

# **NATIONAL INSTITUTE OF TECHNOLOGY ANDHRA PRADESH**



**RULES AND REGULATIONS  
SCHEME OF INSTRUCTION AND SYLLABI  
B.Tech Biotechnology  
Effective from 2024-25 Batch only**



## **NATIONAL INSTITUTE OF TECHNOLOGY ANDHRA PRADESH**

### **VISION**

To nurture and produce highly competent engineers, scientists and entrepreneurs committed towards catering to futuristic societal challenges through holistic education synergetic with innovations and vibrant research eco-system.

### **MISSION**

- To implement best practices in teaching-learning methodologies for establishing dynamic knowledge-connected society.
- To create a conducive environment for carrying out research in multi-disciplinary areas and thereby nurturing novel thinking capabilities.
- To strengthen industry-institute interface to inculcate entrepreneurship abilities.
- To address all technological needs of the Nation for self-sustenance.

## **DEPARTMENT OF BIOTECHNOLOGY**

### **VISION**

To nurture competent biotechnologists who will disseminate their knowledge for the development of sustainable technologies with their innovative approaches.

### **MISSION**

- Maintaining high academic standards by adopting effective pedagogy, and continuously upgrading the program curriculum to meet the current needs.
- Providing a flexible environment for faculty and students to flourish in teaching, research and entrepreneurship.
- Creating Institute-Industry interface by inculcating skills and knowledge through training programmes to address the socio-economic issues.



## Department of Biotechnology:

### About the Department:

The Department of Biotechnology at the National Institute of Technology Andhra Pradesh was established in the year 2015. Currently, we are offering undergraduate B. Tech ,M.Tech (Bioprocess Engineering) and Ph.D. (Part-time and Full time) programmes. The department is committed to impart quality education and offer excellent research environment to its ongoing programmes to motivate budding engineers, scientists and entrepreneurs to enhance their problem-solving skills for societal benefits. The department has faculty members from diverse specializations from reputed national and international institutes. Our laboratories are well equipped with modern infrastructure to meet the requirements of academic programmes. The research area of our faculty members include: Microbial Biotechnology, Bioprocess Engineering, Downstream processing, Modelling and Simulation of Bioprocesses, Prebiotics, Probiotics, Bioinformatics, Plant Biotechnology, Drug Delivery, Phytopharmacology, Environmental Biotechnology, and Nano-biotechnology. The departmental activities are supported by non-teaching staff. The aim of the department is to inculcate the knowledge of Biotechnology to the young minds who can contribute towards the development of the society.

### List of Programs offered by the Department:

Program	Title of the Program
B.Tech.	Biotechnology
M.Tech	Bioprocess Engineering
Ph.D.	Biotechnology

**Note:** Refer to the Rules and Regulations for B.Tech. program (weblink) given on the institute website.



## B.Tech. – BIOTECHNOLOGY

### Program Outcomes (POs)

At the end of the program, the student will be able to:

<b>PO1</b>	Acquire in the depth knowledge on fundamentals of mathematics, bioscience, engineering for the conceptualization of complex biological system.
<b>PO2</b>	Define and analyze of complex engineering problems in biological system and provide potential solutions for solving technological problems in various domains of Biotechnology with a due consideration to the societal, public health, cultural, and environmental factors.
<b>PO3</b>	Design system components or processes for the development of high throughput process and products with due consideration to the public health, safety, cultural, societal, and environment factors.
<b>PO4</b>	Design, execute, analyze and interpret experimental data for investigating complex problems in Biotechnology and allied fields.
<b>PO5</b>	Create and apply modern engineering tools for the prediction and modelling of complex bioengineering activities with valid assumptions.
<b>PO6</b>	Identify societal, health, safety, legal and cultural issues and provide suitable solutions with logical thinking.
<b>PO7</b>	Understand the existing engineering solutions and their possible impact in societal and environmental contexts and able to bring sustainable development through greener way
<b>PO8</b>	Demonstrate adherence to accepted standards of professional bioethics, standards, and social responsibilities.
<b>PO9</b>	Possess self-management and team work skills towards collaborative, multidisciplinary scientific endeavours in order to achieve common goals.
<b>PO10</b>	Acquire communication skills relevant to professional positions and able to comprehend and prepare effective reports, design documentation, make effective presentations, and give and receive clear instructions.
<b>PO11</b>	Develop entrepreneurial and managerial skills for the implementation of multidisciplinary projects.
<b>PO12</b>	Possess the attitude necessary for life-long learning in the broadest context of technological change.

### Program Specific Outcomes (PSOs)

<b>PSO1</b>	Able to apply the knowledge gained during the course of the program from sciences and engineering in general and all biotechnology courses in particular to identify, formulate and solve real life problems faced in industries and/or during research work.
<b>PSO2</b>	Able to design, perform and analyze of experiments independently and update them with latest tools and techniques in the field of biotechnology and inter-Disciplinary areas to choose research career nationally and internationally.
<b>PSO3</b>	Able to think and work independently and/or as a team to involve entrepreneurial activates for developing their own start-ups.



### Degree Requirements for B.Tech. (Biotechnology) Programme

Category	Category Description	Credits	Percentage
BSC	Basic Science Courses (BSC)	15	10%
ESC	Engineering Science Courses (ESC)	15	10%
Professional Major Courses (PMC)	Professional Major Core Courses (PCC)	60	60%
	Professional Major Elective Courses (DEC)	18	
	Professional Major Work (PRC)	6	
	Semester-Long Internship (SLI)	6	
Open/Free Electives	Open Elective Courses (OEC) and DAC approved Free Electives (NPTEL, MOOCs, etc.)	15	10%
HSC Courses	Liberal Arts/Creative Arts Courses (LCA)	6	10%
	Sports Courses (Any two sports of 1 Credit each)	2	
	NCC/Social Service	1	
	Yoga	1	
	English Communication	2	
	Personality Development/Life Skills	1	
	Introduction to Entrepreneurship	1	
	Introduction to Design Thinking	1	
Total Credits		150	100%

**NOTE:** The minimum no. of credits required to award B.Tech. degree is as per the proposed curriculum.

Credit Distribution in Each Semester									
	I	II	III	IV	V	VI	VII	VIII	TOTAL
BSC	7	5	3	0	0	0	0	0	15
ESC	7	8	0	0	0	0	0	0	15
HSC	3	1	2	1	1	4	3	0	15
PCC	0	5	16	16	13	10	0	0	60
DEC	0	0	0	3	5	5	5	0	18
OEC	0	0	0	3	3	3	6	0	15
PRC/ SLI	0	0	0	0	0	0	6	6	12
	17	19	21	23	22	22	20	6	150



## **SCHEME OF INSTRUCTION**

### **B.Tech. (Biotechnology) Course Structure**

**Note:**

- 1. All BSC Courses must be offered within V Semester (Including).**
- 2. All ESC Courses must be offered within VI Semester (Including).**
- 3. For all courses in the HSC basket, slots are reserved in the template.**
- 4. Open electives/DAC approved Free Electives (MOOCS/NPTEL etc.) shall be offered from IV semester.**
- 5. Department electives shall be offered from IV semester.**
- 6. VIII semester is reserved for a semester-long internship or an additional courses/project at the institute.**

**I – Year: I – Semester**

S.No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1	HS1011	English for Engineers-I	2	0	0	2	HSC
2	MA1011	Differential and integral calculus	3	0	0	3	BSC
3	CY1011	Engineering chemistry	2	0	0	2	BSC
4	CS1011	Problem Solving Through Computer Programming	3	0	0	3	ESC
5	EE1601	Basic Electrical and Electronics Theory	2	0	0	2	ESC
6	CY1042	Engineering Chemistry Laboratory	0	1	2	2	BSC
7	CS1012	Problem Solving Through Computer Programming Lab	0	1	2	2	ESC
8	HS1022	Physical Education				1	HSC
<b>Total</b>						<b>17</b>	

**I – Year: II – Semester**

S.No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1	MA1021	Matrices and differential equation	3	0	0	3	BSC
2	BT1011	Biochemical Thermodynamics	3	0	0	3	PCC
3	BT1021	Bioprocess Calculations	2	0	0	2	PCC
4	PH1011	Engineering Physics	2	0	0	2	BSC
5	MM1601	Introduction to Material Science and Engineering	3	0	0	3	ESC
6	ME1013	Engineering Drawing	2	0	0	2	ESC
7	ME1013	Engineering Drawing with CAD	0	0	2	1	ESC
8	ME1062	Fabrication Laboratory	0	1	2	2	ESC
9	HS1032	Health Education				1	HSC
<b>Total</b>						<b>19</b>	

**Note:**

BSC: Basic Science Courses

PCC: Professional Major Core Courses

OEC: Open Elective Courses

PRC: Professional Major Work

ESC: Engineering Science Courses

DEC: Professional Major Elective Courses

HSC: Humanities and Social Science Courses

SLI: Semester Long Internship



**SCHEME OF INSTRUCTION**  
**B.Tech. (Biotechnology) Course Structure**  
**II – Year: I – Semester**

S.No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1.	BT2011	Biochemistry	3	0	0	3	PCC
2.	BT2021	Microbiology	3	0	0	3	PCC
3.	BT2031	Cell biology	3	0	0	3	PCC
4.	BT2041	Transport Phenomena in Bioprocess system	2	1	0	3	PCC
5.	BT2052	Biochemistry laboratory	0	1	2	2	PCC
6.	BT2062	Microbiology laboratory	0	1	2	2	PCC
7.	MA2011	Statistics & Numerical Methods	3	0	0	3	BSC
8.	HS2011	Personality Development				1	HSC
9.	HS2022	Yoga				1	HSC
<b>Total</b>						<b>21</b>	

**II – Year: II – Semester**

S.No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1.	OECXXXX	Open Elective /DAC approved Free Electives (NPTEL, MOOCs, etc.)	3	0	0	3	OEC
2.	BT2081	Molecular Biology and Genetics	3	0	0	3	PCC
3.	BT2091	Computing for Biotechnology	2	1	1	3	PCC
4.	BT2101	Biological Reaction Engineering	3	0	0	3	PCC
5.	BT2111	Analytical Techniques in Biotechnology	3	0	0	3	PCC
6.	BT2122	Transport Phenomena Laboratory	0	1	2	2	PCC
7.	BT2132	Cell and Molecular Biology Laboratory	0	1	2	2	PCC
8.	BT3XXX	Departmental Elective-1	3	0	0	3	DEC
9.	SMXXXX	NCC/Social Service				1	HSC
<b>Total</b>						<b>23</b>	



**SCHEME OF INSTRUCTION**  
**B.Tech. (Biotechnology) Course Structure**

**III – Year: I – Semester**

S.No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1.	OECXXXX	Open Elective /DAC approved Free Electives (NPTEL, MOOCs, etc.)				3	OEC
2.	BT3181	Immunology	3	0	0	3	PCC
3.	BT3191	Genetic Engineering	3	0	0	3	PCC
4.	BT3201	Upstream Bioprocessing	3	0	0	3	PCC
5.	BT3212	Genetic Engineering and Immunology Laboratory	0	1	2	2	PCC
6.	BT3222	Bioreaction and Upstream Bioprocessing Laboratory	0	1	2	2	PCC
7.	BT3XXX	Departmental Elective-2	3	0	0	3	DEC
8.	BT3XXX	Departmental Elective-3	2	0	0	2	DEC
9.	SM3011	Introduction to Entrepreneurship				1	HSC
<b>Total</b>						<b>22</b>	

**III – Year: II – Semester**

S.No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1.	OECXXXX	Open Elective /DAC approved Free Electives (NPTEL, MOOCs, etc.)	3	0	0	3	OEC
2.	BT3301	Downstream Processing	3	0	0	3	PCC
3.	BT3311	Bioinformatics	3	0	0	3	PCC
4.	BT3322	Bioinformatics Laboratory	0	1	2	2	PCC
5.	BT3332	Downstream Processing Laboratory	0	1	2	2	PCC
6.	BT3XXX	Departmental Elective-4	2	0	0	2	DEC
7.	BT3XXX	Departmental Elective-5	3	0	0	3	DEC
8.	HS3011	English for Engineers - II				3	HSC
10.	HS3021	Introduction to Design Thinking				1	HSC
<b>Total</b>						<b>22</b>	



**SCHEME OF INSTRUCTION**  
**B.Tech. (Biotechnology) Course Structure**

**IV – Year: I – Semester**

S.No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1.	OECXXXX	Open Elective /DAC approved Free Electives (NPTEL, MOOCs, etc.)	3	0	0	3	OEC
2.	OECXXXX	Open Elective /DAC approved Free Electives (NPTEL, MOOCs, etc.)	3	0	0	3	OEC
3.	BT4424	Professional Major Work	0	0	12	6	PRC
4.	BT4XXX	Departmental Elective -6	3	0	0	3	DEC
5.	BT4XXX	Departmental Elective-7	3	0	0	2	DEC
6.	HSXXXX	Liberal Arts/Creative Arts Courses – II				3	HSC
<b>Total</b>						<b>20</b>	

**IV – Year: II – Semester**

S.No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1	BT4554	Semester-Long Internship (SLI) /Additional Project at the institute/Additional Department elective-8, courses for 6 credits	0	0	0	6	SLI
<b>Total</b>						<b>6</b>	

**Departmental Elective Courses:**

Year-Sem-Department Elective Number	Course Code	Credits	Course Title
2-2-1	BT3141	3	Plant Biotechnology*
2-2-1	BT3151	3	Biophysics
2-2-1	BT3161	3	Biodiversity and Conservation
3-1-2	BT3231	3	Industrial Biotechnology*
3-1-2	BT3241	3	Nanobiotechnology
3-1-2	BT3251	3	Food Biotechnology
3-1-3	BT3261	2	Bioreactor Design and Analysis*
3-1-3	BT3271	2	Enzyme Technology
3-1-3	BT3281	2	Protein Engineering
3-2-4	BT3341	3	Bioprocess Control and Instrumentation*
3-2-4	BT3351	3	Bioprocess Design and Economics
3-2-4	BT3361	3	Biofuel Technology
3-2-5	BT3371	2	Metabolic Regulation and Engineering
3-2-5	BT3381	2	Biopharmaceutical Technology
3-2-5	BT3391	2	Omics Technologies
4-1-6	BT4431	3	Bioprocess Modelling and Simulation*
4-1-6	BT4441	3	Drug Design and Development
4-1-6	BT4451	3	Systems Biology
4-1-7	BT4461	2	Animal Biotechnology*
4-1-7	BT4471	2	Stem Cell Technology
4-1-7	BT4481	2	Tissue Engineering
4-2-8	BT4491	3	Environmental Biotechnology
4-2-8	BT4501	3	Biomaterials
4-2-8	BT4511	3	Fermentation Technology
4-2-8	BT4521	3	Biosafety and IPR
4-2-8	BT4531	3	Entrepreneurship in Biotechnology
4-2-8	BT4541	3	Biosensors



**Open Elective Courses (offered to other departments):**

Course Code	Credits	Course Title
BT2071	3	Biology for Engineers
BT3171	3	Environmental Technology
BT3291	3	Bioenergy and Biofuel
BT4401	3	Ethics and IPR
BT4411	3	Biosensor Technology

**Minor Degree Program:**

Each engineering department should identify the list of courses for the minor & Double Major degree programmes. These identified courses will be offered to the Minor/Double Major degree students as mentioned below.

S.No	Course Code	Course Title	L	T	P	Credits	Offered Semester
1	BT2031	Slot-I: Cell biology	3	0	0	3	III
2	BT2111	Slot-Analytical Biotechnology	3	0	0	3	IV
3	BT3231	Slot -III Industrial Biotechnology	3	0	0	3	V
4	BT3341	Slot-IV Bioprocess Control and Instrumentation*	3	0	0	3	VI
		TOTAL (6 Core credits + 6 Elective Credits)	12	0	0	12	

**Major Degree Program**

S.No	Course Code	Course Title	L	T	P	Credits	Offered Semester
1.	<b>Slot-I</b>						
	BT2031	Cell biology	3	0	0	3	III
	BT2011	Biochemistry	3	0	0	3	III
2.	<b>Slot -II</b>						
	BT2101/B T2111/BT 2081	Biological Reaction Engineering/Analytical Methods in Biotechnology/Molecular Biology and Genetics	3	0	0	3	IV
	BT3141	Plant Biotechnology	3	0	0	3	IV
3.	<b>Slot-III</b>						
	BT3251	Food Biotechnology	3	0	0	3	V
	BT3231	Industrial Biotechnology	3	0	0	3	V
4.	<b>Slot-IV</b>						
	BT3341	Bioprocess Control and Instrumentation*	3	0	0	3	VI
	BT3311	Bioinformatics	3	0	0	3	VI
		TOTAL (12 Core credits + 12 Elective Credits)	24	0	0	24	

Note:

1. A student is permitted to do either a minor or double major only, but not both.
2. A student is permitted to have only one minor /one double major.

