects while gaining clear understanding on pipeline location and functions of joints like valves, taps, couplings, unions, reducers, elbows, etc.
•	Able to perform wood working carpentry activities like sawing, planning, cutting, etc. while having clear understanding of the joints in roofs, doors, windows and furniture.
•	Able to produce joints like L joint, T joint, Lap joint, Butt joint, etc. through arc welding process while acquiring in depth knowledge in the principle of operation of welding and other accessories
•	Able to perform operations like Turning, Step turning, Taper turning, etc. in lathe and Drilling operation in drilling machine
•	Able to perform sheet metal operations like Forming, Bending, etc. and fabricating models like Trays, funnels, etc.

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
GE23121.1	1	1	1	-	-	2	1	-	2	-	-	2	-	2	1
GE23121.2	1	1	1	-	-	2	1	-	2	-	-	2	-	2	1
GE23121.3	1	1	1	-	-	2	1	-	2	-	-	2	-	2	1
GE23121.4	1	1	1	-	-	2	1	-	2	-	-	2	-	2	1
GE23121.5	1	1	1	-	-	2	1	-	2	-	-	2	-	2	1

<b>Subject Code</b>	<b>MICROBIOLOGY</b>	<b>Category</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>BT23131</b>		<b>PC</b>	<b>2</b>	<b>0</b>	<b>4</b>	<b>4</b>

<b>Objectives:</b>	
•	To inculcate knowledge on fundamentals of microorganisms and microscopy
•	To learn the structural organization, morphology and reproduction of microbes
•	To acquire knowledge on basic principles of microbial culture, growth and its metabolism
•	To understand the principles of sterilization technique and chemotherapeutic agents
•	To gain knowledge on various applications of microbes in biotechnology

<b>UNIT-I</b>	<b>INTRODUCTION TO MICROBIOLOGY</b>	<b>6</b>
History of Microbiology- Spontaneous generation conflict - Contributions of Leeuwenhoek, Louis Pasteur, Robert Koch, Joseph Lister, Edward Jenner and Winogradsky. Microbial Taxonomy- Classification and Nomenclature of microorganisms- Whittaker's Five Kingdom concept. Microscopy: Bright field, Dark field, Phase contrast, Fluorescent Microscopy and Electron microscope.		
<b>UNIT-II</b>	<b>STRUCTURE OF BACTERIA AND VIRUS</b>	<b>6</b>
Structural organization and multiplication of Bacteria. Stains and Staining techniques: Simple staining, Differential staining (Gram's & Acid fast), Special staining (Capsule & Endospore). Virus- Structure, Classification & Multiplication (Lytic and Lysogenic cycle).		



<b>UNIT-III</b>	<b>STRUCTURE AND REPRODUCTION OF FUNGI AND ALGAE</b>	<b>6</b>
Fungi - General structure and its reproduction (Aspergillus & Penicillium). Algae - General structure and its economic importance. Actinomycetes - Features & its biotechnological importance.		
<b>UNIT-IV</b>	<b>MICROBIAL NUTRITION, GROWTH AND METABOLISM</b>	<b>6</b>
Nutritional requirement and classification of microorganisms based on physiological factors, Culture media (defined, complex, selective, differential, and enriched). Growth: Definition, Growth curve. Quantification of microbial growth: (Direct and Indirect methods).		
<b>UNIT-V</b>	<b>CONTROL OF MICROORGANISMS</b>	<b>6</b>
Sterilization (Physical and Chemical) – Definition, Types, Mode of action, Sterility control and its applications. Antimicrobial chemotherapy – Antibiotics (Antibacterial, antifungal and antiviral agents) and its mode of action – Antibiotic Resistance - Antibiotic Sensitivity tests		
<b>Total Contact Hours</b>		<b>: 30</b>

<b>Course Outcomes:</b> The students will be able to	
●	Gain the knowledge on the principles of microscopes
●	Understand and differentiate the microorganisms based on its morphology
●	Apply the knowledge in identification of fungi, algae & actinomycetes
●	Formulate and design the culture media for the growth of microorganisms
●	Analyze and apply the appropriate sterilization technique to control the microorganisms

<b>Text Book(s):</b>	
<b>1</b>	Pelczar, M.J., Chan, E.C.S. and Kreig, N.R. (2002) Microbiology. 7th Edition, Tata McGraw-Hill, New Delhi.
<b>2</b>	Schlegel, H.G.—General Microbiology, 7 <sup>th</sup> Edition, Cambridge University Press, 1993.
<b>3</b>	Ananthanarayan, CK Jayaram Panikars. Text book of Microbiology, 2005, Orient Blackswan Publishers.

<b>Reference Books(s) / Web links:</b>	
<b>1</b>	Joanne W., Kathleen S and Dorothy W., Prescott's Microbiology, 12th Edition, Mc Graw Hill, New York, 2023
<b>2</b>	Black, Text book of microbiology. Freeman Publishers, 2016
<b>3</b>	Talaron K, Talaron A, Casita, Pelczar and Reid. Foundations in Microbiology, W.C. Brown Publishers, 1993.

<b>Objectives:</b>	
•	To Train students in the proper use and maintenance of the Microbiology laboratory with emphasis on observation microbes by staining techniques
•	To demonstrate appropriate methods to estimate the number of microorganisms in a sample
•	To demonstrate an understanding of environmental effects on bacterial growth
•	To familiarize the student on biochemical tests to identify microbes.
•	Provide students with a hands-on familiarity with basic research procedure and associated critical and investigative thinking skills utilizing identification of unknown microorganism from specimens.

<b>List of Experiments</b>	
<b>1</b>	Laboratory Safety
<b>2</b>	Introduction to sterilization techniques
<b>3</b>	Microscopy: Working and its principles
<b>4</b>	Culture media: Media preparation- Broth, Agar (deep, slant and plate)
<b>5</b>	Culture techniques: Isolation- Streak plate, Pour plate, spread plate, Slant and Stab
<b>6</b>	Quantification of microbes from soil, water, and milk (Pour plate & Spread plate technique)
<b>7</b>	Staining: a. Simple Staining                      b. Gram's staining
<b>8</b>	Motility test: - Hanging drop method
<b>9</b>	Growth Curve of bacteria
<b>10</b>	Antibiotic Sensitivity test
<b>Total Contact Hours</b>	
<b>: 60</b>	

<b>Course Outcomes:</b>	
●	The student will be able to identify Microorganism through microscope
●	The student will be able to prepare a suitable media and cultivate the microbes by different techniques.
●	The student can able to isolate and identify microbial strain by staining and biochemical tests
●	The students can able to find out antibiotic susceptibility and resistance prototype of pathogens.
●	The student will be able to check the role of physiological factors on Microbial growth and multiplication.

<b>References</b>	
	Cappuccino, J.G. and N. Sherman —Microbiology: A Laboratory Manual, 4th Edition, Addison-Wesley, 1999. Collee, J.G.etal., -Mackie &McCartney Practical Medical Microbiology, 4th Edition, Churchill Livingstone, 1996.

#### WEB SOURCE REFERENCES:

1	<a href="http://journals.asm.org/">http://journals.asm.org/</a> American Association of Microbiology <a href="http://www.who.int/en/">http://www.who.int/en/</a> World Health Organization <a href="http://www.microbes.info/news/">http://www.microbes.info/news/</a> Microbiology News <a href="http://www.nlm.nih.gov/">http://www.nlm.nih.gov/</a> Library of medicine <a href="http://www.fda.gov/Food/FoodSafety/FoodborneIllness/FoodborneIllnessFoodbornePathogensNaturalToxins/BadBugBook/default.htm">http://www.fda.gov/Food/FoodSafety/FoodborneIllness/FoodborneIllnessFoodbornePathogensNaturalToxins/BadBugBook/default.htm</a>
2	<a href="http://www.microbiologybytes.com/video/Gram.html">http://www.microbiologybytes.com/video/Gram.html</a>
3	<a href="http://www.mansfield.ohio-state.edu/~sabedon/biol2025.htm">http://www.mansfield.ohio-state.edu/~sabedon/biol2025.htm</a>
4	<a href="http://nt.ars-grin.gov/sbmlweb/fungi/index.cfm">http://nt.ars-grin.gov/sbmlweb/fungi/index.cfm</a>

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
BT23131.1	2	1	2	3	3	2	2	2	3	3	2	2	3	2	2
BT23131.2	2	2	2	3	3	2	3	2	3	3	2	3	3	3	2
BT23131.3	1	2	2	3	3	2	3	2	3	3	2	3	2	3	2
BT23131.4	2	2	1	3	2	2	3	2	3	3	2	3	3	2	2
BT23131.5	2	2	3	3	3	3	3	3	3	3	3	3	2	3	2
Average	1.8	1.8	2.0	3.0	2.8	2.2	2.8	2.2	3.0	3.0	2.2	2.8	2.6	2.8	2.0

Subject Code	Subject Name	Category	L	T	P	C
MC23112	ENVIRONMENTAL SCIENCE AND ENGINEERING	MC	3	0	0	0
<b>Non Credit Course - Common to B.E. /B.Tech all branches except CSBS</b>						
<b>Objectives:</b>						
● To develop the understanding of environmental and associated issues						
● To develop an attitude of concern for the environment						
● To promote enthusiasm in participating environmental protection initiatives						
● To nurture skills to solve environmental degradation issues						
● To develop the knowledge about the environmental laws						

<b>UNIT-I</b>	<b>AIR AND NOISE POLLUTION</b>	9
Definition –sources of air pollution –chemical and photochemical reactions in the atmosphere - formation of smog, PAN, acid rain, ozone depletion, particulate pollutants-Air quality standards-Air quality indices - control of particulate air pollutants-gravitational settling chambers,cyclone separators, wet collectors, fabric filters (Bag-house filter), electrostatic precipitators (ESP)-catalytic converters. Noise pollution –sources - health effects - standards- measurement and control methods.		
<b>UNIT-II</b>	<b>WATER POLLUTION AND ITS MANAGEMENT</b>	9

Definition-causes-effects of water pollution-point and nonpoint sources of wastewater-marine pollution - thermal pollution - Control of water pollution by physical, chemical and biological methods – wastewater treatment-primary, secondary and tertiary treatment-sources and characteristics of industrial effluents- zero liquid discharge.		
<b>UNIT-III</b>	<b>SOLID WASTE AND HAZARDOUS WASTE MANAGEMENT</b>	9
Solid waste – types- municipal solid waste management: sources, characteristics, collection, and transportation-sanitary landfill, recycling, composting, incineration, energy recovery options from waste - Hazardous waste – types, characteristics, and health impact - hazardous waste management: neutralization, oxidation reduction, precipitation, solidification, stabilization, incineration and final disposal. E-waste-definition-sources-effects on human health and environment- E-waste management- steps involved - Role of E-waste management within the initiatives of the Govt. of India- Swachh Bharat Mission.		
<b>UNIT-IV</b>	<b>SUSTAINABLE DEVELOPMENT</b>	9
Sustainable development- concept-dimensions-sustainable development goals - value education- gender equality – food security - poverty – hunger - famine - Twelve principles of green chemistry - Green technology - definition, importance - Cleaner development mechanism - carbon credits, carbon trading, carbon sequestration, eco labeling-International conventions and protocols-Disaster management.		
<b>UNIT-V</b>	<b>ENVIRONMENTAL MANAGEMENT AND LEGISLATION</b>	9
Environmental Management systems - ISO 14000 series- Environmental audit-Environmental Impact Assessment- life cycle assessment- human health risk assessment - Environmental Laws and Policy- Objectives - Polluter pays principle, Precautionary principle - The Environment (Protection) Act 1986 - Role of Information technology in environment and human health.		
<b>Total Contact Hours:45</b>		

<b>Course Outcomes:</b>
On completion of the course, the students will be able to
<ul style="list-style-type: none"> <li>• Associate air and noise quality standards with environment and human health.</li> <li>• Illustrate the significance of water and devise control measures for water pollution.</li> <li>• Analyze solid wastes and hazardous wastes.</li> <li>• Outline the goals of sustainable development in an integrated perspective.</li> <li>• Comprehend the significance of environmental laws.</li> </ul>

<b>SUGGESTED EVALUATION METHODS</b>
<ul style="list-style-type: none"> <li>• Continuous assessment tests</li> <li>• Assignments</li> <li>• Case studies, class room presentations (or) site visit</li> </ul>

<b>Text Book(s):</b>
<ul style="list-style-type: none"> <li>• Benny Joseph, 'Environmental Science and Engineering', Tata McGraw-Hill, New Delhi, 2016</li> <li>• Anubha Kaushik and C. P. Kaushik's "Perspectives in Environmental Studies", 6th Edition, New Age International Publisher, 2018.</li> <li>• Johri R., E-waste: implications, regulations, and management in India and current global best practices, TERI Press, New Delhi</li> </ul>

<b>Reference Books(s) / Web links:</b>
<ul style="list-style-type: none"> <li>• R.K. Trivedi, 'Handbook of Environmental Laws, Rules, Guidelines, Compliances and Standards', Vol. I and II, Enviro Media. 38. Edition 2010.</li> <li>• Cunningham, W.P. Cooper, T.H. Gorhani, 'Environmental Encyclopedia', Jaico Publ., House, Mumbai, 2001.</li> <li>• Fowler B, Electronic Waste – 1 st Edition (Toxicology and Public Health Issues), 2017 Elsevier</li> <li>• NPTEL course url <a href="https://onlinecourses.nptel.ac.in/noc19_ge22/">https://onlinecourses.nptel.ac.in/noc19_ge22/</a> NPTEL <a href="https://news.mit.edu/2013/ewaste-mit">https://news.mit.edu/2013/ewaste-mit</a></li> <li>• For downloading text/reference books the weblink is given below can be used <a href="http://libgen.rs/">http://libgen.rs/</a></li> </ul>

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PS01	PSO2	PSO3
MC23112.1	1	2	3	1	-	2	2	2	1	1	1	2	1	-	-
MC23112.2	1	2	3	1	-	2	2	2	1	1	1	2	1	-	-
MC23112.3	-	-	3	1	-	2	3	2	1	-	1	2	1	-	-
MC23112.4	-	1	2	1	1	3	3	2	1	1	1	2	-	-	-
MC23112.5	-	1	2	-	-	2	2	2	1	2	2	2	-	-	-
Average	0.4	1.2	2.6	0.8	0.2	2.2	2.4	2	1	1	1.2	2	0.6	-	-

**அலகு I மொழி மற்றும் இலக்கியம்:**

3

இந்திய மொழிக் குடும்பங்கள் - திராவிட மொழிகள் - தமிழ் ஒரு செம்மொழி - தமிழ் செவ்விலக்கியங்கள் - சங்க இலக்கியத்தின் சமய சார்பற்ற தன்மை - சங்க இலக்கியத்தில் பகிர்தல் அறம் - திருக்குறளில் மேலாண்மைக் கருத்துக்கள் - தமிழிக் காப்பியங்கள், தமிழகத்தில் சமண பௌத்த சமயங்களின் தாக்கம் - பக்தி இலக்கியம், ஆழ்வார்கள் மற்றும் நாயன்மார்கள் - சிற்றிலக்கியங்கள் - தமிழில் நவீன இலக்கியத்தின் வளர்ச்சி - தமிழ் இலக்கிய வளர்ச்சியில் பாரதியார் மற்றும் பாரதிதாசன் ஆகியோரின் பங்களிப்பு.

**அலகு II மரபு - பாறை ஓவியங்கள் முதல் நவீன ஓவியங்கள் வரை - சிற்பக் கலை:**

3

நடுகல் முதல் நவீன சிற்பங்கள் வரை - ஐம்பொன் சிலைகள் - பழங்குடியினர் மற்றும் அவர்கள் தயாரிக்கும் கைவினைப் பொருட்கள், பொம்மைகள் - தேர் செய்யும் கலை - சுடுமண் சிற்பங்கள் - நாட்டுப்புறத் தெய்வங்கள் - குமரிமுனையில் திருவள்ளுவர் சிலை - இசைக் கருவிகள் - மிருதங்கம், பறை, வீணை, யாழ், நாதஸ்வரம் - தமிழர்களின் சமூக பொருளாதார வாழ்வில் கோவில்களின் பங்கு.

**அலகு III நாட்டுப்புறக் கலைகள் மற்றும் வீர விளையாட்டுகள்:**

3

தெருக்கூத்து, கரகாட்டம், வில்லுப்பாட்டு, கணியான் கூத்து, ஓயிலாட்டம், தோல்பாவைக் கூத்து, சிலம்பாட்டம், வளரி, புலியாட்டம், தமிழர்களின் விளையாட்டுகள்.

**அலகு IV தமிழர்களின் திணைக் கோட்பாடுகள்:**

3

தமிழகத்தின் தாவரங்களும், விலங்குகளும் - தொல்காப்பியம் மற்றும் சங்க இலக்கியத்தில் அகம் மற்றும் புறக் கோட்பாடுகள் - தமிழர்கள் போற்றிய அறக்கோட்பாடு - சங்ககாலத்தில் தமிழத்தில் எழுத்தறிவும், கல்வியும் - சங்ககால நகரங்களும் துறை முகங்களும் - சங்ககாலத்தில் ஏற்றுமதி மற்றும் இறக்குமதி - கடல்கடந்த நாடுகளில் சோழர்களின் வெற்றி.

**அலகு V இந்திய தேசிய இயக்கம் மற்றும் இந்திய பண்பாட்டிற்குத் தமிழர்களின் பங்களிப்பு:**

3

இந்திய விடுதலைப்போரில் தமிழர்களின் பங்கு - இந்தியாவின் பிறப்பகுதிகளில் தமிழ்ப் பண்பாட்டின் தாக்கம் - சுயமரியாதை இயக்கம் - இந்திய மருத்துவத்தில், சித்த மருத்துவத்தின் பங்கு - கல்வெட்டுகள், கையெழுத்துப்படிக்கள் - தமிழ்ப் புத்தகங்களின் அச்சு வரலாறு.

TOTAL : 15 PERIODS

Subject Code	Subject Name (Theory course)	Category	L	T	P	C
HS23221	TECHNICAL COMMUNICATION II	Theory	0	0	2	1
Common to all branches of B.E/B. Tech programmes –Second Semester						

**Course Objectives:**

- To facilitate students to improve their vocabulary for a better communication
- To enable learners to understand and reproduce language
- To aid students to write technical reports in a convincing manner
- To expose students to different sentence structures
- To equip learners to present their ideas in an efficient manner

<b>UNIT-I</b>	<b>VOCABULARY FOR BETTER COMMUNICATION</b>	6
<b>Listening:</b> Telephonic Conversations and TV News <b>Reading:</b> Newspapers and Magazines <b>Speaking:</b> Conversational Practice: Speaking in a given situation, asking permission and requesting etc., <b>Writing:</b> Job Application Letter and Resume <b>Grammar:</b> Reference words: pronouns and determiners <b>Vocabulary:</b> Guessing meanings of words in different contexts.		
<b>UNIT-II</b>	<b>FUNCTIONAL LANGUAGE ASPECTS</b>	6
<b>Listening:</b> Motivational listening – listening to real life challenges <b>Reading:</b> Articles and Technical reports <b>Speaking:</b> Using Polite Expressions, Indirect Questions <b>Writing:</b> Paraphrasing a Text, Poem <b>Grammar:</b> Purpose Statements, Cause and Effect Expressions <b>Vocabulary:</b> Neologisms.		
<b>UNIT-III</b>	<b>TECHNICAL REPORTWRITING</b>	6
<b>Listening:</b> Empathetic Listening – Giving Solutions to Problems <b>Reading:</b> Inferential Reading <b>Speaking:</b> Dialogues – Interviewing Celebrities / Leaders / Sportspersons, etc., <b>Writing:</b> Report Writing <b>Grammar:</b> Functional Usage of Expressions – used to, gone / been, etc., <b>Vocabulary:</b> Words Often Confused		
<b>UNIT-IV</b>	<b>STRUCTURAL GRAMMAR</b>	6
<b>Listening:</b> Comprehension (IELTS practice tests) <b>Reading:</b> Intensive Reading for specific information <b>Speaking:</b> Pick and Talk <b>Writing:</b> Proposals <b>Grammar:</b> Sentence Structures – Simple, Compound, Complex Sentences <b>Vocabulary:</b> Replacing dull words with vivid ones		
<b>UNIT-V</b>	<b>PRESENTATION SKILLS</b>	6
<b>Listening:</b> Discriminative listening – sarcasm, irony, pun, etc., <b>Reading:</b> Practice of chunking – breaking up reading materials <b>Speaking:</b> Mini presentation on some topic <b>Writing:</b> Minutes of the meeting <b>Grammar:</b> Correction of Errors <b>Vocabulary:</b> Advanced vocabulary – fixing appropriate words in the given context.		
<b>Total Contact Hours: 30</b>		

**Course Outcomes:**

On completion of the course students will be able to

- Communicate effectively using appropriate vocabulary

• Use the acquired language skills to comprehend various types of language contents
• Evaluate different texts and write effective technical content
• Use appropriate sentence structures to convey their thoughts in varied contexts
• Present their concepts and ideas in an effective manner

**SUGGESTED ACTIVITIES**

- Story Lines
- One truth and two lies
- Hang Man
- Pictionary
- Word Scramble
- Case study

**SUGGESTED EVALUATION METHODS**

- Assignment topics
- Quizzes
- Class Presentation/Discussion
- Continuous Assessment Tests

**Text Book(s):**

5. Raymond Murphy, "Intermediate English Grammar," Second Edition, Cambridge University Press, 2018
6. Meenakshi Raman & Sangeeta Sharma, "Technical Communication" Third Edition, Oxford University Press, 2015
7. Teaching Speaking: A Holistic Approach, Book by Anne Burns and Christine ChuenMeng Goh, Cambridge University Press

**Reference Books(s) / Web links:**

Michael McCarthy (Author), Felicity O'Dell (Author), John D. Bunting (Contributor), "Basic Vocabulary in Use: 60 Units of Vocabulary Practice in North American English with Answers" 2nd Edition

Dale Carnegie, "The Art of Public Speaking," Insight Press

Jack C. Richards & Theodore S. Rodgers, "Approaches and Methods in Language Teaching, Second Edition Cambridge University Press

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
HS23221.1	-	-	-	1	-	-	-	-	-	2	-	-	-	-	-
HS23221.2	-	-	-	1	-	-	-	-	-	3	-	-	-	-	-
HS23221.3	-	2	-	1	-	-	-	-	-	3	-	-	-	-	-
HS23221.4	-	-	-	1	-	-	-	-	2	3	-	-	-	-	-
HS23221.5	-	-	-	1	-	-	-	-	2	2	-	-	-	-	-
Average	-	2	-	1	0	0	0	0	2	2.6	-	-	-	-	-

Subject Code	Subject Name	Category	L	T	P	C
HS23222	ENGLISH FOR PROFESSIONAL COMPETENCE Common to all branches of B.E/B. Tech programmes	HS	0	0	2	1

**Objectives:**

•	To facilitate the learners in acquiring listening and reading competence
•	To enable the learners to communicate effectively through written and oral medium
•	To assist the learners in preparing for competitive examinations
•	To train the students in acquiring corporate skills
•	To inculcate professional standards among the students and make them realize their responsibility in addressing the challenges

<b>UNIT-I</b>	<b>RECEPTIVE SKILLS</b>	6
<b>Listening</b> – Comprehensive Listening – Watching the news – Listening to a peer giving presentation, etc. – Critical Listening – Watching a televised debate, listening to poems – <b>Reading</b> – Extensive Reading – Short stories and One-act Plays – Intensive Reading – Articles or Editorials in Magazines, Blog posts on topics like science and technology, arts, etc.		
<b>UNIT-II</b>	<b>PRODUCTIVE SKILLS</b>	6
<b>Speaking</b> – Demonstrative Speaking – Process description through visual aids – Persuasive Speaking – Convincing the listener with the speaker’s view – <b>Writing</b> – Descriptive Writing - Describing a place, person, process – Subjective Writing – Autobiography, Writing based on personal opinions and interpretations		
<b>UNIT-III</b>	<b>ENGLISH FOR COMPETITIVE EXAMS</b>	6
An introduction to International English Language Testing System (IELTS) – Test of English as a Foreign Language (TOEFL) – Graduate Record Examination (GRE) – Civil Service, Indian Economic Service Examination, Indian Statistical Service Examination, Combined Defence Services Examination, Staff Selection- (Language Related) – Aptitude tests.		
<b>UNIT-IV</b>	<b>CORPORATE SKILLS</b>	6
<b>Critical Thinking and Problem Solving</b> – Case Study, Brainstorming, Q & A Discussion – <b>Team work and Collaboration</b> – Activities like Office Debates, Perfect Square, Blind Retriever, etc. – <b>Professionalism and Strong Work Ethics</b> – Integrity, Resilience, Accountability, Adaptability, Growth Mind set		
<b>UNIT-V</b>	<b>PROJECT WORK</b>	6
Case Study based on the challenges faced by the employers and the employees – Devise Plan, Provide Solution		
<b>Total Contact Hours</b>		30

**Course Outcomes:**

On completion of the course, students will be able to

- Interpret and respond appropriately in the listening and reading contexts.
- Express themselves effectively in spoken and written communication
- Apply their acquired language skills in writing the competitive examinations
- Exhibit their professional skills in their work place
- Identify the challenges in the work place and suggest strategies solutions

**SUGGESTED ACTIVITIES**

- Online Quizzes on Vocabulary
- Online Quizzes on grammar
- Communication Gap Exercises
- Presentations
- Word Building Games
- Case study

**SUGGESTED EVALUATION METHODS**

- Assignment topics
- Quizzes
- Class Presentation/Discussion
- Continuous Assessment Tests

**Reference Books**



1	How to Read Better & Faster, Norman Lewis, Goyal Publishers
2	Teaching Speaking: A Holistic Approach, Book by Anne Burns and Christine Chuen Meng Goh, Cambridge University Press
3	The Official Cambridge Guide To IELTS by Pauline Cullen, Cambridge University Press
4	The 7 Habits of Highly Effective People by Stephen Covey, Simon and Schuster, UK

**Reference Books(s) / Web links:**

1. Board of Editors. Sure Outcomes. A Communication Skills Course for Undergraduate Engineers and Technologists. Orient Black Swan Limited, Hyderabad, 2013.
2. Hartley, Mary. "The Power of Listening," JaicoPublishing House; First Edition (2015).
3. Chambers, Harry. "Effective Communication Skills for Scientific and Technical Professionals," Persues Publishing, Cambridge, Massachusetts, 2000.

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
HS23222. 1	-	1	-	-	-	-	-	-	-	3	-	-	-	-	-
HS23222. 2	-	1	-	-	-	-	-	-	-	3	-	-	-	-	-
HS23222. 3	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-
HS23222. 4	-	-	-	-	-	-	2	2	-	3	-	-	-	-	-
HS23222. 5	-	-	1	-	-	-	2	-	-	3	-	-	-	-	-
Average	0	1	1	0	0	0	2	2	0	3	0	0	-	-	-

Subject Code	Course Title	Category	L	T	P	C
MA23212	DIFFERENTIAL EQUATIONS AND COMPLEX VARIABLES	BS	3	1	0	4
<b>Common to II Sem. B.E. –AERO, AUTO, BME, CIVIL, EEE, ECE, MECH, MCT, R&amp;A and B. Tech. - BT, FT &amp; CHEM</b>						

**Objectives:**

- To provide students with an introduction to the theory of ordinary differential equations through applications, methods of solution, and numerical approximations.
- To introduce students to how to solve linear Partial Differential with different methods.
- To enable the students to study the Laplace Transforms, properties of Laplace Transform, inverse Laplace Transform and some applications to solve the differential equations and integral equations.
- To explain the concept of a vector integration in a plane and in space.
- To describe basic properties of complex variables and to have the ability to compute complex integrals.

<b>UNIT-I</b>	<b>ORDINARY DIFFERENTIAL EQUATIONS</b>	<b>12</b>
Second and higher order Linear differential equations with constant coefficients - Method of variation of parameters – Legendre’s linear equations – Numerical solution of ODE - Single Step methods: Taylor’s series method, Euler’s method.		
<b>UNIT-II</b>	<b>PARTIAL DIFFERENTIAL EQUATIONS</b>	<b>12</b>
Formation of partial differential equations - Classification of PDE – Solutions of standard types of first order partial differential equations - Lagrange’s linear equation –Linear homogeneous partial differential equations of second and higher order with constant coefficients.		
<b>UNIT-III</b>	<b>LAPLACE TRANSFORM</b>	<b>12</b>
Laplace transform –Basic properties – Transforms of derivatives and integrals of functions - Transforms of unit step function and impulse functions, periodic functions. Inverse Laplace transform – Problems using Convolution theorem – Solution of linear ODE of second order with constant coefficients using Laplace transformation techniques		



MA23212.1	3	2	1	-	-	-	-	-	-	-	-	1	1	1	1
MA23212.2	3	2	1	-	-	-	-	-	-	-	-	1	1	1	1
MA23212.3	3	2	1	-	-	-	-	-	-	-	-	-	1	-	-
MA23212.4	2	2	1	-	-	-	-	-	-	-	-	-	1	-	-
MA23212.5	3	2	1	-	-	-	-	-	-	-	-	1	1	-	1
Average	2.8	2	1	-	-	-	-	-	-	-	-	1	1	1	1

Subject Code	PHYSICS FOR BIOSCIENCE					Category	L	T	P	C
PH23231	Common to - B.E. – Biomedical Engineering and B.Tech – Bio Technology & Food Technology					BS	3	0	2	4

**Course Objectives:**

•	To enhance the fundamental knowledge of oscillations, Ultrasonic wave properties and its applications.
•	To strengthen the basic information of semiconducting materials, characteristic and its applications.
•	To study the behaviour of superconducting materials and optical fibres for medical applications.
•	To understand the properties of nuclear radiation and elementary particles.
•	To study the advanced analytical techniques.

<b>UNIT-I</b>	<b>WAVES AND ULTRASONICS</b>	9
Oscillatory motion – forced and damped oscillations: differential equation and its solution – plane progressive waves – wave equation – Fundamentals of sound– generation of ultrasound – magnetostriction and piezo-electric method – properties - acoustical grating- velocity of Ultrasonics- Non-destructive Testing – pulse echo system through transmission and reflection modes - A,B and C – scan displays.		
<b>UNIT-II</b>	<b>PHYSICS OF SEMICONDUCTORS</b>	9
Fundamentals of semiconductors– Intrinsic semiconductor– carrier concentration in an intrinsic semiconductor – variation of Fermi level with temperature – band gap determination-Extrinsic semiconductor- carrier concentration of N-type and P-type –variation of Fermi level with temperature and impurity concentration –Hall effect – Determination of Hall coefficient – Formation of PN junction -LED and Solar cells.		
<b>UNIT-III</b>	<b>MATERIALS FOR MEDICAL APPLICATIONS</b>	9
Introduction to Superconductivity - Properties of Superconductors - BCS theory (qualitative) – Type-I and Type II Superconductors - Applications-Cryotron-Josephson devices- SQUID-MRI scan and Magnetic Levitation. Magnetism in materials - magnetic field and magnetic induction –permeability - susceptibility–types of magnetic materials – Dia, Para, Ferro, anti-ferro and ferrites-hysteresis. Fiber optics –Total internal reflection, Numerical aperture and acceptance angle - types of fibers -Temperature and displacement sensors- endoscopy.		
<b>UNIT-IV</b>	<b>NUCLEAR AND PARTICLE PHYSICS</b>	9
Radioactivity - characteristics of radioactive material – isotopes - probing by isotopes, reactions involved in the preparation of radioisotopes, the Szilard-Chalmer’s reaction – radiochemical principles in the use of tracers - nuclear medicines – Interaction of charged particles with matter –Specific ionization, Linear energy transfer, range, Bremsstrahlung, Annihilation. Gamma-Ray Spectrometry- Liquid Scintillation Counters-Characteristics of Counting Systems-Gamma Well Counters.		
<b>UNIT-V</b>	<b>ADVANCED ANALYTICAL TECHNIQUES</b>	9
Theory, Instrumentation and Applications of: Thermogravimetric Analysis - Differential Thermal Analysis - Differential Scanning Calorimetry. Surface analysis – Electron microscope-magnification-resolving power- Scanning electron microscope, atomic force microscope - Transmission electron microscope, –Principle, instrumentation and applications		
<b>Contact Hours</b>		<b>: 45</b>

**List of Experiments**

1	Determination of Velocity of ultrasound and compressibility of given liquid – Ultrasonic interferometer.
2	Determination of wavelength of diode laser and angular divergence.
3	Determination of Band gap of given semiconducting material.
4	Determination of Hall coefficient of the given semiconducting material.

5	Determination of solar cell characteristics.			
6	Determine the energy loss of material by using B-H curve set up.			
7	Determination of free space permeability using Helmholtz coil.			
8	Determination of Numerical aperture and angle of acceptance of the optical fiber cable.			
9	Spectrometer – Wavelength of Hg spectrum by diffraction grating.			
10	Spectrometer – Determine refractive index of a prism.			
			<b>Contact Hours</b>	<b>: 30</b>
			<b>Total Contact Hours</b>	<b>: 75</b>

**Course Outcomes:**

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

- Apply the knowledge of oscillating particles and generation of waves in real time applications.
- Comprehend the principles of semiconductors and their device fabrication.
- Make use the properties of superconductors and optical fibre in engineering and technology.
- Apply the characteristics of nuclear and elementary particles to develop innovative instruments.
- Utilize the concepts of advanced analytical techniques.

**Suggested Activities**

- Problem solving sessions

**Suggested Evaluation Methods**

- Quizzes
- Class Presentation / Discussion

**Text Book(s):**

- |   |  |
|---|--|
| 1 | Kasap, S.O. “Principles of Electronic Materials and Devices”, McGraw-Hill Education, 2017.                     |
| 2 | Umesh K Mishra & Jasprit Singh, “Semiconductor Device Physics and Design”, Springer, 2014.                     |
| 3 | Wahab, M.A. “Solid State Physics: Structure and Properties of Materials”. Narosa Publishing House, 2009.       |
| 4 | B.H Brown, R.H.Smallwood, D.C Barber . P.V Lawford Medical physics and Biomedical Engineering, CRC Press 1998. |

**Reference Books(s) / Web links:**

- |   |  |
|---|--|
| 1 | S. O. Pillai, Solid state Physics (Multi colour Edition), New Age International Publisher, 2018.     |
| 2 | Arthur Besier and S. Rai Choudhury, Concepts of Modern Physics (SIE), 7 <sup>th</sup> Edition, 2017. |
| 3 | B.L.Theraja, Modern Physics, 16th edition, S.Chand, 2018.  |
| 4 | J.B.Rajam, Atomic Physics, 7th edition, S.Chand, 2010.   |
| 5 | Charles Kittel, Introduction to Solid State Physics, 8th Edition, Willey India Pvt.Ltd, 2012.        |
| 6 | Garcia, N. & Damask, A. “Physics for Computer Science Students”. Springer-Verlag, 2012.              |

**List of Equipment Available  
(Common to B.E. BME and B.Tech. - Bio –Tech. and Food Tech.)**

S. No	Name of the equipment	Quantity Required	Quantity Available	Deficiency
1	Young’s modulus by Uniform bending method Travelling Microscope	6	13	-
2	Young’s modulus by non-Uniform bending method Travelling Microscope	6	13	-
3	Rigidity Modulus - Torsional Pendulum Setup	6	19	-
4	Band gap of a semiconductor Setup	6	19	-
5	Determination of Plank’s constant - Rheostat, Multimeter, LED	6	10	-
6	B-H curve Setup and CRO	6	7	-
7	Determination of permeability of free space - Helmholtz	5	5	-

	coil setup			
8	Refractive index of Prism – Spectrometer	6	12	-
9	LCR circuit kit	6	7	-
10	Wavelength of Laser and Characteristics -Laser source and grating	6	12	-

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
PH23231.1	3	2	1	-	-	-	-	-	-	-	-	-	1	1	-
PH23231.2	3	2	1	-	-	-	-	-	-	-	-	-	-	-	-
PH23231.3	3	1	2	-	-	-	-	-	-	-	-	-	1	1	-
PH23231.4	3	1	1	-	-	-	-	-	-	-	-	-	-	-	-
PH23231.5	3	2	2	-	1	-	-	-	-	-	-	-	1	-	-
Average	3	1.6	1.4	-	0.2	-	-	-	-	-	-	-	0.6	0.4	-

Subject Code	Subject Name (Laboratory Course)	Category	L	T	P	C
<b>GE23231</b>	<b>PROGRAMMING USING PYTHON</b> Common to all branches of B. E. / B.Tech program (Except–CSE, CSBS, CSD, IT, AI/ML, CYBER SECURITY, AI/DS)	<b>ES</b>	<b>1</b>	<b>0</b>	<b>4</b>	<b>3</b>

**Course Objectives:**

- To understand computers, programming languages and their generations and essential skills for a logical thinking for problem solving.
- To write, test, and debug simple Python programs with conditionals, and loops and functions
- To develop Python programs with defining functions and calling them
- To understand and write python programs with compound data-lists, tuples, dictionaries
- To search, sort, read and write data from /to files in Python.

**List of experiments**

1.	Study of algorithms, flowcharts and pseudocodes.		
2.	Introduction to Python Programming and Python IDLE/Anaconda distribution.		
3.	Experiments based on Variables, Data types and Operators in Python.		
4.	Coding Standards and Formatting Output.		
5.	Algorithmic Approach: Selection control structures.		
6.	Algorithmic Approach: Iteration control structures.		
7.	Experiments based on Strings and its operations.		
8.	Experiments based on Lists and its operations.		
9.	Experiments based on Tuples and its operations.		
10.	Experiments based on Sets and its operations.		
11.	Experiments based on Dictionary and its operations.		
12.	Functions: Built-in functions.		
13.	Functions: User-defined functions.		
14.	Functions: Recursive functions.		
15.	Searching techniques: Linear and Binary.		
16.	Sorting techniques: Bubble and Merge Sort.		
17.	Experiments based on files and its operations.		
<b>Contact Hours</b>		<b>:</b>	<b>75</b>

<b>Course Outcomes:</b>	
On completion of the course, students will be able to:	
•	Understand the working principle of a computer and identify the purpose of a computer programming language and ability to identify an appropriate approach to solve the problem.
•	Write, test, and debug simple Python programs with conditionals and loops.
•	Develop Python programs step - wise by defining functions and calling them.
•	Use Python lists, tuples, dictionaries for representing compound data.
•	Apply searching, sorting on data and efficiently handle data using flat files.

<b>Text Books:</b>	
1.	Allen B. Downey, Think Python: How to Think Like a Computer Scientist, Second edition, Updated for Python3, Shroff/ O'Reilly Publishers, 2016 ( <a href="http://greenteapress.com/wp/think-python/">http://greenteapress.com/wp/think-python/</a> )
2.	Guido Van Rossum and Fred L. Drake Jr, An Introduction to Python-Revised and updated for Python3.2, Network Theory Ltd., 2011.

<b>Reference Books:</b>	
1.	JohnVGuttag, Introduction to Computation and Programming Using Python, Revised and expanded Edition, MIT Press, 2013.
2.	Robert Sedgewick, Kevin Wayne, Robert Dondero, Introduction to Programming in Python: An Inter-disciplinary Approach, Pearson India Education Services Pvt. Ltd, 2016.
3.	Timothy A.Budd, Exploring Python, Mc-Graw Hill Education (India) Private Ltd., 2015.
4.	Kenneth A. Lambert, Fundamentals of Python: First Programs, Cengage Learning, 2012.
5.	Charles Dierbach, Introduction to Computer Science using Python: A Computational Problem-Solving Focus, Wiley India Edition, 2013.
6.	Paul Gries, Jennifer Campbell and Jason Montojo, Practical Programming: An Introduction to Computer Science using Python3, Second edition, Pragmatic Programmers, LLC, 2013.

*Platform needed: Python3 interpreter for Windows/Linux*

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
GE23231.1	2	2	2	2	1	-	-	-	1	1	1	1	3	3	-
GE23231.2	2	1	1	1	1	-	-	-	-	-	1	1	3	2	-
GE23231.3	1	1	2	1	2	-	-	-	-	-	1	1	2	3	2
GE23231.4	2	2	3	2	2	-	-	-	-	-	2	1	2	2	2
GE23231.5	2	2	3	2	3	-	-	-	-	-	2	1	2	2	2
Average	1.8	1.6	2.2	1.6	1.8	0.0	0.0	0.0	0.2	0.2	1.4	1	2.4	2.4	2

Subject Code	Subject Name (Theory course)	Category	L	T	P	C
GE23212	BASIC CIVIL AND MECHANICAL ENGINEERING	ES	3	0	0	3

<b>Objectives:</b>	
•	To impart basic knowledge on Civil Engineering and to familiarize the measurements used in Civil Engineering.
•	To provide the exposure on the fundamental elements of civil engineering structures and different types of foundation.

•	To familiarize the materials used in Civil Engineering and to impart basic knowledge on Mechanical Engineering
•	To understand the working principle of power plant units, IC engines.
•	To understand the working principle of Refrigeration & AC system.

<b>UNIT-I</b>	<b>SCOPE OF CIVIL ENGINEERING AND SURVEYING</b>	<b>9</b>
<p>Overview of Civil Engineering - Civil Engineering contributions to the welfare of Society –Specialized sub disciplines in Civil Engineering – Structural, Construction, Geotechnical, Environmental, Transportation and Water Resources Engineering.</p> <p>Surveying: Objective – classification – principles – measurements of distances: Chain surveying– measurements of angles: Compass surveying – leveling: Reduction of levels–Height of instrument method &amp; Rise and fall method – contouring – determination of areas– examples and basic problems.</p> <p><b>Content beyond syllabus (Not for Examination):</b> Discussion related to civil engineering constructions of Ancient Monuments</p>		
<b>UNIT-II</b>	<b>BUILDING COMPONENTS AND STRUCTURES</b>	<b>9</b>
<p>Foundations: Essential Requirements and function of good foundation – Types of Foundations – Shallow foundations and Deep foundations.</p> <p>Superstructure: Brick masonry – stone masonry – beams – columns – lintels – roofing – flooring –plastering – Types of Bridges and Dams – Rain water harvesting - introduction to high way and rail way</p> <p><b>Content beyond syllabus (Not for Examination):</b> Making of model for Building Components</p>		
<b>UNIT-III</b>	<b>CONSTRUCTION MATERIALS AND SCOPE OF MECHANICAL ENGINEERING</b>	<b>9</b>
<p>Construction Materials: Properties, characterization and types of Bricks – stones– sand – cement – concrete – steel– modern materials. Overview of Mechanical Engineering- Interdisciplinary concepts in Civil and Mechanical Engineering - Mechanical Engineering contributions to the welfare of Society –Specialized sub disciplines in Mechanical Engineering - Manufacturing, Automotives, Energy Engineering- Mechanical Properties. <b>Content beyond syllabus (Not for Examination):</b> Case studies</p>		
<b>UNIT-IV</b>	<b>ENERGY AND AUTOMOTIVES ENGINEERING</b>	<b>9</b>
<p>Energy engineering: Introduction-Classification: Conventional and Non-conventional -Layout and working principle of Thermal, Hydro, Nuclear, Solar and Wind Power Plants–working principle of Boilers: Cochran boiler, Babcock and Wilcox boiler, Turbines, Reciprocating Pumps (single acting and double acting) and Centrifugal Pumps. Automotives: IC Engine – Working principle of Petrol and Diesel Engines – Four stroke and two stroke cycles – Emission Standards and regulations – Introduction to Alternate fuels for IC Engines and Electric Vehicle.</p>		
<b>UNIT-V</b>	<b>REFRIGERATION AND AIR-CONDITIONING SYSTEMS</b>	<b>9</b>
<p>Terminology of Refrigeration and Air Conditioning– Characteristics and requirements of good refrigerant – Principle of vapour compression and absorption system–Layout of typical domestic refrigerator–Window and Split type room Air conditioner.</p> <p><b>Content beyond syllabus (Not for Examination):</b> Discussion related to types of refrigerants</p>		
		<b>Total Contact Hours : 45</b>

<b>Course Outcomes:</b> Upon completion of the course students should be able to:	
•	Able to explain the specialized sub disciplines of civil engineering. And they can Measure distances and area by surveying.
•	Able to explain building components, structures and various types of foundations.
•	Able to explain the usage of construction materials and they can explain the specialized sub disciplines of mechanical Engineering.
•	Able to explain the working principles of internal combustion engines and power plant cycle.
•	Able to explain the components of refrigeration and Air conditioning cycle.

<b>Text Books:</b>	
1	Shanmugam G and Palanichamy M S, “Basic Civil and Mechanical Engineering”, Tata McGraw Hill Publishing Co., New Delhi, 2018
2	Rameshbabu V, “Basic Civil and Mechanical Engineering”, VRB publishers Pvt. Ltd., 2018.

Reference Books(s) / Web links:	
1	Palanikumar, K. Basic Mechanical Engineering, ARS Publications, 2010.
2	RamamruthamS., "Basic Civil Engineering", Dhanpat Rai Publishing Co.(P) Ltd.2013.
3	Sadhu Singh., "Basic Mechanical Engineering", S.Chand Publication 2009
4	Shantha Kumar S R J., "Basic Mechanical Engineering", Hi-tech Publications, Mayiladuthurai,2000.