**DETAILED SYLLABUS****I – Year: I – Semester**

<b>HS1011</b>	<b>ENGLISH FOR ENGINEERS-I</b>	<b>HSC</b>	<b>2 – 0 – 0</b>	<b>2 Credits</b>
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**Pre-requisites:** None

**Course Outcomes:**

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

<b>CO1</b>	To develop a strong foundation in grammar
<b>CO2</b>	To develop vocabulary and to write effective paragraphs and formal letters
<b>CO3</b>	To improve reading comprehension and team-skills/collaborative skills
<b>CO4</b>	To cultivate interpretive and critical thinking skills

**Syllabus****Module 1**

Basics of Language: Tense, Concord, Error detection, Reading Comprehension

**Module 2**

Writing: Paragraphs, Precis writing, Formal letters, and Email etiquette

**Module 3**

Interpretation and Critical Thinking: Cross cultural communication, identifying biases, Interpretation of visual data and information, and Logical reasoning

**Module 4**

Understanding Audience/Profiling Readers, Introduction to workplace communication, Group Contract/Team Contract, Presentation skills, and Techniques to enhance listening skills

**Text Books:**

1. Anderson, Marilyn, Pramod K. Nayar, and Madhucchanda Sen. *Critical Thinking*,
2. *Academic Writing and Presentation Skills*. Pearson Education, 2008.
3. Emden, Joan van. *Effective Communication for Science and Technology*. Macmillan Education UK, 2001.
4. Murphy, Raymond. *Intermediate English Grammar*. Cambridge University Press, 2014.
5. Narayanaswami, V. R. *Strengthen Your Writing*. Orient Longman Private Limited, 2005.
6. Sharma, Sangeetha and Binoth Mishra. *Communication Skills for Engineers and Scientists*. PHI, 2023



**Reference:**

1. Aarts, Bas. *Oxford Modern English Grammar*. Oxford University Press, 2011.
2. Blake, Gary. *The Elements of Technical Writing*. Pearson, 2000
3. Carlisle, Joanne and Melinda S. Rice. *Improving Reading Comprehension*
4. *Research-based Principles and Practices*. York Press, 2002.
5. Carter, Ronald and Michael McCarthy. *Cambridge Grammar of English: A Comprehensive Guide*. Cambridge University Press, 2006.
6. Carter, Ronald, Rebecca Hughes, and Michael McCarthy. *Exploring Grammar in Context: Upper-intermediate and Advanced*. Cambridge University Press, 2000.
7. Dobelli, Rolf. *The Art of Thinking Clearly: Better Thinking, Better Decisions*. Sceptre, 2013.
8. Eastwood, John. *Oxford Guide to English Grammar*. Oxford University Press, 1994. Rolf, Dobelli (<https://learnenglish.britishcouncil.org>)



<b>MA1011</b>	<b>DIFFERENTIAL AND INTEGRAL CALCULUS</b>	<b>BSC</b>	<b>3-0-0</b>	<b>3 Credits</b>
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**Pre-requisites:** None

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

<b>CO1</b>	Understand the concepts of limit, continuity, and differentiability.
<b>CO2</b>	Understand the concepts of partial derivative, chain rule and total differentiation.
<b>CO3</b>	Find the maxima and minima of multivariable functions.
<b>CO4</b>	Analyze improper integrals and evaluate multiple integrals in various coordinate
<b>CO5</b>	Apply the concepts of gradient, divergence and curl to formulate engineering
<b>CO6</b>	Convert line integrals into area integrals and surface integrals into volume integrals.

## Syllabus

### Unit 1

**Differential Calculus of functions of several variables:** Review of Limit, continuity (sequential verification) and differentiability, Partial differentiation; Total differentiation; Euler's theorem and generalization; Change of variables- Jacobians; Maxima and minima of functions of several variables (2 and 3 variables); Lagrange's method of multipliers.

### Unit 2

**Integral Calculus:** Convergence of improper integrals; Beta and Gamma integrals; Differentiation under integral sign; Double and Triple integrals - computation of surface areas and volumes; change of variables in double and triple integrals.

### Unit 3

**Vector Calculus:** Scalar and vector fields; vector differentiation; level surfaces; directional derivative; gradient of a scalar field; divergence and curl of a vector field; Laplacian; Line and Surface integrals; Green's theorem in a plane; Stokes' theorem; Gauss Divergence theorem.

### Text Books:

1. Joel R. Hass, Maurice D. Weir, George B. Thomas, Thomas' Calculus, 12th edition, Pearson , 2010.
2. Erwin Kreyszig, Advanced Engineering Mathematics, Eighth Edition, John Wiley and Sons, 2015
3. B. S. Grewal, Higher Engineering Mathematics, Khanna Publications, 2015
4. R. K. Jain and S. R. K. Iyengar, "Advanced Engineering Mathematics", Fifth Edition, Narosa Publishing House, 2016.

### Reference Book:

1. T. M. Apostol, Calculus, Volumes 1 and 2 (2nd Edition), Wiley Eastern, 1980.



<b>CY1011</b>	<b>ENGINEERING CHEMISTRY</b>	<b>BSC</b>	<b>2-0-0</b>	<b>2 Credits</b>
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**Pre-requisites:** None

**Course Objectives:**

<b>CO1</b>	To provide the fundamentals and applications of electrochemistry
<b>CO2</b>	To develop the basic knowledge of structure and applications of polymers and engineering materials
<b>CO3</b>	To provide knowledge on the spectroscopic techniques and their applications in the characterization of samples
<b>CO4</b>	To understand the hardness of water and water-softening methods

**Course Outcomes:**

<b>CO1</b>	Gain foundational knowledge on how chemical principles influence the electrochemical properties of matter
<b>CO2</b>	Understand how basic chemical principles relate to everyday materials.
<b>CO3</b>	Understand the electronic, and vibrational properties of materials
<b>CO4</b>	Analyze and solve problems associated with hardness of water and address the societal issues related to the quality of water.

**Syllabus**

**Chapter-I: Electrochemistry**

Redox reactions; Electrode potential; Electrochemical cells; Electromotive force (EMF); Nernst equation; Batteries, Primary batteries: Daniel and Leclanche cell; Rechargeable batteries: lead- acid, nickel-cadmium and lithium-ion; Fuel Cells: hydrogen-oxygen and methanol-oxygen; Corrosion: dry & wet corrosion, corrosion controlling methods.

**Chapter-II: Polymer Chemistry and Engineering Materials**

Polymers: degree of polymerization, functionality, tacticity, classification, types of polymerization & their mechanism, molecular weight of polymers, polydispersity index, Recycling of Polymers, conducting polymers and their classification; Engineering materials: organic light-emitting diode (OLED).

**Chapter-III: Spectroscopy**

Origin of spectroscopy; Electromagnetic radiation; Quantized energy levels of matter; UV-Vis spectroscopy: electronic transitions, Beer-Lambert's law, instrumentation, Woodward-Fieser rules and applications; Infrared (IR) spectroscopy: vibrational transitions, principle, influencing factors, instrumentation and applications.

**Chapter-IV: Water Technology**

Soft and hard water; Estimation of hardness by EDTA method and numerical problems; Boiler troubles; Softening of water: lime-soda process, ion-exchange process, reverse osmosis; Internal treatment of water: carbonate conditioning, phosphate conditioning, colloidal conditioning, calgon conditioning.



**Text Books:**

1. Engineering Chemistry by Jain and Jain, Dhanpat Rai Publishing Company.
2. Introduction to Spectroscopy by Donald L. Pavia, 5th edition, Cengage Learning India Private Limited, 2015.
3. Polymer Science and Technology by Premamoy Ghosh, 3rd edition, McGraw-Hill, 2010.

**Reference books:**

1. Elements of Physical Chemistry by P. W. Atkins, Oxford University Press, 2007
2. A textbook of Polymer Chemistry by M. S. Bhatnagar, S. Chand, ISBN-13:978-8121932301.
3. Organic Spectroscopy by William Kemp, 2<sup>nd</sup> edition, Macmillan publishers, 2019.



<b>CS1011</b>	<b>PROBLEM SOLVING THROUGH COMPUTER PROGRAMMING</b>	<b>ESC</b>	<b>3 – 0 – 0</b>	<b>3 Credits</b>
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**Pre-requisites:** None

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

<b>CO1</b>	Construct algorithms for solving problems that requires solutions involving searching, sorting, selection and / or a numerical method as a sub-routine.
<b>CO2</b>	Analyze the suitability of different algorithmic design paradigms for solving problems with an understanding of the time and space complexities incurred.
<b>CO3</b>	Construct algorithms for solving problems with an understanding of the internals of a computing system and its components like processor, memory and I/O sub- systems.
<b>CO4</b>	Construct efficient modular programs for implementing algorithms by leveraging suitable control structures.
<b>CO5</b>	Construct efficient programs by selecting and using suitable in-built Data Structures and programming language features available.

**Course Articulation Matrix:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
<b>CO1</b>	S	M	L												
<b>CO2</b>	S	M	L												
<b>CO3</b>	S	M	L		L										
<b>CO4</b>	S	M	L		S										
<b>CO5</b>	S	M	L		S										

S: Strong correlation, M: Medium correlation, L: Low correlation

**Detailed Syllabus:**

Fundamentals of Computers, Historical perspective, Early computers, Components of a computers, Problems, Flowcharts, Memory, Variables, Values, Instructions, Programs.

Problem solving techniques – Algorithmic approach, characteristics of algorithm, Problem solving strategies: Top-down approach, Bottom-up approach, Time and space complexities of algorithms.

Number systems and data representation, Basic data types. Numbers, Digit separation, Reverse order, writing in words, Development of Elementary School Arithmetic Testing System, Problems on Date and factorials, Solutions using flow of control constructs, Conditional statements - If-else, Switch- case constructs, Loops - while, do-while, for Functions – Modular approach for solving real time problems, user defined functions, library functions, parameter passing - call by value, call by reference, return values, Recursion, Introduction to pointers.

Sorting and searching algorithms, Large integer arithmetic, Single and Multi-Dimensional Arrays, passing arrays as parameters to functions. Magic square and matrix operations using Pointers and Dynamic Arrays, Multidimensional Dynamic Arrays.



String processing, File operations Structures and Classes - Declaration, member variables, member functions, access modifiers, function overloading, Problems on Complex numbers, Date, Time, Large Numbers.

### Reference books

1. R.G. Dromey, "How to solve it by Computer", Pearson, 2008.
2. Brian W.Kernighan, Dennis Ritchie, "The C Programming Language", 2<sup>nd</sup>edition, Person Education India, 2015
3. Walter Savitch, "Problem Solving with C++", Ninth Edition, Pearson, 2014.
4. Cay Horstmann, Timothy Budd, "Big C++", 2nd Edition, Wiley, 2009.



EE1601	<b>BASIC ELECTRICAL &amp; ELECTRONICS ENGINEERING</b>	ESC	2 – 0 – 0	2 Credits
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Pre-requisites: Nil

### Course Outcomes:

At the end of the course, the student will be able to:

CO1	Analyze DC & AC circuits and determine power & power factor.
CO2	Understand the principle and operation of transformers
CO3	Identify the type of electrical machines for a given application
CO4	Acquire the knowledge on electrical safety
CO5	Analyze basic electronic circuits.

### Syllabus:

**DC Circuits:** Kirchoff's voltage and current laws, superposition theorem, star delta transformations.

**AC Circuits:** Complex representation of impedance, phasor diagrams, power & power factor, solution of 1-phase series & parallel circuits.

**Single Phase Transformers:** Principle of operation of a single-phase transformer, emf equation, phasor diagram, equivalent circuit of a 1-phase transformer, determination of equivalent circuit parameters, voltage regulation & efficiency.

**Electrical Machines:** DC Machines- principle of operation, classification, emf and torque equations, characteristics of DC generators and motors. 3-Phase induction motor- principle of operation, torque – speed characteristics & applications.

**Electrical Safety:** Electrical shock and precautions, concept of fuses and application; concept of earthing.

**Electronic Devices & Circuits:** P-N junction diode, I-V characteristics, bipolar junction transistor operation and characteristics.

### Text Books:

1. Engineering Circuit Analysis, William H. Hayt Jr., Jack E. Kemmerly, Steven M. Durbin, Tata McGraw Hill, 2020, 9th Edition.
2. Fundamentals of Electrical Circuits by Charles k. Alexander, Matthew N.O. Sadiku, Tata McGraw Hill, 2022, 7th Edition.
3. V.N.Mittle, Basic Electrical Engineering, 2<sup>nd</sup> edition, MC Graw Hill Education, 1 July 2017
4. Ravish R Singh, Basic Electrical Engineering, MC Graw Hill Education, 3<sup>rd</sup> edition, 2018.



5. R. Boylested and L. Nashelsky, "Electronics Devices and Circuits", Prentice Hall India, 2009.

**Reference Books:**

1. J. A. Edminister, Electric Circuit Theory, Schaum's Outline series: 5<sup>th</sup> edition, McGraw Hill, 2017.
2. D. P. Kothari & I.J. Nagrath, Basic Electrical Engineering, 4<sup>th</sup> edition, MC Graw Hill Education, 2019.

<b>CY1052</b>	<b>ENGINEERING CHEMISTRY LABORATORY</b>	<b>BSC</b>	<b>0-0-3</b>	<b>2 Credits</b>
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**Pre-requisites: Nil**

**Course Objectives**

<b>CO1</b>	To provide hands-on experience for analyzing the materials using instrumental methods.
<b>CO2</b>	To develop knowledge of the basic principles of volumetric analysis
<b>CO3</b>	To provide practical skills in quantitative analysis of materials by volumetric methods.

**Course Outcomes:**

<b>CO1</b>	Select a suitable methodology and compare the strategies involved in the estimation of hardness of water for various applications.
<b>CO2</b>	Apply a selective instrumental method to alternate tedious and complex titration processes for repeated and regulated analysis of acids, bases, etc.
<b>CO3</b>	Work independently and in teams to solve problems with effective communication

**Syllabus (experiments):**

1. Standardization of potassium permanganate solution
2. Determination of hardness of water
3. Determination of the concentration of a coloured solution using the colorimetric method
4. Synthesis of Bakelite
5. Conductometric titration of a strong acid vs a strong base
6. pH-metric titration of a strong acid vs a strong base

**Reference books:**

1. Vogel's Textbook of Quantitative Chemical Analysis (Latest ed.), Revised by G. H. Jeffery, J. Bassett, J. Mendham & R. C. Denney.
2. David Collins, Investigating Chemistry: Laboratory Manual, Freeman & Co., 1st Edition, 2006.

<b>CS1012</b>	<b>PROBLEM SOLVING THROUGH COMPUTER PROGRAMMING LAB</b>	<b>ESC</b>	<b>0 –1 – 2</b>	<b>2 Credits</b>
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**Pre-requisites:** None

**Course Outcomes:**

At the end of the course, the student will be able to:

<b>CO1</b>	Construct, debug, test and run efficient programs by leveraging suitable flow of control constructs and syntactic units of the programming language.
<b>CO2</b>	Construct efficient programs by constructing and translating algorithms for solving problems using sorting, searching, selection and / or arithmetic computations.
<b>CO3</b>	Implement, refactor, test and debug functional programs in a shell-based run time environment.
<b>CO4</b>	Construct efficient programs by demonstrating problem-solving skills and out- of-the-box algorithmic thinking.

**Course Articulation Matrix:**

	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>	<b>PO7</b>	<b>PO8</b>	<b>PO9</b>	<b>PO10</b>	<b>PO11</b>	<b>PO12</b>	<b>PSO1</b>	<b>PSO2</b>	<b>PSO3</b>
<b>CO1</b>	S	M	L		S				M			L			
<b>CO2</b>	S	M	L		S				M			L			
<b>CO3</b>	S	M	L		S				M			L			
<b>CO4</b>	S	M	L		S				M			L			

S: Strong correlation, M: Medium correlation, L: Low correlation

**Detailed Syllabus:****List of Experiments:**

1. Familiarization with basic shell commands, execution of and debugging programs in Linux environment
2. Programs on conditional control constructs.
3. Programs on iterative constructs. (while, do-while, for).
4. Programs using user defined functions and in-built function calls
5. Programs related to Recursion.
6. Programs on single and multi-dimensional arrays
7. Programs related to String processing
8. Programs related to Pointers
9. Programs on Structures and Unions
10. Programs related to Files and I/O.