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
GE23212.1	3	1	2	-	1	1	-	-	-	-	1	2	-	-	-
GE23212.2	3	-	2	-	1	-	-	-	-	-	2	2	-	-	-
GE23212.3	3	-	2	-	1	1	1	-	-	-	2	2	-	-	-
GE23212.4	3	-	2	-	1	-	1	-	-	-	1	2	-	-	-
GE23212.5	3	-	2	-	1	-	-	-	-	-	1	2	-	-	-
Average	3	-	2	-	1	0.4	0.4	-	-	-	0.46	2	-	-	-

Subject Code	BIOCHEMISTRY	Category	L	T	P	C
BT23211		PC	3	0	0	3

**Course objectives:**

This course will enable the students to understand

- The chemical basis of life which involves the importance of water, biological buffers
- The structure, properties of carbohydrates and lipids.
- The structure, properties of proteins and nucleic acids.
- Intermediary metabolic reactions and their regulation.
- Energy production from biomolecules

<b>UNIT I</b>	<b>INTRODUCTION TO BIOMOLECULES</b>	<b>9</b>
Basic principles of organic chemistry - role of carbon - types of functional groups - overview of biomolecules and biochemical reactions - chemical nature of water - pH-Henderson & Hasselbalch equation and biological buffers.		
<b>UNIT II</b>	<b>CARBOHYDRATES AND LIPIDS</b>	<b>9</b>
<b>Carbohydrates:</b> (mono, di – oligo & polysaccharides) - mutarotation, glycosidic bond - epimers, anomers and asymmetric nature of carbon - reactions of monosaccharides and reducing sugars.		
<b>Lipids:</b> Classification- structure and properties- fatty acids – glycerol – saponification – iodination – hydrogenation – phospholipids – glycolipids – sphingolipids – cholesterol – steroids		
<b>UNIT-III</b>	<b>STRUCTURE AND PROPERTIES OF PROTEINS AND NUCLEIC ACIDS</b>	<b>9</b>
<b>Proteins:</b> Structure and properties of amino acids - hierarchy of structural organization of proteins- primary, secondary, tertiary and quaternary structures of proteins.		
<b>Nucleic acids:</b> Introduction to nucleic acids - purines pyrimidines, nucleoside and nucleotide - primary structure of DNA - chemical and structural qualities of 3',5'- phosphodiester bond - secondary structure of DNA - Watson & Crick model - physicochemical properties of DNA - Chargaff's rule – RNA – types and structure - difference between DNA and RNA.		
<b>UNIT-IV</b>	<b>INTERMEDIARY METABOLISM AND ITS REGULATION</b>	<b>9</b>
Introduction to enzymes and metabolism -glycolysis - gluconeogenesis - pentose phosphate shunt - $\beta$ oxidation of fatty acid- TCA cycle - reactions of amino acids - deamination, transamination and decarboxylation - urea cycle - interconnection of pathways and their regulation.		
<b>UNIT-V</b>	<b>BIOENERGETICS</b>	<b>9</b>
Structure of mitochondria - general concept of oxidation and reduction - electronegative potential - high energy		



compounds - ATP/ADP cycle - electron transport chain - oxidative phosphorylation - uncouplers- inhibitors - bioenergetics of glucose and palmitic acid oxidation.

**Total Contact Hours : 45**

**Course outcomes:** Upon completion of the course, the students will be able to

- Understand the chemical basis of life which involves the importance of water and biological buffers.
- Comprehend the structure and functions of carbohydrates and lipids.
- Recognize the structure and functions of proteins and nucleic acids.
- Gain more knowledge about the different metabolic pathways.
- Compute the bioenergetics of various oxidative pathways and understand the importance of ATP.

**Text books:**

- Hames D, Hooper N., BIOS Instant notes - Biochemistry. 4<sup>th</sup> edition, Garland Science, Taylor and Francis group, New York and London, 2011.
- Emine Ercikan Abali, Susan D. Cline, David S. Franklin and Susan M. Viselli. Lippincott's Illustrated Reviews, Biochemistry, Eighth Edition, Lippincott Williams & Wilkins 2021.
- Peter Kennelly, Kathleen Botham, Owen McGuinness, Anthony Weil and Rodwell V.W. Harpers Biochemistry. Appleton and Lange, Stanford, Connecticut, 32<sup>nd</sup> Edition, McGraw Hill Education, February 2022.

**Reference books:**

- Nelson D.L. and Cox M.M. Lehninger Principles of Biochemistry, 8<sup>th</sup> edition, WH Freeman & Co, 2021.
- Burtis & Ashwood W.B. Tietz Textbook of Clinical chemistry, Volume 564, Saunders Company, 1999.
- Jeremy Berg, Gregory Gatto Jr, Justin Hines, John L. Tymoczko, Lubert Stryer. Biochemistry, 10<sup>th</sup> Edition McMillan Publishers, 2023.
- Donald Voet & Judith G. Voet. Biochemistry, 4<sup>th</sup> Edition, John Wiley and Sons, Inc., 2010.
- Rama Rao, A.V.S.S., A Textbook of Biochemistry, 11<sup>th</sup> Edition, 2009.
- A.C Deb. Fundamentals of Biochemistry, 10<sup>th</sup> Edition, 2023.

**Web links:**

- <https://nptel.ac.in/courses/102105034>
- <https://nptel.ac.in/courses/102106087>

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
BT23211.1	3	3	3	3	1	3	3	1	1	3	1	3	3	3	3
BT23211.2	3	3	3	3	1	3	3	1	2	3	2	3	3	3	3
BT23211.3	3	3	3	3	3	3	3	1	2	3	2	3	3	3	3
BT23211.4	3	3	3	3	2	3	3	3	1	3	1	3	3	3	3
BT23211.5	3	3	3	3	3	1	1	1	3	1	3	3	3	3	3
Average	3	3	3	3	2	2.6	2.6	1.4	1.5	2.6	1.5	3	3	3	3

Subject Code	Subject Name (Theory course)	Category	L	T	P	C
MC23111	Indian Constitution and Freedom Movement	Theory	3	0	0	0

Non Credit Course - Common to all branches of B.E/B. Tech programmes – First / Second/third Semester

**Objectives:**

- To apprehend the sacrifices made by the freedom fighters.
- To inculcate the values enshrined in the Indian constitution.
- To instill a sense of responsibility as the citizens of India.
- To familiarise about the functions of the various levels of Government.

- To be informed about Constitutional and Non- Constitutional bodies.

<b>UNIT-I</b>	<b>INDIAN FREEDOM MOVEMENT</b>	9
British Colonialism in India-Colonial administration till 1857- Revolt of 1857- Early Resistance to British Rule- Rise of Nationalism in India- <b>Indian Freedom Struggle under Mahatma Gandhi</b> -Non- Cooperation Movement- Civil Disobedience Movement- Quit India Movement-British Official response to National movement- Independence of India Act 1947-Freedom and Partition.		
<b>UNIT-II</b>	<b>CONSTITUTION OF INDIA</b>	9
Historical Background – Indian Constitution: Constitution’ meaning of the term, Sources and constitutional history, Constituent Assembly of India – Philosophical foundations of the Indian Constitution – Preamble – Fundamental Rights – Directive Principles of State Policy – Fundamental Duties – Citizenship – Constitutional Remedies for citizens.		
<b>UNIT-III</b>	<b>STRUCTURE AND FUNCTIONS OF CENTRAL GOVERNMENT</b>	9
Union Government – Structure of the Union Government and Functions – President – Vice President – Prime Minister – Cabinet – Parliament – Supreme Court of India – Judicial Review.		
<b>UNIT-IV</b>	<b>STRUCTURE AND FUNCTION OF STATE GOVERNMENT AND LOCAL BODY</b>	9
State Government – Structure and Functions – Governor – Chief Minister – Cabinet – State Legislature – Judicial System in States – High Courts and other Subordinate Courts- Role and Importance, Municipalities: Introduction, Mayor and role of Elected Representative, CEO of Municipal Corporation, Pachayati Raj: Introduction, Elected officials and their roles, Village level: Role of Elected and Appointed officials.		
<b>UNIT-V</b>	<b>CONSTITUTIONAL FUNCTIONS AND BODIES</b>	9
Indian Federal System – Centre – State Relations – President’s Rule – Constitutional Functionaries – Assessment of working of the Parliamentary System in India- CAG, Election Commission, UPSC, GST Council and other Constitutional bodies-. NITI Aayog, Lokpal, National Development Council and other Non –Constitutional bodies.		
<b>Total Contact Hours: 45</b>		

**Course Outcomes:** Upon completion of the course, students will be able to:

- Appreciate the sacrifices made by freedom fighters during freedom movement.
- Be responsible citizens and abide by the rules of the Indian constitution.
- Be aware of the functions of the Indian government.
- Be knowledgeable about the functions of the state Government and the Local bodies.
- Apply the knowledge on constitutional functions and role of constitutional bodies and non-constitutional bodies.

#### **SUGGESTED ACTIVITIES**

- Famous speeches from around the world relating to independence
- Case study
- Quiz on Portfolio and Cabinet
- Discussions on International Associations like the UN, BRICS, QUAD
- Presentation on issues around the world

#### **SUGGESTED EVALUATION METHODS**

- Assignment topics
- Quizzes
- Class Presentation/Discussion
- Continuous assessments (CAT)

#### **Text Book(s):**

- M. Laxmikanth , “Indian Polity:, McGraw-Hill, New Delhi.
- Durga Das Basu, “Introduction to the Constitution of India “, Lexis Nexis, New Delhi. 21<sup>st</sup>ed 2013.

- P K Agarwal and K N Chaturvedi, PrabhatPrakashan, New Delhi, 1<sup>st</sup>ed , 2017.

**Reference Books(s) / Web links:**

- Sharma, Brij Kishore, "Introduction to the Constitution of India, Prentice Hall of India, New Delhi.
- U.R.Gahai, "Indian Political System ", New Academic Publishing House, Jalaendhar
- Bipan Chandra, India's Struggle for Independence, Penguin Books, 2016.
- Maciver and Page, "Society: An Introduction Analysis ", Mac Milan India Ltd., New Delhi.2<sup>nd</sup>ed, 2014.
- Bipan Chandra, History of Modern India, Orient Black Swan, 2009.

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
MC23111.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MC23111.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MC23111.3	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-
MC23111.4	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
MC23111.5	-	-	-	-	-	1	-	1	1	-	-	-	-	-	-
Average	-	-	-	-	-	1	-	1	1	-	-	-	-	-	-

GE23217

தமிழரும் தொழில்நுட்பமும்

L T P C

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**அலகு I நெசவு மற்றும் பானைத் தொழில்நுட்பம்: 3**

சங்க காலத்தில் நெசவுத் தொழில் - பானைத் தொழில்நுட்பம் - கருப்பு சிவப்பு பாண்டங்கள் - பண்டங்களில் கீறல் குறியீடுகள்.

**அலகு II வடிவமைப்பு மற்றும் கட்டிடத் தொழில்நுட்பம்: 3**

சங்க காலத்தில் வடிவமைப்பு மற்றும் கட்டுமானங்கள் & சங்க காலத்தில் வீட்டுப்பொருட்களில் வடிவமைப்பு - சங்க காலத்தில் கட்டுமான பொருட்களும் நடுகல்லும் - சிலப்பதிகாரத்தில் மேடை அமைப்பு பற்றிய விவரங்கள் - மாமல்லபுரச் சிற்பங்களும், கோவில்களும் - சோழர் காலத்துப் பெருங்கோயில்கள் மற்றும் பிற வழிபாட்டுத் தலங்கள் - நாயக்கர் காலக் கோயில்கள் - மாதிரி கட்டமைப்புகள் பற்றி அறிதல், மதுரை மீனாட்சி அம்மன் ஆலயம் மற்றும் திருமலை நாயக்கர் மஹால் - செட்டிநாடு வீடுகள் - பிரிட்டிஷ் காலத்தில் சென்னையில் இந்தோ - சாரோசெனிக் கட்டிடக் கலை.

**அலகு III உற்பத்தித் தொழில் நுட்பம்: 3**

கப்பல் கட்டும் கலை - உலோகவியல் - இரும்புத் தொழிற்சாலை - இரும்பை உருக்குதல், எஃகு - வரலாற்றுச் சான்றுகளாக செம்பு மற்றும் தங்க நாணயங்கள் - நாணயங்கள் அச்சடித்தல் - மணி உருவாக்கும் தொழிற்சாலைகள் - கல்மணிகள், கண்ணாடி மணிகள் - சுடுமண் மணிகள் - சங்கு மணிகள் - எலும்புத்துண்டுகள் - தொல்லியல் சான்றுகள் - சிலப்பதிகாரத்தில் மணிகளின் வகைகள்.

**அலகு IV வேளாண்மை மற்றும் நீர்ப்பாசனத் தொழில் நுட்பம்: 3**

அணை, ஏரி, குளங்கள், மதகு - சோழர்காலக் குமுழித் தாம்பின் முக்கியத்துவம் - கால்நடை பராமரிப்பு - கல்நடைகளுக்காக வடிவமைக்கப்பட்ட கிணறுகள் - வேளாண்மை மற்றும் வேளாண்மைச் சார்ந்த செயல்பாடுகள் - கடல்சார் அறிவு - மீன்வளம் - முத்து மற்றும் முத்துக்குளித்தல் - பெருங்கடல் குறித்த பண்டைய அறிவு - அறிவுசார் சமூகம்.

**அலகு V அறிவியல் தமிழ் மற்றும் கணித்தமிழ் : 3**

அறிவியல் தமிழின் வளர்ச்சி - கணித்தமிழ் வளர்ச்சி - தமிழ் நூல்களை மின்பதிப்பு செய்தல் - தமிழ் மென்பொருட்கள் உருவாக்கம் - தமிழ் இணையக் கல்விக்கழகம் - தமிழ் மின் நூலகம் - இணையத்தில் தமிழ் அகராதிகள் - சொற்குவைத் திட்டம்.

TOTAL : 15 PERIODS

**TEXT-CUM-REFERENCE BOOKS**

1. தமிழக வரலாறு - மக்களும் பண்பாடும் - கே.கே. பிள்ளை (வெளியீடு: தமிழ்நாடு பாடநூல் மற்றும் கல்வியியல் பணிகள் கழகம்).
2. கணினித் தமிழ் - முனைவர் இல. சுந்தரம். (விகடன் பிரசுரம்).
3. கீழடி - வைகை நதிக்கரையில் சங்ககால நகர நாகரிகம் (தொல்லியல் துறை வெளியீடு)
4. பொருறை - ஆற்றங்கரை நாகரிகம். (தொல்லியல் துறை வெளியீடு)
5. Social Life of Tamils (Dr. K. K. Pillay) A joint publication of TNTB & ESC and RMRL – (in print)
6. Social Life of the Tamils – The Classical Period (Dr. S. Singaravelu)(Published by: International Institute of Tamil Studies.
7. Historical Heritage of the Tamils (Dr. S. V. Subatamanian, Dr.K.D. Thirunavukkarasu) (Published by: International Institute of Tamil Studies).
8. The Contributions of the Tamils to Indian Culture (Dr.M.Valarmathi) (Published by: International Institute of Tamil Studies).
9. Keeladi – 'Sangam City Civilization on the banks of river Vaigai' (Jointly Published by: Department of archaeology & Tamil Nadu Text Book and Educational Services Corporation, Tamil Nadu)
10. Studies in the History of India with Special Reference to Tamil Nadu (Dr.K.K.Pillay) (Published by: The Author)
11. Porunai Civilization (Jointly Published by: Department of Archaeology & Tamil Nadu Text Book and Educational Services Corporation, Tamil Nadu)
12. Journey of Civilization Indus to Vaigai (R.Balakrishnan) (Published by: RMRL) – Reference Book.

<b>BT23221</b>	<b>BIOCHEMISTRY LABORATORY</b>	<b>Category</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		<b>PC</b>	<b>0</b>	<b>0</b>	<b>4</b>	<b>2</b>

**Course objectives:**

- To learn and understand the principles behind the qualitative and quantitative estimation of biomolecules

**List of Experiments**

<b>1</b>	Preparation of buffers of biological importance
<b>2</b>	Qualitative tests for carbohydrates – distinguishing reducing from non-reducing sugars and keto from aldo sugars.
<b>3</b>	Glucose estimation by DNS method
<b>4</b>	Extraction of lipids and analysis by TLC
<b>5</b>	Estimation of rancidity, iodine number and acetyl number of lipids
<b>6</b>	Quantitative estimation of aminoacids using Ninhydrin-distinguishing amino from imino group.
<b>7</b>	Protein estimation by Bradford method.
<b>8</b>	Protein estimation by Folin Lowry method.
<b>9</b>	Estimation of Creatinine in given sample and its significance.
<b>10</b>	Estimation of DNA
<b>Contact Hours</b>	
<b>: 60</b>	

**Course outcomes:** Upon completion of the course, the students will be able to

- Acquire the skill to prepare biologically important buffers
- Perform qualitative analyses for the identification of biomolecules
- Estimate various biomolecules
- Acquire expertise in operation of analytical instruments
- Perform diagnostic tests in biochemical laboratories

<b>Text books:</b>	
•	J.Jayaraman, Laboratory Manual in Biochemistry, 2 <sup>nd</sup> Edition, New Age International Private Limited, January 2011.
•	S. K. Sawhney, Randhir Singh Eds, Introductory Practical Biochemistry, 5th or later edition, Narosa Publishing House, New Delhi, 2014.

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
BT23221.1	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
BT23221.2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
BT23221.3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
BT23221.4	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
BT23221.5	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Average	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3

Subject Code	Course Title	Category	L	T	P	C
<b>MA23311</b>	<b>TRANSFORMS AND APPLIED PARTIAL DIFFERENTIAL EQUATIONS</b>	<b>BS</b>	<b>3</b>	<b>1</b>	<b>0</b>	<b>4</b>
<b>Common to III sem. B.E. - AERO, MCT, R&amp;A and B.Tech. – BT, FT and CHEM</b>						

<b>Objectives:</b>
• To express Fourier series to study the behaviour of periodic functions and their applications in system communications, digital signal processing and field theory.
• To show continuous function arising in wave and heat propagation, signals and systems using Fourier Transforms.
• To obtain solution of one dimensional wave equation with finite difference techniques.
• To solve one and two dimensional heat flow equations using finite difference methods and numerical techniques.
• To make use of Z-transform to illustrate discrete function arising in wave and heat propagation, signals and systems.

<b>UNIT-I</b>	<b>FOURIER SERIES</b>	<b>12</b>
Dirichlet's conditions – General Fourier series – Odd and even functions – Half range sine series – Half range cosine series – Parseval's identity – Harmonic analysis.		
<b>UNIT-II</b>	<b>FOURIER TRANSFORMS</b>	<b>12</b>
Statement of Fourier integral theorem – Fourier transform pair – Fourier sine and cosine transforms – Properties – Transforms of simple functions – Convolution theorem – Parseval's identity - Application to boundary value problems.		
<b>UNIT-III</b>	<b>WAVE EQUATION</b>	<b>12</b>
Solution of one-dimensional wave equation - Finite difference techniques for the solution for PDE- One Dimensional Wave Equation by Explicit method		
<b>UNIT-IV</b>	<b>HEAT EQUATION</b>	<b>12</b>
One dimensional equation of heat conduction – Steady state solution of two-dimensional equation of heat conduction (excluding insulated edges)- Numerical computation: One dimensional heat flow equation by implicit and explicit methods		
<b>UNIT-V</b>	<b>Z-TRANSFORMS</b>	<b>12</b>
Z- transforms - Elementary properties – Inverse Z - transform (using residues) - Formation of difference equations – Solution of difference equations using Z- transform.		
<b>Total Contact Hours: 60</b>		

<b>Course Outcomes:</b>	
On completion of the course, students will be able to	
●	Demonstrate Fourier series to study the behaviour of periodic functions and their applications in engineering problems such as system communications, digital signal processing and field theory.
●	Apply the shifting theorems, Fourier integral theorems, Inverse Fourier sine and cosine transforms appropriate problems in engineering and technology.
●	Evaluate solution of one-dimensional wave equation arising in various field of engineering using finite difference techniques.
●	Apply the numerical techniques of differentiation to solution of heat flow equations arising in various branches of engineering.
●	Use Z-transform to illustrate discrete function arising in wave and heat propagation, signals and systems.

<b>SUGGESTED ACTIVITIES</b>	
●	Problem solving sessions
●	Activity Based Learning
●	Online MATLAB session can be implemented

<b>SUGGESTED EVALUATION METHODS</b>	
●	Problem solving in Tutorial sessions
●	Assignment problems
●	Quizzes and class test
●	Discussion in classroom

<b>Text Books:</b>	
1	Erwin Kreyszig, "Advanced Engineering Mathematics", 10th Edition, Wiley India, 2015.
2	Veerarajan. T., "Transforms and Partial Differential Equations", Tata McGraw Hill Education Pvt.Ltd.,New Delhi, Second reprint, 2012.
3	Grewal B.S., "Higher Engineering Mathematics", 43rd Edition, Khanna Publishers, Delhi, 2014.
4	Ramana B.V., "Higher Engineering Mathematics", Tata McGraw Hill Publishing Company Limited, New Delhi, 2008.
5	P. Kandasamy, K. Gunavathy, Thilagavathy., "Engineering Mathematics Transforms and Partial Differential Equations", S.Chand & Company, 2002.

<b>Reference Books / Web links:</b>	
1	N. Subramaniam, K. S. Ramaswami., "Transforms and Partial Differential Equations", Pearson Education, 2018.
2	Glyn James, "Advanced Modern Engineering Mathematics", 3rd Edition, Pearson Education, 2007.
3	Ray Wylie C and Barrett.L.C, "Advanced Engineering Mathematics" Tata McGraw Hill Education Pvt Ltd, Sixth Edition, New Delhi, 2012.
4	Bali N., Goyal M. and Watkins C., "Advanced Engineering Mathematics", Firewall Media (An imprint of Lakshmi Publications Pvt., Ltd.), 7th Edition, New Delhi, 2009.
5	Peter V.O'Neil, "Advanced Engineering Mathematics", Cengage Learning India Pvt., Ltd, 7 <sup>th</sup> Edition, New Delhi, 2012. <a href="https://drspmaths.files.wordpress.com/2020/01/advanced-engineering-mathematics-peter-v.-o-neil.pdf">https://drspmaths.files.wordpress.com/2020/01/advanced-engineering-mathematics-peter-v.-o-neil.pdf</a>

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
MA23311.1	3	3	3	2	1	-	-	-	-	-	-	1	2	1	2
MA23311.2	3	3	3	2	1	-	-	-	-	-	-	1	2	1	2
MA23311.3	3	3	3	3	2	-	-	-	-	-	-	2	1	2	2
MA23311.4	3	3	2	3	2	-	-	-	-	-	-	2	1	-	1
MA23311.5	2	3	2	-	-	-	-	-	-	-	-	-	1	1	-
Average	2.8	3	2.6	2.5	1.5	-	-	-	-	-	-	1.5	1.4	1.3	2

BT23311	ENZYME TECHNOLOGY AND BIOTRANSFORMATIONS	Category	L	T	P	C
		PC	3	0	0	3

<b>Objectives:</b> To enable the students to	
●	Learn enzyme reactions
●	Investigate kinetics of enzymatic reactions
●	Understand enzyme extraction, production and purification process.
●	Study various methods of enzyme immobilisation and applications of immobilised enzymes
●	Basic knowledge concerning biotransformation reactions with the usage of enzymes.

<b>UNIT-I</b>	<b>INTRODUCTION TO ENZYMES</b>	9
Classification of enzymes – Mechanisms of enzyme action – Concept of active site and energetics of enzyme substrate complex formation – Coenzymes and cofactors - Factors affecting enzyme activity – Specificity of enzyme action – Principles of catalysis – Collision theory and transition state theory – Role of entropy in catalysis.		
<b>UNIT-II</b>	<b>KINETICS OF ENZYME ACTION</b>	9
Kinetics of single substrate reactions; estimation of Michaelis-Menten parameters – Multi- substrate reactions Mechanisms and kinetics – Turnover number – Types of inhibition and models for substrate and product – Allosteric regulation of enzyme – Monod Changeux Wyman model.		
<b>UNIT-III</b>	<b>ENZYME IMMOBILIZATION AND BIOSENSORS</b>	9
Physical and chemical techniques for enzyme immobilization – Adsorption, matrix entrapment, encapsulation, cross-linking, covalent binding and suitable examples – Advantages and disadvantages – Design of enzyme electrodes (calorimetric, potentiometric, amperometric, optical, piezoelectric, immunosensors) - Application of biosensors in industry, healthcare and environment.		
<b>UNIT-IV</b>	<b>PURIFICATION CHARACTERIZATION AND APPLICATION OF ENZYMES</b>	12
Isolation and purification of crude enzyme extracts from plant, animal and microbial sources – Methods of characterization of enzymes – Development of enzymatic assays. Application of enzymes in food, leather and pharmaceutical industry, Industrial applications of hyperthermophilic and psychrophilic enzymes.		
<b>UNIT-V</b>	<b>BIOTRANSFORMATION REACTIONS</b>	6
Enzymes role in reduction reactions – Aldehydes, Ketones, Baeyer-Villiger Oxidation, Enzymes in organic synthesis – esters, amide, peptide – Modified and Artificial Enzymes – Catalytic antibodies.		
		<b>Contact Hours</b> : <b>45</b>

<b>Course Outcomes:</b>	
On completion of the course, the students will be able to	
●	Understand enzyme classification and enzyme reactions.
●	Understand kinetics of enzyme catalysed reactions.
●	Comprehend the immobilization process and its application in various industries
●	Carry out enzyme isolation, purification and characterization.
●	Design biotransformation reactions and production of novel enzymes.



<b>Suggested Activities</b>	
●	Problem solving sessions
●	Industrial Visit
●	Case studies

<b>Suggested Evaluation Methods</b>	
●	Quizzes
●	Seminar Presentation / Discussion

<b>Text Book(s):</b>	
1	Trevor Palmer , Enzymes II Horwood Publishing Ltd
2	Faber K , Biotransformations in Organic Chemistry, IV edition, Springer

<b>Reference Books(s) / Web links:</b>	
1	Harvey W. Blanch, Douglas S. Clark, Biochemical Engineering, Marcel Dekker, Inc.
2	James M. Lee, Biochemical Engineering, PHI, USA.
3	James. E. Bailey & David F. Ollis, Biochemical Engineering Fundamentals, McGraw Hill.
4	Wiseman, Enzyme Biotechnology, Ellis Horwood Pub.

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
BT23311.1	2	1	2	3	1	3	-	-	-	-	-	3	2	1	3
BT23311.2	3	3	2	3	2	-	-	-	-	-	-	3	3	3	3
BT23311.3	3	3	3	3	3	3	2	-	2	-	-	3	3	3	3
BT23311.4	3	3	3	3	3	3	3	-	2	-	2	3	3	3	3
BT23311.5	3	3	3	3	3	3	3	-	2	-	-	3	3	3	3
Average	2.8	2.6	2.6	3	2.4	2.4	1.6	0	1.2	0	0.4	3	2.8	2.6	3

<b>BT23312</b>	<b>STOICHIOMETRY AND FLUID MECHANICS</b>	<b>Category</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		<b>ES</b>	<b>3</b>	<b>1</b>	<b>0</b>	<b>3</b>
<b>Course Objectives:</b>						
● To learn the fundamentals of units and conversion						
● To understand the concepts in material balance for different unit operations						
● To gain knowledge about the concepts of energy balance equations						
● To understand the basics of fluid flow						
● To work with fluidized bed and pumps						

<b>UNIT-I</b>	<b>INTRODUCTION</b>	<b>9</b>
Dimensions – system of units - conversion factors - Compositions of mixtures and solutions - gas laws		
<b>UNIT-II</b>	<b>CONCEPTS IN MATERIAL BALANCES</b>	<b>9</b>
Material balance concept – overall & component – material balance applications in industries - evaporator, absorber, Distillation, Extraction, crystallization, drying, mixing, Chemical Reaction-Limiting, excess component, Fractional conversion and yield, Combustion Reactions.		
<b>UNIT-III</b>	<b>CONCEPTS IN ENERGY BALANCES</b>	<b>9</b>
Energy balance equation for open systems, closed system, sensible and latent heat calculations - Application of energy balance in Bioprocesses		

<b>UNIT-IV</b>	<b>FLUID PROPERTIES &amp; FLUID MECHANICS</b>	<b>9</b>
Fluids – types - Fluid statics and its application – Boundary layer - Fluid Dynamics – equation of continuity – Bernoulli's equation – Flow of incompressible fluids in pipes - Fluid flow measurement - Orifice, venturi and Rotameter.		
<b>UNIT-V</b>	<b>FLOW OF FLUID THROUGH PACKINGS</b>	<b>9</b>
Drag, Flow through packed bed, Fluidization – Types – Applications, Pipes, Fittings and Valves, Pumps – Centrifugal pump and Reciprocating pump.		
<b>Total Contact Hours</b>		<b>: 45</b>

<b>Course Outcomes:</b> Upon the completion of the course, the students will be able to
Learn the fundamentals of the units and conversions
Solve the material balance problems for different unit operations
Solve energy balance equations for different systems
Solve the problems related to fluid flow
Select various valves and pumps for its application in industries

<b>Text Book(s):</b>	
●	Bhatt, B.I. and S.M.Vora–Stoichiometry (SI Units) II, 3rd Edition, Tata McGraw Hill, 1996.
●	McCabe, W.L., J.C. Smith and P. Harriot—Unit Operations of Chemical Engineering II, 6 <sup>th</sup> Edition, McGraw Hill, 2001

<b>Reference Books(s) / Web links:</b>	
●	Himmelblau, D.M. -Basic principles and calculations in Chemical Engineering II, 6th Edition, PHI, 2006.
●	Smith J.M., Van Ness H.C., and Abbot M.M. -Introduction to Chemical Engineering Thermodynamics I, VI <sup>th</sup> Edition. Tata McGraw-Hill, 2003.
●	Sandler S.I.-Chemical and Engineering Thermodynamics II, John Wiley, 1989.
●	Perry's Chemical Engineers' Handbook, 9th Edition, Kindle Edition by Don W. Green, Marylee Z. Southard, Imprint: McGraw-Hill Education.
●	<a href="http://www.learnchem.net/tutorials/stoich.shtml">http://www.learnchem.net/tutorials/stoich.shtml</a>
●	<a href="http://nptel.ac.in/courses/113104010">http://nptel.ac.in/courses/113104010</a>
●	Y.V.C.Rao , Chemical Engineering Thermodynamics' , University Press (India) Ltd., Hyderabad 1997

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
BT23312.1	3	3	1	-	-	-	-	-	1	-	3	3	-	-	3
BT23312.2	3	3	3	3	2	-	-	-	1	-	2	3	-	-	3
BT23312.3	3	3	3	3	2	-	-	-	1	-	2	3	-	-	3
BT23312.4	3	3	2	2	-	-	-	-	-	-	2	3	-	--	3
BT23312.5	3	3	2	-	-	-	-	-	-	-	2	3	-	-	3
Average	3	3	2.2	1.6	0.8	-	-	-	1	-	2.2	3	-	-	3

<b>BT23313</b>	<b>MOLECULAR GENETICS</b>	<b>Category</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		<b>PC</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

<b>Objectives:</b>	
●	Familiarize students with cell and molecular components and their characteristics of both Prokaryotes and Eukaryotes.
●	To elucidate the mechanisms of replication
●	To provide in depth knowledge in transcription process
●	To explain about the decoding process
●	To provide in-depth knowledge in the area of gene expression and their regulation.

<b>UNIT-I</b>	<b>NUCLEIC ACIDS AND THEIR PROPERTIES</b>	9
Introduction to nucleic acids: Nucleic acids as genetic material, Structure and physicochemical properties of DNA and RNA, differences in DNA and RNA. Primary structure of DNA and RNA, Forms of DNA(A-DNA,B-DNA and Z-DNA),Chargaffs rule, Hogsteen base pairing, Denaturation and renaturation ,hyperchromic effect, Organization of genes in prokaryotic and eukaryotic chromosomes		
<b>UNIT-II</b>	<b>DNA REPLICATION AND REPAIR</b>	9
Overview of Central dogma. Organization of prokaryotic and eukaryotic chromosomes. Classic Experiments: DNA as the genetic material, DNA replication: Meselson & Stahl experiment, bi-directional DNA replication, Okazaki fragments, Proteomics of DNA replication, Fidelity of DNA replication, Inhibitors of DNA replication, phage replication, Telomere replication in eukaryotes. D-loop and rolling circle mode of replication. Mutation, various types of repair mechanisms.		
<b>UNIT-III</b>	<b>TRANSCRIPTION</b>	9
Transcription, characteristics of promoter and enhancer sequences. Inhibitors of transcription, ribozymes, post transcriptional modification, splicing, reverse transcription, transcriptomics.		
<b>UNIT-IV</b>	<b>TRANSLATION</b>	9
Introduction to Genetic code: Elucidation of genetic code, Codon degeneracy, Wobble hypothesis and its importance, Prokaryotic and eukaryotic ribosomes. Steps in translation: Initiation, Elongation and termination of protein synthesis. Inhibitors of protein synthesis. Post-translational modifications and its importance. Protein localization		
<b>UNIT-V</b>	<b>REGULATION OF GENE EXPRESSION</b>	9
Prokaryotic gene regulation –lac and trp operon, Eukaryotic Gene Regulation, gene transfer, Regulatable promoter transduction, transformation, Epigenetics		
<b>Total Contact Hours</b>		<b>: 45</b>

<b>Course Outcomes:</b> Students should be able to	
●	Describe the basic structure and biochemistry of nuclear components
●	Demonstrate the replication mechanism
●	Explain how synthesis of RNA occurs in the cell
●	Describe the mechanism of protein synthesis and localization
●	Understand gene expression.

<b>Text Book(s):</b>	
1	Friefelder, David. —Molecular Biology.NarosaPublications, 1999
2	Weaver, Robert F. —Molecular Biology IInd Edition,Tata McGraw-Hill, 2003.
3	Karp, Gerald—Cell and Molecular Biology: Concepts and Experiments, IVthEdition, JohnWiley, 2005.
4	Friefelder, David and George M. Malacinski —Essentials of Molecular BiologyI IInd Edition, Panima Publishing, 1993.

<b>Reference Books(s) / Web links:</b>	
1	Tropp, BurtonE. —Molecular Biology: Genesto ProteinsI. IIIrd Edition.Jones and Bartlett, 2008.
2	Glick, B.R. and J.J. Pasternak. —Molecular Biotechnology : Principles and Applications of Recombinant DNAI 4th Edition. ASM,201

**Suggested activities**

Animated video  
Lecture –PPT  
Lecture –BB

**Suggested assessment**

Quizzes  
Assignment/case study

**Weblink**

<https://www.bing.com/search?q=molecular+biology&cvid=9fcf3cb89a4049f1a77a14ea9c45b483&aqs=edge.0.014j46j0l4.5671j0j9&FORM=ANAB01&PC=U531>

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
BT23313.1	3	3	2	3	-	-	-	3	-	3	-	1	1	2	3
BT23313.2	3	3	3	3	3	-	-	3	-	3	2	3	2	3	3
BT23313.3	3	3	3	3	3	-	1	3	-	3	2	3	2	3	3
BT23313.4	3	3	3	3	3	-	-	3	-	3	2	3	2	3	3
BT23313.5	3	3	3	3	-	2	-	3	3	3	-	3	2	2	3
Average	3	3	2.8	3	1.8	0.4	0.2	3.0	0.6	3	1.2	2.6	1.8	2.6	3

BT23314	CELL BIOLOGY					Category	L	T	P	C
						PC	3	0	0	3

**Objectives:**

•	To understand the structure and functions of cells and their organisation into tissues.
•	To acquire knowledge in the area of transport of ions and the mechanism of transmission of nerve impulses.
•	To analyse the various modes of communication between cells.
•	To study the types of cell division and its role in carcinogenesis.
•	To understand the techniques applied in cell research.

<b>UNIT-I</b>	<b>CELL STRUCTURE AND FUNCTION OF THE ORGANELLES</b>	9
Evolution of cells, Eukaryotic cells, Sub-cellular organelles and functions, Membranes-Structure and Function, Cytoskeletal proteins- Actin, IF, Microtubules -Significance of RBC Cytoskeleton, Extracellular matrix- Composition and function, Cell Junctions -Anchoring Junctions, Tight Junctions, Gap Junctions		
<b>UNIT-II</b>	<b>TRANSPORT ACROSS BIOLOGICAL MEMBRANES</b>	9
Active, passive transport (simple diffusion, facilitated diffusion, glucose transport, anion exchanger), ATP powered pumps – Na <sup>+</sup> /K <sup>+</sup> pumps, Ca <sup>++</sup> pumps – significance, structure and mechanism of transport, secondary active transport, uniport, symport, antiport, exocytosis and endocytosis. Resting potential, action potential, conduction of nerve impulses, neurotransmitters. Ligand gated (acetyl choline) / voltage gated ion channels (Na <sup>+</sup> , K <sup>+</sup> , Ca <sup>++</sup> ).		
<b>UNIT-III</b>	<b>SIGNAL TRANSDUCTION</b>	9
Biosignals, Steps involved in signalling, Modes of Signalling- autocrine, paracrine and endocrine, Types of receptor- Intracellular and Membrane bound - role of second messengers in cell signalling, cyclic AMP- Epinephrine Signalling, cyclic GMP – Visual signal transduction and NO signalling, IP3, DAG, Ca <sup>++</sup> – Phosphoinositol lipid pathway, Ras/MAPK pathway –EGF.		
<b>UNIT-IV</b>	<b>CELL DIVISION, APOPTOSIS AND CANCER</b>	9
Mitosis, Meiosis, Cell cycle and its regulation, molecules controlling cell cycle – cyclins CDKs, CDKIs, check points, cell survival and apoptosis pathways - In relation to cancer.		
<b>UNIT-V</b>	<b>TECHNIQUES USED TO STUDY CELLS</b>	9

Cell fractionation and flow cytometry-FACS, sub cellular fractionation - Differential velocity centrifugation and Equilibrium density centrifugation, Characterization of cells in culture using: Cell viability assays–MTT Assay, Trypan Blue exclusion, Leishman staining, H &E staining, Immunohistochemistry, Cell migration- Scratch assay, Membrane fluidity -FRAP		
<b>Contact Hours</b>	<b>:</b>	<b>45</b>

<b>Course Outcomes:</b>	
On completion of the course, the students will be able to	
•	Apply knowledge in the area of cellular organisation.
•	Analyse the modes of transport and relate the same to function of nervous muscular systems.
•	Examine the methods of communication within the cells.
•	Correlate the basic concepts of cell division and their role in carcinogenesis.
•	Design simple methods to analyse cell and its activity

<b>Suggested Activities</b>	
•	Laboratory session (Unit 5), Interactive animation (Unit 2,3), Interactive videos (Unit 1,4), Discussion on major endocrine systems, Discussion on relevant case studies

<b>Suggested Evaluation Methods</b>	
•	Quizzes
•	Class Presentation / Discussion
•	Assignments
•	Continuous Assessment Tests

<b>Text Book(s):</b>	
1	Lodish, Harvey et al., —Molecular Cell Biology, Vth Edition, W.H.Freeman, 2ss005.
2	Cooper, G.M. and R.E. Hansman —The Cell : A Molecular Approach, IVth Edition, ASM Press, 2007.
3	Jeff Hardin and James P Lodolce – Becker’s World of the Cell, Xth Edition, Pearson Education, 2022
4	Lewis J Kleinsmith – Principles of Cancer Biology, Ist Edition, Pearson Education, 2014

<b>Reference Books(s) / Web links:</b>	
1	Lehninger A.L., Nelson D.L. and Cox M.M. Principles of Biochemistry, 6th edition, CBS publishers and distributors, 2012.
2	Lubert Stryer W.H. Biochemistry, 5th Revised edition Freeman and company, New York, 2002.
3	<a href="https://www.nature.com/scitable/ebooks/cell-biology-for-seminars-14760004/contents/">https://www.nature.com/scitable/ebooks/cell-biology-for-seminars-14760004/contents/</a>
4	<a href="https://openbooks.lib.msu.edu/neuroscience/chapter/the-membrane-at-rest/">https://openbooks.lib.msu.edu/neuroscience/chapter/the-membrane-at-rest/</a>
5	<a href="https://www.physiologyweb.com/lecture_notes/resting_membrane_potential/resting_membrane_potential_in_real_cells_multiple_ions_contribute_to_the_membrane_potential.html">https://www.physiologyweb.com/lecture_notes/resting_membrane_potential/resting_membrane_potential_in_real_cells_multiple_ions_contribute_to_the_membrane_potential.html</a>
6	<a href="https://www.labxchange.org/library/items/lb:LabXchange:4400b96e:lx_simulation:1">https://www.labxchange.org/library/items/lb:LabXchange:4400b96e:lx_simulation:1</a>

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
BT23314.1	1	-	-	3	-	-	2	2	3	3	1	3	3	2	3
BT23314.2	2	3	3	3	3	2	2	2	3	3	2	3	3	3	3
BT23314.3	2	2	2	3	3	2	2	2	3	3	3	2	2	2	2
BT23314.4	2	3	2	3	3	2	2	2	3	3	2	3	3	3	2
BT23314.5	3	3	2	2	3	3	2	3	3	3	2	3	3	3	2
Average	2	2.2	1.8	2.8	2.4	1.8	2.0	2.2	3.0	3.0	2.0	2.8	2.8	2.6	2.4

<b>BT23321</b>	<b>BASIC FOOD AND ENZYME TECHNOLOGY LABORATORY</b>	<b>Category</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		<b>ES</b>	<b>0</b>	<b>0</b>	<b>2</b>	<b>1</b>

<b>Objectives:</b>	
●	To apply the basic concepts of food to analyse the food products
●	To identify the presence of food adulterants
●	To analyze food samples for its physical parameters
●	To demonstrate enzyme isolation experiments
●	To perform assay of enzymes

<b>List of Experiments</b>	
<b>1</b>	Estimation of Vitamin C
<b>2</b>	Identification of monosodium glutamate content of various food preparations
<b>3</b>	Determination of Brix value of different food items
<b>4</b>	Identification of food adulterants
<b>5</b>	Anti-browning effect- Assay of polyphenol oxidase (Catecholase)
<b>6</b>	Isoelectric precipitation of protein from casein milk
<b>7</b>	Estimation of moisture and fiber content in food sample
<b>8</b>	Assay of acid phosphatase from potato.
<b>9</b>	Determination of amylase using Petri-plate method
<b>10</b>	Assay of urease from horsegram
<b>11</b>	Assay of catalase
<b>Contact Hours</b>	
<b>: 60</b>	

<b>Course Outcomes:</b>	
Upon completion student will be able to	
●	Analyze and assess the composition of food products
●	Develop tools to detect the presence of harmful food adulterants
●	Evaluate physical parameters of food samples
●	Isolate enzymes from plant sources
●	Carry out assay of enzymes

<b>Suggested Activities</b>	
●	Demonstrating use of enzymes in food processing

<b>Suggested Evaluation Methods</b>	
●	Quizzes
●	Viva

<b>Text Book(s):</b>	
<b>1</b>	Govindharajan, Sattanathan & Padmapriya, Swaminathan & B, Balamuralikrishnan. (2020). Practical Manual of Biochemistry. 10.22573/spg. 020. BK/S/028.
<b>2</b>	Tiwari, PhD, Anand. (2015). Practical Biochemistry: A Student Companion.
<b>3</b>	Joy PP, Surya S, Aswathy C. Laboratory Manual of Biochemistry. Kerala Agricultural University, 2015.
<b>4</b>	T.P. Coultate – Food – The Chemistry of Its Components, 2 <sup>nd</sup> Edn. Royal Society, London, 1992.
<b>5</b>	B. Sivasanker – Food Processing And Preservation, Prentice-Hall Of India Pvt. Ltd. New Delhi 2002

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
BT23321.1	3	3	1	2	1	1	2	1	1	2	1	3	3	2	1
BT23321.2	3	3	3	3	2	2	2	2	2	2	2	3	3	3	3
BT23321.3	3	3	3	3	2	2	2	2	2	2	2	3	3	3	3
BT23321.4	3	3	3	3	3	2	3	2	3	2	3	3	3	3	3
BT23321.5	3	3	3	3	3	2	3	2	3	2	3	3	3	3	3
Average	3	3	2.6	2.8	2.2	1.8	2.4	1.8	2.2	2	2.2	3	3	2.8	2.6

BT23331	ANALYTICAL TECHNIQUES IN BIOTECHNOLOGY					Category	L	T	P	C
						ES	2	0	2	3

Objectives:	
•	To gain knowledge on the principles of spectrometry and optical instruments.
•	To learn the theoretical and practical aspects of molecular spectroscopy.
•	To identify the suitable structure elucidation and interaction techniques.
•	To know different separation methods used in Biotechnology.
•	To understand various advanced analytical techniques.