**Reading List:**

1. R.G. Dromey, "How to solve it by Computer", Pearson, 2008.
2. Brian W.Kernighan, Dennis Ritchie, "The C Programming Language", 2<sup>nd</sup>edition, Person Education India, 2015



3. Walter Savitch, "Problem Solving with C++", Ninth Edition, Pearson, 2014.
4. Cay Horstmann, Timothy Budd, "Big C++", 2nd Edition, Wiley, 2009.

<b>HS1022</b>	<b>PHYSICAL EDUCATION</b>	<b>HSC</b>	<b>0-0-2</b>	<b>1 Credit</b>
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**Syllabus:**

**Introduction to Physical Education & EAA = Sports and Games**



Meaning & Definition of Physical Education, Aims & Objectives of Physical Education, Importance of Physical Education

### **Physical Fitness & Wellness Lifestyle**

Meaning & Importance of Physical Fitness, Components of Physical Fitness (Cardiovascular Endurance, Strength Endurance Muscular Endurance, Flexibility, Body Composition), Components of Motor Fitness (Agility, Balance, Power, Speed, Coordination), Development of Fitness Components

### **Training Methods in Physical Education**

Circuit Training (Circuit Training), Continues Training (Endurance), Interval Training (Speed & Endurance), Fartlek Training (Speed Endurance), Weight Training (Maximum Strength), Plyometric Training (Power), Flexibility Training

### **Test & Measurements**

Measurements: Height, Weight, Age, Calculation of BMI, Motor Fitness and Physical Fitness Tests (Pre - Test & Post-Test), Cardiovascular Endurance - 9/12 Minute Run or Walk, Muscular Endurance – Sit Ups for abdominal strength, Strength Endurance – Flexed arm hang for girls / Pull ups for boys, (Speed – 50m Dash or 30mts Fly Start, Strength – Broad Jump, Vertical Jump for Lower Body, Medicine Ball Put for Shoulder Strength, Endurance - 800mts, Flexibility - Bend and Reach, Agility (Coordination)) – Shuttle Run and Box Run

### **Formal Activities**

Calisthenics (free hand exercises), Dumbbells, Woops, Wands, Laziums (Rhythmic activities), Aerobic Dance and Marching

### **Sports / Games**

Following sub topics related to any one Game/Sport of choice of student out of: Athletics, Badminton, ball badminton, Kabaddi, Kho-Kho, Table Tennis, Yoga etc., Teaching & Coaching of the Game/Sport, Latest General Rules of the Game/Sport. Specifications of Play Grounds and Related Sports Equipment

## **I– Year: II – Semester**

<b>MA1021</b>	<b>MATRICES AND DIFFERENTIAL EQUATION</b>	<b>BSC</b>	<b>3-0-0</b>	<b>3 Credits</b>
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**Pre-requisites:** MA1011-Differential and Integral Calculus

### **Course Outcomes:**



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

<b>CO 1</b>	solve the consistent system of linear equations
<b>CO 2</b>	apply orthogonal transformations to a quadratic form
<b>CO 3</b>	solve arbitrary order linear differential equations with constant coefficients
<b>CO 4</b>	apply the concepts in solving physical problems arising in engineering
<b>CO 5</b>	apply Laplace transforms to solve physical problems arising in engineering

### Syllabus

**Matrix Theory:** Linear dependence and independence of vectors; Rank of a matrix; Consistency of the system of linear equations; Eigenvalues and eigenvectors of a matrix; Caley-Hamilton theorem and its applications; Reduction to diagonal form; Reduction of a quadratic form to canonical form - orthogonal transformation; Properties of complex matrices - Hermitian, skew-Hermitian and Unitary matrices.

**Ordinary Differential Equations of Higher Order :** Review of First-order Ordinary Differential Equations, Higher order linear differential equations with constant coefficients - homogeneous and non-homogeneous; Euler and Cauchy's differential equations; Method of variation of parameters; System of linear differential equations; applications in physical problems - forced oscillations, electric circuits, etc.

**Laplace Transforms:** Laplace transforms; inverse Laplace transforms; Properties of Laplace transforms; Laplace transforms of unit step function, impulse function, periodic function; Convolution theorem, Solving certain initial value problems, Solving system of linear differential equations, Finding responses of systems to various inputs viz. sinusoidal inputs acting over a time interval, rectangular waves, impulses etc.

### Text Reference:

1. E. Kreyszig, Advanced Engineering Mathematics, Eighth Edition, John Wiley and Sons, 2015.
2. B. S. Grewal, Higher Engineering Mathematics, Khanna Publications, 2015.
3. R. K. Jain and S. R. K. Iyengar, Advanced Engineering Mathematics, Fifth Edition, Narosa Publishing House, 2016.

### Reference Books:

1. G. Strang, Linear Algebra and Its Applications, 4th Edition, Brooks/Cole India, 2006.
2. T. M. Apostol, Calculus, Volume 2 (2nd Edition), Wiley Eastern, 1980.
3. G. F. Simmons, Differential equations with applications and historical notes. CRC Press, 2016

<b>BT1011</b>	<b>BIOCHEMICAL THERMODYNAMICS</b>	<b>PCC</b>	<b>3-0-0</b>	<b>3 Credits</b>
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### Prerequisites:

- i. PH1011 Engineering Physics
- ii. CY1011 Engineering Chemistry
- iii. MA1011 Differential & Integral Calculus
- iv. MA1021 Matrix & Differential Equation

**Course Outcomes:**

At the end of the course the student will be able to:

<b>CO1</b>	Demonstrate the understanding of thermodynamics laws and properties.
<b>CO2</b>	Examine the behavior of gases and analyze the concept of phase equilibria
<b>CO3</b>	Apply the concepts of solution thermodynamics and various reaction equilibria
<b>CO4</b>	Utilize thermodynamics to assess and resolve challenges in biological systems

**Course Articulation Matrix:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
<b>CO1</b>	3	2				-		-		-	-	1	2	1	-
<b>CO2</b>	2	1	3					-		-	2	3	3	2	-
<b>CO3</b>	3	2		3	-			-	2	1	3	3	3	3	3
<b>CO4</b>	2	3		3	2			-	3	2	3	3	3	3	3

1 - Slightly; 2 - Moderately; 3 – Substantially

**Syllabus:****Unit-I**

**Fundamentals of Thermodynamics :** Systems, Open system and closed system, State and path function, Zeroth law of thermodynamics, Reversible and irreversible processes, First law of thermodynamics, Internal Energy, Enthalpy, Flow processes, Concept of Entropy and second law of thermodynamics, Third law of thermodynamics.

**Unit-II**

**Thermodynamic Properties of fluids and Phase Equilibria:** Thermodynamic properties and their relationships, Maxwell's equations, Gibbs-Helmholtz equation, Behavior of ideal gases, non-ideal behavior, heat effect (sensible and latent heat), standard heat of reaction. Phase rule, Vapour-liquid equilibrium, Liquid-liquid equilibrium. Equilibrium and Phase Stability, Raoult's and Henry's law, Activity coefficient.

**Unit-III**

**Properties of Solutions and Chemical Reaction equilibria:** Solution thermodynamics, Partial Molar properties, Chemical Potential, Fugacity, Lewis/Randall Rule, excess properties, Effect of temperature on equilibrium constant, Homogeneous chemical reactions.

**Unit-II**

**Thermodynamics in Biochemical Processes:** Thermodynamics and energetics of metabolic pathways, Protein stability and protein dynamics, Membrane transport, Protein folding and unfolding, ligand- protein binding - entropy and enthalpy calculation, Membrane potential, Energetics of metabolic pathways - oxidation-reduction reactions, Thermodynamics of microbial growth



**Textbooks:**

1. Smith, V. N., Ness, H. C. V., Abbott, M. M., & Swihart, M. T. (2018). Introduction to chemical engineering thermodynamics (8th ed.). McGraw-Hill Education.
2. Narayanan, K. V. A Textbook of Chemical Engineering Thermodynamics. India, PHI Learning, 2013.
3. Sandler, S. I. (2006). Chemical, biochemical and engineering thermodynamics (4th ed.). John Wiley & Sons.
4. Haynie, Donald Templeton. Biological Thermodynamics. United Kingdom, Cambridge University Press, 2014.

<b>BT1021</b>	<b>BIOPROCESS CALCULATIONS</b>	<b>PCC</b>	<b>0–1–2</b>	<b>2 Credits</b>
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**Prerequisites:**

1. CY1011 Engineering Chemistry

**Course Outcomes:**

At the end of the course the student will be able to:

<b>CO1</b>	Perform unit conversion involved in bioprocesses and to know the expression of the
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	concentration of dilute solutions
<b>CO2</b>	Perform material and energy balances on biochemical processes/equipment
<b>CO3</b>	Perform steady state and unsteady state material and energy balances
<b>CO4</b>	Understand the flow diagram and solve the problems involving recycle, purge and bypass in a bioprocess

**Course Articulation Matrix:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
<b>CO1</b>	3	1	2	-	-	3	3	-	3	-	1	-	3	-	-
<b>CO2</b>	-	1	3	2	1	-	1	-	1	-	1	3	3	2	-
<b>CO3</b>	-	1	3	2	-	-	1	-	1	1	1	3	3	-	-
<b>CO4</b>	3	1	3	-	-	-	-	-	1	2	1	3	3	3	2

1 - Slightly; 2 - Moderately; 3 – Substantially

**Syllabus**

**Unit-I**

**Unit and its conversion:** Normality, Molality, Molarity, PVT behaviors, Gas laws, Partial pressure and pure component volume methods. Limiting and excess reactant, theoretical oxygen demand, Percentage Humidity, Relative Humidity, Molal Humidity, Cox Chart.

**Unit- II**

**Steady state Material Balance in Biological system:** General material balance equations - procedure and calculations in Humidification, Filtration, Mixing, Fermentation, Recycle, Bypass and Stream Purge Processes; stoichiometry of cell growth and product formation; elemental balances, electron balance degrees of reduction of substrate and biomass, Yield and percentage yield; or Yield and yield coefficients of biomass and product formation; Theoretical Oxygen demand.

**Unit- III**

**Steady state Energy Balance in Biological system:** General energy balance equations; Enthalpy calculation procedures; Enthalpy change in non-reactive processes; Change of Phase; Mixing and Solution; Steam Tables; Procedure for energy balance calculations without reaction; Heat of Combustion; Heat of reaction at Nonstandard Conditions: Heat of reaction for processes with biomass production; Electron Acceptor, Energy balance equation for cell culture; Case studies with respect to energy balance in typical industrial bioprocesses.

**Unsteady-state material and energy balance:** Introduction to Unsteady-state material and energy balance equations; solving unsteady-state material and energy balances.

**Text Books:**

1. Doran, P. M. (2012). Bioprocess engineering principles (2nd ed.). Academic Press.
2. Himmelblau, D. H., & Riggs, J. B. (2012). Basic principles and calculations in chemical engineering (8th ed.). Pearson Education.
3. Bhatt, B. I., & Vora S. M. (2005). Stoichiometry (4th ed.). McGraw-Hill Higher Education.
4. Hougen, O. A., Watson, K. M., & Ragatz, R. A. (2001). Chemical processes principles (part-1): material and energy balances (2nd ed.). Asia Publication House.
5. K.V. Narayanan and B. Lakshmikuttyamma, Stoichiometry & Process Calculations, Prentice Hall Publishing, Delhi, 2006.

PH1011	ENGINEERING PHYSICS	BSC	2-0-0	2 Credits
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**Pre-requisites:** Nil

**Detailed Syllabus:****UNIT- I: WAVE OPTICS**

**Interference:** Superposition principle, coherence of light, methods to produce coherent



light: division of amplitude and wavefront, Young's double slit and Newton's rings experiment: concept, working principle, and applications.

**Diffraction:** Introduction to Fresnel and Fraunhofer diffraction, Fraunhofer's single-slit diffraction, double-slit diffraction and diffraction grating (quantitative), and resolving power of a grating.

**Polarization:** Introduction to polarization, Types of polarization, Methods to produce polarization: Reflection, refraction, scattering, selective absorption and double refraction.

## **UNIT – II: LASERS**

Basic theory of LASER, Einstein's coefficients and their relations, concept of population inversion, components of lasers, three and four level lasing systems, construction and working principle of various types of lasers: Nd-YAG, Helium-Neon and semiconductor lasers and their applications.

## **UNIT – III: QUANTUM PHYSICS**

Origin of quantum theory and related experiments: Black-Body radiation and photo-electric effect. Heisenberg's uncertainty principle, de- Broglie's wave concept, wave function, and its properties, operators, Schrödinger's time-dependent and time-independent equations (Quantitative), particle in one- dimensional, infinite potential well, quantum tunneling phenomena and their applications in alpha decay, and scanning tunnelling microscopy (STM). Introduction to Quantum Technology (Q-switching, interaction of radiation with matter).

## **UNIT – IV: PHOTOVOLTAICS**

Introduction to semiconductors, Solar spectrum, photovoltaic (PV) effect, materials, structure and working principle, I-V characteristics, power conversion efficiency, quantum efficiency, emerging PV technologies, and applications.

## **UNIT – V: MAGNETIC AND NANO MATERIALS**

### **Magnetic Materials:**

Introduction to Weiss theory of ferromagnetism, concepts of magnetic domains, spontaneous magnetization, Curie transition, hard and soft magnetic materials and their applications.

### **Nanomaterials:**

Introduction, classification, and properties of nanomaterials, various methods of synthesizing nanomaterials: top-down (ball milling) and bottom-up (sol-gel) approaches.

### **Text Books:**

1. A Textbook of Engineering Physics, Revised Edition, M. N. Avadhanulu, P. G. Kshirsagar, S. Chand and Company (2014).
2. Concepts of Modern Physics, 7<sup>th</sup> Edition, Beiser A., Mc. Graw Hill Publishers (2017).
3. Optics, Ajoy Ghatak, 7<sup>th</sup> Edition, Tata Mc Graw Hill (2020).
4. Lasers- Fundamentals and Applications, Ajoy Ghatak and K. Thyagarajan, 2<sup>nd</sup> Edition, Laxmi Publications (2019).



**Reference Books:**

1. Materials Science and Engineering: An Introduction (Tenth edition), William D. Callister, John Wiley & Sons (2018)
2. Introduction to Solid State Physics, 8<sup>th</sup> Edition, Charles Kittel, Wiley Publishers (2012)

<b>MM1601</b>	<b>INTRODUCTION TO MATERIAL SCIENCE AND ENGINEERING</b>	<b>ESC</b>	<b>3-0-0</b>	<b>3 Credits</b>
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**Pre-requisites:** Nil

**Syllabus:**

**Bonding in Crystals** – Ionic bond, covalent bond, molecular bond, hydrogen bond, metallic bond & Van der Waals bond.

**Crystalline and Noncrystalline materials** – Crystal structure, space lattice, unit cell, crystal systems, atomic packing factor, Co-ordination numbers, crystal structure for



metallic elements, Crystal directions & Planes, miller indices, stacking sequence in HCP & FCC.

**Defects in Crystalline Materials:** Point, line, surface and volume defects

**Diffusion:** Diffusion Mechanism, laws of diffusion- Fick's I law, II law, inter-diffusion and Kirkendall effect, Metals and Alloys: Solid solutions, solubility limit, phase rule, binary phase diagrams, intermediate phases, intermetallic compounds, iron-iron carbide phase diagram, recovery, recrystallization and grain growth.

**Ceramics:** Structure and properties of ceramics.

**Polymers:** Classification, polymerization, structure and properties.

**Different properties of materials:** Mechanical properties: stress strain curves, elastic modulus, plastic deformation, slip, dislocation motion, critical resolved shear stress, strengthening mechanisms. Introduction to fatigue and creep properties of materials.

**Electronic Properties:** Concept of energy band diagram for materials – conductors, semiconductors and insulators, electrical conductivity effect of temperature on conductivity, intrinsic and extrinsic semiconductors, dielectric properties.

**Magnetic Properties:** Origin of magnetism in metallic and ceramic materials, paramagnetism, diamagnetism, antiferromagnetism, ferromagnetism, ferrimagnetism, magnetic hysteresis.