<b>UNIT-I</b>	<b>INTRODUCTION TO SPECTROMETRY</b>	<b>6</b>
Properties of Electromagnetic Radiation – Wave Properties – Components of Optical Instruments – Sources of Radiation – Wavelength Selectors – Sample Containers – Radiation Transducers – Signal Process and Read Outs – Signal to Noise Ratio – Sources of Noise – Enhancement of Signal to Noise Ratio– Types of Optical Instruments		
<b>UNIT-II</b>	<b>SPECTROSCOPIC TECHNIQUES - I</b>	<b>6</b>
Beer's Law – UV-Visible Light Spectroscopy – Instrumentation – Applications – Light Scattering –Turbidometric and Nephelometric Analysis – Fluorescence Spectroscopy – Instrumentation – Applications – Fourier Transform Infrared Spectroscopy – Instrumentation – Applications – Raman Spectroscopy – Instrumentation – Applications		
<b>UNIT-III</b>	<b>SPECTROSCOPIC TECHNIQUES - II</b>	<b>6</b>
Nuclear Magnetic Resonance – Theory – Instrumentation – Applications –Electron Paramagnetic Resonance – Instrumentation – X-Ray Diffraction –Theory – Instrumentation – Applications –Mass Spectrometer –Ion Sources – Applications – Atomic Absorption Spectroscopy –Theory – Instrumentation – Applications.		
<b>UNIT-IV</b>	<b>SEPARATION TECHNIQUES</b>	<b>6</b>
General principles of chromatography – Chromatographic Performance Parameters – Ideal Separation – Band Broadening and Optimization – HPLC – Gas Chromatography – Principles of Electrophoresis – Gel Electrophoresis – Capillary Electrophoresis.		
<b>UNIT-V</b>	<b>ADVANCED ANALYTICAL TECHNIQUES</b>	<b>6</b>
Theory, Instrumentation and Applications of: Thermogravimetric Analysis - Differential Thermal Analysis - Differential Scanning Calorimetry – Atomic Force Microscopy – Scanning Tunneling Microscope –Brunauer Emmett Teller Analysis – Vibrating Sample Magnetometer Analysis.		
<b>Total Contact Hours</b>		<b>: 30</b>

EXPERIMENTS
1. Precision and validity in an experiment using absorption spectroscopy and Validating Lambert-Beer's law using $\text{KMnO}_4/\text{K}_2\text{Cr}_2\text{O}_7$
2. Finding the molar absorbtivity and stoichiometry of the Fe (1, 10 phenanthroline) using absorption spectrometry.
3. Estimation of $\text{AL}^{+++}$ by flourimetry.
4. Job's plot for finding stoichiometry of iron salicylate complex.

5. UV spectra of nucleic acids.
6. UV – spectra of proteins.
7. Limits of detection of colorimeter using aluminum alizarin complex/Absorption spectrum
8. Analysis of riboflavin by flourimetry method
9. Separation of sugars by thin layer chromatography
10. Separation of plant pigments by column chromatography

<b>Suggestive activity</b>
1. Demo on HPLC
2. Demo on Thermogravimetric Analysis
3. Demo on Atomic Absorption Spectroscopy

<b>Course Outcomes:</b> At the end of the course the students will be able to
• Demonstrate the principle of spectrometry and the optical instruments
• Assess the theoretical and practical aspects of molecular spectroscopy.
• Detect appropriate techniques for structure elucidation and interactions.
• Comprehend various separation techniques in biotechnology.
• Apply different techniques to analyse the properties of the samples

<b>Text Book(s):</b>
1 Wilson, K and Walker, J - Principles and Techniques of Biochemistry and Molecular Biology, VII <sup>th</sup> Edition, Cambridge University Press, 2010.
2 Skoog, D.A. F. James Holler, and Stanky, R. Crouch —Principles of Instrumental Analysis, VI <sup>th</sup> Edition, Thomson Brooks/Cole, 2007.
3 Willard, Hobart, et al., —Instrumental Methods of Analysis. VII <sup>th</sup> Edition, CBS, 1986.
4 Braun, Robert D. —Introduction to Instrumental Analysis. Pharma Book Syndicate, 1987.

<b>Reference Books(s) / Web links:</b>
1 Sharma, B.K. —Instrumental Methods of Chemical Analysis: Analytical Chemistry   Goel Publishing House, 1972.
2 Haven, Mary C., et al., —Laboratory Instrumentation— .IV <sup>th</sup> Edition, John Wiley, 1995.
3 <a href="https://lecturenotes.in/materials/14302-note-of-instrumental-methods-of-analysis-by-rishab-sahoo">https://lecturenotes.in/materials/14302-note-of-instrumental-methods-of-analysis-by-rishab-sahoo</a>
4 <a href="https://youtu.be/LLPMxBB9hRw">https://youtu.be/LLPMxBB9hRw</a>
5 <a href="https://youtu.be/2oPUyIbPxLo">https://youtu.be/2oPUyIbPxLo</a> (Knowbee)

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
BT23331.1	3	3	3	3	3	-	1	3	-	-	3	3	3	3	3
BT23331.2	3	3	3	3	3	-	1	1	1	1	3	3	3	3	3
BT23331.3	3	3	3	3	3	3	1	1	1	1	3	3	3	3	3
BT23331.4	3	3	3	3	3	3	-	1	1	1	3	3	3	3	3
BT23331.5	3	3	3	3	3	3	1	1	1	1	3	3	3	3	3
Average	3	3	3	3	3	3	1	1.4	1	1	3	3	3	3	3

<b>MA23431</b>	<b>PROBABILITY, STATISTICS AND RELIABILITY</b>	<b>Category</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
	<b>Common to IV sem. B.Tech. - BT, FT and CHEM</b>	<b>BS</b>	<b>3</b>	<b>0</b>	<b>2</b>	<b>4</b>

<b>Course Objectives:</b>
• To introduce the basic concepts of probability, one dimensional random variable.
• To solve the problems those are faced in testing of a hypothesis with reference to the errors in decision making.
• To analyse the different mathematical models with the help of statistical designs and appropriate data and made



valuable conclusions by proper evaluation.
<ul style="list-style-type: none"> <li>To explain the concepts of quality control in industry and to apply various tools to examine the quality of a process and product.</li> </ul>
<ul style="list-style-type: none"> <li>To analyse statistical experiments leading to reliability modelling and to identify reliability testing components for assessment of reliability in engineering design.</li> </ul>

<b>UNIT-I</b>	<b>PROBABILITY</b>	9
One dimensional Discrete and continuous random variables – Moments – Moment generating functions – Binomial, Poisson, Uniform and Normal distributions, Two dimensional Discrete and continuous random variables – Conditional and Marginal densities.		
<b>UNIT-II</b>	<b>STATISTICAL TESTING</b>	9
Maximal Likelihood estimation – Parameters of Binomial and Poisson distribution - Tests of significance – Z test: Single mean, difference of means- Chi square - F test.		
<b>UNIT-III</b>	<b>ANOVA</b>	9
Design of Experiments - Completely randomized design – Randomized block design –Latin square design.		
<b>UNIT-IV</b>	<b>STATISTICAL QUALITY CONTROL</b>	9
Control charts for measurements ( $\bar{X}$ and R charts) – Control charts for attributes (p, c and np charts) – Tolerance limits - Acceptance sampling		
<b>UNIT-V</b>	<b>RELIABILITY</b>	9
Reliability Concepts: Reliability definitions, Importance of Reliability, Quality Assurance and Reliability, Bath Tub Curve - Failure Data Analysis: Hazard rate, failure density, Failure Rate, Mean Time To Failure (MTTF), MTBF, Reliability Functions - Reliability Hazard Models: Constant Failure Rate, Linearly increasing, Time Dependent Failure Rate, Weibull Model- Distribution functions and reliability analysis.		
<b>Total Contact Hours: 45</b>		

S.No.	LIST OF EXPERIMENTS (USING R SOFTWARE)	Total Contact Hours: 30
1	Basic Functions in R and plotting	
2	Mathematical functions in R – Integration	
3	Control flow – Loops in R	
4	Probability Distributions using R- PDF, CDF for Binomial, Poisson, Exponential, Uniform and Normal Distributions.	
5	Testing of Hypothesis – Z testing	
6	Testing of Hypothesis – F and chi square testing	
7	ANOVA – one way and two way	
8	Statistical quality control – p, np, c, $\bar{X}$ charts	
9	Reliability – MTTF, MTBF	
10	Reading, Writing data in R and working with inbuilt data sets in R	

<b>Course Outcomes:</b> on completion of the course, the students will be able to
<ul style="list-style-type: none"> <li>Have the critical thinking in the theory of probability and its applications in real life problems.</li> </ul>
<ul style="list-style-type: none"> <li>Apply the different testing tools like t-test, F-test, chi-square test to analyse the relevant real life problems.</li> </ul>
<ul style="list-style-type: none"> <li>Analyse the different mathematical models with the help of statistical designs and appropriate data and made valuable conclusions by proper evaluation.</li> </ul>
<ul style="list-style-type: none"> <li>Use various tools to examine the quality of a process and product in engineering and technology.</li> </ul>
<ul style="list-style-type: none"> <li>Illustrate the basic concepts and techniques of modern reliability engineering tools.</li> </ul>

<b>SUGGESTED ACTIVITIES</b>
<ul style="list-style-type: none"> <li>Problem solving sessions</li> <li>Smart Class room sessions</li> </ul>

<b>SUGGESTED EVALUATION METHODS</b>
<ul style="list-style-type: none"> <li>Problem solving in Tutorial sessions</li> </ul>

- Assignment problems
- Quizzes and class test
- Discussion in classroom

<b>Text Book(s):</b>	
●	Veerarajan T, 'Probability, Statistics and Random Processes with Queueing Theory and Queueing Networks'.
●	McGraw Hill, 2016. 2 Johnson R.A. and Gupta. C.B., "Miller and Freund's Probability and Statistics for Engineers", Pearson Education, Asia, 7th Edition, 2007.
●	Srinath. L.S., "Reliability Engineering", Affiliated East west press, 1991.
●	Kandasamy P., Thilagavathi and K. Gunavathi., "Statistics and Numerical Methods", S. Chand & Company Ltd. (2010).

<b>Reference Books(s) / Web links:</b>	
●	Jhon wiley& Sons .Erwin Kreyszig., "Advanced Engineering Mathematics", Pearson Education, Asia, 7th Edition, 2007.
●	Ramana. B.V., "Higher Engineering Mathematics ", McGraw Hill Education Pvt. Ltd, New Delhi, 2016.
●	Gupta. R.C., "Statistical Quality control", Khanna Publishers, 1997
●	Douglas.C. Montgomery, "Introduction to Statistical quality control", 7th edition, John Wiley 2012.

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
MA23431.1	2	2	-	-	-	-	-	-	-	-	-	-	1	-	-
MA23431.2	2	2	1	1	-	-	-	-	-	-	-	1	1	-	-
MA23431.3	2	2	-	2	-	-	-	-	-	-	-	1	-	-	-
MA23431.4	2	2	2	2	-	-	-	-	-	-	-	1	-	-	-
MA23431.5	2	2	2	1	-	-	-	-	-	-	-	1	-	-	-
Average	2	2	1.6	1.5	-	-	-	-	-	-	-	1	1	-	-

<b>BT23411</b>	<b>FOOD BIOTECHNOLOGY</b>	<b>Category</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		<b>ES</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

<b>Course Objectives:</b> To enable the students:	
●	To impart knowledge on various foods and their nutritional values
●	Learn the constituents and additives present in the food
●	Gain knowledge about the microorganisms, which spoil food and cause food-borne diseases
●	Familiarise different techniques used for the preservation of foods
●	To know about the Food Safety and standards act

<b>UNIT-I</b>	<b>PRINCIPLES AND BASICS OF FOOD CHEMISTRY</b>	<b>9</b>
Role and functions of macro and micronutrients in human nutrition, food additives with respect to their technological functions, Enzymes as food processing aids, Food allergens and allergenicity, overview of nutraceuticals and food contamination.		
<b>UNIT-II</b>	<b>FOOD SCIENCE AND NUTRITION</b>	<b>9</b>
Food adulteration and their effects on human health. and Food testing, and rapid detection methods, Supplementation, Fortification/Bio-fortification, Poor Diet and consequencest- Stunting, wasting & anemia and Lifestyle diseases- Coronary heart disease, diabetes & obesity.		
<b>UNIT-III</b>	<b>FOOD MICROBIOLOGY &amp; GENERAL PRINCIPLES OF FOOD PROCESSING AND PRESERVATION.</b>	<b>9</b>
Sources of microorganisms in the food, microbial food spoilage and Food-borne diseases, Principles and methods of		

food preservation- Heat processing, pasteurization, canning, Preservation by low temperature- refrigeration, frozen storage, freeze-drying, Irradiation method of foods preservation, modified atmosphere storage and hurdle technology.	
<b>UNIT-IV</b>	<b>FOOD HYGIENE /QUALITY MANAGEMENT</b>
General principles of food safety management systems including traceability and food recall- sanitation, Food Surveillance and Quality control of food-HACCP and Good production and processing practices (GHP, GMP, GAP, BAP, GLP).	
<b>UNIT-V</b>	<b>INDIAN AND INTERNATIONAL FOOD LAWS</b>
Food Safety and Standards Act of India, 2006(FSSAI), Rules and Regulations of FSSAI, Overview of other national bodies- APEDA, BIS, MPEDA, International Food Control Systems- CODEX Alimentarius Commission and WTO agreements (SPS/TBT).	
<b>Total Contact Hours: 45</b>	

<b>Course Outcomes:</b> on completion of the course, the students will be able to
<ul style="list-style-type: none"> <li>• Apply knowledge gained in food chemistry, microbiology and processing/preservation of food products.</li> <li>• Familiar with nutrients and it's functional properties of foods</li> <li>• Design food products that meet the various food regulations and laws.</li> <li>• Knowledge about the importance of food additives and their function and will develop strategies that will promote food safety and prevent food borne illness.</li> <li>• Identify spoilage and deterioration of food and apply the methods to control the food spoilage and deterioration.</li> </ul>

<b>SUGGESTED ACTIVITIES</b>
<ul style="list-style-type: none"> <li>• Activity based sessions</li> <li>• Smart Class room sessions</li> </ul>

<b>SUGGESTED EVALUATION METHODS</b>
<ul style="list-style-type: none"> <li>• Case studies</li> <li>• Assignment problems</li> <li>• Quizzes and class test</li> <li>• Discussion in classroom</li> </ul>

<b>Text Book(s):</b>
<ul style="list-style-type: none"> <li>• T.P.Coultate-Food-The Chemistry of its Components, 2nd edition. Royal society, London, 1992.</li> <li>• B.Sivasanker-Food processing and preservation, Prentice-Hall of India Pvt.Ltd.New Delhi, 2002.</li> <li>• George JB. Basic Food Microbiology, CBS Publishers &amp; Distributors, 1987.</li> </ul>

<b>Reference Books:</b>
<ul style="list-style-type: none"> <li>• W.C.Frazier and D.C.Westhoff-Food Microbiology, 4th Ed.,McGraw-Hill book Co.,New York.</li> <li>• J.M.Jay-Modern Food Microbiology, CBS Pub.New Delhi, 1987.</li> </ul>

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
BT23411.1	3	3	3	3	3	2	3	2	2	2	2	2	2	3	2
BT23411.2	3	3	3	3	3	2	3	2	2	2	2	2	2	3	2
BT23411.3	3	3	3	3	3	2	3	2	2	2	2	2	2	3	2
BT23411.4	3	3	3	3	3	2	3	2	2	2	2	2	2	3	2
BT23411.5	3	3	3	3	3	2	3	2	2	2	2	2	2	3	2
Average	3	3	3	3	3	2	3	2	2	2	2	2	2	3	2

BT23412	GENETIC ENGINEERING					Category	L	T	P	C
						PC	3	0	0	3

**Objectives:**

- To discuss the gene cloning methods, the tools and techniques involved in gene cloning and genome analysis.
- To explain the advanced gene isolation techniques
- To explain the applications of PCR
- To familiarize the students to carry out research in the determination of the gene and its function
- To provide in-depth knowledge about functional genomics

<b>UNIT-I</b>	<b>BASICS OF RECOMBINANT DNA TECHNOLOGY</b>	9
DNA Manipulative enzymes, DNA Modifying Enzymes, Linkers and Adaptors. Characteristics of cloning and expression vectors based on plasmid and bacteriophage, Vectors for Yeast, Insect and Mammalian systems, Introduction of recombinant DNA into host cells and selection methods		
<b>UNIT-II</b>	<b>DNA LIBRARIES</b>	9
Construction of genomic and cDNA libraries, Screening methods for recombinant clones from DNA libraries using nucleic acid hybridization and Immunological and PCR Method. BACs and YACs, Chromosome walking, Restriction Modifying System.		
<b>UNIT-III</b>	<b>DNA SEQUENCING AND AMPLIFICATION OF DNA</b>	9
Maxam Gilbert's and Sanger Coulson's and automated methods of DNA sequencing, pyrosequencing method. Principle of PCR, Types of PCR-Inverse PCR, Nested PCR, AFLP-PCR, Asymmetric PCR, Assembly PCR, Touch down PCR, Colony PCR, Real-time PCR – SYBR green assay and Taqman assay; Site directed mutagenesis.		
<b>UNIT-IV</b>	<b>MAPPING AND SEQUENCING OF GENOME</b>	9
Genome sequencing methods- Conventional and shotgun genome sequencing methods, Next generation sequencing technologies. Genetic maps and Physical maps, Restriction Enzyme Finger Printing, Hybridization mapping, Radiation Hybrid Maps, Optical mapping. ORF finding and functional annotation.		
<b>UNIT-V</b>	<b>FUNCTIONAL GENOMICS</b>	9
Introduction to functional genomics, Applications of Genetic Engineering - Microarrays, Serial Analysis of Gene expression (SAGE), Northern Blotting, Subtractive hybridization, MALDI-TOF, Yeast Two hybrid System.		
<b>Total Contact Hours: 45</b>		

**Course Outcomes:** The students will be able to

- Be aware of how to clone commercially important genes
- Produce the commercially important recombinant proteins
- Gain knowledge about genome sequencing methods
- Gain knowledge about how to characterize a gene
- Learn about DNA amplification and diagnosis of disease

<b>Text Book(s):</b>	
•	Primrose SB and R. Twyman —Principles Of Gene Manipulation &Geneomic Blackwell Science Publications, 2006.
•	Principles of Genome Analysis and Genomics by S.B.Primrose and R.M.Twyman, Third Edition (Blackwell Publishing), 2003.
•	Gene cloning and DNA analysis by T.A Brown ,Sixth edition
•	Primrose SB and R. Twyman —Principles Of Gene Manipulation &Geneomic Blackwell Science Publications, 2006.

<b>Reference Books(s) / Web links:</b>	
•	Ansabel FM, Brent R, Kingston RE, Moore DD, —Current Protocols In Molecular Biology —Greene Publishing Associates, NY,1988.
•	Berger SI, KimmerAR, —Methods In Enzymology ll, Vol 152, Academic Press,1987.
•	Genomes 3 by T.A.Brown, Third Edition (Garland Science Publishing)
•	Ansabel FM, Brent R, Kingston RE, Moore DD, — Current Protocols In Molecular Biology —Greene Publishing Associates, NY,1988.

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
BT23412.1	3	3	3	3	-	3	3	3	3	-	2	3	3	3	3
BT23412.2	3	3	3	3	-	3	3	3	3	-	2	3	3	3	2
BT23412.3	3	3	3	2		3	3	3	3	-	2	3	3	3	3
BT23412.4	3	3	3	3	-	3	3	3	3	-	2	3	3	3	2
BT23412.5	3	3	3	2	-	3	3	3	3	-	2	3	3	3	2
Average	3	3	3	2.6	-	3	3	3	3	-	2	3	3	3	2.8

BT23413	THERMODYNAMICS AND HEAT TRANSFER	Category	L	T	P	C
		ES	3	1	0	3

**Objectives:**

- To endow the students with the thermodynamic relations and concept of partial molar properties
- To solve VLE calculations for binary system
- To study the mechanism of heat transfer by conduction
- To inculcate the heat flow mechanism by convection
- To design heat exchange equipment

UNIT-I	INTRODUCTION TO THERMODYNAMICS	9
Thermodynamic properties and relations, Maxwell's equations and applications; fugacity and activity, Partial molar properties - determination of partial molar properties; Chemical potential, Fugacity in solutions, activity coefficients, Gibbs Duhem equations.		
UNIT-II	PHASE EQUILIBRIA	9
Criteria for phase equilibrium and stability, Phase diagrams for binary solutions, Azeotropes, Activity coefficient equations, Bubble point and dew point equilibria; liquid- liquid equilibrium diagrams.		
UNIT-III	CONDUCTION	9
Steady state conduction; combined resistances; unsteady state conduction - lumped heat capacity; extended surfaces; combined conduction and convection		
UNIT-IV	CONVECTION	9
Dimensional analysis; forced and natural convection; convection in flow over surfaces through pipes; boiling and condensation.		
UNIT-V	HEATEXCHANGERS	9

Heat exchanger- overall heat transfer coefficients; design of heat exchangers; Effectiveness - NTU concept; Evaporators-single effect- mass and enthalpy balances.

**Total Contact Hours: 45**

**Course Outcomes:** Upon the completion of the course, the students will be able to

- Apply the concepts of partial molar properties in solutions
- Determine the VLE composition for binary systems
- Resolve problems for heat flow by conduction for various geometries
- Elucidate the convective heat transfer problems
- Design heat exchanger equipment for bioprocess

**Text books**

- Narayanan K.V.-A Text Book of Chemical Engineering Thermodynamics, Prentice Hall India, 2003
- Binay K.Dutta, Heat transfer: Principles and applications, PHI learning Pvt. Ltd., New Delhi, 1<sup>st</sup> edition, 2006
- Y.V.C.Rao , Chemical Engineering Thermodynamics' , University Press (India) Ltd., Hyderabad 1997

**Reference books**

- Geankoplis C.J. Transport Processes And Unit Operations. Prentice HallIndia.2002.
- Perry's Chemical Engineers' Handbook, 9th Edition, Kindle Edition by Don W. Green , Marylee Z. Southard, Imprint: McGraw-Hill Education.
- <http://nptel.ac.in/courses/112108149>
- [http://onlinecourses.nptel.ac.in/noc20\\_ch12/preview](http://onlinecourses.nptel.ac.in/noc20_ch12/preview)

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
BT23413.1	3	3	3	3	1	1	1	-	1	-	2	3	-	-	3
BT23413.2	3	3	3	3	1	1	1	-	1	-	2	3	-	-	3
BT23413.3	3	3	3	3	-	1	1	-	-	-	2	3	-	-	3
BT23413.4	3	3	3	3	-	1	1	-	-	-	2	3	-	-	3
BT23413.5	3	3	3	3	-	1	1	-	-	-	2	3	-	-	3
Average	3	3	3	3	0.4	1.0	1.0	-	0.4	-	2	3	-	-	3

BT23414	BASIC INDUSTRIAL BIOTECHNOLOGY	Category	L	T	P	C
		PC	3	0	0	3

**Objectives:**

- To impart knowledge on industrial fermentation technology
- To understand the fundamentals of upstream and downstream process in fermentation
- To design fermentation process for the production of various primary metabolites
- To learn new technology for the production of secondary metabolites
- To develop skills for bulk production of commercially and therapeutically important bioproducts

**UNIT-I INTRODUCTION TO INDUSTRIAL FERMENTATION TECHNOLOGY** 8

History and scope of Fermentation technology, Fermentor design, Types of Fermentors. Types of fermentation process- Batch, Continuous and Fed Batch, Submerged fermentation, Solid state fermentation. Fermented Products-

Plants, Animals and Microorganisms.			
<b>UNIT-II</b>	<b>UPSTREAM AND DOWNSTREAM PROCESS</b>	9	
Basic concepts of Upstream- Screening- Primary and Secondary, Strain Improvement, Preparation of inoculum, Media formulation and Sterilization- Equipment, Media, Air. Downstream process in fermentation- Intracellular & Extracellular, Process flow sheet.			
<b>UNIT-III</b>	<b>PRODUCTION OF PRIMARY METABOLITES</b>	8	
Production of commercially important primary metabolites like organic acids (Citric acid and acetic acid), amino acids (Glutamic acid and Lysine), Enzymes (Amylase and Protease), Solvents (Acetone-Butanol, Ethyl alcohol)			
<b>UNIT-IV</b>	<b>PRODUCTION OF SECONDARY METABOLITES</b>	8	
Production of commercially important secondary metabolites: Antibiotics (Penicillin, Streptomycin & Tetracycline), Vitamins (B12, B2 & C) and Biotransformation- Steroids.			
<b>UNIT-V</b>	<b>PRODUCTION OF OTHER MODERN BIOTECHNOLOGY PRODUCTS</b>	12	
Food products (Cheese & Mushroom culture), Alcoholic beverages (Beer & Wine), Biopesticides, Biofertilizers, Biopreservatives (Nisin), Biopolymers (Xanthan gum & PHB), Recombinant therapeutic & diagnostic proteins (Insulin & Monoclonal antibodies).			
		<b>Contact Hours</b>	<b>: 45</b>

<b>Course Outcomes:</b>	
Upon completion of the course, students will be able to	
●	Gain knowledge on fundamentals of fermentation technology
●	Apply appropriate techniques of upstream and downstream process for the bio product production
●	Formulate and design the production process of primary metabolites
●	Analyze and apply the knowledge of fermentation techniques for the production and recovery of secondary metabolites
●	Design and develop the process for the production of modern biotechnology products

<b>Suggested Activities</b>	
●	Problem solving sessions

<b>Suggested Evaluation Methods</b>	
●	Quizzes
●	Class Presentation / Discussion

<b>Text Book(s):</b>	
1	Patel, AH- Industrial Microbiology. 2 <sup>nd</sup> edition, Trinity press Lakshmi publication (P) Ltd., 2017.
2	Satyanarayana, U. —Biotechnology  Books & Allied (P) Ltd., 2005.
3	Kumar, H.D. —A Textbook on Biotechnology  IInd Edition. Affiliated East West Press Pvt. Ltd., 1998.
4	Balasubramanian, D. et. al., —Concepts in Biotechnology  Universities Press Pvt.Ltd., 2004.
5	Ratledge, Colin and Bjorn Kristiansen —Basic Biotechnology  IInd Edition Cambridge University Press, 2001
6	Dubey, R.C. —A Textbook of Biotechnology  S.Chand & Co. Ltd., 2006.

<b>Reference Books(s) / Web links:</b>	
1	Casida, L.E. —Industrial Microbiology , New Age International (P) Ltd, 1968.
2	Presscott, S.C. and Cecil G. Dunn, —Industrial Microbiology , Agrobios (India), 2005.
3	Cruger, Wulf and Anneliese Crueger, —Biotechnology: A Textbook of Industrial Microbiology , IInd Edition, Panima Publishing, 2000.
4	Moo-Young, Murrey, —Comprehensive Biotechnology , 4 Vols. Pergamon Press, (An Imprint of Elsevier) 2004.
5	Stanbury, P.F., A. Whitaker and S.J. Hall —Principles of Fermentation Technology , IInd Edition, Butterworth Heinemann (an imprint of Elsevier), 1995.
6	C.F.A Bryce and EL.Mansi, Fermentation microbiology & Biotechnology, 1999.
7	K.G.Ramawat & Shaily Goyal, Comprehensive Biotechnology, 2009, S.Chand publications.

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
BT23414.1	3	-	-	-	-	-	-	-	-	-	-	2	3	-	-
BT23414.2	-	3	-	-	2	-	-	-	-	-	-	3	-	3	-
BT23414.3	-	3	3	3	3	-	-	-	2	-	-	3	-	3	-
BT23414.4	-	3	3	3	3	-	2	-	-	-	-	3	-	3	-
BT23414.5	-	-	3	3	3	-	3	-	-	-	-	3	3	3	3
Average	3	3	3	3	2.2	-	2.5	-	2	-	-	2.8	3	3	3

CS23422	PYTHON PROGRAMMING FOR MACHINE LEARNING	Category	L	T	P	C
		ES	0	0	4	2

**Course Objectives:**

This course is aimed at enabling the students to:

- To understand the relationship of the data collected for decision making.
- To know the concept of principal components, factor analysis and cluster analysis for profiling and interpreting the data collected.
- Lay the foundation of machine learning and its practical applications and prepare students for real-time problem-solving in data science.
- Develop self-learning algorithms using training data to classify or predict the outcome of future datasets.
- Distinguish overtraining and techniques to avoid it such as cross-validation.

**List of Experiments**

1.	NumPy Basics: Arrays and Vectorized Computation
2.	Getting Started with pandas
3.	Data Loading, Storage, and File Formats
4.	Data Cleaning and Preparation
5.	Data Wrangling: Join, Combine, and Reshape
6.	Plotting and Visualization
7.	Data Aggregation and Group Operations
8.	Time Series
9.	Supervised Learning
10.	Unsupervised Learning and Pre-processing
11.	Representing Data and Engineering Features
12.	Model Evaluation and Improvement
<b>Contact Hours : 60</b>	

**Course Outcomes:**

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

- Develop a sound understanding of current, modern computational statistical approaches and their application to a variety of datasets.
- Analyze and perform an evaluation of learning algorithms and model selection.
- Compare the strengths and weaknesses of many popular machine learning approaches.
- Appreciate the underlying mathematical relationships within and across machine learning algorithms and the paradigms of supervised and unsupervised learning.



- Design and implement various machine learning algorithms in a range of real-world applications.

**Text Books:**

- Wes McKinney, Python for Data Analysis - Data wrangling with pandas, Numpy, and ipython, Second Edition, O'Reilly Media Inc, 2017.
- Andreas C. Müller and Sarah Guido, Introduction to Machine Learning with Python - A Guide for Data Scientists, First Edition, O'Reilly Media Inc, 2016.

**Reference Books:**

- Aurélien Géron, Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow, 2nd Edition, O'Reilly Media Inc, 2019.

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CS23422.1	2	2	2	2	1	-	-	-	1	1	1	1	3	3	-
CS23422.2	2	1	1	1	1	-	-	-	-	-	1	1	3	2	-
CS23422.3	1	1	2	1	2	-	-	-	-	-	1	1	2	3	2
CS23422.4	2	2	3	2	2	-	-	-	-	-	2	1	2	2	2
CS23422.5	2	2	3	2	3	-	-	-	-	-	2	1	2	2	2
Average	1.8	1.6	2.2	1.6	1.8	0.0	0.0	0.0	0.2	0.2	1.4	1	2.4	2.4	2

BT23421	CHEMICAL ENGINEERING LABORATORY FOR BIOTECHNOLOGIST					Category	L	T	P	C
						ES	0	0	4	2

**Course Objectives:** This course is aimed at enabling the students

- To conduct experiments using flow measuring devices
- To perform characteristic studies on centrifugal pumps
- To carryout experiments on separation processes
- To perform mass transfer studies on diffusion of binary mixtures
- To study the effect of operating variables of heat exchanger

**List of Experiments**

1	Flow measurement a) Orifice meter b) Venturimeter c) Rotameter
2	Pressure drop- flow in pipes
3	Characteristics of centrifugal pump
4	Packed bed
5	Fluidized bed
6	Filtration- leaf filter
7	Shell and tube heat exchanger
8	Simple and steam distillation
9	HETP in packed distillation
10	Liquid-liquid extraction
11	Adsorption isotherms
12	Diffusion
13	Leaching
14	Drying
<b>Total Contact Hours : 60</b>	

<b>Course Outcomes:</b> Upon the completion of the course, the students will be able to	
•	Operate different flow meters
•	Work on pumps
•	Carry out experiments on unit operations like distillation, extraction and adsorption
•	Estimate the rate of mass transfer in diffusion
•	Solve the problems on heat exchangers

<b>Text Book(s):</b>	
1	McCabe W.L., Smith J.C. Unit Operations In Chemical Engineering.5 <sup>th</sup> Edition. McGraw Hill. 1993.
2	BinayK.Dutta, Heat transfer: Principles and applications, PHI learning Pvt. Ltd., New Delhi, 1 <sup>st</sup> edition, 2006

<b>Reference Books(s) / Web links:</b>	
1	Geankoplis C.J. Transport Processes And Unit Operations. Prentice HallIndia.2002.
2	Perry's Chemical Engineers' Handbook, 9th Edition, Kindle Edition by Don W. Green , Marylee Z. Southard, Imprint: McGraw-Hill Education.
3	<a href="https://doi.org/10.1017/CBO9780511608346">https://doi.org/10.1017/CBO9780511608346</a>

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
BT23421.1	3	3	3	3	-	-	-	-	1	-	2	3	-	-	3
BT23421.2	3	3	3	3	-	-	-	-	1	-	2	3	-	-	3
BT23421.3	3	3	3	3	-	-	-	-	1	-	2	3	-	-	3
BT23421.4	3	3	3	3	-	-	-	-	1	-	2	3	-	-	3
BT23421.5	3	3	3	3	-	-	-	-	1	-	2	3	-	-	3
Average	3	3	3	3	-	-	-	-	1	-	2	3	-	-	3

<b>BT23422</b>	<b>MOLECULAR BIOLOGY AND GENETIC ENGINEERING LABORATORY</b>	<b>Category</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		<b>PC</b>	<b>0</b>	<b>0</b>	<b>4</b>	<b>2</b>

<b>Objectives:</b>	
•	To provide hands on practical training in the isolation of genomic DNA from different sources.
•	To discuss the principles behind the recombinant DNA technology.
•	To explain the concept of transformation.
•	To provide in depth knowledge in protein characterization techniques.
•	To develop the skills of the students by providing hands on practical training in Molecular biology

<b>List of Experiments</b>	
1	Agarose gel electrophoresis
2	Isolation of genomic DNA from bacteria.
3	Isolation of genomic DNA from plant.
4	Isolation of plasmid DNA from bacteria.
5	Check the purity of DNA by using UV spectrophotometer.
6	PCR
7	Elution of DNA from agarose gel.
8	Restriction enzyme digestion.
9	Ligation

10	Competent cells preparation, transformation and blue white screening method													
11	SDS PAGE													
12	Western blotting													
13	Effect of inducer concentration in gene expression													
14	Effect of inducer time in gene expression													
												<b>Total Contact Hours</b>	:	<b>60</b>

<b>Course Outcomes:</b> Upon completion of this course the students will be able to															
• Produce transgenic animals and plants															
• Analyze nucleic acid molecules quantitatively															
• Clone and express a gene and produce therapeutically valuable proteins.															
• Modify the enzyme activity and improve its half- life by using site directed mutagenesis.															
• Perform protein expression and characterization															

<b>Reference Books(s) :</b>															
1	Sambrook, Joseph and David W. Russell -The Condensed Protocols: From Molecular Cloning: A Laboratory Manual Cold Spring Harbor,2006														
2	Old RW, Primrose SB, -Principles Of Gene Manipulation, An Introduction To Genetic Engineering -, Blackwell Science Publications,1993.														
3	Anselmi FM, Brent R, Kingston RE, Moore DD, -Current Protocols In Molecular Biology -,Greene Publishing Associates, NY,1988.														
4	Berger SI, Kimmer AR, -Methods In Enzymology, Vol 152, Academic Press,1987.														

<b>Web links:</b>															
• <a href="http://sigmaaldrich.com">Plasmid DNA (pDNA) Manufacturing Process: Downstream Purification (sigmaaldrich.com)</a>															
• <a href="http://sigmaaldrich.com">Isopropyl b- D -thiogalactopyranoside ReadyMade IPTG solution for Blue-white screening 367-93-1 (sigmaaldrich.com)</a>															

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
BT23422.1	3	3	3	3	3	3	3	3	3	3	2	3	3	3	2
BT23422.2	3	3	3	3	3	3	3	3	3	3	2	3	3	3	2
BT23422.3	3	3	3	3	3	3	3	3	3	3	2	3	3	2	2
BT23422.4	3	3	3	3	3	3	3	3	3	3	2	3	3	3	2
BT23422.5	3	3	3	3	3	3	3	3	3	3	2	3	3	2	2
Average	3	3	3	3	3	3	3	3	3	3	2	3	3	2.6	2

<b>Subject code</b>	<b>SOFT SKILLS-I</b>	<b>Category</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>GE23421</b>		<b>EEC</b>	<b>0</b>	<b>0</b>	<b>2</b>	<b>1</b>

<b>Course Objectives:</b>	
●	To help students break out of shyness.
●	To build confidence
●	To enhance English communication skills.
●	To encourage students' creative thinking to help them frame their own opinions

**Learning and Teaching Strategy:**

The program is completely student centric where the focus is on activities led by students which include role plays, discussions, debates other games as well. These activities would be supplemented by interactive use of technology and brief trainer input.

<b>Week</b>	<b>Activity Name</b>	<b>Description</b>	<b>Objective</b>
1	Introduction	The trainer and the college facilitator talk to the students about the course and in turn the students introduce themselves.	To set expectations about the course and the students are made aware of the rules and regulations involved in this program
2	If I ruled the world	This is a quick and useful game by getting students to form a circle and provide their point of view. Each student then repeats what the other has said and comes up with their own opinion.	The aim of this activity is to for students to get to know each other and also develop their listening skills as well as learning how to agree and disagree politely.
3	Picture Narrating	This activity is based on several sequential pictures. Students are asked to tell the story taking place in the sequential pictures by paying attention to the criteria provided by the teacher as a rubric. Rubrics can include the vocabulary or structures they need to use while narrating.	The aim of this activity is to make the students develop creative way of thinking.
4	Brainstorming	On a given topic, students can produce ideas in a limited time. Depending on the context, either individual or group brainstorming is effective and learners generate ideas quickly and freely. The good characteristics of brainstorming are that the students are not criticized for their ideas so students will be open to sharing new ideas.	The activity aims at making the students speak freely without the fear of being criticized. It also encourages students to come up with their own opinions.
5	Debate	Is competition necessary in regards to the learning process?	The aim of this activity is to develop the students ability to debate and think out of the box
6	Short Talks	Here the students are given topics for which they take one minute to prepare and two minutes to speak. They can write down points but can't read them out they can only use it as a reference.	The activity aims at breaking the students' shyness and encouraging them to standup in front of the class and speak. It also aims at creating awareness that they are restricted for time so they only speak points that are relevant and important.
7	Debate	Will posting students' grades on bulletin boards publicly motivate them to perform better or is it humiliating?	This activity aims at enhancing the students unbiased thought process when it comes to exams

			and grades as well as develop their skills to debate
8	The Art of diplomacy	The facilitator proceeds to share multiple concepts of conversation and helps the participants to identify the various methods of being diplomatic and how do deal with misinformation.	The aim of the lesson is to provide an opportunity for the participants to learn about body language and choosing the appropriate words for conversation.
9	Debate	Are humans too dependent on computers?	The aim of this activity is to test the students debating skills and thought process with a topic that affects everybody in daily life.
10	Story Completion	The teacher starts to tell a story but after 2 sentences he/she asks students to work in groups to create the rest of the story which includes the plot and the ending.	This activity aims at building their narrating skills as well as their creativity and ability to work in a team.
11	Role play debate	Students scrutinize different points of view or perspectives related to an issue. For example, a debate about the question “Should students be required to wear uniforms at school?” might yield a range of opinions. Those might include views expressed by a student (or perhaps two students – one representing each side of the issue), a parent, a school principal, a police officer, a teacher, the owner of a clothing store, and others.	The aim of this activity is to get students to speak based on other people’s perspective instead of their own. The students take the role of various characters and debate accordingly.
12	I Couldn’t Disagree More	This is a game where students practice rebuttal techniques where one student provides a thought or an idea and the other students starts with the phrase I couldn’t disagree more and continues with his opinion	The aim of this activity is to improve general communication skills and confidence.
	Feedback	At the end of the session in the final week (12) the trainer would provide feedback to the students on best practices for future benefits	The aim is to do both give feedback to students as well as obtain feedback on the course from them.

<b>Course Outcomes:</b> On successful completion of the course, students should be able to	
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●	Be more confident
●	Speak in front of a large audience
●	Be better creative thinkers
●	Be spontaneous
●	Know the importance of communicating in English.

Subject code	BIOPROCESS PRINCIPLES	Category	L	T	P	C
BT23511		PC	3	0	0	3

Objectives:						
●	To impart knowledge on design and operation of fermentation processes with all its prerequisites					
●	To provide knowledge about media preparation and optimization.					
●	To learn about the types of sterilization and its kinetics.					
●	To endow the students with the basics of metabolic stoichiometry and energetics.					
●	To study about chemostat and microbial kinetics					

<b>UNIT-I</b>	<b>OVERVIEW OF FERMENTATION PROCESSES</b>	8
Outline of a bioprocess and the various (upstream and downstream) unit operations involved in bioprocesses, Components and functions of a bioreactor, main parameters to be monitored and controlled in fermentation processes. Different types of bioreactors used in fermentation processes.		
<b>UNIT-II</b>	<b>RAW MATERIALS AND MEDIA DESIGN FOR FERMENTATION PROCESS</b>	8
Criteria for good medium, medium requirements for fermentation processes, carbon, nitrogen, minerals, vitamins and other complex nutrients, precursors, inhibitors, inducers, oxygen requirements, Factors affecting the choice of carbon and nitrogen sources, medium formulation of optimal growth and product formation, examples of simple and complex media, design of various commercial media for industrial fermentations – medium optimization methods		
<b>UNIT-III</b>	<b>STERILIZATION KINETICS</b>	8
Thermal death kinetics of microorganisms, batch and continuous heat sterilization of liquid media, Del factor determination, filter sterilization of liquid media, air sterilization and design of sterilization equipment- batch and continuous.		
<b>UNIT-IV</b>	<b>METABOLIC STOICHIOMETRY AND ENERGETICS</b>	10
Stoichiometry of cell growth and product formation, elemental balances, degrees of reduction of substrate and biomass, yield coefficients of biomass and product formation - problems, available electron balances, maintenance coefficients energetic analysis of microbial growth and product formation, oxygen consumption and heat evolution in aerobic cultures.		
<b>UNIT-V</b>	<b>KINETICS OF MICROBIAL GROWTH AND PRODUCT FORMATION</b>	11
Batch cultivation, Fed batch and continuous cultivation - problems. Simple unstructured models for microbial growth, Monod model, growth of filamentous organisms, product formation kinetics – Leudeking-Piret models, substrate and product inhibition on cell growth and product formation. Biomass estimation – Direct and Indirect methods.		
<b>Total Contact Hours</b>		<b>: 45</b>

Course Outcomes: Upon completion of the course in Bioprocess Principles graduates will be able to	
●	Apply engineering principles to systems containing biological catalysts to meet the needs of the society.
●	Apply the knowledge of media for new processes to make bio- products in economically feasible way.
●	Interpret the sterilization kinetics and types of sterilization during fermentation processes.
●	Enhance and modify the biological materials to improve its usefulness by finding the optimal formulation materials to facilitate product production.
●	Design and work on chemostat and its kinetics
Suggested Activities	
●	Problem solving sessions
Suggested Evaluation Methods	
●	Quizzes
●	Class Presentation / Discussion
●	Tutorial Problems
●	Multiple choice questions

<b>Text Book(s):</b>	
<b>1</b>	Shuler and Kargi, — Bioprocess Engineering, Prentice Hall, 2002.
<b>2</b>	Pauline Doran, Bioprocess Engineering Calculation, Blackwell Scientific Publications, 2 <sup>nd</sup> edition, 2012.