**Text Books:**

1. W.D. Callister & D.G. Rethwisch, Materials Science and Engineering: An Introduction, Wiley, 2019.

**Reference Books:**

1. B.D. Ratner, A.S. Hoffman, F.J. Schoen, J.E. Lemons, Biomaterials Science: An Introduction to Materials in Medicine, Elsevier, 2004.
2. V. Raghavan, Materials Science and Engineering – A First Course, PHI Publications, 2011.
3. J.F. Shackelford, Introduction to Materials Science for Engineers, Pearson, 2015.

<b>ME1013</b>	<b>ENGINEERING DRAWING WITH CAD</b>	<b>ESC</b>	<b>2-0-2</b>	<b>3 Credits</b>
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Pre-Requisites: NIL

**Course Outcomes:**

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

<b>CO1</b>	Apply BIS standards and conventions while drawing Lines, printing Letters and showing Dimensions.
<b>CO2</b>	Classify the systems of projection with respect to the observer, object, and reference planes.



<b>CO3</b>	Construct orthographic views of an object when its position with respect to the reference planes is defined.
<b>CO4</b>	Analyze the internal details of an object through sectional views.
<b>CO5</b>	Analyze the details of an object through the development of surfaces and the Intersection of surfaces.

**Course Articulation Matrix:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
<b>CO1</b>	2	2	2	-	1	-	-	-	1	2	-	-	3	-	2
<b>CO2</b>	2	2	2	-	1	-	-	-	1	2	-	-	3	-	2
<b>CO3</b>	2	2	2	-	1	-	-	-	1	2	-	-	3	-	2
<b>CO4</b>	2	2	2	-	1	-	-	-	1	2	-	-	3	-	2
<b>CO5</b>	2	2	2	-	1	-	-	-	1	2	-	-	3	2	2

**Syllabus:**

**Introduction:** Significance of engineering drawing, BIS conventions of engineering drawing, selection of drawing sheet size and scale, types of lines, lettering, dimensioning, geometrical construction of polygons, and scales. Coordinate systems and reference planes.

**Introduction to Orthographic projections:** Principles of Orthographic projection, Orthographic projections of points in 1st and 3rd quadrants, Orthographic projections of lines, Orthographic projections of planes viz triangle, square, rectangle, pentagon, hexagon, and circular laminae.

**Orthographic Projection of Solids:** Orthographic projection of right regular solids: Prisms, Pyramids, Cylinders, Cones, Cubes, and Tetrahedron.

**Sections of Solids:** Sectional planes, Sectional views - Prism, pyramid, cylinder and cone, true shape of the section.

**Isometric Projections:** Isometric scale, Isometric projection of hexahedron, right regular prisms, pyramids, cylinders, cones and spheres. Isometric projection of combination of two simple solids.

**Development of Surfaces of Solids:** Development of lateral surfaces of right regular prisms, cylinders, pyramids and cones resting with base on HP only. Development of lateral surfaces of their frustums and truncations. Problems related to applications of development of lateral surfaces like funnels and trays. Introduction to Computer Aided Drafting software (AutoCAD): Draw entities, complex entities and edit entities, coordinate systems, and reference lines and planes.

**Text Books:**



1. Engineering Graphics, N.D. Bhatt and V.M. Panchal, Charotar Publishers, 2013.
2. AutoCAD 2017 for Engineers & Designers, Sham Tickoo, Dreamtech Press, 2016, 23rd Edition.

**Reference Books:**

1. Engineering Drawing, Agarwal, B, McGraw Hill Education, 2015, Second edition

<b>ME1062</b>	<b>FABRICATION LABORATORY</b>	<b>ESC</b>	<b>0-1-2</b>	<b>2 Credits</b>
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Pre-Requisites: NIL

**Course Outcomes:**

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

<b>CO1</b>	Identify workshop tools and their operational capabilities
<b>CO2</b>	Practice on manufacturing of components using workshop trades including fitting, carpentry, foundry and welding
<b>CO3</b>	Apply suitable tools for machining processes including turning, facing, thread cutting and tapping



<b>CO4</b>	Apply basic electrical engineering knowledge for House Wiring Practice
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**Course Articulation Matrix:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
<b>CO1</b>	3	3	1	-	-	1	-	-	2	2	-	-	2	-	3
<b>CO2</b>	3	3	1	-	-	1	-	-	2	2	-	-	2	-	3
<b>CO3</b>	3	3	1	-	-	1	-	-	2	2	-	-	2	-	3
<b>CO4</b>	3	3	1	-	-	1	-	-	2	2	-	-	2	-	3

**Syllabus:**

**Demonstration:** Safety practices and precautions to be observed in the workshop.

**Fitting Trade:** Demonstration and practice of fitting tools, Preparation of T-Shape, Dovetail Joint.

**Carpentry:** Demonstration and practice of carpentry tools, Preparation of Cross Half lap joint and Mortise Tenon Joint.

**Plumbing:** Demonstration and practice of Plumbing tools, Preparation of Pipe joints with coupling for the same diameter and with reducer for different diameters.

**Machine shop:** Demonstration and practice on Lathe Machine, Preparation of workpieces involving Facing, Plane Turning, step turning, knurling, and parting operations.

**House Wiring:** Demonstration and practice on Electrical tools, wiring, and earthing, Exercises on Staircase Wiring & Godown wiring.

**Power Tools:** Demonstration and practice on Power tools (Bosch Power Tools) and Safety Practices.

**Foundry Trade:** Demonstration and practice on Moulding tools and processes, Preparation of Green Sand Moulds for given Patterns.

**Welding Shop:** Demonstration and practice on Arc Welding and Gas welding. Preparation of Lap joint and Butt joint.

**Text Books:**

1. Basic Workshop Technology: Manufacturing Process, Felix W.; Independently Published, 2019.
2. Workshop Processes, Practices and Materials; Bruce J. Black, Routledge publishers, 5th Edn. 2015.
3. A Course in Workshop Technology Vol I. & II, B.S. Raghuwanshi, Dhanpath Rai & Co., 2015 & 2017.

**Reference Books:**



1. Elements of Workshop Technology, Vol. I by S. K. Hajra Choudhury & Others, Media Promoters and Publishers, Mumbai. 2007, 14th edition
2. Elements of Workshop Technology, Vol. II by S. K. Hajra Choudhury & Others, Media Promoters and Publishers, Mumbai. 2007, 12th edition
3. Workshop Practice by H. S. Bawa, Tata-McGraw Hill, 2004.
4. Technology of machine tools, Steve F. Krar, Arthur R. Gill and Peter Smid, McGraw Hill Education (India) Pt. Ltd., 2013.
5. Engineering Practices Laboratory Manual, Ramesh Babu.V., VRB Publishers Private Limited, Chennai, Revised edition, 2013 – 2014.
6. Engineering Practices Lab Manual; T.Jeyapoovan, Vikas Pub, 4 th Edn.2008.
7. Mechanical Workshop Practice; John K.C., PHI, 2010.
8. Wiring Estimating, Costing and Contracting; Soni P.M. & Upadhyay P.A.; Atul Prakashan, 2021-22.

### Online Resources:

1. Different Trade E-Books (Fitting, Plumbing, Welding, Carpentry, Foundryman, Turner and House Wiring etc.) developed by National Instructional Media Institute, Chennai. Directorate General of Training, Ministry of Skill Development & Entrepreneurship, Govt. of India. (<https://bharatskills.gov.in>).

<b>HS1032</b>	<b>HEALTH EDUCATION</b>	<b>HSC</b>	<b>0-0-2</b>	<b>1 Credit</b>
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### Syllabus:

#### Health Education & Personal Hygiene

Introduction & Meaning of Health Education, Definition of Health Education, Principles of Health Education, Importance of Health Education, Meaning of Personal Hygiene, Importance of Personal Hygiene, Personal cleanliness (teeth, ears, eyes, nose & throat, nails



& fingers, skin, cloths, and hair).

### **Nutrition**

Introduction of Nutrition, Balanced Diet, Daily Energy Requirements, Nutrient Balance, Nutritional Intake, Eating and Competition, Ideal Weight

### **First Aid & Injury Management**

Introduction, Types and Principles of First Aid, Functions of First Aider, Reasons for Sports Injuries, The First Aid and Emergency Treatment in Various cases ( drowning, dislocation & fractures, burns, electric shock, animal bite, snake bite, poison, etc.

### **Human Posture**

Introduction, Meaning of Posture, types of Good Posture, causes of Poor Posture, preventive and Remedial Poor Posture, common Postural Deformities, Body Types, Advantages of Good Posture

### **Yoga**

Introduction, Meaning & Importance of Yoga, Elements of Yoga, Introduction - Asanas, Pranayama, Meditation & Yogic Kriyas, Yoga for concentration & related Asanas (standing asanas, sitting asanas, supine and prone postures.), Relaxation Techniques for improving concentration – Yoga – nidra, Pranayama

### **Sports / Games**

Following sub topics related to any one Game/Sport of choice of student out of: Athletics, Badminton, ball badminton, Kabaddi, Kho-Kho, Table Tennis, Yoga etc., Teaching & Coaching of the Game/Sport., Latest General Rules of the Game/Sport, Specifications of Play Grounds and Related Sports Equipment

## **II – Year: I – Semester**

<b>BT2011</b>	<b>BIOCHEMISTRY</b>	<b>PCC</b>	<b>3-0-0</b>	<b>3 Credits</b>
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**Prerequisites:** CY1011 Engineering Chemistry

### **Course Outcomes:**

At the end of the course the student will be able to:

<b>CO1</b>	Classify bio-molecules
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<b>CO2</b>	Understand complex biochemical pathways within living cells
<b>CO3</b>	Understand the physiological functioning of the cells
<b>CO4</b>	Understand anabolic and catabolic metabolism
<b>CO5</b>	Understand the mechanism of enzymatic reactions

**Course Articulation Matrix:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
<b>CO1</b>	3	-	-	2	2	1	-	-	-	-	-	-	3	1	-
<b>CO2</b>	3	-	-	-	-	2	1	-	2	1	-	2	2	1	-
<b>CO3</b>	3	-	-	-	-	2	-	1	-	-	-	2	3	1	-
<b>CO4</b>	3	2	2	-	3	-	2	-	-	-	-	1	3	-	1
<b>CO5</b>	3	2	3	2	-	2	3	-	-	-	3	2	3	2	2

1 - Slightly; 2 - Moderately; 3 – Substantially

**Syllabus:****Unit I**

**Introduction to Biochemistry:** Chemical foundations of Biology - pH, acids, bases, buffers, weak bonds and covalent bonds. Carbohydrates: Structure, classification and functions of carbohydrates and glycoconjugates. Lipids: Structure of Fats and Oils, Phospholipids, membrane lipids.

**Unit II**

**Amino acids and Peptides:** Classification of amino acids, Structure and properties of amino acids, Peptide bond and peptides. Proteins: Structure and Classification of Proteins. Primary structure, Secondary structure, Tertiary structure and Quaternary structure, aggregated proteins, Structural importance in function, Denaturation and Renaturation.

**Unit III**

**Nucleic acids:** Structure of nucleic acids, Structure of DNA, specialized secondary structures, kinds of RNA and their structures.

**Unit IV**

**Vitamins:** Introduction, classification and functions of vitamins, disease of vitamins deficiency.

**Unit V**

**Metabolism:** Glycolysis, Gluconeogenesis, Pentose Phosphate Pathway, Citric Acid Cycle, Oxidative Phosphorylation, Photosynthesis, Amino Acid Oxidation, DNA, RNA, Protein and Fatty acid metabolism.

**Text Books:**

1. Nelson, D. L., & Cox, M. M. (2017). Lehninger principles of biochemistry (7th ed.).



WH Freeman.

2. Rodwell, V. W., Bender, D. A., Botham, K. M., Kennelly, P. J., & Weil, P. A. (2015). Harper's illustrated biochemistry (30th ed.). McGraw-Hill Education
3. Berg, J. M., Tymoczko, J. L., Gatto, G. J., & Stryer, L. (2015). Biochemistry (8th ed.). WH Freeman.

<b>BT2021</b>	<b>MICROBIOLOGY</b>	<b>PCC</b>	<b>3-0-0</b>	<b>3 Credits</b>
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**Prerequisites:** None

**Course Outcomes:**

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

<b>CO1</b>	Understand the diversity of microorganisms
<b>CO2</b>	Understand the interaction of microorganisms with their environment



<b>CO3</b>	Apply appropriate methods for the control of microbial growth
<b>CO4</b>	Understand the principles of bacterial genetics and their mechanism
<b>CO5</b>	Understand the role of microorganisms in environmental remediation

**Course Articulation Matrix:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
<b>CO1</b>	3	2	-	2	2	2	-	-	-	-	1	2	3	2	2
<b>CO2</b>	3	2	2	2	1	2	-	-	-	-	1	2	3	2	3
<b>CO3</b>	-	1	1	2	3	2	2	-	-	-	1	2	3	2	2
<b>CO4</b>	3	3	3	2	2	2	-	1	1	-	2	3	3	2	3
<b>CO5</b>	3	2	2	2	2	2	2	-	-	-	1	3	3	2	3

1 - Slightly; 2 - Moderately; 3 – Substantially

**Syllabus:**

**Unit I**

**History and importance of microbiology:** spontaneous generation versus Biogenesis of microorganism; germ theory of disease - Koch's Postulates; Microscopy; Taxonomic classification of microorganisms and microbial relevance; Morphological, Structural and metabolic characteristics of microorganisms (bacteria, fungi, algae, protozoa)

**Unit II**

**Bacterial cell structure and function:** internal and external structure, spores and cysts. Cultivation of Bacteria: Nutritional requirements, physical conditions requirement, selection of culture media, conditions of incubation, reproduction and growth, quantitative measurement of growth. Maintenance and preservation of cultures.

**Unit III**

**Characteristic features of fungi (yeasts and molds), algae and protozoa:** morphology, reproduction, physiology economic importance. **Viruses:** morphology and structure, classification and nomenclature. Bacteriophage: general characteristics, discovery and significance. Animals and plants viruses

**Unit IV**

**Control of microorganisms:** fundamentals of control, physical agents, chemical agents, antibiotics; stress response

**Microbial genetics:** inheritance of characteristics and variability; phenotypic and genotypic changes; bacterial recombination: conjugation, transduction, and transformation.

**Unit V**

**Introduction to Applied Microbiology:** Microbial diseases and host-pathogen interactions; Antibiotics and antimicrobial resistance; microbiology of soil; biogeochemical roles of microorganisms; Nitrogen and phosphorus fixation ; Microbial Ecology - microbes in marine, fresh water and terrestrial ecosystems; Role of microorganisms in wastewater treatment and bioremediation; Industrial importance of



microbes.

**Text Books:**

1. Pelczar, M. J., Chan, E. C. S., & Krieg, N. R. (2001). *Microbiology* (5<sup>th</sup> ed.). McGraw Hill Higher Education.
2. Joanne, M. W., Linda, M. S., & Christopher, J. W. (2019). *Prescott, Harley and Klein's microbiology* (11th ed.). McGraw-Hill Higher Education.
3. Madigan, M. T., Bender, K. S., Buckley, D. H., Sattley, W. M., & Stahl, D. A. (2021). *Brock Biology of Microorganisms* (16th ed.). Pearson.
4. Ingraham, J. L., & Ingraham, C. A. (2004). *Introduction to Microbiology - A case History Approach* (4th ed.). Brooks/Cole Publishers.

<b>BT2031</b>	<b>CELL BIOLOGY</b>	<b>PCC</b>	<b>3-0-0</b>	<b>3 Credits</b>
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Prerequisites: Nil

**Course Outcomes:**

At the end of the course the student will be able to:

<b>CO1</b>	Understand the cell theory and cellular compartmentalization
<b>CO2</b>	Understand the structure and function of the plasma membrane and cell organelles
<b>CO3</b>	Understand the molecular mechanisms of cell cycle and signal transduction



<b>CO4</b>	Understand the significance of apoptosis in cellular regulation and relate the importance of cell cycle on cancer development
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**Course Articulation Matrix:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
<b>CO1</b>	3	-	-	1	1	-	-	-	-	-	-	-	2	-	-
<b>CO2</b>	3	-	-	1	1	-	-	-	-	-	-	-	3	-	-
<b>CO3</b>	3	-	-	1	1	-	-	-	-	-	-	-	3	-	-
<b>CO4</b>	2	2	-	1	-	-	-	-	-	-	-	-	3	-	-

1 - Slightly; 2 - Moderately; 3 – Substantially

**Syllabus:****Unit I**

**Cell structure and function:** Discovery of cells & Basic properties of cell, Cell theory; Cell complexity, Different classes of cells; Prokaryotic & Eukaryotic cell. Intracellular Compartments: Structure and functions of Nucleus and cell organelles, Extra cellular matrix, Cell-cell communication, integrins.

**Unit II**

**Cell Membrane and cell division:** Introduction to cell membrane components, phospholipid bilayers, membrane transport systems ( active, passive and facilitated). Cell division: Molecular Mechanics of Mitosis & Meiosis, Checkpoint cell cycle control, Activation and control of cyclin dependent kinase activity.

**Unit III**

**Cell signaling:** Intracellular signaling and types of signal receptors, Signal Transduction by hormones-Steroid / Peptide hormones, Concept of Secondary messengers, cAMP, cGMP, Protein Kinases, G Proteins, Receptors & Non-receptors associated tyrosine kinases, Protein kinase receptors (calmodulin, RAS, RAF, MAPK), Cytokine receptor-JAK-STAT signaling pathway.

**Unit IV**

**Cell differentiation:** Cancer biology basics, Characteristics of Cancer Cells, Types of Tumors, Molecular Basis of Cancer-Proto oncogene, Tumor Suppressor gene. Concepts of Apoptosis, Necrosis, Ubiquitin Proteasome Pathway, Autophagy and Mitophagy, Aging and Senescence, Therapeutic interventions of uncontrolled cell growth, Stem cell and its application.

**Text Books:**



1. Alberts, B., Johnson, A., Lewis, J., Morgan, D., Raff, M., Roberts, K., & Walter, P. (2014).
2. *Molecular biology of the cell* (6th ed.). Garland Science.
3. Cooper, G. M., & Hausman, R. E. (2015). *The cell: A molecular approach* (7th ed.). Oxford University Press.
4. University Press.
5. Nelson, D. L., & Cox, M. M. (2017). *Lehninger principles of biochemistry* (7th ed.). WH Freeman.
6. Freeman.
7. Rodwell, V. W., Bender, D. A., Botham, K. M., Kennelly, P. J., & Weil, P. A. (2015). *Harper's illustrated biochemistry* (30th ed.). McGraw-Hill Education

<b>BT2041</b>	<b>TRANSPORT PHENOMENA IN BIOPROCESS SYSTEM</b>	<b>PCC</b>	<b>2-1-0</b>	<b>3 Credits</b>
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**Prerequisites:**

1. PH1011 Engineering physics

**Course Outcomes:**

At the end of the course the student will be able to:

<b>CO1</b>	Understand various fluid properties, momentum transfer and isothermal systems
<b>CO2</b>	Understand the mechanisms of heat transfer in a bioreactor



<b>CO3</b>	Understand diffusion properties, film theory concepts and mass transfer between various states
<b>CO4</b>	Application of momentum, mass and energy transfer in biological systems

**Course Articulation Matrix:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
<b>CO1</b>	3	2	1	1	1	-	1	-	1	-	1	1	3	1	-
<b>CO2</b>	3	2	1	2	1	-	1	-	1	-	1	1	3	1	-
<b>CO3</b>	2	2	1	1	1	-	-	-	-	-	-	1	2	-	-
<b>CO4</b>	-	2	2	3	2	1	-	-	1	-	-	-	-	2	1

1 - Slightly; 2 - Moderately; 3 – Substantially

**Syllabus:**

**Unit I**

**Momentum transport:** Mechanism of Momentum Transport: Newton’s Law of Viscosity, Non-Newtonian fluids, theory of viscosity of liquids, time dependent viscosity, rheological properties of fermentation broth, velocity distribution in laminar flow and turbulent flow Equation of change for isothermal system (equation of continuity, equation of motion Bernoulli’s equation), boundary layer concepts, interphase transport in isothermal systems (friction factors for flow in tubes and in packed columns).

**Unit II**

**Energy transport:** type of heat transfer, Fourier’s law, steady state conduction, heat transfer to fluids with and without phase change, heat exchange equipment, temperature distribution in turbulent flow-reference to stirred tank reactor.

**Unit III**

**Mass transport:** Analogy between mass, heat and momentum transfer and applications in biological systems, Diffusivity, theory of diffusion, mass transfer theories, Definition and experimental measurement of mass transfer coefficients, concentration distribution with more than one independent variable- unsteady diffusion, concentration distribution in turbulent flow. Convective mass transfer, liquid-liquid mass transfer, solid-liquid mass transfer, gas-liquid mass transfer.

**Text Books:**

1. Bird, R. B., Stewart, W. E., & Lightfoot, E. N. (2006). *Transport phenomena* (2nd ed.). John Wiley & Sons.
2. Doran, P. M. (2012). *Bioprocess engineering principles* (2nd ed.). Academic Press.
3. McCabe, W. L., Smith, J. C., & Harriott, P. (2005). *Unit operations of chemical engineering* (7th ed.). McGraw Hill Education.
4. Treybal, R. E. (1981). *Mass transfer operations* (3rd ed.). McGraw Hill Education.
5. Blanch, H. W., & Clark, D. S. (2014). *Biochemical engineering* (3rd ed.). CRC Press.



6. Shuler, M. L., Kargi, F., & DeLisa, M. (2017). *Bioprocess engineering: Basic concepts* (3<sup>rd</sup> ed.). Pearson.
7. Plawsky, J.L., 2020. *Transport phenomena fundamentals*. CRC press.

<b>BT2052</b>	<b>BIOCHEMISTRY LABORATORY</b>	<b>PCC</b>	<b>0-0-2</b>	<b>2 Credits</b>
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**Prerequisites:** None

**Course Outcomes:**

At the end of the course the student will be able to:

<b>CO1</b>	Estimate the concentration of biomolecules
<b>CO2</b>	Identify and characterize biomolecules
<b>CO3</b>	Separate biomolecules using Chromatography and Electrophoresis



<b>CO4</b>	Perform biochemical reactions of proteins, carbohydrates and nucleic acids
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**Course Articulation Matrix:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
<b>CO1</b>	2	3	-	2	-	-	1	3	-	-	-	-	-	-	-
<b>CO2</b>	-	-	1	-	-	1	-	-	1	1	-	-	2	-	-
<b>CO3</b>	-	3	-	-	3	-	-	3	-	-	2	-	-	1	-
<b>CO4</b>	2	-	-	-	-	2	2	-	2	-	-	1	-	-	1

1 - Slightly; 2 - Moderately; 3 – Substantially

**Syllabus**

1. Laboratory safety & Hygiene, Units and measurements.
2. Qualitative analysis of Carbohydrates and amino acids & proteins.
3. Quantitative estimation of protein by Biuret method (or) Lowry method
4. Quantitative estimation of reducing sugars by DNS method
5. Quantitative estimation of total sugars by Anthrone method
6. Quantitative estimation of DNA by Diphenylamine method
7. Quantitative estimation of RNA by Orcinol method
8. Determination of purity of biomolecules by UV spectroscopy
9. Separation of amino acids by paper and thin layer chromatography
10. Determination of molecular weight of protein by SDS PAGE (Demonstration)

**Text Books:**

1. Wilson, K., & Walker, J. (2000). *Practical biochemistry: principles and techniques* (5th ed.). Cambridge University Press.
2. Basu, P. (2018). *Biochemistry laboratory manual* (3rd ed.). Academic Publishers.
3. Jayaraman, J. (2011). *Laboratory manual in biochemistry*. New age International.

<b>BT2062</b>	<b>MICROBIOLOGY LABORATORY</b>	<b>PCC</b>	<b>0-0-2</b>	<b>2 Credits</b>
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**Prerequisites:** None

**Course Outcomes:**

At the end of the course the student will be able to:

<b>CO1</b>	Understand the morphology of microorganism using microscopy
<b>CO2</b>	Understand the culturing techniques and preservation of microorganisms
<b>CO3</b>	Identify and characterize microorganism using biochemical tests
<b>CO4</b>	Understand the growth characteristics of microorganisms

**Course Articulation Matrix:**



	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
<b>CO1</b>	3	2	2	3	-	2	-	-	1	1	1	3	3	3	-
<b>CO2</b>	3	2	2	3	-	2	1	2	1	1	1	3	3	3	2
<b>CO3</b>	3	2	3	3	-	2	-	-	1	1	1	3	3	3	2
<b>CO4</b>	3	2	3	3	-	2	-	-	1	1	1	3	3	3	2

1 - Slightly; 2 - Moderately; 3 – Substantially

### Syllabus:

1. Demonstration of Microscope (light, bright-field and phase contrast)
2. Preparation and sterilization of the medium for bacteria and fungi
3. Bacterial culturing techniques (Spread, pour and streak plate).
4. Screening of microorganisms from soil and its preservation
5. Microscopic identification of microorganisms (bacteria and fungi)- staining techniques.
6. Bacterial identification using biochemical tests.
7. Estimation of microbial growth and viability test (Spectrophotometric measurement and cell counting)
8. Control of microorganism: physical and chemical agents
9. Antibiotic susceptibility assay
10. Virulent property of lambda phage on specific bacterial host.

### Text Books:

1. Cappuccino, J. G., & Natalie Sherman, N. (2013). *Microbiology: A laboratory manual* (10th ed.). Pearson.
2. Smith, H., & Brown, A. (2022). *Benson's microbiological applications: Laboratory manual* (15th ed.). McGraw-Hill Education.
3. Pollack, R. A., Findlay, L., Mondschein, W., & Modesto, R. R. (2018). *Laboratory exercises in microbiology* (5th ed.). John Wiley & Sons.

<b>MA2011</b>	<b>STATISTICS &amp; NUMERICAL METHODS</b>	<b>PCC</b>	<b>3-0-0</b>	<b>3 Credits</b>
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### Prerequisites:

1. MA1011 Differential & Integral Calculus
2. MA1021 Matrix & Differential Equation

### Course Outcomes:

At the end of the course the student will be able to:

<b>CO1</b>	Interpret an experimental data using interpolation / curve fitting
<b>CO2</b>	Solve numerically algebraic/transcendental and ordinary differential equations
<b>CO3</b>	Provides a solid foundation about the concept of probability and its features



<b>CO4</b>	Provide the idea of important results used in statistical Inference
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**Course Articulation Matrix:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1															
CO2															
CO3															
CO4															

1 - Slightly; 2 - Moderately; 3 – Substantially

**Syllabus:**

**Probability and Statistics:** Random variables, discrete and continuous random variables, Mean and variance of Binomial, Poisson and Normal distributions and applications. Testing of Hypothesis – Null and alternate hypothesis, level of significance and critical region - Z-test for single mean and difference of means, single proportion and difference of proportions - t-test for single mean and difference of means - F-test for comparison of variances, Chi-square test for goodness of fit - Karl Pearson coefficient of correlation, lines of regression and examples. (21)

**Numerical Methods:** Numerical solution of algebraic and transcendental equations by Regula- Falsi method and Newton-Raphson's method, Gauss-Seidal iteration method to solve a system of linear equations, Newton-Raphson's method to solve a system of nonlinear equations - Lagrange interpolation, Forward and backward differences, Newton's forward and backward interpolation formulae - Numerical differentiation with forward and backward differences - Numerical Integration with Trapezoidal rule, Simpson's 1/3 rule and Simpson's 3/8 rule - Taylor series method, Euler's method, modified Euler's method, 4th order Runge-Kutta method for solving first order ordinary differential equations.

**Text books:**

1. M. K. Jain, S. R. K. Iyengar and R. K. Jain, *Numerical methods for Scientific and Engineering Computation*, New Age International Publications, 2008.
2. S. C. Gupta and V. K. Kapoor, *Fundamentals of Mathematical Statistics*, S.Chand & Co, 2006.
3. E. Kreyszig, *Advanced Engineering Mathematics*, John Wiley and Sons, 8th Edition, 2008.
4. B. S. Grewal, *Higher Engineering Mathematics*, Khanna Publications, 2009.

**Reference Books:**

1. J. E. Freund, and M. Miller, M. *John E. Freund's Mathematical Statistics: With Applications*. Pearson Education India, (2004)



<b>HS2011</b>	<b>PERSONALITY DEVELOPMENT</b>	<b>HSC</b>		<b>1 Credit</b>
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**Course Outcomes:**

At the end of the course the student will be able to:

<b>CO1</b>	Students will develop a deeper self-awareness, gaining insights into their strengths, weaknesses, values, and emotional triggers.
<b>CO2</b>	Students will enhance their communication skills, enabling them to express themselves more clearly and engage effectively with others.
<b>CO3</b>	Students will improve their emotional intelligence and cultivate a growth mindset, equipping them to navigate challenges with resilience and adaptability.



<b>CO4</b>	Students will strengthen their abilities in conflict management, adaptability, and networking, preparing them for successful interactions in personal and professional contexts.
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**Syllabus:****Module 1**

Introduction to personality development - self assessment- SWOT - personal values statement - (punctuality, attitude, responsibility, ethics, integrity, values, and trust, and self-confidence) - imposter syndrome, communication skills (verbal and non-verbal, body language and posture, avoiding miscommunication) - techniques for persuasive communication - key principles to increase clarity of communication

**Module 2**

Emotional Intelligence - ways to improve emotional intelligence - application of emotional intelligence - identifying emotional triggers - Building rapport and maintaining positive interactions - Fixed and growth mindset - emotions in personal and professional relationships, strategies for effective networking - social and dining etiquette - greetings - dress code.

**References:**

1. Mitra, Barun K. *Personality Development and Soft Skills*. 2nd ed. Oxford Higher Education, 2016.
2. Sharma, Prashant. *Soft Skills: Personality Development for Life Success*. 3rd ed. BPB Publications, India, 2022.
3. Goleman, D. (1995). *Emotional intelligence: Why it can matter more than IQ*. Bantam Books.
4. Carnegie, D. (2020). *How to win friends and influence people*. Srishti Publishers and Distributors.
5. Khera, S. (2014). *You can win: A step-by-step tool for top achievers*. Bloomsbury India.

**II – Year: II – Semester**

<b>BT2081</b>	<b>MOLECULAR BIOLOGY AND GENETICS</b>	<b>PCC</b>	<b>3–0–0</b>	<b>3 Credits</b>
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**Prerequisites:**

- i. BT2021 Microbiology
- ii. BT2011 Biochemistry

**Course Outcomes:**

At the end of the course the student will be able to:

<b>CO1</b>	Understand the genome structure and mechanism of DNA replication in prokaryotes and eukaryotes
<b>CO2</b>	Understand the molecular mechanisms of central dogma and gene regulation



<b>CO3</b>	Understand the population genetics , evolution and determine the recombinant frequencies
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**Course Articulation Matrix:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
<b>CO1</b>	3	-	-	-	2	3	-	-	-	-	-	-	3	-	-
<b>CO2</b>	3	-	-	-	2	3	-	-	-	-	2	2	3	1	1
<b>CO3</b>	3	2	-	3	3	3	-	-	-	-	2	2	3	1	1

1 - Slightly; 2 - Moderately; 3 – Substantially

**Syllabus:**

**Unit I**

**Anatomy and Replication of genome:** Anatomy of Prokaryotic and Eukaryotic Genome. DNA Replication mechanisms, Genetic Recombination, transposons, Mutations and mutagenesis, DNA damage and repair mechanism.

**Unit II**

**Transcription and Translation:** Transcription Initiation and Regulation in Prokaryotes and Eukaryotes, Processing of mRNA, Non-coding RNAs (introns, miRNA, siRNA, snRNA). Prokaryotic and Eukaryotic translation, Post-translational processing of proteins. Gene regulation: Concept of operon structure. Mechanisms of Lac and Trp operons.

**Unit III**

**Population Genetics and Evolution:** Principles of Mendelian Law, Epistasis, Sex Determination and Linkage of Genes on the X Chromosome, Linkage maps, Crossing Over, Chromosomal mapping, Chromosome Variation (Number and Structure), Extra Chromosomal Inheritance, Epigenetics, Population Genetics, Selection and inheritance, Adaptive and neutral evolution, Genetic drift, Species and Speciation

**Text Books:**

1. Alberts, B., Johnson, A., Lewis, J., Morgan, D., Raff, M., Roberts, K., & Walter, P. (2014). *Molecular biology of the cell* (6th ed.). Garland Science.
2. Freifelder, D. (2004). *Molecular biology* (2nd ed.). Narosa Publishing House.
3. Brown, T. A. (2017). *Genomes 4* (4th ed.). Garland Science.
4. Watson, J. D., Baker, T. A., Bell, S. P., Gann, A., Levine, M., & Losick, R. (2008). *Molecular biology of the gene* (6th ed.). CSHL Press.
5. Strickberger, M.W. (2008). *Genetics* (3rd ed.). Prentice Hall of India.
6. Futuyma, D.J., 2017. Evolutionary biology today and the call for an extended synthesis. *Interface focus*, 7(5), p.20160145.