<b>Reference Books(s) / Web links:</b>	
<b>1</b>	Lydersen, BjornK.—Bioprocess Engineering Systems, Equipment and Facilities, JohnWiley,1994.
<b>2</b>	Bailey, James E. and David F. Ollis, — Biochemical Engineering Fundamentals, 2 <sup>nd</sup> Edition. McGraw Hill, 1986.
<b>3</b>	Peter F. Stanbury, Stephen J. Hall & A. Whitaker, Principles of Fermentation Technology, Science & Technology Books.
<b>4</b>	Harvey W. Blanch, Douglas S. Clark, Biochemical Engineering, Marcel Dekker, Inc.
<b>5</b>	<a href="https://archive.nptel.ac.in/courses/102/106/102106053/">https://archive.nptel.ac.in/courses/102/106/102106053/</a>

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
BT23511.1	3	3	2	3	3	-	-	-	2	2	2	3	-	2	3
BT23511.2	3	3	2	3	3	-	-	-	2	2	2	3	-	2	3
BT23511.3	3	3	2	3	3	-	-	-	2	2	2	3	-	2	3
BT23511.4	3	3	2	3	3	-	-	-	2	2	2	3	-	2	3
BT23511.5	3	3	2	3	3	-	-	-	2	2	2	3	-	2	3
Average	3	3	2	3	3	-	-	-	2	2	2	3	-	2	3

<b>BT23512</b>	<b>BIOINFORMATICS</b>	<b>Category</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		<b>PE</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

<b>Objectives:</b>	
●	To launch the Bioinformatics core concepts to students
●	To learn basic sequence analysis algorithms to its application in genomics
●	To be able to analyse evolutionary relationships
●	To get exposure to protein structure analysis.
●	To apply Bioinformatics in genomics, proteomics, metabolomics, metagenomics and drug discovery
<b>UNIT-I</b>	<b>BIOLOGICAL DATABASES</b> <span style="float: right;"><b>9</b></span>
Introduction to Bioinformatics and Computational Biology, Biological sequences, Classification of biological databases - Sequence Databases, Structure Databases, Genome specific databases, Special Databases and applications- Microarray, Metabolic pathway, motif, and domain databases, Data file formats.	
<b>UNIT-II</b>	<b>SEQUENCE ANALYSIS</b> <span style="float: right;"><b>9</b></span>
Sequence Alignment- Homology vs Similarity, Similarity vs Identity. Types of Sequence alignment - Pairwise and Multiple sequence alignment, Global alignment, Local alignment, Dotplot, Alignment algorithms- Needleman Wunsch and Smith and Waterman algorithm, Substitution matrices- PAM, 97 BLOSUM. Multiple Sequence Alignment- Application of multiple alignments, Viewing and editing of MSA and Scoring function. Database Similarity Searching- Basic Local Alignment Search Tool (BLAST), FASTA, PHI BLAST, PSI BLAST, BLAST algorithm. Next generation Sequencing Data format, Genome assembly methods. Bioinformatics in Genomics.	
<b>UNIT-III</b>	<b>MOLECULAR PHYLOGENY</b> <span style="float: right;"><b>9</b></span>
Phylogenetics Basics, Molecular clock theory, Ultrametric trees, Distance matrix methods. UPGMA, NJ, Character based methods-Maximum Parsimony. Methods of evaluating phylogenetic methods- bootstrapping, jackknifing.	
<b>UNIT-IV</b>	<b>MACROMOLECULAR STRUCTURE ANALYSIS</b> <span style="float: right;"><b>9</b></span>

Gene prediction, Conserved domain analysis, Prediction of protein secondary structure, Tertiary structure prediction- Homology modeling, Threading, Ab-initio prediction. Validation of the predicted structure using Ramachandran plot, Stereochemical properties, Structure- structure alignment. Role of machine learning in protein structure prediction, Example: Alpha Fold.			
<b>UNIT-V</b>	<b>APPLICATIONS OF DIFFERENT ALGORITHMS</b>		
Introduction to Systems Biology and Synthetic Biology, Gene Network analysis, Metabolic engineering, Microarray data analysis, Bioinformatics approaches for drug discovery, Protein Ligand interaction, Molecular Docking and scoring, Machine learning in Drug discovery, Applications of Bioinformatics in genomics, proteomics and metabolomics- Assembling the genome, Metagenomics and microbiome data analysis.			
			<b>Total Contact Hours : 45</b>
<b>Course Outcomes:</b> On completion of course students will be able to			
●	Use and describe bioinformatics data and information resources.		
●	Apply computational based solutions for biological perspectives		
●	Analyze the evolutionary relationship between the organisms		
●	Understand the macromolecules structure prediction methods		
●	Relate how bioinformatics methods can be used in sequence to structure and function analysis.		
●	Work on the applications of Bioinformatics approach for drug discovery, genomics and proteomics.		

<b>Suggested Activities</b>	
●	Softwares / Tools : Hands on
<b>Suggested Evaluation Methods</b>	
●	Quizzes
●	Class Presentation / Discussion
●	Multiple choice questions
<b>Text Books:</b>	
1	Arthur K. Lesk- Introduction to Bioinformatics, Oxford University Press.
2	Baxivanis and Foulette D- Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins, Wiley Indian Edition, 2001.
3	Attwood TK, parry DJ-Smith, Introduction to Bioinformatics, Pearson Education, 1st Edition, 11th Reprint 2005.
4	David W. Mount-Bioinformatics Sequence and Genome Analysis, Cold Spring Harbor Laboratory Press. 1st edition 2001.

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
BT23512.1	2	2	1	1	2	2	-	1	1	2	1	3	3	3	3
BT23512.2	2	2	2	1	3	2	-	1	1	2	1	3	3	3	3
BT23512.3	2	2	2	1	3	2	-	1	1	2	1	3	3	3	3
BT23512.4	2	2	2	3	3	2	-	1	1	2	1	3	3	3	3
BT23512.5	2	2	3	3	3	2	-	2	1	2	1	3	3	3	3
Average	2	2	2	1.8	2.8	2	-	1.2	1	2	1	3	3	3	3

Subject Code	SEPARATION PROCESS PRINCIPLES											Category	L	T	P	C
<b>BT23513</b>												ES	3	1	0	3
<b>Objectives:</b>																
●	To impart basic knowledge on mass transfer operations and diffusion in solids, Liquids & gases															
●	To gain knowledge on basic principles of gas absorption															



•	To educate knowledge on basic principles and different types of distillation processes	
•	To comprehend on basic principles of L-L equilibrium and solid-liquid equilibrium	
•	To study the basic principles of solid-fluid associated mass transfer operations	
<b>UNIT-I</b>	<b>DIFFUSION AND MASS TRANSFER</b>	9
Molecular diffusion in liquids, gases and solids – Problems ; Inter phase Mass Transfer; Mass Transfer coefficients - Overall and Individual; Theories of Mass transfer - Film Theory, Penetration theory, Surface Renewal Theory.		
<b>UNIT-II</b>	<b>GAS LIQUID OPERATIONS</b>	9
Principles of gas absorption; single component absorption; Absorption with Chemical Reaction; Design principles of absorbers; Equipment for absorption - Plate and Packed tower, HTU, NTU concepts - Problems.		
<b>UNIT-III</b>	<b>VAPOUR LIQUID OPERATIONS</b>	9
V-L Equilibria; Single stage operation - Simple, Steam and Flash Distillation; Continuous distillation; McCabe thiele method – Problems - Maximum, minimum and optimum reflux, Industrial distillation equipments - Molecular, Extractive and Azeotropic distillation.		
<b>UNIT-IV</b>	<b>EXTRACTION OPERATIONS</b>	9
Liquid-Liquid equilibria, Staged and continuous extraction, Problems, Industrial Extractors – Mixers – Settlers, Rotating Disc Contactor, Scheibel Extractor, Pulsed Column and Centrifugal Extractor, Solid-liquid equilibria – Leaching - Principles, Leaching equipments – Bollman Extractor, Dorr Classifier, Shanks systems.		
<b>UNIT-V</b>	<b>SOLID FLUID OPERATIONS</b>	9
Adsorption equilibria – Batch and fixed bed adsorbers – Problems, Drying-Mechanism- Theory of Drying, Drying curves –Time of Drying- Constant rate and Falling Rate; Batch and continuous dryers – Problems.		
		<b>Contact Hours : 45</b>
<b>Course Outcomes:</b>		
On completion of the course, the students will be able to		
•	Classify and use the accurate engineering correlations of diffusion and mass transfer coefficients	
•	Investigate a multi-stage equilibrium separation processes and mass balances in continuous separation processes (absorbers, strippers) and sizing continuous separation units	
•	Demonstrate about vapour- liquid equilibrium	
•	Lay bare the concept of L-L and S-L equilibrium	
•	Design and carryout the construction with operating principles of separating equipments	
<b>Suggested Activities</b>		
•	Problem solving sessions	
<b>Suggested Evaluation Methods</b>		
•	Quizzes	
•	Class Presentation / Discussion	
•	Tutorial Problems	
•	Multiple choice questions	
<b>Text Book(s):</b>		
1	Treybal R.E. Mass Transfer Operations.3rd edition. McGraw-Hill, 1981.	
2	Geankoplis C.J. Transport Processes and Unit Operations.3rd edition, Prentice Hall of India, 2002.	
3	Binay K Dutta. Principles of Mass transfer and Separation Processes, PHI learning Pvt Ltd., 2009	
<b>Reference Books(s) / Web links:</b>		
1	Coulson and Richardson’s Chemical Engineering. Vol. IB, Heat Transfer and Mass Transfer fundamentals & Applications, 7 <sup>th</sup> edition, Butterworth-Heinemann, 2017	
2	Coulson and Richardson’s Chemical Engineering. Vol. I, Fluid Flow, Heat Transfer and Mass Transfer, 6 <sup>th</sup> edition, Butterworth-Heinemann, 1999	
3	<a href="https://archive.nptel.ac.in/courses/103/103/103103034/">https://archive.nptel.ac.in/courses/103/103/103103034/</a>	
4	<a href="https://nptel.ac.in/courses/103103035">https://nptel.ac.in/courses/103103035</a>	
5	<a href="https://archive.nptel.ac.in/courses/103/103/103103154/">https://archive.nptel.ac.in/courses/103/103/103103154/</a>	

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
BT23513.1	3	3	3	3	3	-	-	-	2	2	1	2	-	2	3
BT23513.2	3	3	3	3	3	-	-	-	2	2	1	2	-	2	3
BT23513.3	3	3	3	3	3	-	-	-	2	2	1	2	-	2	3
BT23513.4	3	3	3	3	3	-	-	-	2	2	1	2	-	2	3
BT23513.5	3	3	3	3	3	-	-	-	2	2	1	2	-	2	3
Average	3	3	3	3	3	-	-	-	2	2	1	2	-	2	3

Subject Code	IMMUNOLOGY	Category	L	T	P	C
BT23514		PC	3	0	0	3
<b>Objectives:</b>						
●	To discuss the structure, functions and integration of immune cell networks					
●	To describe the features of T cell and B cell role in the immune system					
●	To familiarize the students about the immune diagnostic techniques					
●	To provide depth knowledge about the role of immune system against pathogens					
●	To explore the significance of immuno prophylaxis					
<b>UNIT-I</b>	<b>ORGANIZATION OF IMMUNE SYSTEM</b>					9
Hematopoiesis, immune cell network and their functions. Lymphoid organs- primary, secondary and tertiary. Immunity- innate and acquired. Immune response – Humoral and cell mediated. Role of MHC in immune response. Antigens and its types - Role of Adjuvants and Haptens in immune response.						
<b>UNIT-II</b>	<b>LYMPHOCYTE AND IMMUNOGLOBINS</b>					9
Development, maturation, activation, differentiation and classification of T-cells and B-cells, antigen processing and presentation –Overview on Immunoglobins structure – Function and properties of IgG, IgD,IgM, IgA and IgE- Inflammation reaction-Role of complement protein and its activation pathway.						
<b>UNIT-III</b>	<b>HYPERSENSITIVITY AND AUTOIMMUNE DISORDERS</b>					9
Hypersensitivity – IgE mediated, Antibody dependent cytotoxicity, immune complex mediated and delayed type hypersensitivity-Reflux hypersensitivity-Diagnosis for allergic reactions. Tolerance and Autoimmunity disorders and its Diagnosis.						
<b>UNIT-IV</b>	<b>IMMUNE RESPONSE , TUMOR AND TRANSPLANTATION IMMUNOLOGY</b>					9
Protective immune responses against virus, bacteria, fungi and parasitic infections. Immuno deficiencies-Primary and secondary-Tumor antigens and mechanism of tumor immune response. Evasion of tumor antigen-Transplantation -HLA typing and graft rejection mechanism- Immuno suppressive agents.						
<b>UNIT-V</b>	<b>IMMUNOTHERAPEUTICS AND IMMUNOTECHNIQUES</b>					9
Vaccine and its types- immunization schedule. Production of Monoclonal and polyclonal antibodies, Antibodies engineering, Abzyme- Agglutination reaction – Blood grouping, comb and Widal reaction. Immunoprecipitations, ELISA, Western Blot, Immunohistochemistry, Complement fixation test and cell sorting technique. Therapy- Autoimmunity, tumor immunotherapy and allergic reaction. Immuno modulators.						
					<b>Contact Hours</b>	<b>: 45</b>
<b>Course Outcomes:</b>						
On completion of the course, the students will be able to						
●	Describe the immune cell networks and the significance of lymphoid organs.					
●	Explain the features of the immune response against antigens.					
●	Articulate the structure and function of immunoglobulin and also elucidate the mechanism of the hypersensitivity reaction.					
●	Categorize the role of the immune response against the pathogens and be able to explain the immunological aspect of graft rejection.					
●	Summarizes the importance of vaccines in disease protection and also articulates the application of					

	immunological background in the immune diagnosis
<b>Suggested Activities</b>	
●	Seminar presentation and discussion
<b>Suggested Evaluation Methods</b>	
●	Test
●	Class Performance / Discussion
<b>Text Book(s):</b>	
1	Roitt I, Male, Brostoff. Immunology, Mosby Publ., 2002.
2	Kuby J, Immunology, WH Freeman & Co., 2000
3	Ashim K. Chakravarthy, Immunology, TataMcGraw-Hill, 1998
<b>Reference Books(s) / Web links:</b>	
1	Coico, Richard "Immunology: A Short Course" VIth Edition. John Wiley, 2008
2	Robert R Rich, Thomas A Fleisher, William T Shearer, Harry Schroeder, Anthony J Frew, and Cornelia M Weyand, Clinical Immunology – Principles and Practive, Elsevier, 4th Edition, 2013.
3	Gerd – Rudiger Burmester, , Antonio Pezzutto and Jurgen Wirth, Colour Atlas of Immunology, Thieme Medical Publishers, 1st Edition, 2003

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
BT23514.1	3	2	3	2	3	2	1	2	3	1	2	2	3	2	3
BT23514.2	3	2	3	2	3	2	1	2	3	1	2	2	3	2	3
BT23514.3	3	2	3	2	3	2	1	2	3	1	2	2	3	2	3
BT23514.4	3	2	3	2	3	2	1	2	3	1	2	2	3	2	3
BT23514.5	3	2	3	2	3	2	1	2	3	1	2	2	3	2	3
Average	3	2	3	2	3	2	1	2	3	1	2	2	3	2	3

<b>BT23521</b>	<b>BIOPROCESS LABORATORY- I</b>	<b>Category</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		<b>PC</b>	<b>0</b>	<b>0</b>	<b>4</b>	<b>2</b>

**Objectives:**

●	To educate the students on the effect of various parameters on enzyme activity
●	To impart the knowledge on enzyme inhibition kinetics
●	To apply the concept of various enzyme immobilization techniques
●	To study the growth kinetic of bacteria and fungi
●	To prepare the suitable media for the growth of microorganisms.

**List of Experiments**

<b>1</b>	Enzyme kinetics – Determination of Michaelis Menten parameters
<b>2</b>	Enzyme activity – Effect of Temperature and Deactivation Kinetics
<b>3</b>	Enzyme activity – Effect of pH
<b>4</b>	Enzyme inhibition kinetics
<b>5</b>	Enzyme immobilization – Gel entrapment
<b>6</b>	Enzyme immobilization – Crosslinking
<b>7</b>	Enzymatic conversion in Packed bed Column/Fluidized bed Column
<b>8</b>	Growth of Bacteria – Estimation of Biomass, Calculation of Specific Growth Rate, Yield Coefficient
<b>9</b>	Growth of yeast – Estimation of Biomass, Calculation of Specific Growth Rate, Yield Coefficient
<b>10</b>	Medium optimization – Plackett Burman Design
<b>11</b>	Biomass Estimation – Direct methods

**Course Outcomes:** Upon completion of this course the students will be able to

- Determine the parameters involved in enzyme kinetics
- Carryout kinetics of enzyme inhibition
- Perform different types of enzyme immobilisation
- Evaluate the various parameters involved in growth kinetics
- Formulate the optimum media for the growth of microorganisms

**Web links for virtual lab (if any)**

- 1 Bailey and Ollis, — Biochemical Engineering Fundamentals, McGraw Hill, 2<sup>nd</sup> edition, 1986.
- 2 Shuler and Kargi, — Bioprocess Engineering —, Prentice Hall, 2002.
- 3 Pauline Doran, Bioprocess Engineering Calculation, Blackwell Scientific Publications, 2<sup>nd</sup> edition, 2012
- 4 Peter F. Stanbury, Stephen J. Hall & A. Whitaker, Principles of Fermentation Technology, Science & Technology Books, 3<sup>rd</sup> edition, 2016.

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
BT23521.1	3	3	3	3	3	1	-	1	2	2	1	2	-	2	3
BT23521.2	3	3	3	3	3	1	-	1	2	2	1	2	-	2	3
BT23521.3	3	3	3	3	3	1	-	1	2	2	1	2	-	2	3
BT23521.4	3	3	3	3	3	1	-	1	2	2	1	2	-	2	3
BT23521.5	3	3	3	3	3	1	-	1	2	2	1	2	-	2	3
Average	3	3	3	3	3	1	-	1	2	2	1	2	-	2	3

BT23522	BIOINFORMATICS LABORATORY	Category	L	T	P	C
		PC	0	0	4	2

**Objectives:**

- To provide a practical exposure to the bioinformatics databases, tools and software
- To select and use functions/packages in R for processing biological data.
- To understand evolutionary relationship among different species.
- To design computer aided drug.
- To analyse gene expression data

**LIST OF EXPERIMENTS**

1. Introduction to UNIX basic commands.
2. R programming and applications to Bioinformatics.
  - Basic programming/Data structure
  - File i/o& control statement.
  - Functions and packages
  - Frequently used R packages
3. Biological databases and their uses
  - Sequence databases including Genome specific databases
  - Structure databases
  - Lead molecule search using databases.
  - Drug target database (TTD and KEGG)
4. Sequence Analysis
  - BLAST, FASTA

<ul style="list-style-type: none"> <li>• Multiple sequence alignment</li> <li>• ExPASy Tools</li> <li>• DOTPLOT</li> </ul>
5. Phylogenetic tree prediction
6. Protein secondary structure prediction
7. Protein tertiary structure prediction- Homology modeling using automated tool and Any open source software.
8. Protein-Ligand docking
9. Protein-Protein docking
10. ADMET modeling
11. Gene prediction tools.
12. Gene Expression Data analysis
<b>Course Outcomes:</b>
On completion of course students will be able to
<ul style="list-style-type: none"> <li>• Understand basic commands of UNIX OS.</li> <li>• Apply R programming to develop bioinformatics tools.</li> <li>• Retrieve and analyze sequence and structure data.</li> <li>• Access the databases and tools used for computer aided drug designing.</li> <li>• Evaluate Gene Predictions and Gene Expression Data analysis</li> </ul>

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
BT23522.1	3	3	3	2	2	-	-	-	3	3	2	3	1	2	3
BT23522.2	2	2	3	2	3	-	-	-	3	3	2	3	1	2	3
BT23522.3	2	2	3	2	2	-	-	-	3	3	2	3	1	2	3
BT23522.4	2	2	3	2	2	-	-	-	3	3	2	3	1	2	3
BT23522.5	2	2	3	3	2	-	-	-	3	3	2	2	1	2	3
<b>Average</b>	2.2	2.2	3	2.2	2.2	-	-	-	3	3	2	2.8	1	2	3

Subject Code	IMMUNOLOGY LABORATORY	Category	L	T	P	C
BT23523		PC	0	0	4	2
<b>Course Objectives:</b>						
<ul style="list-style-type: none"> <li>• To perform various immunology techniques and to interpret the results</li> <li>• To identify different immune cells in the blood</li> <li>• To perform Widal test and identify typhoid antigens</li> <li>• To provide basic skills and advances in the field of immuno diagnosis.</li> <li>• To isolate and characterize immune cells</li> </ul>						
<b>List of Experiments</b>						
1.	Animal handling techniques- Immunization and Blood collection by virtual method					
2.	Immune cell identification and differential leukocyte counting in blood smears					
3.	Identification of blood groups					
4.	Preparation of serum/plasma from blood					
5.	Purification of immunoglobulin from serum					
6.	Immumoprecipitation technique - Double Immunodiffusion					
7.	Electroimmunodiffusion technique- Rocket immunoelectrophoresis					
8.	Agglutination test - Testing for typhoid antigens by Widal test					

9.	Agglutination Inhibition Test -Human chorionic gonadotropin test (Pregnancy)		
10.	Enzyme Linked Immuno Sorbent Assay (ELISA)		
11.	Isolation of Peripheral Blood Mononuclear Cells (PBMC)		
12.	Identification of t cells by T-cell rosetting using sheep RBC		
			<b>Total Contact Hours</b> : <b>60</b>
<b>Course Outcomes:</b>			
On completion of the course, the students will be able to			
●	Carry through various immunology techniques and interpret the results		
●	Investigate different immune cells in the blood		
●	Carry out Widal test and identify typhoid antigens		
●	Excel in immuno diagnosis of various diseases		
●	Perform isolation and characterization of immune cells		
<b>Suggested Activities</b>			
●	Experimentation		
<b>Suggested Evaluation Methods</b>			
●	Experimentation, Test and Discussion		
●	Viva voce		
<b>Reference and Text Book(s):</b>			
1	Roitt I, Male, Brostoff. Immunology, Mosby Publ., 2002.		
2	Current protocols in immunology / editorial board John E. Coligan .et al., 2003, New York : Wiley Interscience, 2003.		
3	Ashim K. Chakravarthy, Immunology, TataMcGraw-Hill, 1998.		
4	Noel R. Rose, Herman Friedman, John L. Fahey. Manual of Clinical Laboratory Immunology. ASM. 3rd ed., 1986.		
5	GP Talwar, A Handbook of Practical & Clinical Immunology, Vol.2, 2Ed		
6	Kuby J, Immunology, WH Freeman & Co., 2000.		

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
BT23523.1	2	2	3	3	2	2	2	2	3	2	3	2	3	2	2
BT23523.2	2	2	3	3	2	2	2	2	3	2	3	2	3	2	2
BT23523.3	2	2	3	3	2	2	2	2	3	2	3	2	3	2	2
BT23523.4	2	2	3	3	2	2	2	2	3	2	3	2	3	2	2
BT23523.5	2	2	3	3	2	2	2	2	3	2	3	2	3	2	2
Average	2	2	3	3	2	2	2	2	3	2	3	2	3	2	2

GE23521	SOFT SKILLS-II				Category	L	T	P	C
					EEC	0	0	2	1

<b>Objectives:</b> To enable the students to	
●	To help students break out of shyness.
●	To build confidence
●	To enhance English communication skills.
●	To encourage students' creative thinking to help them frame their own opinions,

**Learning and Teaching Strategy:**

The program is completely student centric where the focus is on activities led by students which include role plays, discussions, debates other games as well. These activities would be supplemented by interactive use of technology and brief trainer input.

Week	Activity Name	Description	Objective
1	The News hour	Students are made to read news articles from the English newspapers. The students also have to find words and their meaning from the article they have not come across before and share it with the group. They then use these words in sentences of their own	The aim of this activity is not only to get the students to read the newspaper but also aims at enhancing the students' vocabulary.
2	Court Case	The facilitator provides the participants the premise of a story and proceeds to convert the story into a court case. The students are required, department-wise to debate and provide their points to win the case for their clients.	The aim of the lesson is to encourage creative and out-of-the-box thinking to ensure a good debate and defense skills.
3	The ultimate weekend	The students design activities they are going to do over the weekend and they have to invite their classmates to join in the activity. The students move around the class and talk to other students and invite them.	The aim of this activity is to develop the art of conversation among students. It also aims at practicing the grammatical structures of "going to" "have to" and asking questions.
4	The Four Corners	This is a debate game that uses four corners of the classroom to get students moving. The following is written on the 4 corners of the room "Strongly Agree, Somewhat Agree, Somewhat Disagree and Strongly Disagree". The topics are then given to the class and students move to the corner that they feel best explains their opinions	This activity aims at getting students to come up with their own opinions and stand by it instead of being overshadowed by others and forcing themselves to change based on others opinions.
5	Debate	Boarding school or day school? Which is more beneficial for a student?	The aim of this activity is to encourage students to draw up feasible points on the advantages and benefits of both. And enhance their debating ability
6	Grand Master	The facilitator starts the session by keeping an individual in mind, upon which the students guess it only through "Yes or No" questions. Post few trials the students are given same opportunity to do the same with the crowd.	The aim of the lesson is designed to teach the art of questioning. It also helps to enhance the students' speaking and listening skills.
7	Debate	Does violence on the TV and Video games influence children negatively?	This activity aims at encouraging the students to debate on real life scenarios that most students spend a lot of time on.
8	Turn Tables	This is a speaking activity where the students need to speak for and against the given topics when the facilitator shouts out 'Turn Table'.	The aim of this activity is to make the participants become spontaneous and have good presence of mind.
9	Debate	Do marks define the capabilities of a student?	This debate activity aims at allowing the students to argue on this worrisome adage of marks.
10	FictionAD	The Participants are asked to create an Ad for a challenging topic only using fictional characters.	The activity aims at developing their creativity and presentation skills.
11	Debate	Are social networking sites effective, or are they	This activity aims at refining the

		just a sophisticated means for stalking people?	students debating skills on a very real life situation
12	Talent Hunt	Talent Hunt is a fun activity where the students are selected at random and supported to present any of their own skills.	The aim of this activity is designed to evoke their inner talents and break the shyness and the fear of participating in front of a crowd
	Feedback	At the end of the session in the final week (12) the trainer would provide feedback to the students on best practices for future benefits.	The aim is to do both give feedback to students as well as obtain feedback on the course from them.

**Course Outcomes:** On successful completion of the course, students should be able to

●	Be more confident
●	Speak in front of a large audience without hesitation
●	Think creatively
●	Speak impromptu
●	Communicate in English

<b>Subject code</b>	<b>BIOPROCESS TECHNOLOGY</b>	<b>Category</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>BT23611</b>		<b>PC</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

**Objectives:**

●	This course aims at imparting knowledge about the design and non-ideal behaviour of different types of bioreactors
●	The students will be able to scale up reactors
●	To impart knowledge on immobilized reactors
●	To learn about the various structured models
●	To gain knowledge about recombinant cell cultivation

<b>UNIT-I</b>	<b>BIOREACTORS AND ITS MODE OF OPERATIONS</b>	10
Cell recycle cultivation, Cell recycle cultivation in waste water treatment, two stage cultivation. Design behavior of Packed bed reactor, airlift reactor, fluidized bed reactor, bubble column reactor.		
<b>UNIT-II</b>	<b>MASS TRANSFER IN BIOREACTORS AND SCALE-UP</b>	8
Regime analysis of bioreactor processes, oxygen mass transfer in bioreactors - microbial oxygen demands; methods for the determination of mass transfer coefficients - Problems; mass transfer correlations. Scale up criteria for bioreactors based on oxygen transfer, power consumption and impeller tip speed - Problems.		
<b>UNIT-III</b>	<b>OPERATIONAL CONSIDERATIONS IN IMMOBILIZED ENZYME SYSTEMS</b>	8
Analysis of film and pore diffusion effects on kinetics of immobilized enzyme reactions; formulation of dimensionless groups and calculation of effectiveness factors. Design of immobilized enzyme reactors – packed bed, fluidized bed and membrane reactors.		
<b>UNIT-IV</b>	<b>MODELLING AND SIMULATION OF BIOPROCESSES</b>	12
Study of structured models for analysis of various bioprocess – compartmental models, Ramakrishna model, models of cellular energetics and metabolism, single cell models, plasmid replication – Structured and Unstructured models. Dynamic simulation of batch, fed batch, steady and transient culture metabolism.		
<b>UNIT-V</b>	<b>RECOMBINANT CELL CULTIVATION STRATEGIES</b>	7



Different host vector system for recombinant cell cultivation strategies and advantages. <i>E.coli</i> , <i>yeast Pichia pastoris/ Saccharomyces cerevisiae</i> , Animal cell cultivation, plant cell cultivation, Insect cell cultivation. High cell density cultivation, process strategies, reactor considerations in the above system – Case studies.	<b>Total Contact Hours</b>	:	<b>45</b>
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<b>Course Outcomes:</b> The students will be able to	
●	Design different types of reactors like Chemostat, packed bed, fluidized bed, airlift and bubble column reactors
●	Scale up reactors
●	Design of immobilised enzyme bioreactors
●	Analyze, develop and simulate bioprocess models
●	Gain Knowledge in recombinant cell cultivation like animal cell, plant cell, insect cell and high cell density cultivation
<b>Suggested Activities</b>	
●	Problem solving sessions
<b>Suggested Evaluation Methods</b>	
●	Quizzes
●	Class Presentation / Discussion
●	Tutorial Problems
●	Multiple choice questions

<b>Text Book(s):</b>	
1	Shuler, Michael Land Fikret Kargi, —Bioprocess Engineering—, Prentice Hall, 1992.
2	Doran M Pauline -Bioprocess Engineering Principles. 2 nd Edition, Elsevier, 2012.
3	Ghasem D.Najafpour, —Biochemical Engineering and Biotechnology, Elsevier, 2007.

<b>Reference Books(s) / Web links:</b>	
1	Anton Moser, —Bioprocess Technology, Kinetics and Reactors, Springer Verlag.
2	James E. Bailey & David F. Ollis, Biochemical Engineering Fundamentals, McGraw Hill.
3	James M. Lee, Biochemical Engineering, PHI, USA.
4	Atkinson, Handbook of Bioreactors, Harvey W. Blanch, Douglas S. Clark, Biochemical Engineering, Marcel Decker Inc.
5	<a href="https://onlinecourses.nptel.ac.in/noc24_bt17/preview">https://onlinecourses.nptel.ac.in/noc24_bt17/preview</a>

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
BT23611.1	3	2	2	2	2	1	1	-	2	-	-	3	-	3	3
BT23611.2	3	2	2	2	1	1	-	-	2	-	1	2	-	-	3
BT23611.3	3	2	2	2	1	-	1	-	2	-	1	3	-	2	3
BT23611.4	1	1	2	1	1	-	2	-	-	-	1	2	-	-	3
BT23611.5	-	1	2	2	2	2	1	-	2	-	2	3	-	3	3
Average	2.5	1.6	2	1.8	1.4	1.3	1.2	-	2	-	1.2	2.6	-	2.6	3

<b>BT23612</b>	<b>CHEMICAL REACTION ENGINEERING</b>	<b>Category</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		<b>ES</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

<b>Objectives:</b>	
●	To impart knowledge about the different types of chemical reactions and development of kinetic

	models
●	To develop design equation for different types of reactors
●	To study the RTD in various reactors and parameters for design of reactors.
●	To impart knowledge on design of heterogenous catalytic reactions
●	To comprehend the design of heterogenous reactors for fluid-fluid and fluid-particle reactions.

<b>UNIT-I</b>	<b>KINETICS OF HOMOGENEOUS REACTIONS AND INTERPRETATION OF BATCH REACTOR DATA</b>	9
Overview of chemical reaction Engineering, rate equations, concentration and temperature dependence, Design of single ideal reactions and reactors, Constant and variable volume batch reactor.		
<b>UNIT-II</b>	<b>IDEAL REACTORS</b>	9
Ideal batch reactor, Steady state mixed flow reactor and plug flow reactor - Problems, Design consideration for ideal reactors, Size comparison of single reactors, Multiple reactor systems - PFR in series and parallel, CSTR and MFR in series.		
<b>UNIT-III</b>	<b>NON IDEAL FLOW</b>	9
Basic concepts of Non - ideal flow – RTD; E-curve; F-curve, Relationship between E and F curve - Determination of mean residence time, Dispersion model and Tank - in - series model – Conversion in non-ideal reactors		
<b>UNIT-IV</b>	<b>REACTIONS CATALYSED BY SOLIDS</b>	9
Introduction to heterogeneous reactions, Pore diffusion resistance combined with surface kinetics, Performance equation for reactors with porous particles, Performance equation of reactors containing porous catalyst, Packed bed catalytic reactor and fluidized bed reactor of various types, Gas - Liquid reactions on solid catalyst: Trickle bed, slurry reactors and three phase-fluidized bed reactors.		
<b>UNIT-V</b>	<b>NON – CATALYTIC SYSTEMS</b>	9
Fluid-fluid reactions and reactors, Fluid - particle reactions – Examples of fluid- solid reactions, kinetics, Shrinking core model and Progressive conversion model – Solved problems, Fluid – Particle reactor design,		
<b>Total Contact Hours</b>		<b>: 45</b>

<b>Course Outcomes:</b> Upon completion of this course, students will be able to	
●	Identify, analyze and develop kinetic models for different types of homogeneous reactions
●	Develop model equation and design reactors for homogeneous reactions.
●	Apply RTD for various reactors and design real reactor
●	Design reactors for heterogenous catalytic reactions
●	Design reactors for fluid – fluid – particle reactions
<b>Suggested Activities</b>	
•	Problem solving sessions
<b>Suggested Evaluation Methods</b>	
•	Quizzes
•	Class Presentation / Discussion
•	Tutorial Problems
•	Multiple choice questions

<b>Text Book(s):</b>	
1	Levenspiel O. Chemical Reaction Engineering. 3rd Edition. JohnWiley.1999.
2	Fogler H.S. Elements Of Chemical Reaction Engineering. Prentice HallIndia.2002.

<b>Reference Books(s) / Web links:</b>	
1	Missen R.W., Mims C.A., Saville B.A. Introduction To Chemical Reaction Engineering and Kinetics. JohnWiley.1999.

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
	BT23612.1	3	3	3	2	-	-	-	-	2	-	3	3	2	-
BT23612.2	3	3	3	3	-	-	-	-	3	-	3	3	3	-	3
BT23612.3	3	3	3	3	-	-	-	-	3	-	3	3	3	-	3
BT23612.4	3	3	3	3	-	-	3	-	3	-	3	3	3	-	3
BT23612.5	3	3	3	3	-	-	3	-	3	-	3	3	3	-	3
Average	3	3	3	2.8	-	-	3	-	2.8	-	3	3	2.8	-	2.8

<b>BT23621</b>	<b>BIOPROCESS LABORATORY II</b>					<b>Category</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
						<b>PC</b>	<b>0</b>	<b>0</b>	<b>4</b>	<b>2</b>

<b>Objectives:</b> To enable the students to	
●	Apply the earlier learned knowledge about mass transfer kinetics and sterilization kinetics.
●	Train the students to acquire the skills and knowledge in solving problems by analogy typical for the biotechnology industry
●	Design and conduct experiments in bioreactors for the production of commercial products
●	Enhance the students to design various bioreactor systems for the growth of microorganisms for its application in industries
●	Inculcate creativity and innovation in the field of bioprocess engineering for the development of products useful to the society

<b>List of Experiments</b>	
<b>1</b>	Batch Sterilization kinetics
<b>2</b>	Batch sterilization design
<b>3</b>	Thermal death kinetics
<b>4</b>	Estimation of $K_{La}$ – Dynamic Gassing-out method
<b>5</b>	Estimation of $K_{La}$ – Sulphite Oxidation Method
<b>6</b>	Estimation of $K_{La}$ – Power Correlation Method
<b>7</b>	Fed batch cultivation and Total cell retention cultivation (bacteria & Yeast)
<b>8</b>	Algal cultivation – Photobioreactor
<b>9</b>	Residence time distribution
<b>10</b>	Estimation of Mixing Time in reactor
<b>11</b>	Production of Wine
<b>Total Contact Hours</b>	
<b>: 60</b>	

<b>Course Outcomes:</b>	
Upon completion of this course the students will be able to	
●	Gain ability to investigate, design and conduct experiments on batch sterilization kinetics
●	Analyze and interpret data, and apply the laboratory skills to solve complex bioprocess engineering problems related to fed batch cultivation of microbes
●	Demonstrate advancement in their skills in operating instruments like Photobioreactor, exhaust gas analyser
●	Estimate and quantify the distribution and utilization of nutrients by Residence Time Distribution studies
●	Perform competently in chemical and bioprocess industries and become important contributors for solving problems about mass transfer and heat transfer kinetics in bio reactors

<b>Reference Books(s) / Web links:</b>	
<b>1</b>	Anton Moser, —Bioprocess Technology, Kinetics and Reactors, Springer Verlag, 2012.

2	James E. Bailey & David F. Ollis, Biochemical Engineering Fundamentals, McGraw Hill, 2 <sup>nd</sup> edition, 1986.
3	Michael L. Shuler, Fikret Kargi, Matthew De Lisa, Bioprocess Engineering, 3 <sup>rd</sup> Edition, Prentice Hall, 2017
4	Atkinson, Handbook of Bioreactors, Harvey W. Blanch, Douglas S. Clark, Biochemical Engineering, Marcel Decker Inc.

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
BT23621.1	1	1	2	2	-	-	-	-	-	-	-	-	1	2	3
BT23621.2	1	1	2	2	-	-	-	-	-	-	-	-	1	2	3
BT23621.3	-	2	2	-	2	-	-	-	-	-	-	3	1	2	3
BT23621.4	-	2	2	-	2	-	-	-	-	-	-	3	1	2	3
BT23621.5	-	2	2	-	2	-	-	-	-	-	2	3	2	3	3
Average	0.4	1.6	2	0.8	1.2	-	-	-	-	-	0.4	1.8	1	2.2	3

<b>BT23622</b>	<b>NUMERICAL PROGRAMMING FOR BIOTECHNOLOGISTS</b>	<b>Category</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		<b>PC</b>	<b>0</b>	<b>0</b>	<b>2</b>	<b>1</b>

**Objectives:**

- To learn the MATLAB environment and its programming fundamentals
- To be able to write Programs using commands and functions
- To handle polynomials and curve fitting, Interpolation
- To do the numerical integration
- To solve ordinary differential equations

**LIST OF EXPERIMENTS**

1. Basic commands in MATLAB –Arithmetic & Logarithmic Operations
2. Input-Output functions, Reading and Storing Data. Scripts and Functions
3. Control Structures: (For loops, While, If control structures, Switch, Break, Continue statements).
4. Operations on matrices –Basic Commands
5. Operations on Matrices –Arithmetic, Relational, Logical Vectors and Matrix Manipulation
6. Polynomial Evaluation, Roots of Polynomial, Arithmetic operations on Polynomials. Curve fitting with polynomial functions, Interpolation
7. Numerical Integration
8. Solve Ordinary Differential Equation MATLAB

**Course Outcomes:**

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

- Sketch the fundamentals of MATLAB and programming skill.
- Apply MATLAB programs to solve arithmetic operations and polynomials.

●	Learn application of MATLAB to solve linear equation and matrix operations
●	Execute Numerical integration
●	Solve ordinary differential equations
●	Develop data analysis skill by using MATLAB

<b>Text Books:</b>	
1	Bansal.R.K, Goel.A.K, Sharma.M.K, —MATLAB and its Applications in Engineering, Pearson Education, 2012
2	Rudra pratap —Getting Started with MATLAB, A Oxford University press, 2010.
<b>Reference Books:</b>	
1	Amos Gilat, —MATLAB-An Introduction with Applications, Wiley India, 2009.
2	Stephen.J.Chapman, -Programming in MATLAB for Engineers, Cengage Learning, 2011.

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
BT23622.1	3	3	3	2	2	1	1	1	3	3	2	3	1	2	3
BT23622.2	2	2	3	2	3	1	1	1	3	3	2	3	1	2	3
BT23622.3	2	2	3	2	2	1	1	1	3	3	2	3	1	2	3
BT23622.4	2	2	3	2	2	1	1	1	3	3	2	3	1	2	3
BT23622.5	2	2	3	3	2	1	1	1	3	3	2	2	1	2	3
Average	2.2	2.2	3	2.2	2.2	1	1	1	3	3	2	2.8	1	2	3

<b>GE23621</b>	<b>PROBLEM-SOLVING TECHNIQUES</b>	<b>Category</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		<b>EEC</b>	<b>0</b>	<b>0</b>	<b>2</b>	<b>1</b>

Course objectives:	
This course will enable the students to	
●	To improve the numerical ability
●	To improve problem-solving skills.

## Course topics:

S.No.	Topics
1	Numbers system
2	Reading comprehension
3	Data arrangements and Blood relations
4	Time and Work
5	Sentence correction
6	Coding & Decoding, Series, Analogy, Odd man out and Visual reasoning
7	Percentages, Simple interest and Compound interest
8	Sentence completion and Para-jumbles

9	Profit and Loss, Partnerships and Averages
10	Permutation, Combination and Probability
11	Data interpretation and Data sufficiency
12	Logarithms, Progressions, Geometry and Quadratic equations.
13	Time, Speed and Distance

Course outcomes: This course will enable the students to	
•	Have mental alertness
•	Have numerical ability
•	Solve quantitative aptitude problems with more confident

<b>GE23627</b>	<b>DESIGN THINKING AND INNOVATION</b>	<b>Category</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		<b>EEC</b>	<b>0</b>	<b>0</b>	<b>4</b>	<b>2</b>

Course objectives: This course will enable the students to	
•	To understand the design thinking concepts and deep understanding of user needs and experiences.
•	To find the problem statement and to develop innovative design solutions that address identified user challenges
•	To master the process of prototyping and iterating on designs.
•	To conduct thorough market analysis and financial planning
•	To effectively communicate design concepts and findings.

<b>UNIT-I</b>	<b>INTRODUCTION TO DESIGN THINKING</b>	<b>12</b>
The design thinking concepts - Different design thinking models - Details of Stanford Design thinking process: Empathize, Define, Ideate, Prototype, Test <b>Activities:</b> <ul style="list-style-type: none"> <li>Case studies of successful domain based Design Thinking and Innovative projects,</li> </ul> Group discussions on design thinking		
<b>UNIT-II</b>	<b>EMPATHIZE AND DEFINE</b>	<b>12</b>
User research methods (interviews, surveys, observation, contextual inquiry) - Persona development- Journey mapping – Brainstorming Defining the design problem statement <b>Activities:</b> <ul style="list-style-type: none"> <li>Conducting user interviews and surveys</li> <li>Creating user personas and journey maps</li> <li>Identifying key user needs and pain points</li> </ul> Analyze the user needs and Brainstorming to define problem statement		
<b>UNIT-III</b>	<b>IDEATE AND CREATE</b>	<b>12</b>
Brainstorming techniques (e.g., mind mapping, SCAMPER) - Ideation tools (e.g., design thinking tools, concept sketching) - Concept generation and evaluation ( e.g. Brainstorming) <b>Activities:</b>		

<ul style="list-style-type: none"> <li>• Group brainstorming sessions to select the best idea</li> <li>• Creating concept sketches and prototypes</li> </ul> Evaluating ideas based on user needs and feasibility			
<b>UNIT-IV</b>	<b>PROTOTYPE AND TEST</b>		<b>12</b>
Low, Medium and high level fidelity for prototyping-Usability testing -Iterative design <b>Activities:</b> <ul style="list-style-type: none"> <li>• Building low-fidelity prototypes (e.g., paper prototypes)</li> <li>• Conducting usability tests with users</li> </ul> Iterating on designs based on feedback			
<b>UNIT-V</b>	<b>MARKET ANALYSIS AND IMPLEMENTATION</b>		<b>12</b>
Market research and analysis - Business model development- Financial planning- Implementation strategies <b>Activities:</b> <ul style="list-style-type: none"> <li>• Conducting market research</li> <li>• Developing a business model canvas</li> <li>• Creating a financial projection</li> </ul> Developing an implementation plan			
			<b>Total Contact Hours</b>
			<b>: 60</b>

<b>Course outcomes:</b>	
Upon completion of the course, the students will be able to	
•	Construct design challenge and reframe the design challenge into design opportunity.
•	Interview the user, and know the feelings of users to foster deep user understanding and be able to uncover the deep user insights and needs.
•	Develop ideas and prototypes by brainstorming.
•	Organize the user walkthrough experience to test prototype
•	Develop smart strategies and implementation plan that will deliver/achieve the idea/solution deduced from earlier phases.

<b>Assessment:</b>	
•	Encourage students to work on real-world design challenges based on the user needs
•	Group presentations
•	Quizzes and exams
•	Evaluation of Project report and viva and also encourage the students for filing patent/copyright / presenting in conference / publishing in journal

<b>Text Book(s):</b>	
1	Handbook of Design Thinking by Christian Müller-Roterberg, Kindle Direct Publishing, 2018.
2	Design Thinking – A Beginner’s Perspective, by E Balagurusamy, Bindu Vijakumar, MC GrawHill, 2024

<b>Reference Books:</b>	
1	Design Thinking for Entrepreneurs and Small Businesses: Putting the Power of Design to Work – by Beverly Rudkin Ingle, Apress; 1st ed. Edition, 2013

2	Design Thinking: Understanding How Designers Think and Work by Nigel Cross, Bloomsbury Visual Arts; 2 edition 2023
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Web links	
1	Design thinking Guide <a href="https://www.rcsc.gov.bt/wp-content/uploads/2017/07/dt-guide-book-master-copy.pdf">https://www.rcsc.gov.bt/wp-content/uploads/2017/07/dt-guide-book-master-copy.pdf</a>
2	NPTTEL Course on Design Thinking and Innovation By Ravi Poovaiah; <a href="https://onlinecourses.swayam2.ac.in/aic23_ge17/preview">https://onlinecourses.swayam2.ac.in/aic23_ge17/preview</a>
3	IITB Design course tools and Resources <a href="https://www.dsource.in/">https://www.dsource.in/</a>

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
GE23627.1	3	2	3	3	3	2	2	3	3	3	3	3	3	2	2
GE23627.2	3	2	3	3	3	2	2	3	3	3	3	3	3	2	2
GE23627.3	3	2	3	3	3	2	2	3	3	3	3	3	3	2	2
GE23627.4	3	2	3	3	3	2	2	3	3	3	3	3	3	2	2
GE23627.5	3	2	3	3	3	2	2	3	3	3	3	3	3	2	2
Average	3	2	3	3	3	2	2	3	3	3	3	3	3	2	2

Subject code	DOWNSTREAM PROCESSING	Category	L	T	P	C
BT23711		PC	3	1	0	3
<b>Objectives:</b> This course will enable the students						
●	To inculcate depth idea about downstream processing and cell disruption techniques					
●	To learn the operation of solid-liquid separation equipment					
●	To study the fundamentals about Extraction and membrane separation techniques and will learn how to develop models for precipitation technique.					
●	To work on chromatographic techniques which will be useful for bioproduct separation					
●	To educate the fundamental concept and operational principles of crystallization, drying and lyophilization and to do research					

<b>UNIT-I</b>	<b>DOWNSTREAM PROCESSING</b>	9
Introduction to downstream processing, principles, characteristics of bio-molecules and bioprocesses. Cell disruption for product release – mechanical, enzymatic and chemical methods. Pretreatment and stabilisation of bio-products.		
<b>UNIT-II</b>	<b>PHYSICAL METHODS OF SEPARATION</b>	9
Unit operations for solid-liquid separation – filtration – compressibility factor - filter medium resistance and specific cake resistance – problems, Industrial filters. Centrifugation- Principles - Industrial centrifuges – disc bowl centrifuge, tubular bowl and multi-chamber bowl centrifuge - applications.		
<b>UNIT-III</b>	<b>ISOLATION OF PRODUCTS</b>	9
Adsorption - isotherms and break through curve in fixed bed adsorption, liquid-liquid extraction, aqueous two-phase extraction, membrane separation – ultrafiltration, microfiltration and reverse osmosis, dialysis, precipitation of proteins by different methods – ammonium sulphate precipitation, isoelectric precipitation.		
<b>UNIT-IV</b>	<b>PRODUCT PURIFICATION</b>	9
Chromatography – principles, instruments and practice, adsorption, reverse phase, ion-exchange, size exclusion, hydrophobic interaction, HPLC, bio-affinity and pseudo affinity chromatographic		



techniques.	
<b>UNIT-V</b>	<b>FINAL PRODUCT FORMULATION AND FINISHING OPERATIONS</b>
	9
Crystallization – principle and mechanism, drying and lyophilization in final product formulation, Industrial dryers – Tray, Spray, Fluidized Bed, Rotary Drum and Pneumatic Dryer – Applications in Biopharmaceutical and Food Industries – Case studies.	
	<b>Total Contact Hours : 45</b>

<b>Course Outcomes:</b> Upon completion of this course the students will	
•	Have in depth idea about downstream processing and cell disruption techniques
•	Learn the operation of solid-liquid separation equipment
•	Be able to know the fundamental idea about extraction and membrane separation techniques and will learn how to develop models for precipitation technique.
•	Be able to work on chromatographic techniques for different applications
•	Apply the fundamental concept and operational principles of crystallization , drying and lyophilization and to do research
<b>Suggested Activities</b>	
•	Casestudies
<b>Suggested Evaluation Methods</b>	
•	Quizzes
•	Class Presentation / Discussion
•	Tutorial Problems
•	Multiple choice questions

<b>Text Book(s):</b>	
•	Belter, P.A., E.L.CusslerandWei-Houhu—Bioseparations– DownstreamProcessingforBiotechnology, John Wiley, 1988.
•	Sivasankar, B. —Bioseparations: Principles and Techniquesl. PHI, 2005.
•	Ghosh, R., “Principles of Bioseparations Engineering”, World Scientific Publishers, 2006.

<b>Reference Books(s) / Web links:</b>	
•	R.O. Jenkins, (Ed.) – Product Recovery In Bioprocess Technology – Biotechnology By Open Learning Series, Butterworth-Heinemann (1992).
•	Roger, H., “Bio-separations Science and Engineering”, Oxford University Press, 2006
•	<a href="https://archive.nptel.ac.in/courses/102/106/102106022">https://archive.nptel.ac.in/courses/102/106/102106022</a>

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
BT23711.1	2	-	2	-	-	3	1	-	2	-	-	-	-	1	2
BT23711.2	3	3	2	2	-	-	-	-	-	-	-	1	-	1	2
BT23711.3	3	2	2	1	1	-	-	-	-	-	1	1	1	1	2
BT23711.4	3	3	3	2	2	-	-	-	1	-	-	-	1	1	2
BT23711.5	3	2	3	3	2	-	-	-	1	-	-	-	-	1	2
Average	2.8	2	2.4	1.6	1	0.6	0.2	-	0.8	-	0.2	0.4	0.4	1	2

<b>BT23712</b>	<b>PROTEIN ENGINEERING</b>	<b>Category</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		<b>PC</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

<b>Objectives:</b> To enable the students	
●	To gain a strong knowledge about the amino acids, bonds and protein structure.
●	To educate about the protein architecture, super secondary structure.
●	To learn the ways to predict the structure using various structure prediction tools.
●	To know the basic structure and function relationship of proteins.
●	To learn the proteomics techniques

<b>UNIT-I</b>	<b>BONDS, ENERGIES, BUILDING BLOCKS OF PROTEINS</b>	6	
Covalent, Ionic, Hydrogen, Coordinate, hydrophobic and Vander walls interactions in protein structure. Amino acids (three and single letter codes) and their molecular properties (size, solubility, charge, pKa). Chemical reactivity in relation to post-translational modification (involving amino, carboxyl, hydroxyl, thiol, imidazole groups).			
<b>UNIT-II</b>	<b>PROTEIN ARCHITECTURE</b>	10	
Primary structure: peptide mapping, peptide sequencing - automated Edman method & mass-spec. Secondary structure: Alpha, beta and loop structures and methods to determine. Super-secondary structure: Alpha-turn-alpha, beta-turn-beta (hairpin), beta-sheets, alpha-beta-alpha, topology diagrams, up and down & TIM barrel structures nucleotide binding folds, Ramachandran plot – Interpretation of data.			
<b>UNIT-III</b>	<b>TERTIARY STRUCTURE</b>	8	
Tertiary structure with special reference to myoglobin and glyceraldehyde - 3- phosphate dehydrogenase: Domains, Protein folding theory, denaturation and renaturation, overview of methods to determine 3D structures – X-ray diffraction and NMR, Quaternary structure with reference to aspartate transcarbamoylase.			
<b>UNIT-IV</b>	<b>STRUCTURE-FUNCTION RELATIONSHIP</b>	9	
DNA-binding proteins: prokaryotic transcription factors, Helix-turn-Helix motif in DNA binding, Trp repressor, Eukaryotic transcription factors, Zn fingers, helix-turn helix motifs in homeodomain, Leucine zippers, Membrane proteins: General characteristics, Trans-membrane segments, prediction, bacteriorhodopsin and Photosynthetic reaction center, Immunoglobulins: IgG Light chain and heavy chain architecture, Enzymes: Serine proteases, understanding catalytic design by engineering trypsin, chymotrypsin and elastase.			
<b>UNIT-V</b>	<b>PROTEOMICS</b>	12	
Introduction to the concept of proteome, components of proteomics, proteomic analysis, importance of proteomics in biological functions, protein-protein interactions and methods to study it: protein arrays, cross linking methods, affinity methods, yeast hybrid systems and protein arrays.			
		<b>Total Contact Hours</b>	<b>: 45</b>

<b>Course Outcomes:</b> Upon completion of this course the students will	
●	Explain the different types of bonds and interactions and describe the molecular properties of amino acids.
●	Analyze the primary, secondary, and super-secondary structures of proteins
●	Evaluate the tertiary structure of proteins
●	Apply the knowledge of protein structure to predict the function of DNA-binding proteins
●	Design and develop strategies for proteomic analysis
<b>Suggested Activities</b>	
●	Case studies
<b>Suggested Evaluation Methods</b>	
●	Quizzes
●	Class Presentation / Discussion
●	Tutorial Problems
●	Multiple choice questions

<b>Text Book(s):</b>	
1	Branden C. and Tooze J., —Introduction to Protein Structure 2nd Edition, Garland Publishing, 1999.
2	Creighton T.E. —Proteins 2nd Edition. W.H. Freeman, 1993.
3	Pennington, S.R and M.J. Dunn, —Proteomics: Protein Sequence to Function. Viva Books, 2002
4	Liebler, —Introduction to Proteomics Humana Press, 2002.

<b>Reference Books(s) / Web links:</b>	
1	Voet D. and Voet G., —Biochemistry. 3rd Edition. John Wiley and Sons, 2008.
2	Haggerty, Lauren M.—Protein Structure: Protein Science and Engineering I. Nova Science Publications, 2011.
3	Williamson, Mike —How Proteins Work. Garland Science, 2012.

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
BT23712.1	2	1	1	2	1	1	-	-	-	-	-	1	1	1	2
BT23712.2	1	2	1	2	1	-	-	-	-	-	-	1	1	1	2
BT23712.3	1	2	1	2	2	-	-	-	-	-	-	2	2	1	2
BT23712.4	1	1	1	2	2	-	-	-	-	-	-	2	2	1	2
BT23712.5	1	1	1	3	2	2	-	-	-	-	-	2	1	1	2
Average	1.2	1.4	1	2.2	1.6	1.5	-	-	-	-	-	1.6	1.4	1	2

BT23713	COMPREHENSION IN BIOTECHNOLOGY	Category	L	T	P	C
		PC	2	0	0	2

<b>Objectives:</b> To enable the students	
●	Reminisce and apply the basic concepts in the different facets of biotechnology.
●	Understand the chemical basis of life, cellular and immune processes and mechanisms.
●	Apply analytical and bioinformatics approach to drug design and delivery.
●	Understand and apply the basic principles in stoichiometry, thermodynamics and transport processes.
●	Gain knowledge in the field of bioprocess, upstream and downstream processing.

<b>UNIT-I</b>	<b>FUNDAMENTALS OF LIFE SCIENCES</b>	5
Basic principles of Bio organic chemistry (covalent and non-covalent interactions with respect to structure and functions of biomolecules – peptide , phosphor diester and glycosidic bonds, hydrogen bonds, ionic interactions , hydrophobic interactions and vander waals forces) Isomers, stereo isomers, epimers, anomers, mutarotation, pH, buffers. Enzymes and significance of metabolic pathways. ATP as energy currency. Eukaryotes and prokaryotes – structure and functions. Production of secondary metabolites like antibiotics and enzymes. Cell signalling and biological transport.		
<b>UNIT-II</b>	<b>BASIC CONCEPTS IN MOLECULAR BIOLOGY AND IMMUNOLOGY</b>	5
Structure of nucleic acids, DNA replication, repair, transcription, translation and regulation of gene expression. rDNA technology (cloning vectors, Crispr Cas 9). Transgenic techniques in animals and plants. Types of immune response, innate and acquired immunity (antigen, antibodies, APC, MHC, T, B and cytotoxic T Lymphocytes, ELISA, hypersensitivity and autoimmunity.		
<b>UNIT-III</b>	<b>ANALYTICAL TECHNIQUES IN BIOTECHNOLOGY, BIOINFORMATICS AND DRUG DISCOVERY</b>	7
Instrumentation and analytical techniques in biotechnology – Principles and applications of colorimetry, spectrophotometry, flow cytometry, electrophoresis, NMR, X-Ray diffraction etc., BLAST - Phylogeny trees - Homology modelling - ANN in PSSP. Bioinformatics in drug designing .Pharmacokinetics, pharmacodynamics, clinical trials and drug discovery.		

<b>UNIT-IV</b>	<b>ENGINEERING PRINCIPLES APPLIED TO BIOLOGICAL SYSTEMS, THERMODYNAMICS AND TRANSPORT PROCESSES</b>	6
Material and energy balances. Recycle, bypass and purge processes; Stoichiometry of growth and product formation. Laws of thermodynamics; Solution thermodynamics; Phase equilibria. Newtonian and non-Newtonian fluids, fluid flow - laminar and turbulent; Mixing in bioreactors, Molecular diffusion and film theory; kLa and its measurement; Conductive and convective heat transfer, overall heat transfer coefficient; Heat exchangers.		
<b>UNIT-V</b>	<b>BIOPROCESS ENGINEERING AND PROCESS BIOTECHNOLOGY</b>	7
Rate law, zero and first order kinetics; Ideal reactors - batch, mixed flow and plug flow; Enzyme immobilization kinetics, Optimization and scale up. Kinetics of cell growth, substrate utilization and product formation; Batch, fed-batch and continuous processes. Media formulation and optimization; Sterilization of air and media; Cell disruption; Principles of chromatography.		
		<b>Total Contact Hours</b>
		<b>: 30</b>

Course outcomes:

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

•	Perform well in competitive exams.
•	Gain knowledge about theoretical and practical aspects of biotechnology.
•	Apply bioinformatics tools in molecular modelling and drug designing.
•	Solve problems in the Material and energy balances, thermodynamics, heat and mass transfer.
•	Solve problems in reactor design and downstream processing.

Text/Reference books:

•	Pamela C Champe, Richard A. Harvey, Lippincott's illustrated reviews, Biochemistry, Third Edition, Lippincott Williams & Wilkins 2005.
•	Cooper, G.M. and R.E. Hansman -The Cell : A Molecular Approach, IVth Edition, ASM Press, 2007.
•	Wilson & Walker, Principles and Techniques of Biochemistry and Molecular Biology, 7 <sup>th</sup> edition, 2018.
•	Friefelder, David. -Molecular Biology. Narosa Publications, 1999.
•	Introduction to Bioinformatics by Arthur K. Lesk, Oxford University Press.
•	Kuby J, Immunology, WH Freeman & Co., 7th Edition 2012.
•	Presscott, S.C. and Cecil G. Dunn, —Industrial Microbiology, Agrobios (India), 2005.
•	Bhatt, B.I. and S.M. Vora -Stoichiometry (SI Units), 3rd Edition, Tata McGrawHill, 1996.
•	Smith J.M., Van Ness H.C., and Abbot M.M. -Introduction to Chemical Engineering Thermodynamics, VIth Edition. Tata McGraw-Hill, 2003.
•	Geankoplis C.J. Transport Processes And Unit Operations. Prentice Hall India.2002.
•	McCabe W.L., Smith J.C. Unit Operations In Chemical Engineering.5 <sup>th</sup> Edition. McGrawhill. 1993.
•	Shuler, Michael L. and Fikret Kargi, — Bioprocess Engineering —, Prentice Hall, 1992.
•	Doran, Pauline -of Bioprocess Engineering Principles -. Elsevier, 1995.
•	Treybal R.E. Mass Transfer Operations.3rd edition. McGraw-Hill, 1981.
•	Levenspiel O. Chemical Reaction Engineering. 3rd Edition. John Wiley.1999.
•	Belter, P.A., E.L. Cussler and Wei-Houhu —Bioseparations – Downstream Processing for Biotechnology, John Wiley, 1988.

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
BT23713.1	2	2	2	1	1	2	1	-	1	-	-	2	1	2	3
BT23713.2	2	2	2	1	1	2	1	-	1	-	-	2	1	2	3
BT23713.3	2	2	2	2	2	2	1	-	1	-	2	2	1	2	3
BT23713.4	2	2	2	2	2	2	1	-	1	-	2	2	1	2	3
BT23713.5	2	2	2	2	2	2	1	-	1	-	2	2	1	2	3
Average	2	2	2	1.6	1.6	2	1	-	1	-	2	2	1	2	3

Subject code	DOWNSTREAM PROCESSING LABORATORY											Category	L	T	P	C
BT23721												PC	0	0	4	2
<b>Objectives:</b> This course will enable the students																
●	Acquire knowledge for the separation of whole cells and other insoluble ingredients from the culture broth.															
●	Apply their knowledge for cell disruption and specify the techniques to release intracellular products.															
●	Apply the techniques like extraction, precipitation, membrane separation for concentrating biological products															
●	Apply the basic principles and techniques of chromatography to purify the biological products															
●	Learn broad education in formulating the product which is necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context															

List of Experiments			
1	Solid liquid separation – centrifugation, membrane filtration		
2	Batch sedimentation		
3	Flocculation		
4	Cell disruption techniques – Ultrasonication		
5	Cell disruption by enzymatic method		
6	Precipitation – Ammonium Sulphate precipitation, Isoelectric method		
7	Aqueous two phase extraction of biologicals		
8	HPLC		
9	High resolution purification – Affinity chromatography.		
10	High resolution purification – Ion exchange chromatography.		
11	High resolution purification – Gel filtration chromatography		
12	Product polishing – Freeze drying		
			<b>Total Contact Hours</b>
			<b>: 60</b>

Course Outcomes: The students will be able to	
●	Acquire knowledge for the separation of whole cells and other insoluble ingredients from the culture broth.
●	Apply knowledge for cell disruption and specify the techniques to release intracellular products
●	Apply the techniques like extraction, precipitation, membrane separation for concentrating biological products.
●	Work on chromatography to purify the biological products
●	Formulate the product which is necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context.

Reference Books(s) / Web links:	
1	P.A. Belter, E.L. Cussler And Wei-Houhu – Bioseparations – Downstream Processing For Biotechnology, Wiley Interscience Pun. (1988).
2	R.K. Scopes – Protein Purification – Principles And Practice, Narosa Pub. (1994).
3	Sivasankar, B. “Bioseparations: Principles and Techniques”. PHI, 2005.
4	Ghosh, R., “Principles of Bioseparations Engineering”, World Scientific Publishers, 2006.
5	<a href="https://archive.nptel.ac.in/courses/102/106/102106022/">https://archive.nptel.ac.in/courses/102/106/102106022/</a>

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
BT23721.1	3	3	2	-	3	2	3	-	2	-	3	3	2	3	3
BT23721.2	2	-	-	2	-	--	-	-	2	-	3	3	3	3	2
BT23721.3	2	-	-	1	3	-	-	-	2	-	3	3	3	3	3
BT23721.4	2	-	-	2	2	-	-	-	2	-	3	3	2	3	1
BT23721.5	2	-	-	2	3	-	3	-	2	-	3	3	3	3	2
Average	2.2	0.6	0.4	1.4	2.2	0.4	1.2	-	2	-	3	3	2.6	3	2.2

Subject Code	ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING FOR BIOTECHNOLOGIST	Category	L	T	P	C
BT23722		PC	0	0	4	2

**Objectives:**

- To know the fundamentals of machine learning.
- To create regression models from biological datasets.
- Be familiar with basic machine learning algorithms with classification.
- To understand machine learning algorithms with clustering.
- To know about usage of dimensionality reduction for biological datasets.

**List of Experiments**

- 1 Univariate regression, bivariate regression and multivariate regression
- 2 Animal Species Identification
- 3 Cancer Prediction
- 4 Alpha Fold
- 5 Liver Disease Classification
- 6 Anti-biofilm target
- 7 Image processing based diagnostics
- 8 Computational Drug Discovery
- 9 Gene Feature Prediction
- 10 Dimensionality reduction – PCA

<b>Contact Hours</b>	<b>:</b>	<b>30</b>
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**Course Outcomes:**

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

- Understand fundamentals of machine learning and application in biotechnology.
- Apply feature engineering in creation of linear models of biological data.
- Understand and explore the machine learning algorithms with classification.
- Apply machine learning algorithms with clustering and feature extraction.

●	Understand the application of deep learning algorithms to solve biotechnology problems.
<b>Suggested Activities</b>	
●	Problem solving sessions
<b>Suggested Evaluation Methods</b>	
●	Interactive Quizzes
●	Programming assignments
<b>Text Book(s):</b>	
1	Aurélien Géron - Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow, 2nd Edition. September 21019, Reilly Media, Inc., ISBN: 9781492032649.
2	Stephen Marsland, —Machine Learning – An Algorithmic Perspective, Second Edition, Chapman and Hall/CRC Machine Learning and Pattern Recognition Series, 2014.
3	Shai Shalev-Shwartz and Shai Ben-David, ” Understanding Machine Learning: From Theory to Algorithms”, Cambridge University Press 2014.
<b>Reference Books(s) / Web links:</b>	
1	Alex Smola and S.V.N. Vishwanathan, ” Introduction to Machine Learning”, Cambridge University Press 2008.
2	Andreas C. Müller and Sarah Guido, ” Introduction to Machine Learning with Python: A Guide for Data Scientists”, O'Reilly Media, Inc, 2016.
3	S. Russel and P. Norvig, “Artificial Intelligence: A Modern Approach”, Third Edition, Prentice Hall, 2009.
4	C. M. Bishop, “Pattern Recognition and Machine Learning”, Springer, 2007.
5	<a href="https://www.coursera.org/lecture/python-machine-learning/introduction-4f2So">https://www.coursera.org/lecture/python-machine-learning/introduction-4f2So</a>
6	<a href="https://nptel.ac.in/courses/106/106/106106139/">https://nptel.ac.in/courses/106/106/106106139/</a>

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
BT23722.1	2	2	1	1	1	2	1	2	3	2	2	3	3	3	3
BT23722.2	3	3	3	3	3	3	1	2	3	2	2	3	3	2	3
BT23722.3	3	3	3	3	3	3	1	2	3	2	2	3	3	2	3
BT23722.4	3	3	3	3	3	3	1	2	3	2	2	3	3	2	3
BT23722.5	3	3	3	2	3	3	1	2	3	2	2	3	3	2	3
Average	2.8	2.8	2.6	2.4	2.6	2.8	1	2	3	2	2	3	3	2.2	3

**PROFESSIONAL ELECTIVES**  
**VERTICAL I – BIOPROCESS AND BIOCHEMICAL TECHNOLOGY**

Subject Code	BIOPROCESS CONTROL AND INSTRUMENTATION	Category	L	T	P	C
BT23A11		PE	3	0	0	3
<b>Objectives:</b>						
●	To impart basic concepts on bioprocess variables and their measurements					

•	To provide knowledge on Laplace transforms			
•	To learn about the closed loop system analysis			
•	To understand the frequency response of closed loop systems			
•	To evaluate the advanced process control systems			
<b>UNIT-I</b>	<b>BIOCHEMICAL PROCESS VARIABLES AND THEIR MEASUREMENTS</b>			<b>9</b>
Temperature, flow measurement and control, Pressure measurement and control, shaft power, rate of stirring, detection and prevention of foam, measurement of cells, measurement and control of dissolved oxygen, inlet and outlet gas analysis, pH measurement and control, on-line and off-line analysis of biomass estimation.				
<b>UNIT-II</b>	<b>OPEN LOOP SYSTEMS</b>			<b>9</b>
Laplace transformation, application to solve ODEs. Open-loop systems, first order systems and their transient response for standard input functions, first order systems in series, linearization and its application in process control, second order systems and their dynamics; transportation lag.				
<b>UNIT-III</b>	<b>CLOSED LOOP SYSTEMS</b>			<b>9</b>
Closed loop analysis -development of block diagram for feed-back control systems -Servo and Regulatory problems for First and second order systems, transfer functions for controllers and final control element.				
<b>UNIT-IV</b>	<b>FREQUENCY RESPONSE</b>			<b>9</b>
Introduction to frequency response of closed-loop systems, control system design by frequency response techniques, Bode Bode diagram, stability criterion, tuning of controller settings				
<b>UNIT-V</b>	<b>ADVANCED PROCESS CONTROL AND BIOSENSORS</b>			<b>9</b>
Introduction to advanced control systems, cascade control, feed forward control, Introduction to biosensors; Transduction principles used in biosensors; Characteristics of biosensors; Microbial biosensors. Use of computer in control and optimization of microbiological processes. Artificial neural networking and use in prediction of bioprocess and control				
			<b>Contact Hours</b>	<b>: 45</b>
<b>Course Outcomes:</b>				
On completion of the course, the students will be able to				
•	Measure the bioprocess variables			
•	Apply the concept of Laplace transforms in control systems			
•	Implement the control systems in loop and transfer functions			
•	Analyze the stability of control systems			
•	Apply the ANN in bioprocess variables prediction and control			
<b>Suggested Activities</b>				
•	Problem solving sessions			
<b>Suggested Evaluation Methods</b>				
•	Quizzes			
•	Class Presentation / Discussion			
•	Tutorial Problems			
•	Multiple choice questions			
<b>Text Book(s):</b>				
<b>1</b>	Stephanopoulos, G., "Chemical Process Control", Prentice Hall of India, 2003.			
<b>2</b>	Coughnowr, D., "Process Systems Analysis and Control", 3rd ed., McGraw Hill, 2008.			
<b>3</b>	John Twork., "Sensors in Bioprocess Control (Biotechnology and Bioprocessing Series), CRC Press, 2020.			
<b>Reference Books(s) / Web links:</b>				
<b>1</b>	Process Control Instrumentation Technology (8th Edition) by Curtis Johnson, 2008			
<b>2</b>	Marlin, T. E., "Process Control" 2 <sup>nd</sup> Edn, McGraw Hill, New York, 2000.			
<b>3</b>	Smith, C. A. and Corripio, A. B., "Principles and Practice of Automatic Process Control", 2 <sup>nd</sup> Edn., John Wiley, New York, 1997.			
<b>4</b>	<a href="https://nptel.ac.in/courses/103105064">https://nptel.ac.in/courses/103105064</a>			



PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
BT23A11.1	3	3	3	3	3	-	-	-	2	2	1	2	-	2	3
BT23A11.2	3	3	3	3	3	-	-	-	2	2	1	2	-	2	3
BT23A11.3	3	3	3	3	3	-	-	-	2	2	1	2	-	2	3
BT23A11.4	3	3	3	3	3	-	-	-	2	2	1	2	-	2	3
BT23A11.5	3	3	3	3	3	-	-	-	2	2	1	2	-	2	3
Average	3	3	3	3	3	-	-	-	2	2	1	2	-	2	3

Subject Code	BIOPROCESS ECONOMICS AND PLANT DESIGN	Category	L	T	P	C	
<b>BT23A12</b>		PE	<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>	
<b>Objectives:</b>							
•	To define and explain the fundamental concepts of bioprocess economics						
•	To apply principles of project design and development to select and design a bioprocess project, incorporating market surveys, techno-economic viability studies, and process alternatives						
•	To analyze cost estimation and profitability factors and to evaluate project financial performance						
•	To develop an optimized process design incorporating various process optimization techniques						
•	To evaluate quality control measures and standards, including current good manufacturing practices (GMP), statistical process control (SPC), and ISO 9000 requirements, to ensure adherence to quality standards and certification requirements						
<b>UNIT-I</b>	<b>PROCESS ECONOMICS AND BUSINESS ORGANIZATIONS</b>					<b>9</b>	
Definition of Bioprocess, Bioprocess Economics, Importance of various M-inputs - Globalization concept - Competition by Dumping – its effect on plant site - Status of India with adjoining ASEAN countries, Project profile concept – details, Structure and types of Organizations.							
<b>UNIT-II</b>	<b>PROJECT DESIGN AND DEVELOPMENT</b>					<b>9</b>	
Choosing a project, market survey, Importance of Techno-economic - Viability studies, Sourcing of processes, Process Alternatives, Fixing most Economic Processes, Technology - Scanning, Plant Location principles, plant Layout, process Flowsheets, preparation of Budgetary Investment and Production cost.							
<b>UNIT-III</b>	<b>COST ESTIMATION, PROFITABILITY AND ACCOUNTING</b>					<b>9</b>	
Capital Investment, Concept of time - Value of Money, Source sink concept of profitability, Capital cost, Depreciation, Estimation of capital cost, Manufacturing cost, Working capital, Profitability standards, Project profitability evaluation, alternative Investment and replacement, Annual report, balance sheets, Performance Analysis.							
<b>UNIT-IV</b>	<b>PROCESS OPTIMIZATION TECHNIQUES</b>					<b>9</b>	
Optimum design - Design Strategy, Economic-balance, different unit - operations with single and multiple variables.							
<b>UNIT-V</b>	<b>QUALITY AND QUALITY CONTROL</b>					<b>9</b>	
Current good manufacturing practices, concepts of Quality control in 20 <sup>th</sup> century, Elements of Quality control envisaged by ISI since 1947, Emergence of Statistical Process Control (SPC) simple SPC concept details, Fundamental concepts of ISO 9000 Quality system and the various requirements for ISO certification							
					<b>Contact Hours</b>	<b>:</b>	<b>45</b>
<b>Course Outcomes:</b>							
On completion of the course, the students will be able to							
•	Articulate key concepts related to bioprocess economics and business organization structures						
•	Design a bioprocess project by conducting market surveys, assessing techno-economic viability, selecting process alternatives, and preparing a comprehensive project profile.						
•	Analyze and interpret financial data related to capital investment, cost estimation, and profitability						
•	Carryout process optimization plans, including economic-balance considerations and process flow						

	sheets
•	Evaluate quality control practices and systems, including the application of SPC and ISO 9000 standards.
<b>Suggested Activities</b>	
•	Case Studies
<b>Suggested Evaluation Methods</b>	
•	Quizzes
•	Class Presentation / Discussion
•	Tutorial Problems
•	Multiple choice questions
<b>Text Book(s):</b>	
1	Peters, M., Timmerhaus, K & West, R. Plant Design and Economics for Chemical Engineers, 4th Ed., McGraw-Hill Publishing Company Limited, 1991.
2	Butterworth, H. A compendium of Good Practices in Biotechnology, BIOTOL Series, 1993.
3	Seiler, J.P. Good Laboratory Practice - the Why and the How? 2nd Ed., Springer, 2005.
4	Lydersen, B.K., D'Elia, N. A. & Nelson K.L. Bioprocess Engineering: Systems, Equipment and Facilities, Wiley, 1994.
1	Rudd and Watson, Strategy for Process Engineering, Wiley Publications, 1987.
2	<a href="https://archive.nptel.ac.in/courses/103/105/103105166/">https://archive.nptel.ac.in/courses/103/105/103105166/</a>

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
BT23A12.1	3	3	3	3	3	-	-	-	2	2	1	2	-	2	3
BT23A12.2	3	3	3	3	3	-	-	-	2	2	1	2	-	2	3
BT23A12.3	3	3	3	3	3	-	-	-	2	2	1	2	-	2	3
BT23A12.4	3	3	3	3	3	-	-	-	2	2	1	2	-	2	3
BT23A12.5	3	3	3	3	3	-	-	-	2	2	1	2	-	2	3
Average	3	3	3	3	3	-	-	-	2	2	1	2	-	2	3

Subject Code	BIOREACTOR CONSIDERATIONS FOR RECOMBINANT PRODUCTS	Category	L	T	P	C
BT23A13		PE	3	0	0	3
<b>Objectives:</b>						
•	To expose students to application of recombinant DNA technology in biotechnological research					
•	To train students in strategizing research methodologies employing animal cell cultures					
•	To understand rDNA technology in evolving plants for resistance to pest and diseases					
•	To analyze the problems associated with production and purification of recombinant proteins					
•	To inculcate ideas on environmental applications of genetic engineering through bioremediation					
<b>UNIT-I</b>	<b>GENETICALLY ENGINEERED ORGANISMS</b>					<b>9</b>
Different host vector systems, Guidelines for choosing Host Vector systems, Process constraints – Genetic instability, considerations in plasmid design, Regulatory constraints, principles and implementation of containment, good industrial large-scale practice (GILSP).						
<b>UNIT-II</b>	<b>CONSIDERATIONS FOR ANIMAL CELL CULTURES</b>					<b>9</b>
Structure and biochemistry of animal cells - Methods Used for the cultivation of animal cells - Bioreactor considerations for animal cell culture - Products of animal cell cultures, economics of animal cell tissue cultures.						

<b>UNIT-III</b>	<b>CONSIDERATIONS FOR PLANT CELL CULTURES</b>	<b>9</b>
Overview of plant cell cultures - Plant cells in culture compared to microbes - Bioreactor considerations for plant cell culture - Bioreactors for suspension cultures - Reactors using cell immobilization - Bioreactors for organized tissues, economics of plant cell tissue cultures.		
<b>UNIT-IV</b>	<b>DOWNSTREAM PROCESSING CONSIDERATIONS</b>	<b>9</b>
Release of protein from Biological Host, genetic approaches to facilitate protein purification, Solid Liquid separation, extraction of Recombinant protein, Avoidance of proteolysis from extracts, membranes for protein isolation and purification, Chromatographic techniques, Removal of detergent from protein fractions, precipitation of proteins, protein crystallization for large scale bio separation.		
<b>UNIT-V</b>	<b>SAFETY CONSIDERATIONS ASSOCIATED WITH AGRICULTURAL AND ENVIRONMENTAL APPLICATIONS</b>	<b>9</b>
Risk assessment methods, safety considerations, Application of rDNA organism in the environment, Survival, multiplication and/or dissemination in the environment, Interactions with species or biological systems, effects on the environment, evaluating environmental risks of rDNA organisms released from industrial applications.		
<b>Contact Hours</b>		<b>: 45</b>
<b>Course Outcomes:</b>		
On completion of the course, the students will be able to		
•	Acquire skills on techniques of isolation of gene of interest and construction of recombinant DNA	
•	Apply techniques for production of pharmaceuticals, growth hormones, vaccines, gene therapy in expression system	
•	Apply rDNA technology in evolving plants for resistance to pest and disease, tolerance to herbicides and abiotic factors.	
•	Identify problems associated with production of recombinant proteins and protein purification and devising strategies to overcome problem	
•	Work on environmental applications of genetic engineering through bioremediation	
<b>Suggested Activities</b>		
•	Case Studies, Problem solving sessions	
<b>Suggested Evaluation Methods</b>		
•	Quizzes	
•	Class Presentation / Discussion	
•	Tutorial Problems	
•	Multiple choice questions	
<b>Text Book(s):</b>		
<b>1</b>	Michael L. Shuler, Fikret Kargi, Matthew De Lisa, Bioprocess Engineering, 3rd Edition, Prentice Hal, 2017	
<b>2</b>	Bailey J.A and Ollis D.F., "Biochemical Engineering Fundamentals", McGraw Hill (New York), 2nd Edition, 2010	
<b>3</b>	Cutler, P. ed., 2004. Protein purification protocols (Vol. 244). Springer Science & Business Media	
<b>4</b>	Perry R H, "Perry's Chemical Engineers' Handbook", McGraw-Hill, 8th Edition, 2008.	
<b>Reference Books/Weblinks:</b>		
<b>1</b>	Pörtner, R. and Barradas, O.B.J.P., 2007. Animal cell biotechnology. Methods and Protocols, 2nd. Edition. Humana	
<b>2</b>	Slater, A., Scott, N. and Fowler, M., 2008. Plant biotechnology: the genetic manipulation of plants. OUP Oxford	
<b>3</b>	Pörtner, R. and Barradas, O.B.J.P., 2007. Animal cell biotechnology. Methods and Protocols, 2nd. Edition. Humana.	
<b>4</b>	Slater, A., Scott, N. and Fowler, M., 2008. Plant biotechnology: the genetic manipulation of plants. OUP Oxford.	
<b>5</b>	<a href="https://archive.nptel.ac.in/courses/102/106/102106053/">https://archive.nptel.ac.in/courses/102/106/102106053/</a>	

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
BT23A13.1	3	3	3	3	2	-	1	-	2	1	2	2	-	1	3
BT23A13.2	3	3	3	3	2	-	1	-	2	1	2	2	-	1	3
BT23A13.3	3	3	3	3	2	-	1	-	2	1	2	2	-	1	3
BT23A13.4	3	3	3	3	2	-	1	-	2	1	2	2	-	1	3
BT23A13.5	3	3	3	3	2	-	1	-	2	1	2	2	-	1	3
Average	3	3	3	3	2	-	1	-	2	1	2	2	-	1	3

Subject Code	ADVANCES IN BIOENERGY AND BIOFUELS	Category	L	T	P	C
<b>BT23A14</b>		<b>PE</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>
<b>Objectives:</b>						
•	To impart knowledge on different biomass feedstock based on their constituents and properties					
•	To understand various biomass pretreatment and processing techniques in terms of their applicability for biomass conversion processes					
•	To summarize the principles of combustion, pyrolysis, gasification and liquefaction for production of value added bio-products, biogas, bio-CNG generation					
•	To comprehend the basics of biofuels, their production technologies and applications in various energy utility routes					
•	To analyze the challenges and opportunities of biorefineries					
<b>UNIT-I</b>	<b>BIOMASS RESOURCE ASSESSMENT</b>					<b>9</b>
Introduction, Classification and properties of biomass, Biomass characterization, Different energy conversion methods, Bio Energy Resources, World Bio Energy Potential, India's Bio Energy Potential, Biomass Resources and classification, Physio-chemical characteristics. Biomass Combustion, Loose biomass densification, Biomass based power generation and utilization for domestic cooking, Improved biomass cookstoves.						
<b>UNIT-II</b>	<b>BIOGAS SYSTEMS</b>					<b>9</b>
Technology of Biogas production, Biogas Plants, Digester types, Digester design, Chemical kinetics and mathematical modeling of bio methanation process, Dung, Vegetable Waste and Municipal Waste based Biogas plants, Biogas as fuel for transportation, Lighting, Running Dual Fuel Engines, Electricity generation, Biogas Bottling Plant Technology, Application of Biogas slurry in agriculture, Design of Biogas for cold climates. Case studies and numerical.						
<b>UNIT-III</b>	<b>BIOMASS GASIFIERS</b>					<b>9</b>
History , Principle , Design of Bio mass Gasifiers , updraft gasifier, down draft gasifier, zero carbon biomass gasification plants, Gasification of plastic-rich waste, applications for cooking, electricity generation, Gasifier Engines, Operation of spark ignition and compression ignition engine with wood gas, methanol, ethanol and biogas, Biomass integrated gasification/combined cycles systems, gasification, pyrolysis, liquification, biomass pre- treatment and processing, Case studies, biodiesel, improved biomass cookstove, biohydrogen generation, electricity generation from biomass gasifier, engine systems, bio-gasoline, bio-diesel and duel fuel engine, case studies.						
<b>UNIT-IV</b>	<b>BIOFUELS</b>					<b>9</b>
Bioethanol production from lignocelluloses, waste material, including crop residue, sugar and starch; biodiesel production from vegetable oil and animal fat, algae; biofuel derived from; economics of biofuel production; environmental impacts of biofuels; biofuel blends; green diesel from vegetable oil; biodiesel production process, by-product utilization. Production of butanol and propanol; Production of biohydrogen; production of						

hydrogen by fermentative bacteria.															
<b>UNIT-V</b>	<b>BIO-REFINERY CONCEPT</b>													<b>9</b>	
Bio-refinery concept: definition; different types of bio-refinery; challenge and opportunities; Fuel and chemical production from saccharides, lignocellulosic biomass, protein; vegetable oil; algal biorefinery.															
													<b>Contact Hours</b>	<b>:</b>	<b>45</b>
<b>Course Outcomes:</b>															
On completion of the course, the students will be able to															
•	Characterize different biomass feedstocks based on its constituents and properties														
•	Evaluate various biomass pretreatment and processing techniques in terms of their applicability for biomass conversion processes														
•	Analyze the principles and process of combustion, pyrolysis, gasification and liquefaction for production of value added bio-products, biogas, bio-CNG generation														
•	Apply knowledge on basics of biofuels, their production technologies and applications in various energy utility routes														
•	Execute projects with biorefineries														
<b>Suggested Activities</b>															
•	Case Studies														
<b>Suggested Evaluation Methods</b>															
•	Quizzes														
•	Class Presentation / Discussion														
•	Tutorial Problems														
•	Multiple choice questions														
<b>Text Book(s):</b>															
<b>1</b>	Mutha, V. K. (2010). Handbook of bioenergy and biofuel SBS Publishers, Delhi														
<b>2</b>	Clark, J. H., & Deswarte, F. (Eds.), 2014. Introduction to chemicals from biomass. John														
<b>3</b>	Wiley & Sons.														
<b>4</b>	Klass, D. L. (1998). Biomass for renewable energy, fuels, and chemicals. Elsevier.														
<b>Reference Books/Weblinks:</b>															
<b>1</b>	Mukunda, H. S. (2011). Understanding clean energy and fuels from biomass. Wiley India.														
<b>2</b>	Higman C. and Burgt M v d (2003) Gasification, Elsevier Science														
<b>3</b>	Speight, J. (2008). Synthetic fuels handbook: properties, process and performance. McGraw-Hill														
<b>4</b>	Dahiya, A. (Ed.). (2014). Bioenergy: Biomass to biofuels. Academic Press.														
<b>5</b>	Hall, D. O., & Overend, R. P. (1987). Biomass: regenerable energy.														
<b>6</b>	<a href="https://archive.nptel.ac.in/courses/103/103/103103207/">https://archive.nptel.ac.in/courses/103/103/103103207/</a>														

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
BT23A14.1	3	3	3	3	3	-	-	-	2	2	1	2	-	2	3
BT23A14.2	3	3	3	3	3	-	-	-	2	2	1	2	-	2	3
BT23A14.3	3	3	3	3	3	-	-	-	2	2	1	2	-	2	3
BT23A14.4	3	3	3	3	3	-	-	-	2	2	1	2	-	2	3
BT23A14.5	3	3	3	3	3	-	-	-	2	2	1	2	-	2	3
Average	3	3	3	3	3	-	-	-	2	2	1	2	-	2	3

Subject Code	BIOSENSOR TECHNOLOGY	Category	L	T	P	C	
BT23A15		PE	3	0	0	3	
<b>Objectives:</b>							
•	To impart knowledge on different components of sensors						
•	To apply the principles of various transducer types						
•	To analyze different biorecognition systems and evaluate their mechanisms						
•	To design a conceptual model for integrating DNA-based molecular wires, switches, and memory stores with nanofabricated electrodes						
•	To evaluate different glucose sensing Technologies						
<b>UNIT-I</b>	<b>BASICS OF BIOSENSORS</b>					<b>9</b>	
Basics of Biosensors - Definition – Components and Functionality, Key components, Historical perspective; Sensor characteristics - Calibration, Dynamic range, Signal to noise, Sensitivity, Selectivity interference - Examples - Applications- problems.							
<b>UNIT-II</b>	<b>TYPES OF TRANSDUCERS</b>					<b>9</b>	
Transducer – Definition - Types – Principles - Optical, Electrochemical, Electrochemical Transducer (Amperometric, Potentiometric, Conductimetric); - Thermal, Mass – Piezoelectric - Acoustic wave with examples.							
<b>UNIT-III</b>	<b>BIORECOGNITION SYSTEMS</b>					<b>9</b>	
Introduction, Principles, Enzyme based biorecognition systems - Microorganism based biosensor, Immobilization of microorganism - Botanical biosensors – Biosensors using cultured cells – Intact tissues - Receptor Elements.							
<b>UNIT-IV</b>	<b>DNA ELECTRONIC APPLICATIONS</b>					<b>9</b>	
Principle – DNA based Molecular wires and switches, Biomolecular computers, molecular arrays as memory stores, DNA for molecular devices – Integration of DNA with Nanofabricated Electrodes, Applications of DNA Electronics.							
<b>UNIT-V</b>	<b>GLUCOSE SENSORS</b>					<b>9</b>	
Definition, Historical developments - Generation of Glucose sensing – Types of glucose monitoring – Invasive, Non-invasive, Implantable and Wearable Sensors, Working Principle, Sensor market – Indian Status, Future trends and Innovations.							
					<b>Contact Hours</b>	<b>:</b>	<b>45</b>
<b>Course Outcomes:</b>							
On completion of the course, the students will be able to							
•	Articulate the basic concepts of biosensors, including their components, functionality, and sensor characteristics.						
•	Apply appropriate transducers to specific biosensing scenarios, using real-world examples to illustrate their functionality and effectiveness.						
•	Analyze and compare various biorecognition systems, including enzyme-based and cell-based biosensors, and assess their mechanisms of action.						
•	Create a conceptual framework for DNA-based electronic applications, integrating DNA molecular wires and switches with nanofabricated electrodes						
•	Evaluate different glucose sensor technologies, including their working principles, market trends, and future innovations, and assess their effectiveness and relevance in diabetes management and other applications.						
<b>Suggested Activities</b>							
•	Case Studies						
<b>Suggested Evaluation Methods</b>							
•	Quizzes						
•	Class Presentation / Discussion						
•	Tutorial Problems						
•	Multiple choice questions						
<b>Text/ Reference Books/Weblinks:</b>							
<b>1</b>	Jon Cooper and Tony Cass, Biosensors, 2 <sup>nd</sup> edition, Oxford University Press, 2004.						
<b>2</b>	Bansi Dhar Malhotra, Anthony Turner Advances in Biosensors -Perspectives in Biosensors, First						

	Edition, Volume 5, 2003.
3	Ashok Mulchandani (Editor), Kim Rogers, Enzyme and Microbial Biosensors: Techniques and Protocols: 6 (Methods in Biotechnology), 2010.
4	<ul style="list-style-type: none"> <li>Xueji Zhang, Huangxian Ju, Joseph Wang, Electrochemical Sensors, Biosensors and their Biomedical Applications, First Edition, 2007.</li> </ul>
5	<a href="https://onlinecourses.nptel.ac.in/noc22_ph01/preview">https://onlinecourses.nptel.ac.in/noc22_ph01/preview</a>

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
BT23A15.1	3	3	3	3	3	-	-	-	2	2	1	2	-	2	3
BT23A15.2	3	3	3	3	3	-	-	-	2	2	1	2	-	2	3
BT23A15.3	3	3	3	3	3	-	-	-	2	2	1	2	-	2	3
BT23A15.4	3	3	3	3	3	-	-	-	2	2	1	2	-	2	3
BT23A15.5	3	3	3	3	3	-	-	-	2	2	1	2	-	2	3
Average	3	3	3	3	3	-	-	-	2	2	1	2	-	2	3

<b>BT23A16</b>	<b>ENVIRONMENTAL BIOTECHNOLOGY</b>	<b>Category</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		<b>PE</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

<b>Objectives:</b>						
●	To teach students the scientific and engineering principles of microbiological treatment technologies.					
●	To clean up contaminated environments in aquatic systems					
●	To generate valuable methodologies for solid waste treatment					
●	To replace conventional treatment methodologies with advancements in biotechnological field such as molecular biology and genetic engineering					
●	To develop alternate sources of energy to avoid environmental issues.					
<b>UNIT-I</b>	<b>ECOSYSTEMS AND THEIR MANAGEMENT</b>					<b>7</b>
Microbial flora of soil, Ecological adaptations, Interactions among soil microorganisms, biogeochemical role of soil microorganisms. Biodegradation, Microbiology of degradation and its mechanism, Bioaugmentation, Biosorption, Bioleaching, Bioremediation- Types of Bioremediation, Bioreactors for Bioremediation, Metabolic pathways for Biodegradation for specific organic pollutants.						
<b>UNIT-II</b>	<b>WASTEWATER TREATMENT</b>					<b>11</b>
Physico-chemical characteristics of wastewater – Overview of aerobic and anaerobic treatment processes – Process design of aerobic and anaerobic system – Activated sludge process – Trickling filter –Up flow anaerobic sludge blanket reactor (UASB) – Membrane bioreactors & its design– Algal photosynthesis in wastewater treatment.						
<b>UNIT-III</b>	<b>INDUSTRIAL AND SOLID WASTE MANAGEMENT</b>					<b>9</b>
Industrial waste management- Dairy, Paper & Pulp, Textile, leather, hospital and pharmaceutical industrial waste management, e-waste- radioactive and nuclear power waste management- Solid waste management.						
<b>UNIT-IV</b>	<b>APPLICATIONS OF ENVIRONMENTAL BIOTECHNOLOGY</b>					<b>9</b>
Alternate Source of Energy, Biomass as a source of energy, Biocomposting, Vermiculture, Biofertilizers, Organic farming, Biofuels, Biomining, Bioethanol and Biohydrogen, Bioelectricity through microbial fuel cell, Production of bioplastics and biopolymers.						
<b>UNIT-V</b>	<b>METABOLIC ENGINEERING APPROACH</b>					<b>9</b>
Molecular biology tools for Environmental management, rDNA technology in waste treatment, Genetically						

modified organisms in Waste management, Genetic Sensors, Metagenomics, Bioprospecting, Nanoscience in Environmental management, Phytoremediation for heavy metal pollution, Biosensors development to monitor pollution, Case Studies.													
											<b>Total Contact Hours</b>	:	<b>45</b>
<b>Course Outcomes:</b>													
On completion of course students will be able to													
●	Put forth the microbiological treatment technologies for pollutants.												
●	Construct systems for the treatment of wastewater												
●	Create methodology for treatment of solid waste												
●	Implement the metabolic engineering in solving environmental issues.												
●	Apply the concepts in developing eco-friendly bioproducts												
<b>Suggested Activities</b>													
●	Case Studies												
<b>Suggested Evaluation Methods</b>													
●	Quizzes												
●	Class Presentation / Discussion												
●	Multiple choice questions												

<b>Text Books:</b>												
1	Chakrabarty K.D., Omen G.S., Biotechnology And Biodegradation, Advances In Applied Biotechnology Series, Vol.1, Gulf Publications Co., London, 1989.											
2	Metcalf and Eddy, Wastewater Engineering: Treatment and Reuse, 5th edition, New Delhi: Tata McGraw Hill Publishing Company, 2007.											
3	Forster, C. F and Wase, D.A. J. Environmental Biotechnology, Ellis Horwood Halsted Press, 1987											
4	Bruce E. Rittmann, Eric Seagren, Brian A. Wrenn and Albert J. Valocchi, Chittaranjan Ray, Lutgarde Raskin, "In-situ Bioremediation" (2nd Edition) Naves Publication, U.S.A, 1991.											
5	Old R.W., and Primrose, S.B., Principles of Gene Manipulation (7 <sup>th</sup> Edition) Blackwell Science Publication, Cambridge, 2006.											