<b>BT2091</b>	<b>COMPUTING FOR BIOTECHNOLOGY</b>	<b>PCC</b>	<b>2-1-2</b>	<b>3 Credits</b>
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**Prerequisites:**

- i. CS1011 – Problem Solving through Computer Programming
- ii. CS1012- Problem solving through Computer programming Lab

**Course Outcomes:**

At the end of the course the student will be able to:

<b>CO1</b>	Develop a basic program in Python.
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<b>CO2</b>	Apply the programming structures, file handling, and file management to develop programs
<b>CO3</b>	Apply Biopython for biological sequence comparison and manipulating Biological sequences
<b>CO4</b>	Apply R functions and libraries and use R for manipulating biological Sequence

**Course Articulation Matrix:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
<b>CO1</b>	3	2	2	-	3	-	-	3	3	2	-	-	2	2	2
<b>CO2</b>	3	2	2	-	3	-	-	3	3	2	-	-	2	2	3
<b>CO3</b>	3	2	2	-	3	-	-	3	3	2	-	-	1	2	2
<b>CO4</b>	3	2	2	-	3	-	-	3	3	2	-	-	2	3	3

1 - Slightly; 2 - Moderately; 3 – Substantially

**Syllabus:**

**UNIT I**

**Introduction to Python:** Python fundamentals: installing Python, basic usage, running program, basic elements and syntax; Python built-in data structures: lists, tuples, sets and dictionaries, Control Structures: Decision control and loop control structures; Arrays; Numpy Array, Functions: built-in and user-defined functions; object-oriented programming in Python: class and instances, polymorphism, encapsulation, inheritance; String and File handling: basic string operations, comparison, join, formatting strings, modules and packages, file opening, writing, reading csv files, Data handling with Pandas, Introduction to Matplotlib or Seaborn for data visualization.

**UNIT II**

**Introduction to Biopython:** Installation and setup, understanding Biopython modules and documentation; Biological sequence analysis using Biopython: working with FASTA files, parsing DNA data file, sequence motif analysis, working with PDB file, Basic sequence manipulations (complement, reverse, transcription, translation), sequence alignment, dynamic programming pairwise sequence alignment and multiple sequence alignment.

**UNIT III**

**Introduction to R Programming:** R and Rstudio installation, R components: data types, array and matrices, operators, for and ifelse, functions, data frames, apply function and its variants. Input data sets from text files, CSV files, or database systems. Output data by creating tables, text files, or CSV files. Manipulate and store data using dplyr. SeqinR package for biological sequence analysis; Visualize data and build plots using ggplot2



package; R advanced statistical analysis techniques: Correlation, Regression, Clustering.

### Textbooks

1. Brown, M. C. (1999). *Python: The complete reference* (4th ed.). McGraw Hill Education.
2. Gowrishankar S, Veena A, Introduction to python programming, CRC Press, 2019, 1<sup>st</sup> Edition.
3. Magnus Lie Hetland, Beginning Python, Apress, 2008, 1<sup>st</sup> edition.
4. Necaise, R. D. (2011). *Data structures and algorithms using python*. John Wiley & Sons.
5. Matloff, N. (2011). *The art of R programming: A tour of statistical software design* (1st ed.). No Starch Press.
6. Matloff, N. (2009). *The art of R programming*. UC Davis.

### Reference Books:

1. Jason M. Kinser, Python for Bioinformatics, Jones and Bartlett Publishers, 2020, 1st edition.
2. Steve Conger, Hands-On Database: An Introduction to Database Design and development, Pearson Education, Inc., 2012, 3<sup>rd</sup> Edition.

### Other Suggested Readings:

<https://nptel.ac.in/courses/106106145>

<https://www.r-project.org>

[www.biopython.org](http://www.biopython.org)

### List of Experiments

1. Program to find the length of the given sequence.
2. Program to reverse and concatenation of the given sequence.
3. Program to complement and reverse complement of DNA sequence.
4. Program to translate DNA into Protein Sequence.
5. Make modules and packages for handling genome sequences using Python.
6. Program to calculate GC content in the given DNA sequence.
7. Finding motif in a given sequence using modules like Regular expression.
8. Handling biological sequences using Biopython.
9. Using Biopython perform pairwise alignment and multiple sequence alignment.
10. Download and install R-Programming environment and install basic packages using `install.packages ()` command in R.
11. Implement a program to read a csv file and analyze the data in the file in R and perform data manipulation using `dplyr`.
12. SeqinR package for analyzing biological sequences in R.
13. Plotting and visualization in R.



14. Perform advanced statistical analysis in R: Correlation, Regression, Clustering.

<b>BT2101</b>	<b>BIOLOGICAL REACTION ENGINEERING</b>	<b>PCC</b>	<b>3-0-0</b>	<b>3 Credits</b>
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**Prerequisites:**

- i. BT1021 Bioprocess calculations

**Course Outcomes:**

At the end of the course the student will be able to:

<b>CO1</b>	Understand the basics of reaction kinetics and reactor design
<b>CO2</b>	Understand the concept of enzyme kinetics and kinetics parameters estimation
<b>CO3</b>	Understand the modelling principles of microbial, substrate and product kinetics



<b>CO4</b>	Understand the concepts of ideal reactors and non-ideality
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### Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
<b>CO1</b>	3	-	-	1	3	-	-	-	-	-	-	-	3	-	-
<b>CO2</b>	3	-	-	1	3	-	-	-	-	-	-	-	3	1	-
<b>CO3</b>	3	-	-	1	3	-	-	-	-	-	-	-	3	-	-
<b>CO4</b>	3	-	-	2	3	-	-	-	-	-	-	-	3	-	-

1 - Slightly; 2 - Moderately; 3 – Substantially

### Syllabus:

#### Unit I

**Introduction to reaction kinetics:** Introduction to ideal reactor (batch and continuous reactors), performance equations, Levenspiel plot, elementary and non-elementary reactions, homogenous and heterogenous reactions, the effect of concentration and temperature on rate kinetics. Rate equations, concepts of molecularity, order, and mechanisms; Interpretation of batch reactor data, constant volume batch reactor, integral and differential methods

#### Unit II

**Enzyme kinetics:** Enzyme kinetics for single substrate reaction, Rapid equilibrium and Quasi steady approaches, model parameter estimation (Lineweaver–Burk, Eadie–Hofstee, Hanes–Woolf plots), Type of inhibitions (competitive, uncompetitive and non-competitive), substrate and product inhibition kinetics, immobilization and its kinetics

#### Unit III

**Microbial kinetics:** modelling of growth curve, balanced growth models, substrate utilization models - Monod equation and its modifications, unstructured and structured models, morphology-based models, product formation kinetics

#### Unit IV

**Ideal reactors and Non-ideality:** Batch and plug flow and CSTR reactors, non-ideality, RTD, concept of tracer studies, construction of C, E and F curves, selection of suitable reactor systems for multiple reactions, Models of non-ideal reactors.

### Text Books:

1. Levenspiel, O. (1998). *Chemical reaction engineering* (3rd ed.). John Wiley and Sons.
2. Doran, P. M. (2012). *Bioprocess engineering principles* (2nd ed.). Academic Press.
3. Bailey, J. E., & Ollis, D. F. (1989). *Biochemical engineering fundamentals* (2nd ed.) McGraw Hill Education.
4. Ravi, R., Vinu, R., & Gummadi, S. N. (2017). *Chemical and biochemical reactors and reaction engineering, Volume 3A, Coulson and Richardson's chemical engineering* (4<sup>th</sup> ed.). Butterworth-Heinemann.



5. Nithya, M. & Seenivasan A. (2022). *Design and kinetics of homogenous biochemical reactors*. In *Bioprocess Engineering & Technology: Fundamentals, Upstream and Downstream Processing and Plant Design, Vol-II (Bioprocess Engineering and Technology: Upstream Process)*. CRC Press.

<b>BT2111</b>	<b>ANALYTICAL METHODS IN BIOTECHNOLOGY</b>	<b>PCC</b>	<b>3-0-0</b>	<b>3 Credits</b>
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**Prerequisites:**

- i. PH1011 Engineering Physics
- ii. CY1011 Engineering Chemistry
- iii. BT2011 Biochemistry

**Course Outcomes:**

At the end of the course the student will be able to:

<b>CO1</b>	Understand the basics of bioanalysis and types of bioanalytical instruments
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<b>CO2</b>	Apply spectroscopic techniques for characterization of biomolecules
<b>CO3</b>	Select the appropriate chromatographic technique for bioanalysis

**Course Articulation Matrix:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
<b>CO1</b>	3	-	-	1	3	-	-	3	-	-	-	-	3	-	-
<b>CO2</b>	3	-	-	2	3	-	-	3	-	-	-	-	3	3	-
<b>CO3</b>	3	-	-	1	3	-	-	2	-	-	-	-	3	1	-

1 - Slightly; 2 - Moderately; 3 – Substantially

**Syllabus:**

**Unit I**

**Introduction, Modern approaches in Bioanalysis and Bioassays, Microscopy Techniques-** Dark-field, Phase contrast, Fluorescence, Confocal, Polarization microscopy; SPM, AFM, Electron microscopy: TEM & SEM.

**Unit II**

**Radioisotope techniques-** Basic concepts, GM and scintillation counter, autoradiography, RIA, Applications in biological science.

**Molecular Spectroscopic techniques:** Basic concepts and experimental methods of UV- Visible spectroscopy, Fluorescence spectroscopy, CD spectroscopy, NMR, X-ray, Mass spectroscopy, atomic absorption spectroscopy (AAS, inductively coupled plasma emission (ICP/AES), Fourier transform infrared spectrometry (FTIR).

**Unit III**

**Advanced chromatographic techniques—** Mass Spectrometry – various ionization methods – EI, CI, ESI, MALDI-TOF, HRMS. Gas Chromatography (GC) with detectors— electron capture (ECD), flame ionization (FID), and mass spectrometry (MS), Liquid chromatography with mass spectroscopy (LC-MS), high-performance thin layer chromatography (HPTLC).

**Unit IV**

**Advanced Techniques:** Next-generation sequencing (NGS), multiplex fluorescent in situ hybridization (m-FISH), comparative genome hybridization (CGH), flow cytometry-fluorescence-activated cell sorting (FACS)

**Text Books:**

1. Wilson, K., & Walker, J. (2005). *Principles and techniques of biochemistry and molecular biology* (6th ed.). Cambridge University Press.
2. Pavia, D. L., Lampman, G. M, Kriz, G. S., & Vyvyan, J. R. (2015). *Introduction to spectroscopy* (5th ed.). Cengage Learning.



3. Skoog, D. A., Holler, F. J., & Crouch, S. R. (2018). *Principles of instrumental analysis* (7<sup>th</sup> ed.). Cengage Learning.

<b>BT2122</b>	<b>TRANSPORT PHENOMENA LABORATORY</b>	<b>PCC</b>	<b>0-0-2</b>	<b>2 Credits</b>
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**Prerequisites:** PH1011 Engineering Physics

**Course Outcomes:**

At the end of the course the student will be able to:

<b>CO1</b>	Estimate various properties of fluids in aspects of industrial application
<b>CO2</b>	Understand the various types of fluid flow and Reynolds number.
<b>CO3</b>	Understand heat transfer mechanisms



<b>CO4</b>	Understand diffusion in gases and simple mass transfer operations
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**Course Articulation Matrix:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
<b>CO1</b>	2	3	3	1	1	-	2	-	-	-	-	-	2	1	1
<b>CO2</b>	2	3	3	1	1	-	2	-	-	1	-	-	2	1	1
<b>CO3</b>	2	3	3	1	1	-	2	-	-	-	-	-	2	1	1
<b>CO4</b>	2	3	3	1	1	-	2	-	-	-	-	-	2	1	1

1 - Slightly; 2 - Moderately; 3 – Substantially

**Syllabus**

1. Determination of dynamic viscosity of liquids.
2. Flow measurement using venturimeter/orificemeter/ Pitot-tube.
3. Reynolds experiment to demonstrate various types of flow.
4. Flow through packed bed and fluidized bed reactor column.
5. Heat conduction experiment to determine the thermal conductivity.
6. Natural and forced convection to correlate theoretical and experiment heat transfer coefficient.
7. Heat transfer characteristics in heat exchange equipment.
8. Estimation of Terminal settling velocity to design a thickener.
9. Separation of liquids using Batch distillation.
10. Extraction mass transfer operation (liquid-liquid /solid-liquid).
11. Drying characteristics of biomass.

**Text Books:**

1. Penney, W. R., & Clausen, E. C. (2018). Fluid mechanics and heat transfer: Inexpensive demonstrations and laboratory exercises (1st ed.). CRC Press.
2. McCabe, W. L., Smith, J. C., & Harriott, P. (2005). Unit operations of chemical engineering (7th ed.). McGraw Hill Education.
3. Treybal, R. E. (1981). Mass transfer operations (3rd ed.). McGraw Hill Education.
4. Plawsky, J.L., 2020. Transport phenomena fundamentals. CRC press.

<b>BT2132</b>	<b>CELL AND MOLECULAR BIOLOGY LABORATORY</b>	<b>PCC</b>	<b>0–0–2</b>	<b>2 Credits</b>
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**Prerequisites:**

- i. BT2062 Microbiology Lab
- ii. BT2052 Biochemistry Lab.

**Course Outcomes:**

At the end of the course the student will be able to:



<b>CO1</b>	Demonstrate safe laboratory practices and handle the equipment safely
<b>CO2</b>	Isolation and detection of nucleic acids from different organisms using Gel-electrophoresis
<b>CO3</b>	Microscopic detection of cell counting, staining and cell viability
<b>CO4</b>	Separation and determining various phases of cell division in eukaryotic cell

**Course Articulation Matrix:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
<b>CO1</b>	-	1	-	-	-	3	-	3	-	-	2	2	3	3	1
<b>CO2</b>	2	1	-	1	-	2	-	-	-	-	2	3	3	3	1
<b>CO3</b>	2	1	-	1	-	2	-	-	-	-	2	3	3	3	1
<b>CO4</b>	2	1	-	1	-	3	-	-	2	-	2	3	3	3	2

1 - Slightly; 2 - Moderately; 3 – Substantially

**Syllabus**

1. Separation of RBCs, WBCs and its microscopic observation
2. Cell counting using hemocytometer (RBCs and WBCs )
3. Cell viability and membrane permeability
4. Isolation and detection of Genomic DNA from Bacteria
5. Isolation and detection of Plasmid by Alkali Lysis Method
6. Isolation and detection of Genomic DNA from Blood Cells
7. Isolation and detection of genomic DNA from Plant Tissue
8. Phases of cell division.

**Text Books:**

1. Sambrook, J. & Russell, D. (2004). Molecular cloning: A laboratory manual (3rd ed.). CSHL Press.
2. Gerstein, A. S. (2001). Molecular biology problem solver: A laboratory guide (1st ed.). John Wiley & Sons

**III – Year: I – Semester**

<b>BT3181</b>	<b>IMMUNOLOGY</b>	<b>PCC</b>	<b>3–0–0</b>	<b>3 Credits</b>
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Prerequisites:

- i. BT2011 Biochemistry
- ii. BT2081 Molecular Biology & Genetics

**Course Outcomes:**



At the end of the course the student will be able to:

<b>CO1</b>	Understand cells and components of innate and adaptive immune responses.
<b>CO2</b>	Understand the organization and expression of Immunoglobulins genes.
<b>CO3</b>	Understand the mechanism of antigen and antibody interaction and immune responses
<b>CO4</b>	Comprehend the role of immune system in maintaining health and protecting from diseases

**Course Articulation Matrix:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
<b>CO1</b>	3	3	1	1	-	1	-	-	-	-	1	3	3	1	-
<b>CO2</b>	3	3	1	2	-	1	-	-	-	-	2	3	3	2	-
<b>CO3</b>	3	3	2	3	-	3	-	-	2	1	3	3	3	3	3
<b>CO4</b>	3	3	3	3	-	3	-	-	3	2	3	3	3	3	3

1 - Slightly; 2 - Moderately; 3 – Substantially

**Syllabus:**

**Unit I**

**Introduction to Immune System:** Types of immunity: Innate & Adaptive Immunity, Cells and components of Immune system, Organs of Immune system: Primary lymphoid organs: Structure and Functions, Secondary lymphoid organs: Structure and Functions.