<b>Reference Books:</b>												
1	Stanier R.Y., Ingraham J.L., Wheelis M.L., Painter R.R., General Microbiology, Mcmillan Publications, 2008.											
2	Jogdand, S.N., Environmental Biotechnology, 4 <sup>th</sup> edition, Himalaya Publishing House, New Delhi, 2015											
3	Young Murray Moo., Comprehensive Biotechnology (Vol. 1-4) (2 <sup>nd</sup> Ed.) , Elsevier Sciences, 2011.											
4	Lee, C.C. and Shun dar Lin, Handbook of Environmental Engineering Calculations, 2 <sup>nd</sup> edition, Mc Graw Hill, New York, 2007.											
5	Hendricks, D. 'Water Treatment Unit Processes – Physical and Chemical' CRC Press, New York 2006.											
6	Martin, A.M., Biological Degradation of Wastes, Elsevier Appl. Science, New York, 2014.											

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
BT23A16.1	3	3	3	3	2	-	1	-	2	1	2	2	-	1	3
BT23A16.2	3	3	3	3	2	-	1	-	2	1	2	2	-	1	3
BT23A16.3	3	3	3	3	2	-	1	-	2	1	2	2	-	1	3
BT23A16.4	3	3	3	3	2	-	1	-	2	1	2	2	-	1	3
BT23A16.5	3	3	3	3	2	-	1	-	2	1	2	2	-	1	3
Average	3	3	3	3	2	-	1	-	2	1	2	2	-	1	3



**VERTICAL II - BIOSCIENCES**

<b>BT23B11</b>	<b>BIOENTREPRENEURSHIP AND PATENT DESIGN</b>	<b>Category</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		<b>PE</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

<b>Objectives:</b> To enable students,						
●	To realise the importance of becoming an entrepreneur					
●	To develop a business plan					
●	To analyze on various aspects of establishing a business					
●	To inculcate the business ethics					
●	To apply the various patent aspects for business					
<b>UNIT-I</b>	<b>INTRODUCTION TO ENTREPRENEURSHIP</b>					<b>9</b>
Why entrepreneurship?-Entrepreneurship skills-Characteristics of a team member-Identify and meet a market need: Target market, Identifying target market, Market segments, customer profile, role of market research, Steps of market research-Types of competition-Entrepreneurs in a market economy-Types of Ownership.						
<b>UNIT-II</b>	<b>BUSINESS PLAN DEVELOPMENT</b>					<b>9</b>
What is a business plan?- Elements of a Business Plan- How to develop a business plan?- Writing a sample business plan.						
<b>UNIT-III</b>	<b>MARKETING, FINANCE AND ACCOUNTING, STAFF MANAGEMENT</b>					<b>9</b>
Location and Set up for Business- Market your Business: Marketing, Marketing Mix, Marketing strategy, Types of goals, Marketing Plan, Product Mix, Pricing Objectives- Finance, Protect and Insure Your Business- Record Keeping and Accounting-Financial Management- Hire and Management of staffs.						
<b>UNIT-IV</b>	<b>LEGAL AND ETHICAL CONCERNS</b>					<b>9</b>
Meet your legal, ethical and social obligations: Ethics and Business, Social responsibilities, Respect the environment, Exports and Imports, International business- Growth in Today's market place- Case studies.						
<b>UNIT-V</b>	<b>IPR AND PATENT DESIGN</b>					<b>9</b>
Fundamentals of IPR-Patenting: Technology, Research, Innovation- Patent Rights- Licensing and Technology Transfer- IPR of biological systems-Industrial Design.						
					<b>Total Contact Hours</b>	<b>: 45</b>
<b>Course Outcomes:</b>						
On completion of course students will be able to						
●	Acquire relevant knowledge on Entrepreneurs Need and Market Need					
●	Learn key strategies for a business plan					
●	Perform how to set up a business, manage finance, marketing and manage a staff					
●	Get ideas on Legal, Ethical, Social Obligation					
●	Understand IPR and patent filing process					
<b>Suggested Activities</b>						
●	Case Studies					
<b>Suggested Evaluation Methods</b>						
●	Quizzes					
●	Class Presentation / Discussion					
●	Multiple choice questions					
<b>Text Books:</b>						
<b>1</b>	Entrepreneurship Ideas in Action – South Western, 2000					
<b>2</b>	Neeraj Pandey and Khushdeep Dharni, Intellectual Property Rights, First edition, PHI Learning Pvt Ltd., Delhi, 2014					
<b>Reference Books:</b>						

1	BAREACT, Indian Patent Act 1970 Acts & Rules, Universal Law Publishing Co. Pvt. Ltd., 2007.
2	2 Kankanala C., Genetic Patent Law & Strategy, 1st Edition, Manupatra Information Solution Pvt. Ltd., 2007.
3	3 S.S.Kanka Entrepreneurship Development, S.Chand and Co, New Delhi 1997.
4	4 Uma Sekaran and Roger Bougie, Research methods for Business, 5 <sup>th</sup> Edition, Wiley India, New Delhi, 2012

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
BT23B11.1	1	2	2	1	-	1	-	3	3	1	3	2	-	-	2
BT23B11.2	1	2	2	1	-	1	-	3	3	1	3	2	-	-	2
BT23B11.3	1	2	2	1	-	1	-	3	3	1	3	2	-	-	2
BT23B11.4	1	2	2	1	-	1	-	3	3	1	3	2	-	-	2
BT23B11.5	1	2	2	1	-	1	-	3	3	1	3	2	-	-	2
Average	1	2	2	1	-	1	-	3	3	1	3	2	-	-	2

BT23B12	FUNDAMENTALS OF NANO BIOTECHNOLOGY	Category	L	T	P	C
		PE	3	0	0	3
<b>Objectives</b>						
●	To learn the basics of nanobiotechnology, types and properties.					
●	To understand the synthesis and characterization techniques of nanomaterials.					
●	To gain knowledge on applications of nanomaterials in diagnostics and imaging.					
●	To impart knowledge about importance of nanomaterials in healthcare.					
●	To explore the environmental applications of nanobiotechnology.					
<b>UNIT-I</b>	<b>INTRODUCTION TO NANOBIO TECHNOLOGY</b>					<b>9</b>
Basic concepts and scope of nanobiotechnology, Historical development and milestones. Nanomaterials - classifications and types - Three-dimensional, two dimensional, one-dimensional and zero-dimensional Nanomaterials. Carbon-based nanomaterials, Bio-nanomaterials, polymer nanoparticles and lipid nanoparticles - Properties of Nanomaterials - Physical & Chemical Properties.						
<b>UNIT-II</b>	<b>SYNTHESIS AND CHARACTERIZATION OF NANOMATERIALS</b>					<b>9</b>
Nanomaterial synthesis - Top-down and Bottom-up approaches. Synthesis routes - Physical, Chemical, and Biological methods, Self Assembly, Surface modification techniques - Principle and working of characterization techniques - UV, FT-IR, SEM, TEM, AFM, DLS, and XRD.						
<b>UNIT-III</b>	<b>NANOMATERIALS IN DIAGNOSTICS AND IMAGING</b>					<b>9</b>
Carbon Nanotubes - SWCNT and MWCNT. Principles of nanobiosensing - MEMS and NEMS, Nanosensors in Disease Detection - Gold nanoparticles in cancer and neurological disorders. Role of nanomaterials in the detection of food contaminants, food pathogens, and pesticides. Nanoparticles and Quantum Dots in Bioimaging.						
<b>UNIT-IV</b>	<b>NANOMATERIALS IN HEALTHCARE</b>					<b>9</b>
Nanomaterials as drug delivery carriers - Nanofibre Scaffolds - Bone Substitutes, Nanobots in dentistry - Tissue engineering - tissue Regeneration, growth, and repair. Role of nanobiotechnology in the treatment of chronic diseases (diabetes, and cardiovascular disease) and infectious diseases. Antimicrobial Nanomaterials. Safety considerations of Nanomaterials.						
<b>UNIT-V</b>	<b>NANOBIOTECHNOLOGY IN ENVIRONMENTAL APPLICATIONS</b>					<b>9</b>
Nanobioremediation - Nanomaterials in wastewater treatment and air purification, Nanomaterials for Food Safety and Packaging, Nanotechnology in agriculture, Nanomaterials for CO <sub>2</sub> capture and Conversion, Life cycle assessment of nanomaterials. Green Nanotechnology Principles.						
<b>Total Contact Hours</b>						<b>: 45</b>

**Course Outcomes:**

Upon completion of the course, students will be able to

- Understand the types and properties of various nanomaterials
- Know about synthesis and characterization techniques of nanomaterials
- Explain the role of nanomaterials in various diagnosis and imaging processes
- Build the knowledge on importance of nanomaterials in healthcare
- Acquire knowledge on the environmental applications of nanobiotechnology

**Text Books/References**

1	Nanobiotechnology: A Multidisciplinary Field of Science (Nanotechnology in the Life Sciences) 1st ed. 2020, by Basma A. Omran.
2	Lynn J. Frewer, Willehm Norde, R. H. Fischer and W. H. Kampers, Nanotechnology in the Agri-food sector, Wiley-VCH Verlag, (2011).
3	A .S. Edelstein and R.C. Cammearata, eds., —Nanomaterials: Synthesis, Properties and Applications, Institute of Physics Publishing, Bristol and Philadelphia, 1996
4	Jennifer Kuzma and Peter VerHage, Nanotechnology in agriculture and food production, Woodrow Wilson International Center, (2006).
5	Nanotechnology in Biology and Medicine: Methods, Devices and Application by Tuan Vo-Dinh .CRC press, 2007.

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
BT23B12.1	1	2	2	3	1	1	-	-	3	3	3	3	-	1	1
BT23B12.2	1	2	2	3	3	1	-	-	3	3	3	3	-	1	1
BT23B12.3	1	2	3	3	3	3	-	1	3	3	3	3	3	2	1
BT23B12.4	1	2	3	3	3	3	-	1	3	3	3	3	3	3	1
BT23B12.5	1	2	3	3	3	3	3	1	3	3	3	3	3	-	1
Average	1	2	2.6	3	2.6	2.2	0.6	0.6	3	3	3	3	1.8	1.4	1

Subject code	BIOMATERIAL ENGINEERING	Category	L	T	P	C
BT23B13		PE	3	0	0	3

**Objectives:**

- To study the properties of various metals used in implant applications
- To acquire knowledge on importance of ceramics and polymer used biomedical diagnostics
- To analyse different types of biomaterials applied *in-vitro* and *in-vivo* biomedical implants
- To evaluate biomaterials used in various biomedical implant application.
- To test the toxicity and biocompatibility of biomaterials

UNIT-I	INTRODUCTION	9
Definition of biomaterials, requirements and classification of biomaterials, Comparison of properties of some common biomaterials. Effects of physiological fluid on the properties of biomaterials. Biological responses (extra and intra-vascular system). Surface properties of materials, physical properties of materials, mechanical properties.		
UNIT-II	METALLIC IMPLANT MATERIALS	9
Stainless steel, Co-based alloys, Ti and Ti-based alloys. Importance of stress-corrosion cracking. Host tissue reaction with bio metal, corrosion behavior and the importance of passive films for tissue adhesion. Hard tissue replacement implant: Orthopedic implants, Dental implants. Soft tissue replacement implants: Percutaneous and skin implants, Vascular implants, Heart valve implants-Tailor made composite in medium.		
UNIT-III	POLYMERIC IMPLANT MATERIALS	9
Polyolefin's, polyamides, acrylic polymers, fluorocarbon polymers, silicon rubbers, acetyls. Viscoelastic		

behaviour: creep-recovery, stress-relaxation, strain rate sensitivity. Importance of molecular structure, hydrophilic and hydrophobic surface properties, migration of additives aging and environmental stress cracking. Physiochemical characteristics of biopolymers. Biodegradable polymers for medical purposes, Biopolymers in controlled release systems. Synthetic polymeric membranes and their biological applications.		
<b>UNIT-IV</b>	<b>CERAMIC IMPLANT MATERIALS</b>	<b>9</b>
Definition of bio ceramics. Common types of bioceramics: Aluminum oxides, Glass ceramics, Carbons. Bio resorbable and bioactive ceramics. Importance of wear resistance and low fracture toughness. Host tissue reactions: importance of interfacial tissue reaction (e.g. ceramic / bone tissue reaction). Composite implant materials: Mechanics of improvement of properties by incorporating different elements. Polymers Filled with osteogenic fillers (e.g. hydroxyapatite). Host tissue reactions, a short overview on designing.		
<b>UNIT-V</b>	<b>TESTING OF MATERIALS</b>	<b>9</b>
Biocompatibility and Toxicological screening of biomaterials: Definition of biocompatibility blood compatibility and tissue compatibility. Toxicity tests: acute and chronic toxicity studies ( <i>in situ</i> implantation, tissue culture, haemolysis, thrombogenic potential test, systemic toxicity, intracutaneous irritation test), sensitization, carcinogenicity, mutagenicity and special tests, Case studies.		
		Total Contact Hours : 45

Course Outcomes: Upon completion of the course in Biomaterials Engineering in Biotechnology, graduates will be able to	
•	Understand the basic principle and properties of biomaterials
•	Analyze various types of metals used in implant applications
•	Explain the process of importance of polymer used in biomedical diagnostics
•	Design biomaterial implants using ceramics
•	Comprehend the various testing techniques for biomaterial implants
<b>Suggested Activities</b>	
•	Debates
<b>Suggested Evaluation Methods</b>	
•	Quizzes
•	Class Presentation / Discussion
•	Multiple choice questions
Text Book(s):	
1	Biomaterials Science: An Introduction to Materials in Medicine, By Buddy D. Ratner, et. al. Academic Press, San Diego, 1996.
2	Sujata V. Bhat, Biomaterials, Narosa Publishing House, 2003.
Reference Books(s) / Web links:	
1	J B Park, Biomaterials – Science and Engineering, Plenum Press, 1984.
2	Joon park, R.S Lakes, “Biomaterials an Introduction” Springer, 2007.
3	Larry L. Hench and Julian R. Jones, Biomaterials, artificial organs and tissue engineering, CRC Press 2010.

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
BT23B13.1	3	2	-	-	-	-	2	1	-	-	-	1	3	1	2
BT23B13.2	3	2	-	-	-	-	2	-	-	-	-	1	3	1	2
BT23B13.3	3	2	-	-	-	-	2	-	-	-	-	1	3	1	2
BT23B13.4	3	2	-	-	-	-	2	-	-	-	-	1	3	1	2
BT23B13.5	3	2	-	-	-	-	3	2	-	-	-	1	3	1	2
Average	3	2	-	-	-	-	2.2	0.6	-	-	-	1	3	1	2

<b>BT23B14</b>	<b>GENOME EDITING</b>	<b>Category</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		<b>PE</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

<b>Objectives:</b>						
<b>On completion of the course, the students will be able to</b>						
●	Understand the basic concepts of genome editing					
●	Gain knowledge about DNA binding protein and their functions					
●	Analyse the gene rearrangements for recombinant protein expression					
●	Familiarize with gene labelling and its applications					
●	Understand targeted gene editing					
<b>UNIT-I</b>	<b>INTRODUCTION TO GENOME EDITING</b>					<b>9</b>
Genome structure (eukaryotic and prokaryotic), DNA breakage repair mechanisms (base excision repair (BER), nucleotide excision repair (NER), mismatch repair (MMR), homologous recombination (HR) and non-homologous end joining (NHEJ)), Overview of traditional methods: homologues recombination for gene knockout. RNAi system, Design considerations for siRNA. miRNA mediated gene regulation. Gene knock out - gene knock-in. Cre-LoxP system for gene editing - Flp-FRT system for gene editing						
<b>UNIT-II</b>	<b>DNA BINDING PROTEIN AND THEIR FUNCTIONS</b>					<b>9</b>
Engineered enzyme systems: Zinc finger domain, Zinc finger nucleases (ZFNs), design considerations for zinc finger nucleases, transcription-activator like effector nucleases (TALEN), design considerations for TALENS, meganucleases and the clustered regularly interspaced short palindromic repeats (CRISPR/Cas9) system – crRNA, tracrRNA, sgRNA, PAM sites.						
<b>UNIT-III</b>	<b>GENE REARRANGEMENT FOR RECOMBINANT PROTEIN</b>					<b>9</b>
Design of sgRNA. Evolution of sgRNA to its current state, softwares used in sgRNA design, Multiplex Automated Genomic Engineering (MAGE) – key parameters of MAGE experiment design. Applications in Targeted gene mutation – mouse target, Gene therapy, creating chromosome rearrangement						
<b>UNIT-IV</b>	<b>GENE LABELING</b>					<b>9</b>
Study gene function with stem cells, Transgenic animals, Endogenous gene labeling, Tracking genome editing outcomes using fluorescent labels, targeted transgene addition – stable and transient expression systems. Alternatives to Cas9 enzyme – Trex2 - Selection & Genotyping of edited cells						
<b>UNIT-V</b>	<b>TRANSGENIC IMPLICATIONS</b>					<b>9</b>
GM plants, applications in biofuel production and in bioremediation. Off-target checking - Cas-OFFinder, Delivery Methods, Generation of disease models, Ethics – case study of editing in Atlantic Salmon, FDA, UNESCO guidelines, safety and risk of targeted gene editing						
					<b>Total Contact Hours</b>	<b>: 45</b>
<b>Course Outcomes:</b>						
On completion of course students will be able to						
●	Apply the basic concepts of genome editing					
●	Attain knowledge about DNA binding protein and their functions					
●	Aware of gene rearrangements for recombinant protein expression					
●	Apply the knowledge of gene labelling for various applications					
●	Apply the knowledge in targeted gene editing					

<b>Suggested Activities</b>						
●	Class Presentation					
<b>Suggested Evaluation Methods</b>						
●	Quizzes					
●	Class Discussion					
●	Multiple choice questions					

<b>Text Books:</b>						
<b>1</b>	CRISPR Gene Editing, Methods and Protocols, Editors: Luo, Yonglun (Ed.)					

2	Genome Editing and Engineering, From TALENs, ZFNs and CRISPRs to MolecularSurgery. Edited by Krishnarao Appasani.
3	Progress in Molecular Biology and Translational Science Vol 149-Genome Editing inPlants. Edited by Donald P. Weeks and Bing Yang. Academic Press.
4	Precision Medicine, CRISPR, and Genome Engineering, Moving from Association toBiology and Therapeutics, Editors: Tsang, Stephen H. (Ed.). Springer.

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
BT23B14.1	3	3	3	3	3	2	2	3	2	1	2	3	3	1	3
BT23B14.2	3	3	3	3	3	2	2	3	2	1	2	3	3	1	3
BT23B14.3	3	3	3	3	3	2	2	3	2	1	2	3	3	1	3
BT23B14.4	3	3	3	3	3	2	2	3	2	1	2	3	3	1	3
BT23B14.5	3	3	3	3	3	2	2	3	2	1	2	3	3	1	3
Average	3	3	3	3	3	2	2	3	2	1	2	3	3	1	3

Subject Code	GLYCOBIOLOGY	Category	L	T	P	C
BT23B15		PE	3	0	0	3
<b>Objectives:</b>						
•	To understand the historical context and fundamental concepts of sugars and glycans, including their structural units, configurations, and linkages.					
•	To gain knowledge about the subcellular localization of glycosylation processes and the functions of different glycosylation precursors					
•	To apply the principles of glycan recognition and lectin interactions to understand their structural roles and associated diseases					
•	To understand the involvement of glycans in cancer and their potential as therapeutic targets.					
•	To develop practical applications of glycosylated biomolecules in the food industry, biofuels, and medical therapies, including therapeutic glycoproteins and vaccine components.					
<b>UNIT-I</b>	<b>INTRODUCTION</b>					<b>9</b>
Historical background sugars as language monosaccharides as basic structural units: structure, configuration, conformation, and linkages, Glycan structure and diversity, examples from natural sources.(Structure and functions of hyaluronans, proteoglycans. structure and functions of glycolipids)						
<b>UNIT-II</b>	<b>GLYCOSYLATION AND GLYCOCONJUGATES</b>					<b>9</b>
Biosynthesis of N&O Glycans Subcellular localization of glycosylation process; Glycosylation precursors-activated and interconversion of monosaccharides, Enzymes involved in synthesis/cleavage of glycosylated glycosyl transferases, Glycoside hydrolases and transglycosidases, Polysaccharide lyases, Carbohydrate esterases; typical examples of glycoconjugates						
<b>UNIT-III</b>	<b>GLYCOLIPIDS AND GLYCAN BINDING PROTEINS</b>					<b>9</b>
Structure and biosynthesis of glycolipids, Glycosyl-Phosphatidyl- Inositol (GPI) anchors, Glycosylated glycerophospholipids, Glycosphingolipids, associated diseases, structural role in cell membranes; principles of glycan recognition, lectins						
<b>UNIT-IV</b>	<b>GLYCANS IN PHYSIOLOGY AND DISEASE</b>					<b>9</b>
Glycoprotein quality control, glycans as signaling molecules, role in bacterial and viral infections, glycosylation- genetic and acquired disorders, cancer						
<b>UNIT-V</b>	<b>APPLICATION OF GLYCATED BIOMOLECULES</b>					<b>9</b>

Applications in food industry, biofuel from sugars, medical applications-therapeutic glycoproteins, glycans as components of small molecule drugs, vaccine components			
<b>Contact Hours</b>			<b>45</b>
<b>Course Outcomes:</b>			
On completion of the course, the students will be able to			
•	Explain the carbohydrate structure and its organization into various conjugates		
•	Illustrate the process of glycosylation, including the roles of glycosyl transferases, glycoside hydrolases, and other enzymes		
•	Compare the structures and functions of glycolipids, including GPI anchors and glycosphingolipids		
•	Evaluate the impact of glycans on various diseases, including bacterial and viral infections, genetic disorders, and cancer		
•	Assess the role of glycosylated biomolecules in practical contexts and their effectiveness in various applications		
<b>Suggested Activities</b>			
•	Class Presentation / Discussion		
<b>Suggested Evaluation Methods</b>			
•	Quizzes		
•	Case studies		
•	Tutorial Problems		
•	Multiple choice questions		
<b>Text Book(s):</b>			
<b>1</b>	Introduction to Glycobiology. Maureen E. Taylor and Kurt Drickamer. 3 <sup>rd</sup> edition, Oxford University Press, 2011		
<b>2</b>	Essentials of Glycobiology, Ajit Varki Richard D Cummings, Jeffrey D Esko, Hudson H Freeze, Pamela Stanley, Carolyn R Bertozzi, Gerald W Hart, and Marilyn E Etzler. 2 <sup>nd</sup> edition, Cold Spring Harbor, New York, 2009.		
<b>3</b>	Lehninger principles of biochemistry. Lehninger, Nelson and Cox. 4 <sup>th</sup> ed, W.H. Freeman and Company		
<b>Reference Books(s) / Web links:</b>			
<b>1</b>	Allen HJ, Kisailus EC, editors. Glycoconjugates: Composition, structure, and function. Marcel Dekker, 1992, CRC Press.		

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
BT23B15.1	2	2	2	2	1	2	1	1	2	1	2	2	3	2	3
BT23B15.2	2	2	2	2	1	2	1	1	2	1	2	3	3	3	3
BT23B15.3	2	2	2	2	1	2	1	1	2	1	2	2	3	2	2
BT23B15.4	2	2	2	2	1	2	1	1	2	1	2	2	3	2	2
BT23B15.5	2	2	2	2	1	2	1	1	2	1	2	3	3	3	3
Average	2	2	2	2	1	2	1	1	2	1	2	2.4	3	2.4	2.6

<b>BT23B16</b>	<b>NEUROBIOLOGY AND COGNITIVE SCIENCES</b>				<b>Category</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
					<b>PE</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

<b>Objectives:</b> To enable the students	
•	Know the general organization of brain, neurons and glial cells
•	Learn physiological aspects and coding of neurons

●	Apply the mechanism of action of neurotransmitters and hormones
●	Analyze the mechanism of five senses
●	Illustrate behavioural aspects such as sleep feeding and motivation

<b>UNIT-I</b>	<b>NEUROANATOMY</b>	9
What are central and peripheral nervous systems; Structure and function of neurons; types of neurons; Synapses; Glial cells; myelination; Blood Brain barrier; Neuronal differentiation; Characterization of neuronal cells; Meninges and Cerebrospinal fluid; Spinal Cord.		
<b>UNIT-II</b>	<b>NEUROPHYSIOLOGY</b>	9
Resting and action potentials; Mechanism of action potential conduction; Voltage dependent channels; nodes of Ranvier; Chemical and electrical synaptic transmission; information representation and coding by neurons.		
<b>UNIT-III</b>	<b>NEUROPHARMACOLOGY</b>	9
Synaptic transmission, neurotransmitters and their release; fast and slow neurotransmission; characteristics of neurites; hormones and their effect on neuronal function.		
<b>UNIT-IV</b>	<b>APPLIED NEUROBIOLOGY</b>	9
Basic mechanisms of sensations like touch, pain, smell and taste; neurological mechanisms of vision and audition; skeletal muscle contraction.		
<b>UNIT-V</b>	<b>BEHAVIOUR SCIENCE</b>	9
Basic mechanisms associated with motivation; control of feeding, sleep and brain waves recorded on EEG, hearing and memory; Disorders associated with the nervous system like Alzheimers disease, Parkinsons disease, schizophrenia and depression.		
<b>Total Contact Hours</b>		<b>: 45</b>

<b>Course Outcomes:</b> Upon completion of the laboratory sessions, the students will be able to	
●	Comprehend the anatomy and organization of nervous systems
●	Describe the function of nervous systems
●	Analyze how drugs and hormones affect cellular function in the nervous system
●	Apply the basic mechanisms of five senses
●	Illustrate the mechanisms associated with behavioral science

<b>Text Book(s):</b>	
1	Mathews G.G. Neurobiology, 2 <sup>nd</sup> edition, Blackwell Science, UK, 2000.
2	Gordon M. Shepherd G.M, and Shepherd Neurobiology, 3rd Edition Oxford University Press, USA,1994
3	

<b>Reference Books(s) / Web links:</b>	
1	Mason P., Medical Neurobiology, Oxford University Press, 2011.

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
BT23B16.1	3	3	3	2	2	3	2	3	2	0	0	3	3	2	1
BT23B16.2	3	3	3	2	2	3	2	2	2	0	0	2	3	2	1
BT23B16.3	3	3	3	2	2	2	2	2	2	0	0	2	3	2	1
BT23B16.4	3	3	3	2	2	3	2	2	2	0	0	3	3	2	1
BT23B16.5	3	3	3	3	2	2	2	2	2	0	0	3	3	2	1
Average	3	3	3	2.2	2	2.6	2	2.2	2	0	0	2.6	3	2	1



**VERTICAL III – MEDICAL BIOTECHNOLOGY**

<b>BT23C11</b>	<b>HUMAN GENETICS</b>	<b>Category</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		<b>PE</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

<b>Objectives:</b>						
●	To discuss the patterns of inheritance and their relevance in disease and therapy					
●	To describe various genetic laws, learn the chromosome structure function and understand methodologies for cytogenetic applications.					
●	To understand human chromosome pathologies and karyotyping					
●	To learn genetic mapping and genetic linkages					
●	To study about genetic disorders and syndromes					
<b>UNIT-I</b>	<b>INTRODUCTION</b>					<b>9</b>
History of genetics – Mendel’s principles and experiments, segregation, multiple alleles –Independent Assortments, Genotypic interactions, epistasis and Sex chromosomes, Sex determination, Dosage compensation, sex linkage and pedigree analysis						
<b>UNIT-II</b>	<b>COMPLEX TRAITS</b>					<b>9</b>
Approaches to analysis of complex traits- 'Nature vs nurture', role of family and shared environment, monozygotic and dizygotic twins and adoption studies – Polygenic inheritance of continuous (quantitative) traits and discontinuous {dichotomous} traits – Genetic susceptibility in complex traits - Estimation of genetic components of multifactorial traits: emperic risk, heritability, coefficient of relationship, application of Baye’s theorem.						
<b>UNIT-III</b>	<b>HUMAN CYTOGENETICS</b>					<b>9</b>
Origins and developments in the study of human cytogenetics - Chromosome banding – Human chromosomal pathologies: Numerical and Structural aberrations and their common syndromes –Human karyotype: banding patterns, ideogram, nomenclature of banding – Nomenclature of aberrant karyotypes						
<b>UNIT-IV</b>	<b>APPLIED GENETICS</b>					<b>9</b>
Genetic linkage and gene mapping – Genetic polymorphism, RFLP, SNP, STRP – Physical mapping of the human genome – Transcriptional mapping – Molecular techniques in human chromosome analysis (FISH, GISH, CGH, SKY).						
<b>UNIT-V</b>	<b>CLINICAL GENETICS</b>					<b>9</b>
Genetic basis of syndromes and disorders – Monogenic diseases: Cystic fibrosis, Marfan syndrome – Inborn errors of metabolism: Phenylketonuria, Mucopolysaccharidosis, Galactosemia – Syndromes due to triplet nucleotide expansion: Muscle genetic disorders, Sickle cell anemia, Thalassemias, Colour Blindness, Retinitis pigmentosa.						
					<b>Total Contact Hours</b>	<b>: 45</b>
<b>Course Outcomes:</b>						
On completion of thecourse students will be able to						
●	Understand the concept of Mendelian and non-Mendelian genetics					
●	Analyse complex traits inheritance and mechanism of sex determination					
●	Discuss clearly about chromosomal pathologies					
●	Describe the principles behind methodologies using molecular markers RFLP, RAPD, STRP, and SNP’s					
●	Create awareness to human society on various genetic disorders, their inheritance patterns and to develop methods and techniques to fight against the diseases					
<b>Suggested Activities</b>						
●	Case Studies					
<b>Suggested Evaluation Methods</b>						
●	Quizzes					
●	Class Presentation / Discussion					

- Multiple choice questions

Text Books:	
1	Michael Goldberg, Janice Fischer, Leroy Hood and Leland Hartwell, "Genetics: From Genes to Genomes", 7 <sup>th</sup> Edition. McGraw Hill Education, 2020.
2	Tom Strachan & Andrew Read, "Human molecular genetics" 4th Edition, Taylor & Francis Group, Garland Science, 2011.
Reference Books:	
1	Benjamin A. Pierce, "Genetics: A Conceptual Approach", 7th Edition, Macmillan Learning, 2020.
2	William S Klug, Michael Cummings, Charlotte A. Spencer, Michael A Palladino & Darrell Killian, "Concepts of Genetics", 12th Edition, Pearson, 2019.
3	D. Peter Snustad, Michael J. Simmons, "Principles of Genetics", 7 <sup>th</sup> Edition, published by Wiley, 2015

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
BT23C11.1	3	3	2	3	-	3	3	3	3	3	3	1	1	2	3
BT23C11.2	3	3	3	3	3	3	3	3	3	3	3	3	2	3	3
BT23C11.3	3	3	3	3	3	3	3	3	3	3	3	3	2	3	3
BT23C11.4	3	3	3	3	3	3	3	3	3	3	3	3	2	3	3
BT23C11.5	3	3	3	3	-	3	3	3	3	3	3	3	2	2	3
Average	3	3	2.8	3	1.8	0.4	0.2	3.0	0.6	3	1.2	2.6	1.8	2.6	3

Subject Code	CANCER BIOLOGY	Category	L	T	P	C
BT23C12		PE	3	0	0	3

**Objectives:**

- To understand the regulation of cell cycle, apoptosis and their role in cancer.
- To categorize the mechanism of chemical, physical and virus induced carcinogenesis.
- To comprehend the molecular mechanism of carcinogenesis, signal transduction pathways and their relation to cancer.
- To explore the concepts of molecular mechanism of cancer metastasis.
- To evaluate the current modes of cancer treatment and diagnosis, useful for scientific research.

**UNIT I FUNDAMENTALS OF CANCER BIOLOGY 10**

Definition types – benign, malignant tumors, properties, grading, stages, regulation of cell cycle, mutations that cause changes in signal molecules, signaling pathways – growth factors, G proteins, Wnt, JAK-STAT, TGF- $\beta$ , PI3K/AKT, intrinsic and extrinsic apoptotic pathways.

**UNIT-II PRINCIPLES OF CARCINOGENESIS 9**

Carcinogenesis – classification and metabolism of chemical carcinogens mechanism of chemical carcinogenesis, identification of carcinogens, radiations and cancer – UV, ionising radiations – X-ray, nuclear, microwave etc, DNA damage due to chemicals & radiations and DNA repair mechanisms, infectious agents and cancer – RNA, DNA virus, bacteria- *H. pylori*; parasites- blood fluke, liver fluke and carcinogenesis. Heredity and cancer.

**UNIT-III PRINCIPLES OF MOLECULAR CELL BIOLOGY OF CANCER 9**

Molecular cell biology of cancer, oncogenes – identification, classification and activation of proto oncogenes to oncogenes, tumour suppressor genes – caretaker and gate keeper genes, 2 hit hypothesis, loss of heterozygosity, APC, CDKN2A, PTEN, Rb, Smad4, TGF $\beta$ , P53 and BRCA – Telomeres and Telomerases, Hall marks of cancer.

**UNIT-IV PRINCIPLES OF CANCER METASTASIS 8**

Clinical significance of invasion, heterogeneity of metastatic phenotype, metastatic cascade, angiogenesis, basement membrane disruption, three step theory of invasion, proteinases and tumour cell invasion – MMPs, cadherins integrins, Rho GTPase & HGF in cancer metastasis, metastatic suppressors.

UNIT-V	CANCER DETECTION AND THERAPY	9
Cancer prevention, screening and detection protocols, Diagnostic tools- PET,CT and MRI Scanning, DNA microarray, NGS sequencing, identification of tumor markers. Different forms of therapy - chemotherapy, surgery, radiation therapy, recent advances in cancer therapy – Stem cell, immunotherapy - CAR T-Cell therapy, gene therapy, molecular targeting and CRISPr technology.		
		<b>Total Contact Hours</b> : <b>45</b>
<b>Course Outcomes:</b>		
On completion of the course, the student will be able to		
●	Interpret the role of signal transduction pathways and cell cycle in cancer	
●	Analyse the risk factors and prevent cancer	
●	Study the molecular mechanism of oncogenes	
●	Evaluate cancer metastasis and angiogenesis	
●	Analyse and design chemo, radiation and advanced therapies for cancer	
<b>Suggested Activities</b>		
●	Cancer related journal article search and group discussion	
<b>Suggested Evaluation Methods</b>		
●	Quizzes	
●	Seminar presentation based on case study	
●	Debate on Cancer treatment and diagnosis protocols	
<b>Text Book(s):</b>		
1	Lewis J Kleinsmith, —Principles of Cancer Biology Pearsonnew int. Edition, 2016	
<b>Reference Books(s) / Web links:</b>		
1	The Cell: A Molecular Approach by Geoffrey M. Cooper and Robert E. Hausman eighth edition ;2018.	
2	McDonald, F etal., — Molecular Biology of Cancer  IInd Edition. Taylor & Francis, 2004	

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
BT23C12.1	3	3	2	3	-	-	2	-	-	-	-	2	3	2	3
BT23C12.2	2	3	2	2	2	3	3	2	2	-	-	3	3	3	3
BT23C12.3	2	3	2	2	1	-	2	-	-	-	-	2	3	2	2
BT23C12.4	3	3	2	2	2	2	3	-	-	-	-	2	3	2	2
BT23C12.5	3	3	3	3	3	3	3	3	2	-	2	3	3	3	3
Average	2.6	3	2.2	2.4	1.6	1.6	2.6	1	0.8	0	0.4	2.4	3	2.4	2.6

Subject Code	BIOPHARMACEUTICAL TECHNOLOGY	Category	L	T	P	C
BT23C13		PE	3	0	0	3

**Objectives:**

●	To give strong foundation and advanced information on biopharmaceutical aspects in relation to drug development
●	To provides core responsibilities for the development and monitoring of the drug and the preparation of medicines according to the norms
●	To provide in depth knowledge in the preparation of different types of drug formulations

●	To discuss the preparation of advanced drug delivery systems		
●	To analyse the physicochemical properties, pharmacology of commonly used biopharmaceuticals		
<b>UNIT I</b>	<b>INTRODUCTION</b>		<b>9</b>
Drug development-preclinical trials, Clinical trials (Phase I, II and III) and regulatory aspects - FDA and CDSCO; Pharmacovigilance, List of drugs banned at national and International level, Types of therapeutic agents and their uses.			
<b>UNIT-II</b>	<b>DRUG ACTION AND PHARMACOKINETICS</b>		<b>9</b>
Route of drug administration, pharmacodynamics- Enzyme, Ion channel, Transporters, Receptors. Pharmacokinetics – Absorption, Distribution, Metabolism and Excretion of drugs / metabolites, Pro-drugs – drug targeting, Significance of protein binding of drugs.			
<b>UNIT-III</b>	<b>PRINCIPLES OF DRUG MANUFACTURE</b>		<b>9</b>
Solid dosage forms – Introduction to types of tablets, excipients, granulation techniques, compression machinery, processing problems. Coated tablets - types – enteric coated tablets, film coated tablets and sugar coated tablets. Evaluation of coated tablets- Dissolution test and Disintegration test. Production of hard and soft gelatine capsules, liquid dosage form– suspension and emulsion. Semisolid dosage form – ointment.			
<b>UNIT-IV</b>	<b>CONTROLLED RELEASE MEDICATIONS</b>		<b>6</b>
A hypothetical plasma concentration-time profile from conventional multiple dosing and single doses of sustained and controlled delivery system. Design of oral controlled drug delivery systems- dissolution controlled release system, Diffusion controlled release system and oral osmotic pump. Parenteral controlled drug delivery – liposomes. Osmotic pump (Implants). Transdermal drug delivery systems.			
<b>UNIT-V</b>	<b>BIOPHARMACEUTICALS</b>		<b>9</b>
Various categories of therapeutics like Laxatives, NSAID, Contraceptives, Antibiotics- penicillin, Broad spectrum antibiotics, Aminoglycoside antibiotics and Macrolide antibiotics, Drugs for Cough, Insulin.			
		<b>Total Contact Hours</b>	<b>: 45</b>
<b>Course Outcomes:</b>			
On completion of the course, the student will be able			
●	Develop a new drug with therapeutic value.		
●	Understand the basic principles of pharmacodynamics and pharmacokinetics		
●	Prepare different types of formulations of drugs such as tablets, capsules, syrups etc.		
●	Develop an advanced drug delivery systems.		
●	Comprehend the pharmacodynamics and pharmacokinetics properties of different types of		
<b>Suggested Activities</b>			
●	Cancer related journal article search and group discussion		
<b>Suggested Evaluation Methods</b>			
●	Quizzes		
●	Seminar presentation based on case study		
●	Debate on Cancer treatment and diagnosis protocols		
<b>Text Book(s):</b>			
1	Finkel, Richard, et al., —Lippincott's Illustrated Reviews Pharmacology  4 <sup>th</sup> Edition. Wolters Kluwer. Lippincott Williams & Wilkins, 2009.		
2	D.M. Brahmkar, —Biopharmaceutics and pharmacokinetics  A treatise, 2005.		
3	K D Tripathi: Essentials of Medical Pharmacology.		
<b>Reference Books(s) / Web links:</b>			
1	Gareth Thomas. Medicinal Chemistry. An introduction. John Wiley. 2000.		
2	Katzung B.G. Basic and Clinical Pharmacology, Prentice Hall of Intl. 1995.		
3	Reminton .The Science and Practice of Pharmacy, 21st edition		
	Weblink:		
	<a href="#">Introduction to Drug Discovery and Drug Development   Udemy</a>		

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
BT23C13.1	3	3	2	3	3	3	3	3	3	3	3	3	3	3	3
BT23C13.2	3	3	2	2	3	3	-	3	3	3	3	2	3	2	3
BT23C13.3	3	3	3	2	-	3	3	3	2	3	3	-	2	3	-
BT23C13.4	3	3	3	2	3	3	-	3	3	3	3	-	3	3	-
BT23C13.5	3	3	2	1	-	3	-	3	3	3	3	-	3	2	1
Average	3	3	2.4	2	3	3	3	3	2.8	3	3	1	2.8	2.6	1.4

Subject Code	CLINICAL BIOCHEMISTRY	Category	L	T	P	C
BT23C14		PE	3	0	0	3

Objectives:	
●	To provide information about clinical changes in disorders of metabolic pathways
●	To disseminate knowledge on hormone related disorders
●	To analyse lifestyle diseases and their prevention
●	To interpret the results of organ function tests
●	To describe diagnosis of diseases using enzymes and xenobiotics

<b>UNIT-I</b>	<b>INBORN ERRORS OF METABOLISM</b>	9
Scope of clinical biochemistry. Inherited diseases of carbohydrates, protein, lipid and nucleic acid metabolisms -Sickle cell anaemia, Phenyl ketonuria, alkaptonuria, albinism, Lesch-Nyhan Syndrome, Niemann Pick disease, Glycogen storage diseases- Metabolic defect and symptoms-Gaucher's disease, and hemochromatosis		
<b>UNIT-II</b>	<b>HORMONAL DISORDERS</b>	9
Overview of hormones and their actions. Classification and mechanism of their action. Dwarfism, acromegaly, gigantism, hyperthyroidism, hypothyroidism, goitre, cushing's syndrome, diabetes insipidus. Diseases of adrenal cortex and adrenal medullary hormones. Disorders of male and female reproductive systems.		
<b>UNIT-III</b>	<b>LIFE STYLE DISEASES</b>	9
Etiology symptoms and management-Diabetes types, biochemical changes and complications of diabetes mellitus, Obesity, Atherosclerosis, cardiovascular diseases and stroke.		
<b>UNIT-IV</b>	<b>DISEASES OF LIVER, KIDNEY AND DIGESTIVE SYSTEM</b>	9
Cirrhosis, hepatitis, jaundice, nephritis, nephrosis, ulcer, Organ function tests-liver, renal and gastric.		
<b>UNIT-V</b>	<b>CLINICAL DIAGNOSIS OF DISEASES AND XENOBIOTICS</b>	9
Composition of blood and urine in normal and disease conditions. Diagnostic enzymes and isoenzymes. Xenobiotics-role of liver and kidney in the metabolism and excretion of xenobiotics.		
<b>Total Contact Hours</b>		<b>: 45</b>

Course Outcomes: Upon completion of the course, the graduates will be able to	
●	Comprehend the abnormalities associated with metabolic pathways
●	Ascertain the importance of hormones and associated disorders
●	Learn to protect against lifestyle disorders
●	Interpret the results of organ function tests
●	Apply enzymes and xenobiotics in diagnosis of diseases

<b>Suggested Activities</b>	
•	Case Studies
<b>Suggested Evaluation Methods</b>	
•	Quizzes
•	Class Presentation / Discussion
•	Multiple choice questions

<b>Text Book(s):</b>	
1	Richard A. H, Denise R. F, Lippincott's Illustrated Reviews: Biochemistry, Fifth Edition - Lippincott Williams & Wilkins
2	M.N. Chatterjee, Rane shinde, Text book of medical biochemistry Eighth Edition - JAYPEE publications

<b>Reference Books(s) / Web links:</b>	
1	Carl A. Burtis, David E. Bruns, Edward R. Ashwood, Tietz Fundamentals of Clinical Chemistry, 6th Edition – Saunders Company.
2	<u>Thomas M. Devlin</u> , Textbook of Biochemistry with Clinical Correlations, 4th Edition - Wiley and Sons Ltd. 1997.
3	Salway, J.G., –Metabolism at a Glance. II <sup>nd</sup> Edition, Blackwell Science Ltd., 2000.
4	Alan H. Gowenlock, Varley's Practical Clinical Biochemistry, Sixth Edition- CBS Publisher

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
	BT23C14.1	3	3	3	3	2	3	2	2	3	2	2	3	3	3
BT23C14.2	3	3	3	3	2	3	2	2	3	2	2	3	3	3	3
BT23C14.3	3	3	3	3	2	3	2	2	3	2	2	3	3	3	3
BT23C14.4	3	3	3	3	2	3	2	2	3	2	2	3	3	3	3
BT23C14.5	3	3	3	3	2	3	2	2	3	2	2	3	3	3	3
Average	3	3	3	3	2	3	2	2	3	2	2	3	3	3	3

BT23C15	FREE RADICALS IN HEALTH AND DISEASE	Category	L	T	P	C
		PE	3	0	0	3

<b>Objectives:</b>						
•	To provide information about free radicals and their types					
•	To disseminate knowledge on the role of free radicals in toxicology					
•	To analyse role of free radicals in causing diseases					
•	To interpret the formation and assay of oxidants and antioxidants					
•	To understand the usefulness of free radicals					
<b>UNIT-I</b>	<b>FREE RADICALS- TYPES -GENERATION OF FREE RADICALS</b>					<b>9</b>
The superoxide theory of oxygen toxicity, ROS-Chemistry of oxygen radicals and other oxygen derived species -production and detection of hydroxyl radicals – singlet oxygen superoxide radicals, reactive nitrogen species -RNS in biological systems.						
<b>UNIT-II</b>	<b>ROLE OF FREE RADICALS IN TOXICOLOGY</b>					<b>9</b>
Bipyridyl herbicides, Alloxan and streptozotocin, phenolic compounds, cigarette smoke, air pollutants, nephrolytic and antimalarial drugs, halogenated hydrocarbons, antipyretics, antibiotics, metal toxicity, UV light.						
<b>UNIT-III</b>	<b>ROLE OF FREE RADICALS IN DISEASES</b>					<b>9</b>
Cancer, Atherosclerosis, Chronic inflammation and autoimmune diseases, Ischaemia, injury, lung damage						

and respiratory distress syndrome, ageing and exercise induced damage.			
<b>UNIT-IV</b>	<b>OXIDANTS AND ANTIOXIDANTS</b>	<b>9</b>	
Mechanism of Lipid peroxidation, lipid peroxidation in erythrocytes, measurement of lipid peroxidation-identification markers – TBARS, MDA, LHP, CD, Antioxidants , types of antioxidants- enzymes, small molecules and its measurement, metal ions sequestration, antioxidant repair systems, Assay of Oxidative stress markers- DPPH assay, FRAP assay, ABTS assay.			
<b>UNIT-V</b>	<b>FREE RADICALS AS USEFUL SPECIES</b>	<b>9</b>	
Reduction of ribonucleosides - oxidation, carboxylation and hydroxylation reactions, phagocytosis, peroxidase and NADH oxidase enzymes, fruit ripening, EDRF- synthesis of eicosanoids, Prostaglandins and leukotrienes.			
			<b>Total Contact Hours : 45</b>
<b>Course Outcomes:</b>			
On completion of course students will be able to			
●	Gain knowledge about free radicals		
●	Disseminate the role of free radicals in toxicology		
●	Apply the role of free radicals in toxicology		
●	Carryout assay of oxidants and antioxidants in biological sources		
●	Evaluate the benefits of free radicals		
<b>Suggested Activities</b>			
●	Case Studies		
●	Journal article search		
<b>Suggested Evaluation Methods</b>			
●	Quizzes		
●	Class Presentation / Discussion		
●	Multiple choice questions		

<b>Text Books:</b>	
<b>1</b>	Rabia Hamid- Textbook of Free radicals concepts in Biology and Medicine, Atlantic publishers , 2018
<b>Reference Books:</b>	
<b>1</b>	Barry Halliwell, John Gutteridge. Free Radicals in Biology and Medicine 4th Edition, 2015
<b>2</b>	Science direct.com

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
BT23C15.1	3	3	2	3	-	-	-	3	-	3	-	1	1	2	3
BT23C15.2	3	3	3	3	3	-	-	3	-	3	2	3	2	3	3
BT23C15.3	3	3	3	3	3	-	1	3	-	3	2	3	2	3	3
BT23C15.4	3	3	3	3	3	-	-	3	-	3	2	3	2	3	3
BT23C15.5	3	3	3	3	-	2	-	3	3	3	-	3	2	2	3
Average	3	3	2.8	3	1.8	0.4	0.2	3.0	0.6	3	1.2	2.6	1.8	2.6	3

<b>BT23C16</b>	<b>MEDICAL MICROBIOLOGY</b>				<b>Category</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
					<b>PE</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>
<b>Objectives:</b> To enable the students									
●	To understand the host parasite relationship in microbial disease								
●	To impart knowledge on the pathogenesis of medical bacteriology								
●	To analyse the replication of viruses in diseases								
●	To learn the medical importance of Mycology & Parasitology								
●	To identify potential hazardous biological materials and the risk associated with them and the diagnosis								

of diseases
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<b>UNIT-I</b>	<b>BASICS IN MEDICAL MICROBIOLOGY</b>	9
Basics in Medical microbiology - Infectious diseases overview. Infection: Sources, portals of entry and transmission, Pathogenesis - adhesion, invasion, host cell damage, release of pathogens. Microbial virulence and virulence factors - Signs and symptoms of microbial diseases, Immunity of microbial diseases, human microcrobioime and macrobiota.		
<b>UNIT-II</b>	<b>BACTERIOLOGY</b>	9
Morphology, pathogenesis, diagnosis treatment, prevention and control of diseases caused by Staphylococci, Streptococci, Bacillus, Clostridium, Corynebacterium, Escherichia, Salmonella, Shigella, Klebsiella, Proteus, Vibrio, Pseudomonas, Mycobacteria, Spirochaetes and Rickettsia, Methods for the identification of pathogenic bacteria- Pneumococcus, Micrococci, gram negative enteric bacteria and spirochaetes.		
<b>UNIT-III</b>	<b>VIROLOGY</b>	9
Structure, multiplication, pathogenesis- diagnosis –, treatment – prevention and control of diseases caused by of DNA viruses - Pox, Herpes, Hepatitis, Adeno; RNA viruses - Picorna, Orthomyxo, Paramyxo, Rabdo and HIV virus.		
<b>UNIT-IV</b>	<b>MYCOLOGY &amp; PARASITOLOGY</b>	9
General characteristics-morphology, pathogenesis- diagnosis, treatment, prevention and control of human mycotic infections caused by Dermatophytes, Histoplasma, Cryptococcus, Candida, opportunistic mycoses. Mycotoxins. Medically important Parasitic disease caused by Entamoeba, Giardia, Plasmodium, Taenia, Ascaris, Wucherhiria.		
<b>UNIT-V</b>	<b>LABORATORY MANAGEMENT AND DIAGNOSIS OF MICROBIAL DISEASES</b>	9
Diagnosis of disease: Collection, transportation and preliminary processing of clinical specimens. Primary contaminant for biohazards, Biosafety levels of specific microorganisms, Recommended biosafety levels for infectious agents. Laboratory diagnosis of viral and mycotic infections, Molecular diagnosis – Amplification of DNA and PCR, Determination of susceptibility of bacteria to antimicrobial agents, Prevention and control of microbial infections.		
		<b>Total Contact Hours : 45</b>
<b>Outcomes:</b> On completion of this course, the students will be able to		
●	Gain knowledge about the host parasite relationship in microbial disease	
●	Elucidate the pathogenesis of medical bacteriology	
●	Analyze the replication of viruses in diseases	
●	Apply the medical importance of Mycology & Parasitology	
●	Assess the effects of hazardous materials and microorganisms	

<b>Suggested Activities</b>	
●	Case Studies
<b>Suggested Evaluation Methods</b>	
●	Quizzes
●	Class Presentation / Discussion
●	Multiple choice questions

<b>Reference Books(s) / Web links:</b>	
1	Chaechter M. Medoff G. and Eisenstein BC. (1993) Mechanism of Microbial Diseases 2nd edition. Williams and Wilkins, Baltimore.
2	Collee, JG. Duguid JP, Fraser AG, Marimon BP. (1989) Mackie and Mc Cartney Practical Medical Microbiology, 13th Edition. Churchill Livingstone.
3	Ananthanarayan and Paniker's Text book of Microbiology (1978) Universities Press (9th edition), Hyderabad.
4	David Greenwood, Richard CD, Slack, John Forrest Peutherer. (1992) Medical Microbiology. 14th



	edition. ELBS with Churchill Livingstone.
5	Hugo WB and Russell AD. (1989) Pharmaceutical Microbiology IV edition. Blackwell Scientific Publication, Oxford.
6	Joan Stokes E, Ridgway GL and Wren MWD. (1993). Clinical Microbiology, 7th edition. Edward Arnold. A division of Hodder and Stoughton.
7	Ronald M. Atlas. (1989) Microbiology. Fundamentals and Applications. II edition, Maxwell Macmillan international editions.
8	Topley & Wilson's. (1990) Principles of Bacteriology, Virology and Immunity, VIII edition, Vol. III Bacterial Diseases, Edward Arnold, London.

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
BT23C16.1	3	2	2	3	1	3	2	1	3	2	2	3	3	1	2
BT23C16.2	2	1	1	1	1	3	0	0	2	2	1	3	3	2	1
BT23C16.3	2	1	1	1	1	3	0	0	2	2	1	3	3	2	1
BT23C16.4	2	1	1	1	1	3	0	0	2	2	1	3	3	2	1
BT23C16.5	3	2	3	3	3	3	2	1	3	2	2	3	3	3	3
Average	2.4	1.4	1.6	1.8	1.4	3	0.8	0.4	2.4	2	1.4	3	3	2	1.6

#### VERTICAL IV – ANIMAL BIOTECHNOLOGY

Subject Code	FUNDAMENTALS AND APPLICATIONS OF ANIMAL CELL CULTURE	Category	L	T	P	C
BT23D11		PE	3	0	0	3

<b>Course objectives:</b>	
This course will facilitate the students to	
•	Understand the basic requirements for an animal cell culture facility
•	Illustrate general composition and types of cell culture media
•	Analyse various methods of animal tissue and organ cultures
•	Identify various types of cell cultures and cell culture contaminant
•	Evaluate the valuable products obtained from animal cell culture

UNIT I	BASIC REQUIREMENTS FOR ANIMAL CELL CULTURE FACILITY	9
Basic equipment and facilities for animal cell culture: Sterile work area, cell culture hood, incubation facilities, refrigerators and freezer, microscopes, tissue culture ware, washing up and sterilizing facilities, liquid nitrogen/deep freezer, reverse osmosis apparatus, facilities for cells counting - List of essential, beneficial and useful additional equipment in animal cell culture		
UNIT II	TYPES OF ANIMAL CELL CULTURE MEDIA	9
Animal cell culture media – General composition - Types of media: Natural media, Synthetic media, chemically defined, Protein free media - Advantages and disadvantages of serum-containing and Serum-free media - Criteria for the selection of media - Common Cell Culture Media: BSS, Eagle's Minimum Essential Medium (EMEM), Dulbecco's Modified Eagle's Medium (DMEM), RPMI-1640, CMRL.		
UNIT-III	BASIC TISSUE CULTURE METHODS	9



<b>Subject Code</b>	<b>ADVANCED ANIMAL CELL CULTURE AND INDUSTRIAL BIOTECHNOLOGY</b>	<b>Category</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>BT23D12</b>		<b>PE</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

**Course objectives:**

This course will facilitate the students to

•	Understand the principles and types of cell cultures used in animal biotechnology.
•	Comprehend the principles and operation of bioreactors in animal cell culture.
•	Explore the biology and applications of common animal viral vectors.
•	Analyse the processes involved in hybridoma technology.
•	Design the production methods and applications of therapeutics in animal infections.

<b>UNIT I</b>	<b>SCALE-UP METHODS IN ANIMAL CELL CULTURE</b>	<b>9</b>
Cell culture – Types (brief details only); Scale-up of monolayers - Nunc cell factory, Multi tray, Disk, spirals & tubes, and Roller bottle method; Microcarrier cell culture Technology - Microcarriers, Processing of microcarriers, and technique. Production of vaccine using microcarriers. Scale up of suspension culture.		
<b>UNIT II</b>	<b>BIOREACTORS IN ANIMAL CELL CULTURE</b>	<b>9</b>
Bio-reactors in animal cell culture - Bioreactor process control, stirred animal cell culture, Air-lift fermentor, hemostat/Turbidostat. Fixed-bed reactor system – Principle and applications; Lab-scale Fixed-bed cultivation – Design and technique.		
<b>UNIT-III</b>	<b>BIOLOGY AND APPLICATIONS OF ANIMAL VIRAL VECTORS</b>	<b>9</b>
Introduction to viral vectors and their importance - Biology of viral vectors - SV40, adeno virus, retrovirus, vaccinia virus, herpes virus, adenoassociated virus and baculo virus - Pros, and cons of viral vectors - The role of Baculo virus in biocontrol - Commercial viral vectors and their applications.		

<b>UNIT-IV</b>	<b>MONOCLONAL ANTIBODY PRODUCTION AND APPLICATIONS</b>	<b>9</b>		
Over view of monoclonal antibodies - Process of hybridoma production, purification, and characterization of monoclonal antibodies - Alternative methods of monoclonal antibodies production - Phage display method, Recombinant DNA technology, and Single B cell technologies - Applications of monoclonal antibodies - In vivo imaging agent, targeting agent, and therapeutic agent.				
<b>UNIT-V</b>	<b>RECOMBINANT CYTOKINES AND VACCINE: PRODUCTION AND APPLICATIONS</b>	<b>9</b>		
Cytokines - Definition, mode of actions, and functions - Recombinant cytokines – Production and their use in the treatment of animal infections - Vaccines - Definition, types/classification, conventional approaches for vaccine production and recombinant approaches for vaccine production - Application of vaccines in animal infections.				
		<b>Total Contact Hours</b>	<b>:</b>	<b>45</b>

**Course outcomes:**

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

•	Implement various scale-up techniques for monolayers and suspension.
•	Critically analyze and choose suitable bioreactors for specific applications in animal cell culture.
•	Describe the biological features and actions of animal viral vectors.
•	Explain the production and purification processes of monoclonal antibodies.
•	Design and implement strategies for the production of vaccines

**Reference books:**

•	Ranga M.M. Animal Biotechnology. Agrobios India Limited, 2002
•	Freshney, R. I. (2010). <i>Culture of animal cells: A manual of basic technique and specialized applications</i> (6th ed.). Wiley-Blackwell.

•	Pörtner, R. (Ed.). (2010). <i>Methods in Biotechnology™ 24: Animal Cell Biotechnology: Methods and Protocols</i> (2nd ed.). Humana Press.
•	Glick, B.R. and Pasternack, J.J. <i>Molecular Biotechnology</i> , 3rd ed., ASM Press, 2003
•	Aoki N, Xing Z. Use of cytokines in infection. <i>Expert Opin Emerg Drugs</i> . 2004;9(2):223-236. doi: 10.1517/14728214.9.2.223.
•	Frazzini S, Riva F, Amadori M. Therapeutic and Prophylactic Use of Oral, Low-Dose IFNs in Species of Veterinary Interest: Back to the Future. <i>Vet Sci</i> . 2021;8(6):109. doi: 10.3390/vetsci8060109.
•	Goding, J. W. (1996). <i>Monoclonal Antibodies: Principles and Practice</i> . Academic Press.

**Web links:**

•	<a href="https://www.slideshare.net/slideshow/production-and-applications-of-monoclonal-antibodies/239502265">https://www.slideshare.net/slideshow/production-and-applications-of-monoclonal-antibodies/239502265</a>
•	<a href="https://microbenotes.com/monoclonal-antibodies-types-uses-and-limitations/">https://microbenotes.com/monoclonal-antibodies-types-uses-and-limitations/</a>

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
BT23D12.1	3	3	3	3	3	3	-	3	3	3	3	3	3	3	3
BT23D12.2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
BT23D12.3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
BT23D12.4	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
BT23D12.5	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Average	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3

Subject Code	TECHNIQUES IN ANIMAL DISEASE MANAGEMENT AND TRANSGENIC TECHNOLOGY	Category	L	T	P	C
BT23D13		PE	3	0	0	3

**Course objectives:**

This course will facilitate the students to

•	Understand animal diseases and their management
•	Enrich knowledge about various diagnostic techniques concerning animal infections
•	Study micromanipulation techniques and their applications.
•	Explore the principles and applications of various gene transfer methods.
•	Analyse the generation/development of transgenic animals.

UNIT I	ANIMAL DISEASES AND THEIR MANAGEMENT	9
Bacterial and viral diseases in animals: Infectious agent, host, symptoms, mode of transmission, and disease management/treatment. Parasitic infections in animals and their treatment.		
UNIT II	ANIMAL DISEASE DIAGNOSIS	9
Diagnostic assays based on antigen and antibody reactions – Radioimmunoassay, Enzyme immunoassays - Immunoblotting - Nucleic acid based diagnostic methods - Nucleic acid probe hybridization/in-situ hybridization - Southern blotting - Northern blotting – PCR.		
UNIT-III	MICROMANIPULATION AND ITS APPLICATION	9
Micromanipulation technology – Definition, equipment used in micromanipulation and breeding of farm animals; Enrichment of x and y bearing sperms from semen samples of animals; Artificial insemination (AI); Germ cell manipulations – <i>In vitro</i> fertilization (IVF) and embryo transfer (ET).		

UNIT-IV	GENE TRANSFER TECHNIQUES IN TRANSGENIC ANIMAL TECHNOLOGY	9
Gene transfer - types/classification; Gene transfer techniques in embryos, oocytes, sperm cells, and somatic cells - Pronuclear microinjection, Sperm-mediated gene transfer (SMGT), Electroporation, Liposome & Viral vectors mediated gene transfer, Somatic cell nuclear transfer (SCNT) and Particle Bombardment (Gene Gun).		

<b>UNIT-V</b>	<b>TRANSGENIC ANIMAL TECHNOLOGY</b>	<b>9</b>
Concepts of transgenic animal technology; Development of transgenic animals - rat/mice, sheep, goat, cow, and pig; Stem cell cultures in the production of transgenic animals; Applications of transgenic animals in biotechnology.		
<b>Total Contact Hours</b>		<b>45</b>

**Course outcomes:**

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

•	Know the various animal diseases and their management.
•	Apply various diagnostic methods for the detection of animal diseases.
•	Analyse the principles and methods of micromanipulation in research and animal breeding.
•	Perform suitable gene transfer technique(s) in embryos, oocytes, sperm cells, and somatic cells.
•	Describe and implement the processes involved in transgenic animal development.

**Reference books:**

•	Freshney, R. I. (2010). Culture of animal cells: A manual of basic technique and specialized applications (6th ed.). Wiley-Blackwell.
•	Harrison, R. G., Todd, P. W., Rudge, S. R., & Petrides, D. P. (2003). <i>Bioseparations Science and Engineering</i> . Oxford University Press.
•	Elder, K., & Dale, B. (2019). Micromanipulation Techniques. In (Editor's Name) (Ed.), <i>Book Title</i> (pp. Pages). Cambridge University Press.
•	Cibelli, J., Lanza, R., Campbell, K., & West, M. D. (Eds.). (2002). <i>Principles of Cloning</i> . Academic Press.
•	Shakweer WME, Krivoruchko AY, Dessouki SM, Khattab AA. A review of transgenic animal techniques and their applications. J Genet Eng Biotechnol. 2023;21(1):55. doi: <a href="https://doi.org/10.1186/s43141-023-00502-z">10.1186/s43141-023-00502-z</a> .

**Web links:**

•	<a href="https://www.sciencedirect.com/topics/nursing-and-health-professions/nuclear-magnetic-resonance-imaging">https://www.sciencedirect.com/topics/nursing-and-health-professions/nuclear-magnetic-resonance-imaging</a>
•	<a href="https://www.researchgate.net/publication/247439762">https://www.researchgate.net/publication/247439762</a> Flow Cytometry in Animal Cell Culture

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
BT23D13.1	3	3	3	3	3	3	-	3	3	3	3	3	3	3	3
BT23D13.2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
BT23D13.3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
BT23D13.4	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
BT23D13.5	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Average	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3

<b>BT23D14</b>	<b>MOLECULAR PATHOGENESIS</b>	<b>Category</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		<b>PE</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

**Objectives: The students will be able to**

•	Comprehend the definitions of pathogenicity and entrance points
•	Examine the host's defense mechanisms against infections and their tactics
•	Understand the molecular mechanism underlying pathogenicity
•	Identify the control systems governing the interactions between hosts and pathogens

●	Discover the most recent advances in molecular methods for regulating microbial pathogenicity
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<b>UNIT-I</b>	<b>OVERVIEW AND BASICS OF MICROBIAL PATHOGENESIS</b>	5
Historical perspective - discovery of microscope, Louis Pasteur's contributions, Robert Koch's postulates, early discoveries of microbial toxins, toxic assays, antibiotics and birth of molecular genetics and modern molecular pathogenesis studies, Various pathogen types (bacteria, fungi, virus and parasites) and their modes of entry.		
<b>UNIT-II</b>	<b>HOST-DEFENSE AGAINST PATHOGENS AND PATHOGENIC STRATEGIES</b>	8
Attributes & components of microbial pathogenesis, Host defense mechanism by humoral and cellular, complements, inflammation process, general disease symptoms, Pathogenic adaptations to overcome the above defenses.		
<b>UNIT-III</b>	<b>MOLECULAR PATHOGENESIS (WITH SPECIFIC EXAMPLES)</b>	16
Bacterial secretion system in Gram negative bacteria, <i>E.coli</i> , Enterotoxigenic <i>E.coli</i> (ETEC), Enterohaemorrhagic <i>E.coli</i> (EHEC). <i>Vibrio cholerae</i> : Cholera toxin, Bacterial secretion system in Gram positive bacteria, <i>Mycobacterium tuberculosis</i> – transmission and pathogenesis. Shigellosis, Candidiasis, Plasmodium: Life cycle and its mechanism. Influenza virus pathogenesis.		
<b>UNIT-IV</b>	<b>EXPERIMENTAL STUDIES ON HOST-PATHOGEN INTERACTIONS</b>	8
Virulence, virulence factors, virulence - associated factors and virulence lifestyle factors molecular genetics and gene regulation in virulence of pathogens, virulence assays: biofilm formation and development, adherence, invasion, cytopathic, cytotoxic effects. Criteria & tests in identifying virulence factors, attenuated mutants, molecular characterization of virulence factors, signal transduction & host responses. Antibiotic resistant mechanism in pathogens.		
<b>UNIT-V</b>	<b>MODERN APPROACHES TO CONTROL PATHOGENS</b>	8
Classical approaches based on serotyping. Modern diagnosis based on highly conserved virulence factors, immuno & DNA-based techniques: Microarray Gene Expression. New therapeutic strategies based on recent findings on molecular pathogenesis of a variety of pathogens, Vaccines - DNA, subunit and cocktail vaccines.		
		<b>Total Contact Hours : 45</b>

<b>Course Outcomes:</b> Upon completion of the course, the students will be able to	
●	Describe the basic elements of pathogenesis and the role that microbes play in the development of diseases
●	Understand the defense mechanisms used in bacteria and viruses to thwart host defenses
●	Analyze the causes of bacterial infections and the molecular mechanisms underlying pathogenicity
●	Apply the basic concepts of host-pathogen interactions
●	Explore the molecular methods for managing the infection by microbial pathogens

<b>Suggested Activities</b>	
●	Case Studies
<b>Suggested Evaluation Methods</b>	
●	Quizzes
●	Class Presentation / Discussion
●	Multiple choice questions
<b>Text Book(s):</b>	
1	Iglewski B.H and Clark V.L – Molecular basis of Bacterial Pathogenesis –, Academic Press, 1990.
2	Eduardo A. Groisman, Principles of Bacterial Pathogenesis, Academic Press, 2001

<b>Reference Books</b>	
1	Peter Williams, Julian Ketley & George Salmond, —Methods in Microbiology: Bacterial Pathogenesis, Vol. 27I, Academic Press, 1998.
2	Recent reviews in Infect. Immun., Mol. Microbiol., Biochem. J., EMBOetc
3	Nester, Anderson, Roberts, Pearsall, Nester, —Microbiology: A Human Perspective, Mc Graw Hill, 3rd Edition, 2001.

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
BT23D14.1	1	3	3	3	1	2	1	-	-	2	1	3	3	2	1
BT23D14.2	1	3	3	3	1	2	1	1	2	2	1	3	3	2	2
BT23D14.3	1	3	3	3	-	2	1	-	2	2	1	3	3	3	3
BT23D14.4	1	3	3	3	1	2	1	-	2	2	1	3	3	3	3
BT23D14.5	1	3	3	3	1	2	2	1	2	2	2	3	3	3	3
Average	1	3	3	3	0.8	2	1.2	0.2	1.6	2	1.2	3	3	2.6	2.4

BT23D15	IMMUNOTECHNOLOGY	Category	L	T	P	C
		PE	3	0	0	3

Course objectives: This course will enable the students
<ul style="list-style-type: none"> <li>To understand the role of antigen profiling</li> <li>To articulate the mechanism of antibody diversity with reference to gene expression</li> <li>To describe the principle of immunohaematology</li> <li>To analyse strategies for vaccine production</li> <li>To design immunodiagnostic tools</li> </ul>

UNIT-I	ANTIGEN PROFILING	9
Antigen- Classification – Antigenic drift and shift – Genetic re-assortment of virus, epitope and its mapping, CD antigens – Types of CD antigens, Role of CD antigens in cell identification and characterization. Blood grouping antigens - types and their role in identification of blood groups. Antigen preparation and modification, adjuvant and its role in antigen preparation, Experimental immunology - Handling and route of administration of antigen in lab animals.		
UNIT-II	ANTIBODY ENGINEERING	9
Organization and Expression of Immunoglobulin Genes - Genetic Model Compatible with Ig Structure- Multigene Organization of Ig Genes- Variable-Region Gene Rearrangements- Light-Chain DNA -V-J Rearrangements- Heavy-Chain DNA -V-D-J Rearrangements- Allelic Exclusion Ensures a Single-Antigenic Specificity- Generation of Antibody Diversity-Antibody characterization techniques – Application antibody in clinical diagnosis. Human recombinant antibodies-antibody humanisation and applications of humanized antibodies.		
UNIT-III	IMMUNO HAEMATOLOGY	9
Study of human blood group systems, antibody screening and identification- reverse grouping blood and its uses in forensic science, blood components, Blood transfusion, Pretransfusion testing & cross match, Adverse effects of transfusion, compatibility testing, donor selection and processing, blood bank and its regulations, HLA typing- Tissue typing, Apheresis.		
UNIT-V	VACCINOLOGY	9
Immunization strategies for disease control and eradication- <b>Epidemiological perspective of vaccine</b> - Vaccine Design, Development, types and Safety, Vaccines against AIDS and Tropical Infectious Diseases – Leprosy, malaria and TB, Strategies of vaccine production, Development of vaccines and antibodies in plants and animals, Vaccine Policy: Legal aspects of vaccination -Role of the FDA (EUA)in vaccine development and applications, Immunization programs, Vaccinomics, Immunoinformatics, and Molecular modeling strategies for designing multi-epitope vaccines.		
UNIT V	IMMUNO DIAGNOSTICS	9
Antigen localization with reference to cancer and autoimmune disorders, Immunodiagnostic test for fungal		

infection- Assessment of cell mediated cytotoxicity and humoral immune response- Immunoblotting- FISH, IFT-*in-vivo* reactions- skin tests, immune complex demonstration. Diagnostic evaluation of lymphocytic - haemagglutination inhibition-Macrophage detection assay.

**Total Contact Hours** : **45**

Course outcomes:

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

- Describe the avenues of antigen characterization and modifications
- Elucidate the importance of antibody diversity with reference to antibody engineering
- Explain hematological concepts with reference to immunodiagnostics
- Design molecular modeling strategies for infectious diseases
- Develop immunodiagnostic tools

#### Suggested Activities

- Case Studies

#### Suggested Evaluation Methods

- Quizzes
- Class Presentation / Discussion
- Multiple choice questions

Text books:

- Kuby immunology, Owen, J. A., Punt, J., &Stranford, S. A. New York: W H Freeman. (2013).
- 2. Roitt'sEssentialimmunology( 7theds) byPeterJ.Delves, SeamusJ.Martin, DennisR.Burton, Ivan M, Wiley-Black. 2017
- 3. The elements of Immunology(1stEds)by Fahim Halim Khan, Pearson Education, 2009
- 4.Talwar GP, Rao KVS and Chauhan VS, Recombinant and Synthetic Vaccines; Narosa, New Delhi. 1994.
- 5. Benjamini E, Coico R and Sunskise G,;Immunology – A short course, Wiley – Liss Publication, NY. Ed.4; 2000.
- Kuby immunology, Owen, J. A., Punt, J., &Stranford, S. A. New York: W H Freeman. (2013).

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
BT23D15.1	3	3	2	2	2	3	2	1	1	1	3	3	3	3	3
BT23D15.2	3	3	3	2	2	3	2	1	1	1	3	3	3	3	3
BT23D15.3	3	3	3	2	2	3	2	1	1	1	3	3	3	3	3
BT23D15.4	3	3	3	2	2	3	2	1	1	1	3	3	3	3	3
BT23D15.5	3	3	3	2	2	3	2	1	1	1	3	3	3	3	3
Average	3	3	3	1	2	3	2	1	1	1	3	3	3	3	3

BT23D16	STEM CELL AND REGENERATIVE MEDICINE	Category	L	T	P	C
		PE	3	0	0	3

Course objectives:

This course will enable the students

- To understand the fundamentals of stem cell technology.
- To study the types of stem cells and their regulations.



•	To learn about cancer stem cells.
•	To know the details of haemopoietic stem cells and their regulation.
•	To identify the ethical concerns, and applications of stem cell in clinical research.

<b>UNIT-I</b>	<b>STEM CELLS AND CELLULAR PEDIGREES</b>	<b>9</b>
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Scope of stem cells, History perspective of stem cells, definition of stem cells, concepts of stem cells- differentiation, maturation, proliferation, potency and plasticity, self-maintenance and self-renewal – Stem cells markers, Stem cell bank, Stem cells niches, Trans differentiation. Obstacles for stem cell maintenance - preservation protocols.

<b>UNIT-II</b>	<b>STEM CELLS TYPES AND REGULATION</b>	<b>9</b>
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Adult stem cells in animals, skeletal muscle stem cells - Mammary stem cells- Intestinal Stem cells- Keratinocyte stem cells of cornea-skin and hair follicles - Embryonic stem cell biology- Characterization of Embryonic stem cells, Extracellular signalling involved in Embryonic Vs Adult stem cells, factors influencing proliferation and differentiation of stem cells - hormonal role in differentiation. Cancer stem cells and its types.

<b>UNIT-III</b>	<b>HEMATOPOIETIC STEM CELLS AND THEIR DIFFERENTIATION</b>	<b>9</b>
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Hematopoietic stem cells mobilization, mesenchymal stem cells and their properties, Hematopoietic Vs mesenchymal stem cells. Isolation of hematopoietic and mesenchymal stem cells, Ex vivo expansion, Characterization of Hematopoietic and mesenchymal stem cells. Growth factors for hematopoietic stem cells. Transcriptional regulation of hematopoietic and mesenchymal stem cells, hematopoietic differentiating pathway.

<b>UNIT-IV</b>	<b>STEM CELLS AND REGENERATIVE MEDICINE</b>	<b>9</b>
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Stem cells in Genetic disease. Role of stem cells in hemolytic anemia. Cellular therapies- stem cells therapy for degenerative neuronal diseases, stem cells therapy in spinal cord regeneration and muscular dystrophies. Immunotherapy - tissue engineering - blood and bone marrow. Stem cells for corneal repair. Platelet Rich Plasma Therapy.

<b>UNIT V</b>	<b>ETHICAL ISSUES AND REGULATIONS</b>	<b>9</b>
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Ethical issues in stem cell technology, stem cell regulations, Social and ethical concerns associated with it. Assessing Human Stem Cell Safety, Use of Genetically Modified Stem Cells in Experimental Gene Therapies.

<b>Total Contact Hours</b>	<b>:</b>	<b>45</b>
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Course outcomes:

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

- |   |   |
|---|---|
| • | Gain knowledge on key principles of stem cell technology                              |
| • | Define the types of stem cells and their regulations                                  |
| • | Elucidate the role of cancer stem cells   |
| • | Describe the haemopoietic stem cells and their regulation                             |
| • | Understand the ethical concerns and apply stem cell research in regenerative medicine |

<b>Suggested Activities</b>
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- |   |              |
|---|--------------|
| • | Case Studies |
|---|--------------|

<b>Suggested Evaluation Methods</b>
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- |   |                                 |
|---|---------------------------------|
| • | Quizzes                         |
| • | Class Presentation / Discussion |
| • | Multiple choice questions       |

Text books:

- |   |   |
|---|---|
| • | CS. Potten. Stem cells - Elsevier: 1997.                  |
| • | Robert Paul Lanza, Essentials of stem cell biology, 2006. |

Reference books:

- |   |  |
|---|--|
| • | Clive Svendensen and Allison D. Ebert, Encyclopedia of stem cell research, volume 1.                 |
| • | Stem cell basics and application” Ed. By K. D. Deb and S. M. Totey, Tata McGraw Hill Pvt. Ltd, 2011. |

•	Berger A.C. Beachy S.H and Olson S .Stem Cells Therapies, National Academic press, Washington DC, USA 2014.
•	Daniel R. Marshak, —Stem cell biology  cold spring laboratory press.
•	Robert Lanza, -Essentials of stem cell biology  Elsevier, 2001
•	Stem cell therapy for organ failures- Edited by S. Indumathi, Springer Verlag, 2015.

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
BT23D16.1	2	3	1	2	3	2	3	1	2	3	1	3	1	1	2
BT23D16.2	3	2	2	3	1	1	3	2	3	1	3	3	2	3	2
BT23D16.3	3	3	3	2	2	2	1	3	1	3	2	1	2	3	3
BT23D16.4	3	3	3	2	2	3	2	3	3	2	3	2	3	2	3
BT23D16.5	2	3	2	3	3	2	3	2	2	2	1	3	1	3	2
<b>Average</b>	2.6	2.8	2.2	2.4	2.2	2	2.4	2.2	2.2	2.2	2	2.4	1.8	2.4	2.4

### VERTICAL V – COMPUTATIONAL BIOLOGY

BT23E11	R FOR BIOINFORMATICS APPLICATIONS				Category	L	T	P	C	
					PE	3	0	0	3	
<b>Objectives:</b>										
•	To improve the programming skills and database integration									
•	To introduce the fundamentals of R programming language									
•	To familiarize with R packages and to write scripts for manipulating/processing genomic and proteomic data									
•	To apply ML in data mining and data visualisation									
•	To analyse various type of biological data using R									
<b>UNIT-I   INTRODUCTION</b> <span style="float: right;"><b>9</b></span>										
Introduction to Operating systems, Linux commands, Database management system models. Structured Query Language (SQL) – CRAN – BIOCONDUCTOR – Bioconda - Tidyverse – Parallel programming										
<b>UNIT-II   R PROGRAMMING</b> <span style="float: right;"><b>9</b></span>										
R overview, objects and data structures, control Structure, loops- while loop, for loop, if statement, File handling - opening and closing files, reading and writing files, Functions, S3 and S4 object class										
<b>UNIT-III   DATA WRANGLING AND STATISTICS</b> <span style="float: right;"><b>9</b></span>										
Importing data from csv, xlsx files and APIs, apply functions (apply, sapply, lapply, mapply), plots (scatterplot, box plot), Normalization, Correlation, Clustering, Survival analysis, Multiple hypothesis testing.										
<b>UNIT-IV   PROGRAM DEVELOPMENT</b> <span style="float: right;"><b>9</b></span>										
Regular expressions, Markdown and Quarto for literature computation, interactivity with Shiny, RStudio, Machine Learning (PCA, kNN, random forest, neural network), chatGPT for code debugging and improvement, AWS cloud solutions for software deployment.										
<b>UNIT-V   APPLICATIONS OF R IN BIOINFORMATICS</b> <span style="float: right;"><b>9</b></span>										
Quantitative RNA-seq, Finding genetic variants, Domain and Motif search in gene and protein sequences, Phylogenetic analysis and Visualization, Analyzing gene annotations, Importing and analyzing mass spectrometry data.										
								<b>Total Contact Hours</b>	<b>:</b>	<b>45</b>
<b>Course Outcomes:</b>										
On completion of this course students will be able to										
•	Understand the installation and usage of R in Linux operating system and SQL for database integration									
•	Use the R data types to construct programs in R									

●	Apply R packages for genomics and proteomic data
●	Comprehend the applications of R Programming in data mining and data visualisation
●	Analyse various biological data using R
<b>Suggested Activities</b>	
●	Case Studies
<b>Suggested Evaluation Methods</b>	
●	Quizzes
●	Class Presentation / Discussion
●	Multiple choice questions

<b>Text Books:</b>	
1	Dan MacLean, “R Bioinformatics Cookbook: Utilize R packages for bioinformatics, genomics, data science, and machine learning”, 2 <sup>nd</sup> edition, Packt Publishing, 2023.
2	Edward Curry, “Introduction to Bioinformatics with R: A Practical Guide for Biologists”, CRC Press, 2020.
3	Robert Gentleman, ‘R Programming for Bioinformatics’. CRC Press, 2009

<b>Reference Books:</b>	
1	Robert Gentleman, Vincent J. Carey, Wolfgang Huber, Rafael A. Irizarry, Sandrine Dudoit, “Bioinformatics and Computational Biology Solutions Using R and Bioconductor”, Springer, 2005.
2	Hadley Wickham and Jenny Bryan, “R Packages”, O’Reilly, 2023.
3	Garrett Golemund, Hadley Wickham, and Mine Çetinkaya-Rundel , ‘R for Data Science’, O’Reilly, 2019.

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
BT23E11.1	3	3	3	3	2	1	1	1	2	1	2	2	1	1	3
BT23E11.2	3	3	3	3	2	1	1	1	2	1	2	2	1	1	3
BT23E11.3	3	3	3	3	2	1	1	1	2	1	2	2	1	1	3
BT23E11.4	3	3	3	3	2	1	1	1	2	1	2	2	1	1	3
BT23E11.5	3	3	3	3	2	1	1	1	2	1	2	2	1	1	3
Average	3	3	3	3	2	1	1	1	2	1	2	2	1	1	3

BT23E12	<b>COMPUTER AIDED DRUG DESIGN</b>				<b>Category</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
					<b>PE</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

<b>Objectives:</b>									
●	To comprehend fundamentals of drug target interaction.								
●	To understand molecular modeling and informatics behind drug design								
●	To present appropriate tools for structure based, ligand based drug design								
●	To apply knowledge of 2D and 3D QSAR in drug design								
●	To analyze Molecular docking and Molecular dynamics								
<b>UNIT-I</b>	<b>ELECTRONIC STRUCTURE METHODS</b>								<b>8</b>
Quantum chemical methods semi-empirical and ab initio methods. Conformational analysis, energy									

minimization, predicting the mechanism of organic reactions using electronic structure methods.		
<b>UNIT-II</b>	<b>MOLECULAR MODELING</b>	<b>9</b>
Bioactive vs. global minimum conformations. Automated methods of conformational search. Advantages and limitations of available software. Molecular graphics. Computer methodologies behind molecular modeling including artificial intelligence methods.		
<b>UNIT-III</b>	<b>STRUCTURE ACTIVITY RELATIONSHIPS IN DRUG DESIGN</b>	<b>9</b>
Qualitative versus quantitative approaches advantages and disadvantages. Random screening, Non-random screening, rational approaches to lead discovery. Homologation, chain branching, ring-chain transformations. Insights into molecular recognition phenomenon. Structure based drug design, ligand based drug design.		
<b>UNIT-IV</b>	<b>QSAR: ELECTRONIC EFFECTS</b>	<b>9</b>
Hammett equation, lipophilicity effects. Hansch equation, steric effects. Taft equation. Experimental and theoretical approaches for the determination of physicochemical parameters, parameter inter-dependence: Regression analysis, Descriptor calculation. The importance of biological data in the correct form; 2D QSAR; 3D-QSAR examples of CoMFA and CoMSIA.		
<b>UNIT-V</b>	<b>MOLECULAR DOCKING</b>	<b>10</b>
Rigid docking, flexible docking, manual docking. Advantages and disadvantages of Flex-X, Flex-S, Autodock and Dock softwares, with successful examples. Dynamics of drugs, biomolecules, drug receptor complexes, Monte Carlo simulations and Molecular dynamics in performing conformational search and docking.		
		<b>Total Contact Hours : 45</b>
<b>Course Outcomes:</b>		
On completion of course students will be able to		
●	Gain knowledge on fundamental concepts, challenges, and opportunities in drug development	
●	Interpret and practice the fundamental concepts of Molecular Modeling and Computer aided Drug Design.	
●	Develop practical skills in computational approaches to analyse, predict, and engineer biomolecules and biomolecular systems.	
●	Design a chemical compound that can fit to a specific cavity based on structure activity relationship (QSAR) and ML	
●	Demonstrate the appropriate tools for such Molecular modelling, molecular docking and molecular dynamics	

<b>Suggested Activities</b>	
●	Case Studies
<b>Suggested Evaluation Methods</b>	
●	Quizzes
●	Class Presentation / Discussion
●	Multiple choice questions

<b>Text Books:</b>	
<b>1</b>	Andrew R. Leach, Molecular Modelling Principle and Application, 2nd Edition, Prentice Hall, England, 2001.
<b>2</b>	Richard B. Silverman, Mark W. Holladay, Organic Chemistry of Drug Design and Drug Action, 3rd Edition, Academic Press, USA, 2014.
<b>3</b>	Paul S. Charifson, Practical Applications of computer aided drug design, 1st Edition, Marcel Dekker, New York, 1997
<b>4</b>	J. M. Goodman, Chemical Applications of Molecular Modelling, The Royal Society of Chemistry, Cambridge, 1998.

<b>Reference Books:</b>	
<b>1</b>	Donald J. Abraham, Burger's Medicinal Chemistry and Drug Discovery, Vol V, 6th Edition, John Wiley and Sons, Inc., 2003.
<b>2</b>	John B. Taylor and David J. Triggle, Comprehensive Medicinal Chemistry II, Vol IV, Elsevier Science, 2006.
<b>3</b>	Graham L. Patrick, An Introduction to Medicinal Chemistry, 5th Edition, Oxford University Press, UK, 2013.
<b>4</b>	David. C. Young, Computational Drug Design – A Guide for Computational and Medicinal Chemists, John

	Wiley and Sons Ltd, Hoboken, United States, 2009.
5	Alan Hinchliffe, Molecular Modelling for Beginners, 2nd Edition, Wiley, United University of California, 2008.