**Unit II**

**Immunoglobulins:** Immunogen, Haptens & Adjuvants, Epitope, Immunoglobulin Isotypes: Structure and Functions, Monoclonal Antibodies: Hybridoma Technology and Applications, Recombinant & Chimeric Antibodies (Application in pharmaceutical), Humanized & Bispecific Antibodies, Immunotoxins, Polyclonal antibodies, Abzymes, Antigen-antibody interactions: Agglutination, Precipitation, Immuno diffusion, ELISA, RIA, Immuno electrophoresis. .

**Unit III**

B-cell Maturation & activation by thymus-independent (TI) and thymus-dependent (TD) antigens, T Lymphocyte development and activation: Cell mediated cytotoxic responses, MHC: Structure and Functions. Immune response during bacterial, parasitic and viral infections.

**Unit IV**

Complement system, Toll like receptors, Hypersensitivity reactions, Cytokines, Blood transfusion, Immunological tolerance, Autoimmune disorders, Transplantation, Graft rejection & Immunosuppressive Therapy, Vaccines: Types of Vaccines, Tumor Immunology, Cortisol Therapy.

**Text Books:**

1. Punt, J., Stranford, S., Jones, P., & Owen, J. (2019). *Kuby*



- immunology* (8th ed.).Macmillan Education.
2. Abbas, A. K., Lichtman, A. H., & Pillai, S. (2021). *Cellular and molecular immunology* (10thed.). Elsevier.
  3. Delves, P. J., Martin, S. J., Burton, D. R., & Roitt, I. M. (2016). *Roitt's essential immunology* (13th ed.). Wiley-Blackwell.

### Reference Books:

1. Richard Coico, Geoffrey Sunshine (2015). *Immunology: A short course*, 7th Edition.
2. Ian Todd, Gavin Spickett, Lucy Fairclough, (2015). *Immunology*, 7th Edition.

<b>BT3191</b>	<b>GENETIC ENGINEERING</b>	<b>PCC</b>	<b>3-0-0</b>	<b>3 Credits</b>
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### Prerequisites:

- i. BT2021 Microbiology
- ii. BT2011 Biochemistry
- iii. BT2081 Molecular Biology & Genetics

### Course Outcomes:

At the end of the course the student will be able to:



<b>CO1</b>	Understand the basic components of genetic engineering
<b>CO2</b>	Understand the molecular techniques in genetic engineering.
<b>CO3</b>	Understand the basic principles of DNA sequencing and mutagenesis
<b>CO4</b>	Apply the concepts of genetic engineering for biotechnological applications

**Course Articulation Matrix:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
<b>CO1</b>	3	2	3	2	1	-	-	-	-	-	2	3	3	3	1
<b>CO2</b>	3	3	3	3	1	-	-	-	-	-	2	3	3	3	2
<b>CO3</b>	3	3	3	3	1	-	-	-	-	-	2	3	3	2	2
<b>CO4</b>	3	3	3	3	2	-	-	2	2	-	3	3	3	3	3

1 - Slightly; 2 - Moderately; 3 – Substantially

**Syllabus:**

**Unit I**

**Components of recombinant DNA technology:** Restriction and modification enzymes, linkers and adaptors, cloning and expression vectors: Plasmids and Phage Vectors, Vectors for insect, yeast and mammalian system, Prokaryotic and eukaryotic host systems, Introducing DNA into host (bacteria, yeast, animal and plant cell), gene transfer by viral transduction, selection marker.

**Unit II**

**Basic Molecular techniques:** Electrophoresis (DNA/Protein), blotting techniques, transformation of *E. coli*, PCR, RT-PCR, Real Time PCR, microarray, gene chip, Hybridization: Radio labeling, Fluorescent in situ hybridization (FISH), gene tagging, DNA finger printing. Genomic and cDNA libraries construction, Screening of libraries and recombinant clone selection.

**Unit III**

**Mutagenesis and molecular markers:** Site-directed mutagenesis, reverse mutagenesis, cassette mutagenesis. Molecular markers: non-PCR based (RFLP) and PCR based molecular marker (RAPD, SSR, AFLP), gene knockout, gene mapping.

**Unit IV**

**Applications of genetic engineering:** Prokaryotic and eukaryotic expression systems, transgenic animals and plants, molecular pharming, gene therapy, Targeted Genome Editing: RNA Interference (RNAi), CRISPR system.

**Text Books:**

1. Primrose, S. B., Tywman, R. M., & Old, R. W. (2001). *Principles of gene*



- manipulation* (6<sup>th</sup> edition). Blackwell Publishing Company.
2. Glick, B. R., & Patten, C. L. (2017). *Molecular biotechnology: Principles and applications of recombinant DNA* (5th ed.). ASM Press.

**Reference Book:**

1. T. A. Brown (2013). *Gene Cloning and DNA Analysis: An Introduction*, Wiley BlackWell Scientific, Publications, 6thEdition.

<b>BT3201</b>	<b>UPSTREAM BIOPROCESSING</b>	<b>PCC</b>	<b>3–0–0</b>	<b>3 Credits</b>
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Prerequisites:

- i. BT1021 Bioprocess calculations
- ii. BT1011 Biochemical Thermodynamics
- iii. BT2101 Biological Reaction Engineering

**Course Outcomes:**

At the end of the course the student will be able to:

<b>CO1</b>	Understand the role of Bioprocess Engineer in Upstream Bioprocessing
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<b>CO2</b>	Design of media and batch and continuous sterilization processes
<b>CO3</b>	Design of bioreactors and scale-up and down concepts
<b>CO4</b>	Understand the importance of broth rheology, mass transfer and control concepts in the bioreactor

**Course Articulation Matrix:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
<b>CO1</b>	2	3	-	2	-	-	-	-	-	-	-	-	3	2	-
<b>CO2</b>	3	3	-	3	-	-	-	-	-	-	-	-	3	-	-
<b>CO3</b>	-	3	3	3	-	-	-	1	-	-	-	-	3	-	-
<b>CO4</b>	2	3	3	3	-	-	-	-	-	-	-	-	3	3	-

1 - Slightly; 2 - Moderately; 3 – Substantially

**Syllabus:**

**Unit I**

**Introduction:** Role of a Bioprocess Engineer, Upstream and Downstream Bioprocess Engineering, Design of media – Simple and complex and its constitutes, Inoculum development, solid and submerged fermentation, upstream equipment

**Unit II**

**Sterilization:** Media sterilization: Kinetics of thermal death of cells and spores, Design of Batch and Continuous thermal sterilization, Del value calculations for heating, cooling and holding regions, Calculation of length of holding region in ideal and non-ideal conditions, D, Z, and F values of sterilization, Sterilization of air and filter design, Radiation and chemical sterilization, acid and base cleaning, Clean-in-place (CIP) and steam-in-place (SIP) practices

**Unit III:**

**Reactor Design:** Batch, Fed-batch and Continuous processes, CSTR with washout concept, Bioreactor considerations for animal and plant cell culture and immobilized enzymes, high density cell culture and algal growth, single use reactor

**Unit IV:**

**Rheology of fermentation fluids:** Newtonian and non-Newtonian fluids, aeration and agitation, power requirement for gassed and un-gassed systems, gas holdup, mixing calculations.

**Unit V:**



**Mass transfer, scaling up concepts and Instrumentation:** Mass transfer concepts in bioreactors, role of diffusion, factors affecting oxygen transfer, measurement of volumetric oxygen mass transfer coefficient, Correlations, Scale up and scale down concepts.

#### Unit VI:

**Instrumentation in bioreactors:** On-line and off-line measurement and process control concepts of fermentation process, PAT and QbD Concepts, Design and optimization of process parameters (OFAT, DoE, RSM).

#### Text Books:

1. Stanbury, P., Whitaker, A., & Hall, S. J. (2016). *Principles of fermentation technology* (3<sup>rd</sup> ed.). Butterworth-Heinemann.
2. Pauline M. Doran, Ross Carlson, and Kate Morrissey (2024). *Bioprocess engineering principles* (3<sup>rd</sup> ed.). Academic Press.
3. Bailey, J. E., & Ollis, D. F. (1989). *Biochemical engineering fundamentals* (2nd ed.). McGraw Hill Education.
4. Vieth, W. R. (1994). *Bioprocess engineering: kinetics, mass transport, reactors and gene expression* (1st ed.). Wiley.
5. Lee, J. M. (1992). *Biochemical engineering* (1st ed.). Prentice Hall.
6. Clark, D. S., and Blanch, H. W. (1997). *Biochemical engineering* (2nd ed.). CRC Press
7. Shuler, M. L., Kargi, F., & DeLisa, M. (2017). *Bioprocess engineering: Basic concepts* (3rd ed.). Pearson
8. [https://onlinecourses.nptel.ac.in/noc19\\_bt20/preview](https://onlinecourses.nptel.ac.in/noc19_bt20/preview)

<b>BT3212</b>	<b>GENETIC ENGINEERING &amp; IMMUNOLOGY LABORATORY</b>	<b>PCC</b>	<b>0-0-2</b>	<b>2 Credits</b>
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Prerequisites:

- i. BT2062 Microbiology Laboratory
- ii. BT2132 Cell and Molecular Biology Laboratory

#### Course Outcomes:

At the end of the course the student will be able to:



<b>CO1</b>	Demonstrate basic safe laboratory practices and set up laboratory equipment safely.
<b>CO2</b>	Manipulate nucleic acids employing basic laboratory techniques and use standard procedures to clone them.
<b>CO3</b>	Plan the gene manipulation procedures and interpret the experimental results.
<b>CO4</b>	Analyze antigen-antibody interactions and interpret the results.
<b>CO5</b>	Perform different immunoassays that are used in clinical diagnostics.
<b>CO6</b>	Design assays for immunological research.

**Course Articulation Matrix:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
<b>CO1</b>	3	1	1	1	-	2	1	1	-	1	-	3	2	-	-
<b>CO2</b>	2	3	3	3	1	2	1	2	-	3	-	2	3	1	-
<b>CO3</b>	2	3	3	3	1	2	-	2	2	3	-	2	2	1	1
<b>CO4</b>	2	3	3	3	1	2	-	-	-	3	-	2	2	-	1
<b>CO5</b>	2	3	3	3	1	2	1	2	2	3	-	2	2	1	-
<b>CO6</b>	2	3	3	3	1	2	1	2	1	3	-	2	3	1	1

1 - Slightly; 2 - Moderately; 3 – Substantially

**Syllabus:**

**Genetic Engineering Laboratory:**

1. Competent cell preparation
2. Transformation of plasmid DNA to *E. coli*
3. Restriction digestion of DNA
4. Ligation of DNA
5. PCR primer designing and PCR
6. Gel elution of PCR product
7. Analysis of DNA polymorphism using RAPD/RFLP marker

**Immunology Laboratory:**

1. ABO blood grouping test
2. Ouchterlony double diffusion (Antigen-antibody pattern)
3. Counter current immuno-electrophoresis
4. Widal Test
5. DOT ELISA

**Text Books:**

1. Sambrook, J. & Russell, D. (2004). *Molecular cloning: A laboratory manual* (3rd ed.). CSHL Press.
2. Vennison, S. J. (2009). *Laboratory manual for genetic engineering*. PHI Learning.
3. David Wild, *The Immunoassay Handbook: Theory and Applications of Ligand Binding, ELISA and Related Techniques*, Elsevier Science, 2013, 4<sup>th</sup> Edition.



<b>BT3222</b>	<b>BIOREACTION AND UPSTREAM BIOPROCESSING LABORATORY</b>	<b>PCC</b>	<b>0-0-2</b>	<b>2 Credits</b>
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**Prerequisites:**

1. BT1021 Bioprocess calculations
2. BT2101 Biological Reaction Engineering

**Course Outcomes:**

At the end of the course the student will be able to:

<b>CO1</b>	Predict the kinetics of cell and enzymatic reaction
<b>CO2</b>	Planning, collection and analysis of experimental data
<b>CO3</b>	Calculation of design data for the kinetics and reactor design

**Course Articulation Matrix:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
<b>CO1</b>	2	3	1	3	3	-	-	-	-	-	-	-	3	-	-
<b>CO2</b>	2	3	-	3	3	-	-	-	-	-	-	-	3	-	-
<b>CO3</b>	2	3	1	3	1	-	-	-	-	-	-	-	2	1	-

1 - Slightly; 2 - Moderately; 3 – Substantially

**Syllabus:**

1. Kinetics analysis of bacterial growth
2. Sterilization of media and thermal death kinetics
3. Enzyme kinetics - effect of substrate, temperature, and pH
4. Enzyme Immobilization (Free and immobilized)
5. Enzyme Inhibition kinetics
6. Reactor component and its operations
7. Volumetric oxygen mass transfer coefficient determination – Dynamic method
8. Determination of mixing time and power number
9. Residence time distribution experiments
10. Estimation of ammonia and phosphate
11. Online measurement of substrate using HPLC

**Text Books:**

1. Laboratory manual of NIT Andhra Pradesh
2. Das, D., & Das, D. (2021). *Biochemical engineering: A laboratory manual* (1st ed.). Jenny Stanford Publishing.
3. Doran, P. M. (2012). *Bioprocess engineering principles* (2nd ed.). Academic Press

<b>SM3011</b>	<b>INTRODUCTION TO ENTREPRENEURSHIP</b>	<b>HSC</b>	<b>1–0–0</b>	<b>1 Credit</b>
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**Prerequisites:** None

**Course Outcomes:**



At the end of the course the student will be able to:

<b>CO1</b>	Acquaint themselves with starting new ventures and introducing new products and service ideas
<b>CO2</b>	Explore the processes of establishing a start-up and develop strategies and methods to mobilize resources
<b>CO3</b>	Create venture capitalists, consultants to new firms or new business development units of larger corporates

### Syllabus:

The entrepreneur's role, task, and personality- typology of entrepreneurs: entrepreneurship as a style of management

Identify problems worth solving-political economical, and social- technical analysis-opportunity recognition-business model identification-new product franchising-sponsorship and acquisition- internal & external entry strategies

Startup ecosystem and support system- role of incubators- government initiatives

Writing and pitching business plan-entrepreneurial tool-venture capital and other forms of financing-sources of external support-developing entrepreneurial marketing-competencies-maintaining competitive advantage

### References:

1. B.D.Singh. *Managing Conflict and Resolution*. Excel Books.2008
2. B. R. Barringer and D. Ireland, *Entrepreneurship*, Prentice Hall,2009.
3. G. Kawasaki, L. Filby, *The Art of the Start 2.0: The Time-Tested, Battle-Hardened Guide for Anyone Starting Anything* , Penguin,2015.
4. R. Bansal, *Connect the Dots*, Westland, 2011.
5. Ries, Eric *The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses*, Crown Business, 2011.
6. S. S. Khanka, *Entrepreneurial Development*, S. Chand & Co.2006.

## III – Year: II – Semester

<b>BT3301</b>	<b>DOWNSTREAM BIOPROCESSING</b>	<b>PCC</b>	<b>3–0–0</b>	<b>3 Credits</b>
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### Prerequisites:

- i. BT1011 Biochemical Thermodynamics
- ii. BT2041 Transport phenomena in biological system

**Course Outcomes:**

At the end of the course the student will be able to:

<b>CO1</b>	Understand the basis of separation of biomolecules
<b>CO2</b>	Understand the principles of major unit operations of biopharmaceuticals.
<b>CO3</b>	Design and optimization of downstream processes
<b>CO4</b>	Understand the principles of product purification and storage

**Course Articulation Matrix:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
<b>CO1</b>	3	2	2	2	-	1	1	-	-	-	1	-	1	-	-
<b>CO2</b>	2	2	2	-	-	-	1	-	-	1	2	-	2	-	-
<b>CO3</b>	3	2	3	-	2	-	1	1	-	-	2	-	2	1	-
<b>CO4</b>	3	2	2	1	1	-	-	-	-	-	1	1	1	-	1

1 - Slightly; 2 - Moderately; 3 – Substantially

**Syllabus:****Unit I**

Scope of Downstream Processing: Importance of downstream processing (DSP) in biotechnology, Characteristics of products, criteria for selection of bio-separation techniques. Role of DSP methods in bioprocess economics, Role of upstream processing on DSP - microbial protein expression and purification. Economics of Downstream Processing, Scale down, Scale up, Scale up sustainability

**Unit II**

Cell disruption methods: Various cell disruption methods, need for cell disruption for intracellular products, cell disruption equipment. Applications in bio-processing.