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
BT23E12.1	3	3	3	3	2	1	1	1	2	1	2	2	1	1	3
BT23E12.2	3	3	3	3	2	1	1	1	2	1	2	2	1	1	3
BT23E12.3	3	3	3	3	2	1	1	1	2	1	2	2	1	1	3
BT23E12.4	3	3	3	3	2	1	1	1	2	1	2	2	1	1	3
BT23E12.5	3	3	3	3	2	1	1	1	2	1	2	2	1	1	3
Average	3	3	3	3	2	1	1	1	2	1	2	2	1	1	3

BT23E13	MOLECULAR MODELING				Category	L	T	P	C
					PE	3	0	0	3

<b>Objectives:</b>			
●	To learn Classical Mechanics for MM		
●	To comprehend basic Statistical Mechanics		
●	To analyze basic Quantum Mechanics		
●	To demonstrate the molecular behavior of proteins, nucleic acids and small molecules in the biological system.		
●	To apply Gaussian for QM/MM Calculation		
<b>UNIT-I INTRODUCTION TO CLASSICAL MECHANICS 9</b>			
Newtons laws of motion – time intervals- algorithms			
<b>UNIT-II INTRODUCTION TO STATISTICAL MECHANICS 9</b>			
Boltzman's Equation – Ensembles – Distribution law for non interacting molecules – Statistical mechanics of fluids.			
<b>UNIT-III QUANTUM MECHANICS 9</b>			
Photoelectric effect – De Broglies hypothesis – Uncertainty principle – Schrodingers time independent equation – particle in a one -dimensional box.			
<b>UNIT-IV GROMOS , GROMACS, AMBER &amp; DOCK 9</b>			
Various forcefields for proteins and nucleic acids – Molecular mechanics – Molecular dynamics– Molecular dynamics simulations in water and organic solvents.			
<b>UNIT-V GAUSSIAN 9</b>			
Preparing input files – job types – model chemistries – basis sets – molecule specifications running Gaussian – examples.			
			<b>Total Contact Hours : 45</b>
<b>Course Outcomes:</b>			
On completion of course students will be able to			
●	Understand the behavior of Small and macro molecules in biological system by molecular mechanics.		
●	Comprehend the behavior of molecular ensemble		
●	Utilize quantum mechanics in molecule formation and electron exchanging		
●	Simulate the biomolecules using molecular modelling softwares		
●	Apply Gaussian for MM/QM		

<b>Suggested Activities</b>	
●	Case Studies

Suggested Evaluation Methods	
•	Quizzes
•	Class Presentation / Discussion
•	Multiple choice questions

Text Books:	
1	Leach, Andrew R. "Molecular Modelling : Principles and Applications" IInd Edition, Pearson, 2010.
2	Cohen, N.C. "Guide Book on Molecular Modeling in Drug Design" Academic Press/ Elsevier, 1996.

Reference Books:	
1	Statistical Mechanics ; D. McQuarrie, Narosa, University Science Books; 1st edition 2000
2	Quantum Mechanics; D. McQuarrie, Narosa, 1999.
3	GROMOS Handbook <a href="http://www.gromacs.org">www.gromacs.org</a>

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
BT23E13.1	3	3	3	3	2	1	1	1	2	1	2	2	1	1	3
BT23E13.2	3	3	3	3	2	1	1	1	2	1	2	2	1	1	3
BT23E13.3	3	3	3	3	2	1	1	1	2	1	2	2	1	1	3
BT23E13.4	3	3	3	3	2	1	1	1	2	1	2	2	1	1	3
BT23E13.5	3	3	3	3	2	1	1	1	2	1	2	2	1	1	3
Average	3	3	3	3	2	1	1	1	2	1	2	2	1	1	3

BT23E14	FUNDAMENTALS OF ALGORITHMS FOR BIOINFORMATICS	Category	L	T	P	C
		PE	3	0	0	3

Objectives:		
•	To understand the basics of algorithms used in Bioinformatics	
•	To understand dynamic programming algorithm for sequence alignment	
•	To apply HMM in Biological sequence analysis	
•	To execute ANN in Biological data interpretation and problem solving	
•	To comprehend DNA/RNA related algorithm	
<b>UNIT-I</b>	<b>INTRODUCTION TO ALGORITHMS</b>	<b>9</b>
Algorithms-Complexity of algorithms and running time, Polynomial, NP complete problems, Recursion, Linear, Exhaustive search, Branch and Bound, divide and conquer algorithms, Travelling sales man problem, sorting.		
<b>UNIT-II</b>	<b>DYNAMIC PROGRAMMING AND SEQUENCE BASED ALGORITHMS</b>	<b>9</b>
Dynamic programming Principles and its uses. Local and Global alignment principles, Finding longest common subsequences, Heuristics second generation alignment tools for database searching : (Blast, FASTA, ClustalW), Statistical and Similarity based methods for gene prediction, Models of evolution.		
<b>UNIT-III</b>	<b>EXACT MATCH AND HIDDEN MARKOV MODELS</b>	<b>9</b>
Knuth-Morris- Pratt and Boyer-Moore algorithm for exact match and graph and maximumlikelihood algorithm, Hidden Markov Model: Forward and Backward Algorithms, Most probable state path: Viterbi algorithm, Parameter Estimation for HMMs:-Baum-Welch Algorithm, EMAlgorithm, Applications of profile HMMs for multiple alignment of proteins and for finding genes in the DNA.		
<b>UNIT-IV</b>	<b>ARTIFICIAL NEURAL NETWORKS</b>	<b>9</b>
Introduction to Artificial Neural Networks (ANN): A Simple Neuron, Firing rule, Network layers, Architectures		

of Artificial Neural Network: Feed-Forward networks, Feed-Back networks, Perceptrons, Pattern recognition problems, Back Propagation Algorithm, Applications of Neural Networks.			
<b>UNIT-V</b>	<b>DNA AND RNA RELATED ALGORITHMS</b>		<b>9</b>
Restriction enzyme mapping algorithms: algorithms for partial digest- double digest problem, Motif finding, Finding regulatory motifs in DNA, DNA computing, Genome alignment, Suffix Trees, RNA secondary structure prediction: Base pair maximisation and the Nussinov folding algorithm, Energy minimization and the Zuker folding algorithm, Design of covariance models, Application of RNA Fold.			
			<b>Total Contact Hours : 45</b>
<b>Course Outcomes:</b>			
On completion of course students will be able to			
●	Design various algorithm techniques and applying it in bioinformatics		
●	Apply dynamic programming in sequence analysis		
●	Analyze the sequences using HMM		
●	Apply ANN in data interpretation and biological problem solving		
●	Comprehend DNA/RNA related algorithm		

<b>Suggested Activities</b>	
●	Case Studies
<b>Suggested Evaluation Methods</b>	
●	Quizzes
●	Class Presentation / Discussion
●	Multiple choice questions

<b>Text Books:</b>	
<b>1</b>	Dan Gusfield-Algorithms on Strings, Trees and Sequences Computer Science and Computational Biology (1997) Cambridge University Press. ISBN-10: 0521585198
<b>2</b>	Horowitz, S. Sahini, and Rajasekharan: Fundamentals of Computer Algorithms, Galgotia Publications.
<b>Reference Books:</b>	
<b>1</b>	Neil C. Jones and Pavel.A Pevzner An introduction to Bioinformatics Algorithms, (computational Molecular Biology) (2004) MIT press. ISBN-10: 0262101068.
<b>2</b>	R. Durbin, S.Eddy, A.Krogh, G.Mitchison Biological sequence analysis: Probabilistic models of Proteins and Nucleic acids (2005) Cambridge University Press 0521540798
<b>3</b>	Michael.S.Waterman Introduction to Computational Biology: Maps, Sequences and Genomes, Waterman. Edition 2 (2012) Chapman and Hall/ CRC Press ISBN:1439861315

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
<b>BT23E14.1</b>	3	3	3	3	2	1	1	1	2	1	2	2	1	1	3
<b>BT23E14.2</b>	3	3	3	3	2	1	1	1	2	1	2	2	1	1	3
<b>BT23E14.3</b>	3	3	3	3	2	1	1	1	2	1	2	2	1	1	3
<b>BT23E14.4</b>	3	3	3	3	2	1	1	1	2	1	2	2	1	1	3
<b>BT23E14.5</b>	3	3	3	3	2	1	1	1	2	1	2	2	1	1	3
Average	3	3	3	3	2	1	1	1	2	1	2	2	1	1	3

<b>BT23E15</b>	<b>METABOLOMICS AND METABOLIC ENGINEERING</b>				<b>Category</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
					<b>PE</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

<b>Objectives:</b>	
●	To provide the fundamental knowledge on upcoming field of Metabolomics
●	To explore metabolic engineering in the post genomic era
●	To apply the Bioinformatics tools in metabolomics
●	To do the analysis of metabolic pathways using flux control
●	To redesign metabolism to enable the cells to produce new products
<b>UNIT-I</b>	<b>INTRODUCTION TO METABOLOMICS</b> <b>9</b>
Role of metabolomics in systems biology –application of metabolomics- Analytical methods in metabolomics — Data standards– Databases for Chemical, Spectral and Biological Data — Reconstruction of dynamic metabolic network model- examples- study of metabolome of a simple organism like <i>E.coli</i> . Online databases and pipelines for metabolomics – GC-MS based metabolomics – Computational methods to compute and integrate metabolic data-software for metabolomics- metabolomics and medical sciences	
<b>UNIT-II</b>	<b>INTRODUCTION TO METABOLIC ENGINEERING</b> <b>9</b>
Metabolic engineering: introduction, mass balance, black box, metabolic flux analysis,stoichiometry,Principles of metabolic engineering, Importance of metabolic engineering-comprehensive models for cellular reactions-material balances & data consistency- metabolic pathway synthesis	
<b>UNIT-III</b>	<b>METABOLIC FLUX ANALYSIS</b> <b>9</b>
Flux balance analysis, flux balance methods, group based flux balance, metabolic control analysis: overview, control coefficients, methods of measuring control. Flux analysis of networks- top down approach, bottom up approach	
<b>UNIT-IV</b>	<b>METABOLIC NETWORKS AND APPLICATIONS</b> <b>9</b>
Gene regulatory Network, Regulatory, Noncoding RNA, Computational Epigenetics. Constraint based Modeling, Kinetic model of metabolic networks-Systems metabolic engineering of <i>E.coli</i> .Applications of Metabolomics to biology:examples and casestudies,Metabolome informatics, data integration and mining	
<b>UNIT-V</b>	<b>NETWORK APPROACHES</b> <b>9</b>
Network approaches for microbial communities, host-pathogen interactions, Synthetic Biology,Classic Circuit design experiments, Designing modules, systems theoretic approaches, Robustness in Biological systems, Genotype Spaces and Genotype Networks, Quantifying Robustness, Software tools	
<b>Total Contact Hours</b> : <b>45</b>	
<b>Course Outcomes:</b>	
On completion of course students will be able to	
●	Understand the concept of Metabolome and Metabolomics.
●	Apply the Bioinformatics tools in metabolomics
●	Summarize the fundamentals of Metabolic engineering
●	Analyze the metabolic pathways using flux control.
●	Develop new products using metabolic engineering

<b>Suggested Activities</b>	
●	Case Studies
<b>Suggested Evaluation Methods</b>	
●	Quizzes
●	Class Presentation / Discussion
●	Multiple choice questions

<b>Text Books:</b>	
<b>1</b>	Jens Hřiriis Nielsen, Michael C. Jewett, “Metabolomics: A Powerful Tool in Systems Biology”,Springer, 2007.
<b>2</b>	Dr. ChristophWittmann, Sang Yup. Lee, “Systems Metabolic Engineering”, Springer 2012.
<b>3</b>	Gregory N. Stephanopoulos, “Metabolic Engineering- Principles and Methodologies”, Academicpress, First Edition, 1998.
<b>4</b>	Sang Yup Lee, E. Terry Papoutsakis, “Metabolic engineering”, CRC Press, 1999.



<b>Reference Books:</b>	
<b>1</b>	Tomita M., T. Nishioka, "Metabolomics: The Frontier of Systems Biology", Springer, 2003
<b>2</b>	Gregory N. Stephanopoulos, "Metabolic Engineering: Principles and Methodologies", Academic Press, First Edition, 1998
<b>3</b>	Wolfram Weckwerth, "Metabolomics: Methods And Protocols", Humana Press, 2007
<b>4</b>	Cortassa S. "An Introduction to Metabolic and Cellular Engineering", World scientific public company Ltd., 2002.

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
<b>BT23E15.1</b>	3	3	3	3	2	1	1	-	2	2	2	2	2	2	3
<b>BT23E15.2</b>	3	3	3	3	2	1	1	-	2	2	2	2	2	2	3
<b>BT23E15.3</b>	3	3	3	3	2	1	1	-	2	2	2	2	2	2	3
<b>BT23E15.4</b>	3	3	3	3	2	1	1	-	2	2	2	2	2	2	3
<b>BT23E15.5</b>	3	3	3	3	2	1	1	-	2	2	2	2	2	2	3
Average	3	3	3	3	2	1	1	-	2	2	2	2	2	2	3

<b>BT23E16</b>	<b>DATA MINING AND MACHINE LEARNING TECHNIQUES FOR BIOINFORMATICS</b>	<b>Category</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		<b>PE</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

<b>Objectives:</b>	
●	To study the overview of machine learning techniques.
●	To acquire knowledge of machine learning techniques and its application
●	To demonstrate data mining and its importance in ML
●	To understand the data pre-processing and visualization.
●	To apply data mining in Biological data.
<b>UNIT-I</b>	<b>OVERVIEW OF MACHINE LEARNING TECHNIQUES</b> <b>9</b>
Supervised and unsupervised techniques. Empirical Risk Minimization, Structural Risk Minimization; Measuring the accuracy of learned hypotheses. Comparing learning algorithms: cross-validation, learning curves, and statistical hypothesis testing.	
<b>UNIT-II</b>	<b>MACHINE LEARNING TECHNIQUES</b> <b>9</b>
Classification: Decision tree, Bayesian, Rule based classification, ANN, SVM, HMM; Case based reasoning and Applications in Bioinformatics. Clustering: Partition Methods, Hierarchical methods, Density based methods, Grid based clustering, Model based clustering, clustering of high dimensional data, constraints based clustering, Analysis of MD trajectories, Protein Array data Analysis.	
<b>UNIT-III</b>	<b>INTRODUCTION TO DATA MINING</b> <b>9</b>
Introduction to Data mining, Data mining Functionalities, Classification of Data mining Systems, Data Mining Task Primitives, Integration of Data mining systems, Major issues of Data mining.	
<b>UNIT-IV</b>	<b>DATA PREPROCESSING AND VISUALIZATION</b> <b>9</b>
Overview of data preprocessing, Data cleaning, Data integration, Data reduction, Data transformation and discretization, Visualization- Visualizing a single attributes, Visualizing pair of attributes, Visualizing several attributes, Visualizing results of machine learning.	
<b>UNIT-V</b>	<b>APPLICATIONS OF DATA MINING</b> <b>9</b>
Application of Data Mining in Biodata analysis: DNA/protein sequence Analysis, Genome analysis, Protein Structure Analysis, Pathway analysis, microarray data analysis, annotation, gene ontology, gene mapping. Biological data mining tools: Entrez, Blast, sequence retrieval system (SRS).	
<b>Total Contact Hours</b> : <b>45</b>	

<b>Course Outcomes:</b>	
On completion of course students will be able to	
●	Recognize the basic notions and terminology used in Machine learning and Data mining.
●	Comprehend the essential machine learning techniques.
●	Understand fundamental principles of modern data mining.
●	Realize the applications of Machine learning and Data mining in biological data processing and visualization.
●	Correlate various applications of data mining in Biological data.

<b>Suggested Activities</b>	
●	Softwares / Tools : Hands on
<b>Suggested Evaluation Methods</b>	
●	Quizzes
●	Class Presentation / Discussion
●	Multiple choice questions

<b>Text Books:</b>	
1	Witten, H. I., Frank, E. and Hall, M. A. 2011. Data Mining: Practical Machine Learning Tools and Techniques.
2	Hastie, T., Tibshirani, R., Friedman, J. H. 2009. The Elements of Statistical Learning: Data Mining Interface and Prediction.
3	Clarke, S. B., Fokoue, E. and Zhang, H. H. 2009 Principles and Theory for Data Mining and Machine Learning.

<b>Reference Books:</b>	
1	Data Mining: Concepts and Techniques by Jiawei Han and Micheline Kamber, 2000
2	Data Mining Techniques, A. K. Pujari, University Press, Hyderabad, 2006
3	Data mining in bioinformatics by Wang et al, Springer-Verlag, 2005

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
BT23E16.1	1	1	1	1	2	2	1	1	1	2	1	3	3	3	3
BT23E16.2	1	1	2	1	3	2	1	1	1	2	1	3	3	3	3
BT23E16.3	1	1	2	1	3	2	1	1	1	2	1	3	3	3	3
BT23E16.4	1	1	2	3	3	2	1	1	1	2	1	3	3	3	3
BT23E16.5	1	1	3	3	3	2	1	2	1	2	1	3	3	3	3
Average	1	1	2	1.8	2.8	2	1	1.2	1	2	1	3	3	3	3

### VERTICAL VI – PLANT AND MARINE TECHNOLOGY

Subject code	FUNDAMENTALS OF PLANT BIOTECHNOLOGY	Category	L	T	P	C
BT23F11		PE	3	0	0	3

<b>Objectives:</b>	
●	To understand the structure and function of nucleosomes and their significance in the organization of genetic material in plant cells.
●	To explore the structure, function, and genetic material of chloroplasts and mitochondria, and

	understand the synthesis and assembly of rubisco.
•	To study the mechanisms of nitrogen fixation, including the role of nitrogenase, nod genes, nif genes, and bacteroids.
•	To learn about the pathogenesis of Agrobacterium, crown gall disease, and the importance of Ti plasmids and viral vectors in genetic engineering.
•	To understand the principles and applications of plant tissue culture, the development of transgenic plants, and the creation of herbicide and pest-resistant plants.

<b>UNIT-I</b>	<b>ORGANIZATION OF GENETIC MATERIAL</b>	9
Genetic material of plant cells – nucleosome structure and its biological significance; junk and repeat sequences; outline of transcription and translation. Regulation of Eukaryotic gene expression.		
<b>UNIT-II</b>	<b>CHLOROPLAST &amp; MITOCHONDRIA</b>	9
Structure, function and genetic material; rubisco synthesis and assembly, coordination, regulation and transport of proteins. Mitochondria: Genome, cytoplasmic male sterility and import of proteins.		
<b>UNIT-III</b>	<b>NITROGEN FIXATION</b>	9
Nitrogenase activity - Structure and Function of Nitrogenase, Regulation of Nitrogenase Activity, Inhibition of Nitrogenase; Nod genes - Types of Nod Genes, Nod Factors, Regulation of Nod Gene Expression, Role in Symbiosis; Nif genes - Structure and Function of nif Genes, nif Gene Regulation, Horizontal Gene Transfer, Biotechnological Applications; Bacteroids - Bacteroid Formation, Metabolic Activity in Bacteroids, Symbiosome Structure, Senescence and Degradation.		
<b>UNIT-IV</b>	<b>AGROBACTERIUM &amp; VIRAL VECTORS</b>	9
Pathogenesis, crown gall disease, genes involved in the pathogenesis, Ti plasmid – t-DNA, importance in genetic engineering. Viral Vectors: Gemini virus, cauliflower mosaic virus, viral vectors and its benefits		
<b>UNIT-V</b>	<b>APPLICATION OF PLANT BIOTECHNOLOGY</b>	9
Outline of plant tissue culture, Transgenic plants, Herbicide and pest resistant plants, Molecular pharming, Vertical Farming and Aquaponics, Therapeutic products, Case studies on the development of GMO crops in India and US.		
		<b>Total Contact Hours : 45</b>

Course Outcomes: Upon completion of the course, the students will be able to	
•	Explain the role of nucleosomes in the organization of genetic material and how they affect gene expression.
•	Demonstrate knowledge of the genetic and functional differences between chloroplasts and mitochondria, including their roles in cellular processes.
•	Describe the biochemical processes of nitrogen fixation and the genetic components involved.
•	Analyze the mechanisms of Agrobacterium-mediated gene transfer and the use of viral vectors in plant genetic engineering.
•	Discuss the techniques and implications of producing transgenic plants and the benefits of biotechnology in agriculture.
<b>Suggested Activities</b>	
•	Problem solving sessions
•	Case studies discussion
<b>Suggested Evaluation Methods</b>	
•	Quizzes
•	Class Presentation / Discussion
•	Multiple choice questions

Text Book(s):	
1	Gamburg OL, Philips GC, Plant Tissue & Organ Culture fundamental Methods, Narosa Publications. 1995.
2	Singh BD. Text Book of Biotechnology, Kalyani Publishers. 1998
3	Adrian Slater, —Plant Biotechnologyll, Oxford University Press, USA, 2003.

Reference Books(s) / Web links:	
1	Heldt HW. Plant Biochemistry & Molecular Biology, Oxford University Press. 1997.
2	Ignacimuthu .S, Applied Plant Biotechnology, Tata McGraw Hill. 1996.
3	<a href="https://archive.nptel.ac.in/courses/102/106/102106080/">https://archive.nptel.ac.in/courses/102/106/102106080/</a>

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
BT23F11.1	1	1	1	1	1	1	2	1	1	2	1	3	2	1	1
BT23F11.2	1	1	1	1	1	1	2	1	1	2	1	3	2	1	1
BT23F11.3	1	1	1	1	1	1	2	1	1	2	1	3	2	1	1
BT23F11.4	2	2	2	1	2	1	2	2	1	2	2	3	3	2	1
BT23F11.5	3	3	3	2	2	2	2	2	1	2	3	3	3	3	3
Average	1.6	1.6	1.6	1.2	1.4	1.2	2	1.4	1	2	1.6	3	2.4	1.6	1.4

Subject code	THERAPEUTIC APPLICATIONS OF PHYTOCHEMICALS	Category	L	T	P	C
			3	0	0	3
BT23F12		PC	3	0	0	3

**Course objectives:**

This course will enable the students to

- Understand the history and classification of plant natural products
- Summarize the biological properties of glycosides and flavonoids
- Analyze the therapeutic properties of anthocyanins and coumarins
- Understand the importance and the medical purpose of lignans, terpenes, volatile oils, saponins, lignans and neolignans
- Comprehend biogenesis and physicochemical properties of carotenoids and alkaloids

<b>UNIT I</b>	<b>INTRODUCTION OF PLANT NATURAL PRODUCTS</b>	<b>9</b>
History- general significance- classification: Alkaloids, phenylpropanoids, polyketides, terpenoids - list of floral sources- general detection, extraction and characterization procedures.		
<b>UNIT II</b>	<b>GLYCOSIDES AND FLAVONOIDS GLYCOSIDES</b>	<b>9</b>
Classification, therapeutic value, chemical properties & tests for identification: Baljet's test, Keller killian's test, Raymond's reaction, Kedde's reaction. Flavonoids: Sources, classification, biogenesis, extraction, isolation, identification and therapeutic applications.		
<b>UNIT-III</b>	<b>ANTHOCYANINS AND COUMARINS ANTHOCYANINS</b>	<b>9</b>
Sources, classification, extraction, isolation, identification, functions and therapeutic applications of Coumarins, Furanocoumarins and pyranocoumarins.		
<b>UNIT-IV</b>	<b>LIGNANS, TERPENES, VOLATILE OILS, SAPONINS LIGNANS AND NEOLIGNANS</b>	<b>9</b>
Classification, natural sources and pharmacological applications. Terpenes:, Classification, biosynthesis, origin of 5-carbons isoprene unit, head to tail coupling and tail-totail coupling of isoprene units - Volatile Oils: Classifications, sources, medicinal and non-medicinal uses - Saponins : Sources, classification, physical and biological properties, Lignans and Neolignans: Source and biological properties.		
<b>UNIT-V</b>	<b>CAROTENOIDS AND ALKALOIDS CAROTENOIDS</b>	<b>9</b>
Sources, Biogenesis, classification, biological functions and therapeutic values. Alkaloids: Classification, distribution in nature, localization, nomenclature, physico -chemical properties, extraction, detection, isolation, purification, biosynthetic origin and pharmacological activities, Nutraceuticals.		
<b>Total Contact Hours</b>		<b>: 45</b>

<b>Course outcomes:</b> Upon completion of the course, the students will be able to	
•	Understand the history and classification of plant natural products
•	Comprehend the classification and biological properties of glycosides and flavonoids
•	Recognize the therapeutic properties of anthocyanins and coumarins
•	Elucidate the importance and the medical purpose of lignans, terpenes, volatile oils, saponins, lignans and neolignans
•	Compute the biogenesis and physicochemical properties of carotenoids and alkaloids
<b>Suggested Activities</b>	
•	Problem solving sessions
<b>Suggested Evaluation Methods</b>	
•	Quizzes
•	Class Presentation / Discussion
•	Tutorial Problems
•	Multiple choice questions

<b>Text books:</b>	
•	Agarwal, O. P. 2002. Organic chemistry–Chemistry of organic natural products. Vol. II. Goel publishing house, Meerut.
•	Farooqui, A. A. and Sreeraman, B. S. 2001. Cultivation of medicinal and aromatic crops. Universities Press.
•	Harborne, J. B. 1998. Phytochemical methods –a guide to modern techniques of plant analysis 3rd edition, Chapman and Hall.
•	Yesodha, D., Geetha, S and Radhakrishnan, V. 1997. Allied Biochemistry. Morgan publications, Chennai.

<b>Reference books:</b>	
•	Ramawat, K. G. and Mérillon, J.M., 2013. Natural Products. Springer. doi:10.1007/978-3-642-22144-6 .
•	Kalsi, P. S. and Jagtap, S., 2012. Pharmaceutical medicinal and natural product chemistry. N.K. Mehra for Narosa Publishing House Pvt. Ltd. New Delhi.

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO 1	PSO2	PSO3
BT23F12.1	2	3	-	2	-	-	1	-	-	2	2	3	3	3	3
BT23F12.2	2	3	-	2	-	-	1	-	-	2	2	3	3	3	3
BT23F2.3	2	3	-	2	-	-	1	-	-	2	2	3	3	3	3
BT23F12.4	2	3	-	2	-	-	1	-	-	2	2	3	3	3	3
BT23F12.5	2	3	-	2	-	-	1	-	-	2	2	3	3	3	3
Average	2	3	-	2	-	-	1	-	-	2	2	3	3	3	3

<b>Subject code</b>	<b>MARINE BIOTECHNOLOGY</b>	<b>Category</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>BT23F13</b>		<b>PE</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

<b>Objectives:</b>	
•	To provide strong knowledge on marine ecosystem and marine biotechnology
•	To educate about the flora and fauna of marine environment
•	To comprehend the ways and means to protect the environment from various types of pollution
•	To know the importance of marine products

●	To learn the importance of aquaculture technology	
<b>UNIT-I</b>	<b>INTRODUCTION TO MARINE ENVIRONMENT</b>	7
World oceans and seas – ocean currents – physical and chemical properties of sea water– abiotic and biotic factors of the sea – ecological divisions of the sea – history of marine biology, biogeochemical cycles – food chain – definition and types – Ecosystem - food web.		
<b>UNIT-II</b>	<b>IMPORTANT MARINE ORGANISMS</b>	7
Phytoplanktons – zooplanktons – nektons – benthos – marine mammals – marine algae – mangroves – establishment nursery and restoration - coral reefs – deep sea animals and adaptation – intertidal zone – fauna and flora –Genetically modified organisms.		
<b>UNIT-III</b>	<b>MARINE ENVIRONMENTAL BIOTECHNOLOGY</b>	8
Marine pollution – biology indicators (marine micro, algae)- Biofilm – Biodegradation - bioremediation – Marine fouling – corrosion (physical and chemical/electrochemical), - Ill effects on Marine and Threat to Micro environment, Case study of application of biotechnology in marine bioremediation – Biological approach and ecological approach - Cost effectiveness of bioremediation.		
<b>UNIT-IV</b>	<b>MARINE PHARMACOLOGY</b>	11
Medicinal compound from marine flora and fauna (cone snails, bacteria, cyanobacteria, fungi, and halophytes) - neuroprotective, anticancer, or anti-inflammatory properties – marine toxins, antiviral and antimicrobial agents. Pharmacology of marine derived drugs - Marine-derived drug development.		
<b>UNIT-V</b>	<b>AQUACULTURE TECHNOLOGY</b>	12
Importance of coastal aquaculture - sustainability model – Environmental impact assessment – Marine fishery resources – common fishing, crafts and gears – Aqua farm design and construction: Aquaponics – Biotechnology in controlling sex and breeding cycle – Disease and health management – Nutrition and feed.		
		<b>Total Contact Hours : 45</b>

<b>Course Outcomes:</b> Upon completion of the course, the students will be to	
●	Learn about different marine ecosystems
●	Identify the flora and fauna of marine environment
●	Aware of the ways and means to protect the environment from various types of pollution.
●	Comprehend the importance of marine organisms and produce new marine products
●	Design aquaculture farm with new technology
<b>Suggested Activities</b>	
●	Problem solving sessions
<b>Suggested Evaluation Methods</b>	
●	Quizzes
●	Class Presentation / Discussion
●	Multiple choice questions

<b>Text Book(s):</b>	
1	Recent advances in marine biotechnology volume 3 – M.Fingerman, R .Nagabhushanam Mary – Frances Thomson.
2	Recent advances marine biotechnology volume 2 – M.Fingerman , R .Nagabhushanam Mary – Frances Thomson.

<b>Reference Books(s) / Web links:</b>	
1	Aquaculture Biotechnology, First edition, 2012, Eds. Garth L. Fletcher and Mathew L Rise, Wiley-Blackwell publication
2	Bhakuni, D.S., and Rawat, D.S., (Eds.), 2005, Bioactive Marine Natural Products, Springer, Anamya Publications, New Delhi
3	Steven M. Colegate and Russel J. Molyneux. 2008. Bioactive Natural Products (II Ed.). CRC Press
4	<a href="https://onlinecourses.swayam2.ac.in/cec23_bt22/preview">https://onlinecourses.swayam2.ac.in/cec23_bt22/preview</a>

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
BT23F13.1	3	3	-	1	-	2	3	2	-	2	3	3	3	3	3
BT23F13.2	3	3	-	2	-	2	3	2	-	2	3	3	3	3	3
BT23F13.3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
BT23F13.4	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
BT23F13.5	3	3	3	3	3	3	3	3	3	2	3	3	3	3	3
Average	3	3	3	2.4	3	2.6	3	2.6	3	2.4	3	3	3	3	3

Subject code	BIO-FERTILIZER PRODUCTION AND MUSHROOM CULTIVATION	Category	L	T	P	C
BT23F14		PC	3	0	0	3
<b>Course objectives:</b>						
•	To gain knowledge on different types of mushrooms, its medicinal and nutritional benefits.					
•	To equip with skills in bio-composting and biofertilizer production.					
•	To instill the ability and skills required to become self-employed / entrepreneur.					
•	To gain knowledge on the marketing potential of the produced mushroom and composts.					
•	To assess the challenges and opportunities in bio-fertilizer production.					

<b>UNIT I</b>	<b>BIO-FERTILIZERS AND THEIR PRODUCTION</b>	<b>9</b>
Introduction - Types: Microbes as biofertilizer, Green manure, importance of macronutrients ;Biofertilizers vs Chemical fertilizers; Nitrogen fixers – types and examples; Phosphate solubilizers – role of bacteria and Mycorrhizae -Mass cultivation and Application of the following biofertilizers: i)Rhizobium ii)Azospirillum iv) Cyanobacteria v) Mycorrhizae Quality control; Challenges and opportunities; Biofertilizer Entrepreneurship.		
<b>UNIT II</b>	<b>COMPOSTING TECHNIQUES</b>	<b>9</b>
History of composting – compost - composting processes - microbiology of composting fate of pathogens - ingredients in composting - various methods of composting: vermi-composting and home composting-steps in composting.		
<b>UNIT-III</b>	<b>MUSHROOM BIOLOGY MORPHOLOGY</b>	<b>9</b>
Classification: edible and poisonous mushrooms. Life cycle of Basidiomycetes fungi. Breeding and Genetic improvement of mushroom strains. Medicinal and Nutritional value of mushrooms.		
<b>UNIT-IV</b>	<b>MUSHROOM CULTIVATION TECHNIQUES</b>	<b>9</b>
Cultivation conditions for tropical and temperate countries. Isolation, spawn production, growth media, spawn running and harvesting of mushrooms ( <i>Volvariella spp.</i> , <i>Pleurotus spp.</i> , <i>Agaricus spp.</i> , <i>Calocybe spp.</i> , and <i>Lentinus spp.</i> ). Diseases / contamination; Post Harvest Technology: Freezing, drying, freeze drying and canning.		
<b>UNIT-V</b>	<b>ECONOMICS OF MUSHROOM CULTIVATION</b>	<b>9</b>
Economics of the production of oyster mushroom, milky mushroom and paddy straw mushroom cultivation: Infrastructure facilities, expenditure on fixed assets, plant and machinery, cost of the project, recurring expenditure, interest and depreciation of the expenditure, cost of production and profit. Entrepreneurship in mushroom cultivation.		
<b>Total Contact Hours</b>		<b>: 45</b>

<b>Course outcomes:</b> Upon completion of the course, the students will be able to	
•	Understand mushroom cultivation, using different types of mushrooms
•	Acquire the skills in bio-composting and biofertilizer production.
•	Identify the ability and skills required to become self-employed / entrepreneur.

•	Understand about the marketing potential of the produced mushroom and composts.
•	Assess the challenges and opportunities in bio-fertilizer production.
<b>Suggested Activities</b>	
•	Problem solving sessions
<b>Suggested Evaluation Methods</b>	
•	Quizzes
•	Class Presentation / Discussion
•	Multiple choice questions

<b>Text books:</b>	
1.	Nita Bahl, 2002. Hand Book on Mushroom Cultivation. 4th Edition, Vijay Primlani for Oxford & IBH Publishing Co., Press, New York, New Delhi.
2.	Biswas, S, Datta, M and Nagachan, S.V. 2012. Mushrooms- A manual for cultivation. PHI Learning Private Limited, New Delhi.
3.	Krishnamoorthy, 1999. Hand Book of Mushroom Cultivation. TNAU Publications, Coimbatore, TN, India.
4.	SubbaRao, N. S., 1988, Biofertilizers in agriculture. Oxford & IBH Publishing Company, New Delhi.
5.	SubbaRao, N. S., 1977, Soil microorganisms and Plant Growth. Oxford & IBH Publishing Company, New Delhi.
6.	SubbaRao, N. S., 1998, Biofertilizers in agriculture and forestry. India Book House Ltd. New Delhi.

<b>Reference books:</b>	
1.	Chang, T.S. and Hayes, W.A. 1978. The Biology and Cultivation of Edible Mushrooms. Academic Press, New York.
2.	M.C. Nair, C. Gokulapalan and Lulu Das, 1997. Topics on Mushroom Cultivation. Scientific Publishers, Jodhpur, India.

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
BT23F14.1	3	3	3	3	3	2	2	-	1	1	2	3	3	3	3
BT23F14.2	3	3	3	3	3	2	2	-	1	1	2	3	3	3	3
BT23F14.3	3	3	3	3	3	2	2	-	1	1	2	3	3	3	3
BT23F14.4	3	3	3	3	3	2	2	-	1	1	2	3	3	3	3
BT23F14.5	3	3	3	3	3	2	2	-	1	1	2	3	3	3	3
Average	3	3	3	3	3	2	2	-	1	1	2	3	3	3	3

<b>Subject code</b>	<b>PLANT TISSUE CULTURE AND TRANSFORMATION TECHNIQUES</b>	<b>Category</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>BT23F15</b>		<b>PC</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

**Course objectives:** This course will enable the students to

•	Understand the history and basic principles of plant tissue culture
•	Elucidate the principles and protocol for embryogenesis and germ plasm
•	Analyse the basic principles and protocols of organ culture
•	Apply the propagation and importance of tissue culture in forest trees
•	Develop various applications and methods of genetic transformation in plants

<b>UNIT I</b>	<b>PLANT TISSUE CULTURE - 1</b>	<b>9</b>
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History of plant tissue culture research - basic principles of plant tissue callus culture, meristem culture, organ culture, Totipotency of cells, differentiation and redifferentiation. Methodology -sterilization (physical and chemical methods), culture media – composition and preparation of Murashige and Skoog's (MS medium), phytohormones, medium for micro-propagation/clonal propagation of ornamental and horticulturally important plants, Callus subculture maintenance, growth measurements, morphogenesis.		
<b>UNIT II</b>	<b>PLANT TISSUE CULTURE - 2</b>	<b>9</b>
Endosperm culture: types and procedure – Embryo culture -culture requirements – applications, embryo rescue technique. Production of secondary metabolites. Cryopreservation; Germ plasm conservation.		
<b>UNIT-III</b>	<b>ORGAN CULTURE</b>	<b>9</b>
Anther and pollen culture techniques, Embryo & Meristem culture. Organogenesis – principle, protocol and application, somatic embryogenesis and artificial seeds. Somatic Hybridization: Isolation, fusion and protoplast culture. Somoclonal Variation & cryopreservation.		
<b>UNIT-IV</b>	<b>TISSUE CULTURE IN FOREST TREES</b>	<b>9</b>
Micropropagation and its application, In vitro propagation via enhanced release of auxiliary buds. Somatic organogenesis and somatic embryo genesis, leaf diseases, Embryoid and synthetic seed production. Haploid culture and production of homodiploids, Protoplast isolation, culture and regeneration.		
<b>UNIT-V</b>	<b>TRANSFORMATION TECHNIQUES</b>	<b>9</b>
Genetic transformation techniques in plants: Gene transfer methods in plants – Direct DNA transfer methods: PEG, micro injection, electroporation, microprojectile (biolistics) method, Agro bacterium mediated nuclear transformation. Ti and Ri plasmids, binary & cointegrated vector systems; genetic markers; reporter genes; genetic transformation techniques for overcoming biotic and abiotic stress. Green house and green home Technology. Arid and semiarid Technology.		
		<b>Total Contact Hours : 45</b>

<b>Course outcomes:</b> Upon completion of the course, the students will be able to	
•	Understand the history and basic principles of plant tissue culture.
•	Comprehend the principles and protocol for embryogenesis and germ plasm.
•	Elucidate the basic principles and protocol of organ culture.
•	Apply knowledge on propagation and importance of tissue culture in forest trees.
•	Enumerate the various applications and methods of genetic transformation in plants.
<b>Suggested Activities</b>	
•	Problem solving sessions
<b>Suggested Evaluation Methods</b>	
•	Quizzes
•	Class Presentation / Discussion
•	Tutorial Problems
•	Multiple choice questions

<b>Text books:</b>	
•	Botany-Plant tissue culture and its biotechnological applications, by B. R. C. Murthy & V. S. T. Sai, Venkateswara Publications.
•	Kalyan Kumar De (2001) An Introduction to Plant Tissue Culture, New Central Book Agency (P) Ltd., Calcutta
•	Razdan, M.K. (2005) Introduction to Plant Tissue Culture, Oxford & IBH Publishers, Delhi

<b>Reference books:</b>	
•	Pullaiah. T. and M.V.Subba Rao. 2009. Plant Tissue culture. Scientific Publishers, New Delhi.
•	Bhojwani, S.S. and Razdan, M.K., (1996). Plant Tissue Culture: Theory and Practice. Elsevier Science Amsterdam. The Netherlands.
•	Glick, B.R., Pasternak, J.J. (2003). Molecular Biotechnology- Principles and Applications of recombinant DNA. ASM Press, Washington.

●	Bhojwani, S.S. and Bhatnagar, S.P. (2011). The Embryology of Angiosperms. Vikas Publication House Pvt. Ltd., New Delhi. 5th edition.
●	Snustad, D.P. and Simmons, M.J. (2010). Principles of Genetics. John Wiley and Sons, U.K. 5th edition.
●	Stewart, C.N. Jr. (2008). Plant Biotechnology & Genetics: Principles, Techniques and Applications. John Wiley & Sons Inc. U.S.A.

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO 1	PSO2	PSO3
BT23F15.1	2	1	-	-	-	-	3	-	-	1	3	3	3	3	3
BT23F15.2	2	1	-	-	-	-	3	-	-	1	3	3	3	3	3
BT23F15.3	2	1	-	-	-	-	3	-	-	1	3	3	3	3	3
BT23F15.4	2	1	-	-	-	-	3	-	-	1	3	3	3	3	3
BT23F15.5	2	1	-	-	-	-	3	-	-	1	3	3	3	3	3
Average	2	1	-	-	-	-	3	-	-	1	3	3	3	3	3

Subject code	TOTAL QUALITY MANAGEMENT	Category	L	T	P	C
ME23712		PC	3	0	0	3

**Objectives:**

●	To understand the Fundamentals of Quality and TQM
●	To explore Leadership and Customer Focus in TQM
●	To master Quality Tools and Techniques
●	To apply Advanced Quality Management Concepts
●	To gain knowledge of ISO Standards and Environmental Management Systems

UNIT-I	INTRODUCTION	8
Introduction - Need for quality - Evolution of quality - Definitions of quality - Dimensions of product and service quality - Basic concepts of TQM - TQM Framework - Contributions of Deming, Juran and Crosby - Barriers to TQM - Quality statements - Customer focus - Customer satisfaction, Customer complaints, Customer retention.		
UNIT-II	TQM PRINCIPLES	10
Leadership, Quality Councils - Employee involvement - Motivation, Empowerment, Team and Teamwork, Recognition and Reward, Performance appraisal - Continuous process improvement – Juran Trilogy, PDCA cycle, 5S, Kaizen, 8D methodology - Supplier partnership - Partnering, Supplier selection and certification, Supplier rating.		
UNIT-III	TQM TOOLS & TECHNIQUES I	9
The seven traditional quality tools - New management tools - Six Sigma, Lean Six Sigma: Concepts, Methodology, applications to manufacturing, service sector including IT - Bench marking – Types, Reason to Bench mark, Bench marking process, Benefits - FMEA - Stages, Procedure, Types.		
UNIT-IV	TQM TOOLS & TECHNIQUES II	9
Quality Circles – Cost of Quality – Quality Function Deployment (QFD) – House of Quality – QFD Process - Taguchi quality loss function – Total Productive Maintenance (TPM) – Concepts, development program, fundamental activities, benefits, POKA-YOKE, JIT Concepts.		
UNIT-V	QUALITY MANAGEMENT SYSTEM	9
Introduction—Benefits of ISO Registration—ISO 9000 Series of Standards—Sector-Specific Standards—AS 9100, TS16949 and TL 9000– ISO 9001 Requirements—Implementation—Documentation—Internal Audits—Registration - Environmental Management System: Introduction—ISO 14000 Series Standards—Concepts of ISO 14001— Requirements of ISO 14001— EMS implementation - Benefits of EMS.		
<b>Total Contact Hours</b>		<b>: 45</b>

**Course Outcomes:** Upon completion of the course in Quality Management in Biotechnology, graduates will be able to

●	Understand the importance of quality in engineering.
●	Conceptualize various principles in TQM and continuous process improvement.
●	Explore the knowledge of implementing various TQM tools.
●	Demonstrate the applications of various tools like QFD and TPM for quality improvement.
●	Implement ISO-9000 & ISO-14000 in manufacturing and service sectors.

**Suggested Activities**

- Debates

**Suggested Evaluation Methods**

- Quizzes
- Class Presentation / Discussion
- Multiple choice questions

**Text Book(s):**

1	Dale H.Besterfield, Carol B.Michna,Glen H. Bester field,MaryB.Sacre, HemantUrdhwareshe and RashmiUrdhwareshe, “Total Quality Management”, Pearson Education Asia, Revised Third Edition, Indian Reprint, Sixth Impression,2013.
2	Quality Control & Application by B. L. Hanson & P. M. Ghare, Prentice Hall of India, 2004
3	Total Quality Management by R.S Naagarazan ,New Age international,3e, 2015

**Reference Books(s) / Web links:**

1	Joel.E. Ross, “Total Quality Management – Text and Cases, Routledge, 2017.
2	Kiran.D.R, “Total Quality Management: Key concepts and case studies, Butterworth – Heinemann Ltd, 2016.
3	Oakland, J.S. “TQM – Text with Cases”, Butterworth – Heinemann Ltd., Oxford, Third Edition, 2003.
4	Suganthi, L and Anand Samuel, “Total Quality Management”, Prentice Hall (India) Pvt. Ltd., 2006
5	Zeiri. “Total Quality Management for Engineers”, Wood Head Publishers, 1991

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
ME23712.1	1	1	1	1	1	2	1	2	1	1	1	3	2	2	3
ME23712.2	1	1	2	1	1	2	1	2	1	1	1	3	2	2	3
ME23712.3	1	1	2	1	1	2	2	2	2	1	1	3	2	2	3
ME23712.4	1	1	2	1	1	2	2	2	2	1	1	3	2	2	3
ME23712.5	1	1	3	2	1	2	3	2	2	1	1	3	2	2	3
Average	1	1	2	1.2	1	2	1.8	2	1.6	1	1	3	2	2	3