**Unit III**

Separation techniques: Filtration, Centrifugation (basket centrifuge, tubular centrifuge, disc-bowl centrifuge), Adsorption, Adsorption isotherms, Adsorber design, Extraction methods – solid liquid extraction, liquid-liquid extraction, aqueous two-phase extraction,

**Unit IV**

Purification technique: Precipitation, Dialysis, Membrane separation processes, Principles of chromatographic separation methods- ion-exchange chromatography, gel chromatography, affinity chromatography. Product polishing: Crystallization, drying – spray and freeze drying, formulation and storage.

**Text Books:**

1. Harrison, R. G., Todd, P., Rudge, S. R., & Petrides, D. P. (2015). *Bioseparations science and engineering* (2nd ed.). Oxford University Press.
2. Ghosh, R. (2006). *Principles of bioseparations engineering*. World Scientific Publishing Company.



3. Stanbury, P., Whitaker, A., & Hall, S. J. (2016). *Principles of fermentation technology* (3rd ed.). Butterworth-Heinemann.
4. J. D. Seader and E.J. Henley, Separation Process Principles, 3rd Edn., Wiley, 2010
5. Venko N. Beschkov (2012), *Downstream Processing in Biotechnology*. Springer
6. Ronald, & Lee, J. (2007). *Principles of downstream processing* (1st ed.). Wiley Publications.
7. Michael R. Ladisch (2001). *Bioseparation Engineering: Principles, Practice, and Economics*. Wiley-Interscience publications
8. Weatherley, L. R. (1994). *Engineering processes for bio separations* (1st ed.). Butterworth-Heinemann.
9. Juan A. Asenjo (2020). Separation Process in Biotechnology. 1st Edition. CRC Press .

<b>BT3311</b>	<b>BIOINFORMATICS</b>	<b>PCC</b>	<b>3–0–0</b>	<b>3 Credits</b>
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Prerequisites:

- i. BT2011 Biochemistry
- ii. BT2081 Molecular Biology & Genetics

**Course Outcomes:**

At the end of the course the student will be able to:

<b>CO1</b>	Understand the biological sequences, algorithms for sequence alignments, and
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	phylogenetic analysis.
<b>CO2</b>	Understand the types of biological databases available in the open-sourcedomain.
<b>CO3</b>	Perform the homology search and sequence evolution identification.
<b>CO4</b>	Understand the principles of protein structure and drug discovery.

**Course Articulation Matrix:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
<b>CO1</b>	3	-	-	1	3	-	-	2	-	-	-	-	3	1	2
<b>CO2</b>	3	-	-	1	3	-	-	2	-	-	-	-	3	1	-
<b>CO3</b>	3	-	-	1	3	-	-	2	-	-	-	-	3	1	2
<b>CO4</b>	3	-	-	2	3	-	-	2	-	-	-	-	3	-	-

1 - Slightly; 2 - Moderately; 3 – Substantially

**Syllabus:****Unit I**

Introduction and Overview of Bioinformatics, Collecting and Storing Sequences in the Laboratory, Alignment of Pairs of Sequences, Introduction to Probability and Statistical Analysis of Sequence Alignments, Multiple Sequence Alignment, Sequence Database Searching for Similar Sequences.

Biological databases, Classification, database searching, Sequence Alignment: Pairwise and Multiple sequence Alignment, Sequence homology search.

**Unit II**

Phylogenetic trees, Phylogenetic Prediction, Prediction of RNA Secondary Structure, Gene Prediction and Regulation. Genome Analysis, Genome organization and evolution,

**Unit III**

Protein Classification and Structure Prediction, Structural bioinformatics in drug discovery, Molecular Docking- Rigid docking, flexible docking, manual Docking, docking based Screening, De novo Drug design, Virtual Screening Techniques-Drug likeness screening, Concept of Pharmacore mapping and pharmacophore-based Screening. Bioinformatics Programming Using Perl and Perl Modules

**Unit IV**

Introduction to Systems Biology, Computational Bioengineering, Introduction, Strategies in Bioengineering, Synthetic Biology, Design of Synthetic Systems, and Metabolic pathways

**Text books:**

10. Mount, D. W. (2004). *Bioinformatics: Sequence and genome analysis* (2nd ed.); CSHLPRESS.
11. Lesk, A. M. (2014). *Introduction to bioinformatics* (4th ed.) Oxford University



Press.

12. Baxevanis, A. D. (2004). *Bioinformatics: A practical guide to the analysis of genes and proteins* (3rd ed.). Wiley-Interscience.
13. Leach, A. (2001). *Molecular modelling: Principles and applications* (2nd ed.). Prentice Hall.
14. Whitford, D. (2005). *Proteins: Structure and function* (1st ed.). Wiley.
15. Basant K. Tiwary (2022). *Bioinformatics and Computational Biology*. (1<sup>st</sup> ed.) Springer

<b>BT3322</b>	<b>BIOINFORMATICS LABORATORY</b>	<b>PCC</b>	<b>0–0–2</b>	<b>2 Credits</b>
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**Prerequisites:**

1. BT2011 Biochemistry
2. BT2081 Molecular Biology & Genetics

**Course Outcomes:**

At the end of the course the student will be able to:



<b>CO1</b>	Retrieve data from open-source biological databases.
<b>CO2</b>	Use open-source tools for biological sequence analysis.
<b>CO3</b>	Identify the evolutionary relationships using biological sequences.
<b>CO4</b>	Construct and analyze protein models, function, and interaction using bioinformatic tools.

**Course Articulation Matrix:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
<b>CO1</b>	1	3	-	-	3	1	2	-	-	-	-	-	3	1	-
<b>CO2</b>	2	2	2	3	3	2	2	-	-	-	-	-	-	2	-
<b>CO3</b>	2	1	1	3	2	3	1	-	-	-	-	-	3	3	-
<b>CO4</b>	3	3	3	3	3	3	3	-	-	-	-	-	3	2	3

1 - Slightly; 2 - Moderately; 3 – Substantially

**Syllabus:**

1. Overview of Biological Databases
2. Sequence Retrieval from NCBI
3. Structure Retrieval from PDB
4. Pairwise Alignment (LOCAL and GLOBAL ALIGNMENT)
5. Multiple Sequence Alignment and Phylogenetic Tree Building (CLUSTAL O and MEGA)
6. Finding homologues sequence in a database using BLAST
7. Designing of primer for a nucleotide sequence
8. Gene Prediction (GENSCAN)
9. Finding the restriction sites
10. Protein Structure Visualization (RASMOL/PYMOL)
11. Protein Homology Modelling
12. Molecular Docking and interaction Analysis (using iGEMDOCK)

**Text Books:**

1. Craig, P. Bioinformatics exercises. Rochester Institute of Technology.

**Online Resources:**

1. Website tutorials @ NCBI, PDB.

<b>BT3332</b>	<b>DOWNSTREAM BIOPROCESSING LABORATORY</b>	<b>PCC</b>	<b>0-0-2</b>	<b>2 Credits</b>
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**Prerequisites:**

1. BT2011 Biochemistry

**Course Outcomes:**



At the end of the course the student will be able to:

<b>CO1</b>	Apply the knowledge to select appropriate downstream process
<b>CO2</b>	Plan the downstream processing experiments, collect and evaluate the data
<b>CO3</b>	Design the efficient experimental setup for purification and polishing operations

### Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
<b>CO1</b>	3	-	-	3	-	1	-	-	-	1	-	-	-	-	1
<b>CO2</b>	3	1	-	3	-	-	1	-	1	3	-	-	2	3	1
<b>CO3</b>	3	1	1	3	-	-	2	1	1	3	-	-	2	1	3

1 - Slightly; 2 - Moderately; 3 – Substantially

### Syllabus:

1. Localization of enzyme and cell lysis using physical and chemical methods
2. Solid – liquid separation methods (filtration and centrifugation)
3. Extraction methods (solid-liquid, liquid-liquid and aqueous two phase)
4. Precipitation of protein
5. Dialysis for desalting the macromolecules
6. Chromatography for separation of biological molecules based on charge/size.
7. Membrane separation (Ultrafiltration/cross flow filtration/Tangential Flow filtration)
8. Lyophilization for preservation of biological product
9. Stability analysis of protein during storage

### Text Books

1. Ahuja, S. (2000). *Handbook of bioseparations – volume 2*. Academic Press.
2. Desai, M. A. (2012). *Downstream processing of proteins: methods and protocols*. Humana Press.
3. Scopes, R. K. (2020). *Protein purification: Principles and practice* (4th ed.). Springer.
4. Wilson, K. & Walker, J. M. (2018). *Principles and techniques of practical biochemistry* (7th ed.). Cambridge University Press

<b>HS3011</b>	<b>ENGLISH FOR ENGINEERS II</b>	<b>HSC</b>	<b>2–0–2</b>	<b>3 Credits</b>
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Prerequisites: English for Engineers 1

### Course Outcomes:

At the end of the course the student will be able to:



<b>CO1</b>	To equip students to develop Questionnaire and to pitch ideas
<b>CO2</b>	To cultivate delegation skills and strategic planning
<b>CO3</b>	To equip students to creating career related documents
<b>CO4</b>	To equip students with technical and business writing
<b>CO5</b>	To improve oral communication and interview readiness

### Syllabus:

**Module 1 :** Cover letter - resume - statement of purpose

**Module 2 :** Technical report writing - proposal writing - minutes of the meeting

**Module 3 :** Pitching ideas - client correspondence - preparation of questionnaire

**Module 4 :** Diplomacy skills - strategic planning - delegation skills - feedback

### Language Laboratory

Group presentation-presentation with emphasis on body language- public speaking- extempore speech; Pronunciation practice (Automatic Speech Recognition).

**Mock interview:** Interview etiquette, common interview questions

### Text books

1. Brown, Carla L. *Essential Delegation Skills*. Routledge, 2017.
2. Carter, Ronald and Michael McCarthy. *Cambridge Grammar of English: A Comprehensive Guide*. Cambridge University Press, 2006.
3. Harris, David.F. *Complete Guide to Writing Questionnaires*. I&M Press, 2014.
4. Hering, Lutz and Heike Hering. *How to Write Technical Reports: Understandable Structure, Good Design, Convincing Presentation*. Springer; 2010.
5. Mohan, Krishna and Meera Banerji. *Developing Communication Skills*. Macmillan India Limited, 2000.
6. Muralikrishna and Sunitha Mishra. *Communication Skills for Engineers*. Pearson, 2011.

### References

1. Busan, Tony. *Mind Map Mastery*. Walkins, 2018.
2. Huckin N. Thomas and Leslie A. Olsen *Technical Writing and Professional Communication for Non-native Speakers*. McGraw-Hill Education, 1991.
3. Laplante, Phillip A. *Technical Writing: A Practical Guide for Engineers, Scientists, and Nontechnical Professionals*. CRC Press, 2018.
4. Mc Quail, Dennis. *Audience Analysis*. Sage, 1997



5. Ogden, Richard. *Introduction to English Phonetics*. Edinburgh University Press, 2017.
6. Parker, Glenn M. *Team Players and Teamwork: New Strategies for Developing Successful Collaboration*. Wiley, 2011.
7. Seely, John. *Oxford Guide to Effective Writing and Speaking: How to Communicate Clearly*. Oxford University Press: 2013

HS3021	INTRODUCTION TO DESIGN THINKING	HSC	1-0-0	1 Credit
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**Course Outcomes:**

At the end of the course the student will be able to:

CO1	Understand and apply advanced Design Thinking techniques for problem-solving.
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<b>CO2</b>	Develop proficiency in ideation and visualization tools to structure innovative concepts, analyze biases in user and developer perspectives to enhance communication.
<b>CO3</b>	Implement frameworks to sustain a culture of innovation, apply Design Thinking principles to real-world challenges through exercises and case-based discussions.

### Syllabus:

Listening and empathizing techniques, observation techniques, structured open-ended approaches, overcoming cognitive fixedness, behavior models, innovation heuristics, case-based discussions-exercises.

Use of diagrams and maps in design thinking, empathy map, affinity diagram, mind map, journey map-combining ideas into complex innovation concepts, storytelling and scenario planning-improvisation, scenario development, evaluation tools, frog design-prototyping, interactive workshops, case-based discussions.

### References:

1. Roger Martin, *The Design of Business: Why Design Thinking is the Next Competitive Advantage*, Harvard Business Press , 2009.
2. Christoph Meinel, Larry Leifer, and Hasso Plattner (eds), *Design Thinking: Understand – Improve– Apply*, Springer, 2011.
3. Idris Moo tee, *Design Thinking for Strategic Innovation: What They Can't Teach You at Business or Design School*, John Wiley & Sons, 2013.

**DEPARTMENTAL ELECTIVES**

<b>BT3141</b>	<b>PLANT BIOTECHNOLOGY</b>	<b>DEC</b>	<b>3-0-0</b>	<b>3 Credits</b>
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**Prerequisites:**

- i. BT2011 Biochemistry
- ii. BT2081 Molecular Biology & Genetics
- iii. BT2031 Cell Biology
- iv. BT3212 Genetic engineering

**Course Outcomes:**

At the end of the course the student will be able to:

<b>CO1</b>	Comprehend the concepts of plant tissue culture techniques
<b>CO2</b>	Understand the technology of plant transformation
<b>CO3</b>	Understand in vitro techniques for production of plant secondary metabolites.
<b>CO4</b>	Understand the phytochemical production and assessment of transgenic plants

**Course Articulation Matrix:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
<b>CO1</b>	3	1	-	-	3	2	3	-	-	-	1	2	3	-	2
<b>CO2</b>	-	-	3	-	3	-	3	-	-	-	1	-	-	-	-
<b>CO3</b>	-	3	-	2	-	-	3	-	-	-	1	2	-	3	2
<b>CO4</b>	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-

1 - Slightly; 2 - Moderately; 3 – Substantially

**Syllabus:****Unit I**

Introduction to Plant Biotechnology, Plant agriculture: The impact of biotechnology, Special features and organization of Plant cells, Plant growth hormones: biosynthesis and signaling pathways, Physiology, Transpiration, Movement of water and ions.

**Unit II**

Plant Tissue Culture, Media, culture conditions, Callus, cell suspension culture, Anther, protoplast, embryo and meristem cultures, Totipotency, regeneration methods of plants in cultures, Somatic hybrids and cybrids, Applications of cell and tissue culture, Production of Secondary metabolites, Engineering considerations for the production of phytochemicals.

**Unit III**

Successful gene transfer mechanism, Direct and Indirect methods, Agrobacterium-mediated gene transfer, Applications of Transgenic plants, Insecticidal, herbicidal,



and viral resistance, Other applications of Transgenic plants.

#### **Unit IV**

Transgenic Plant Analysis, Initial screens, Definitive molecular characterization, Field Testing of Transgenic Plants, Environmental risk assessment, IPR in PBT.

#### **Text Books:**

1. Slaton, A., Scott, N. W., & Fowler, M. R. (2008). Plant biotechnology: The genetic manipulation of plants (2nd ed.). Oxford University Press.
2. Stewart, C. N. (2008). Plant biotechnology and genetics: Principles, techniques, and applications (2nd ed.). John Wiley and Sons.
3. Srivastava, P. S., Narula, A., & Srivastava, S. (2005). Plant biotechnology and molecular markers. Springer.
4. Chawla, H. S. (2020). Introduction to plant biotechnology (3rd ed.). Science Publishers.
5. Taiz, L. & Zeiger, E. (2010). Plant physiology (5th ed.). Oxford University Press.



<b>BT3151</b>	<b>BIOPHYSICS</b>	<b>DEC</b>	<b>3-0-0</b>	<b>3 Credits</b>
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**Pre-Requisites:**

- i. BT2011 Biochemistry

**Course Outcomes:**

At the end of the course the student will be able to:

<b>CO1</b>	Define ergocity in a system and concept of ensembles
<b>CO2</b>	Understand forces involved in biological systems
<b>CO3</b>	Illustrate difference between quantum and molecular mechanics
<b>CO4</b>	Identify stochastic and deterministic simulation techniques
<b>CO5</b>	Apply molecular dynamics simulations for biological systems

**Course Articulation Matrix:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
<b>CO1</b>	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<b>CO2</b>	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<b>CO3</b>	2	-	-	-	-	-	-	-	-	-	-	-	-	1	-
<b>CO4</b>	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-
<b>CO5</b>	-	2	-	-	2	-	-	-	-	-	-	-	-	2	-

1 - Slightly; 2 - Moderately; 3 – Substantially

**Syllabus:**

**Unit I**

**Introduction to Statistical Mechanics:** Concept of macro-state and microstate thermodynamic ensembles- Boltzman distribution- introduction to quantum mechanics and molecular mechanics. integration of Newton's laws of motion, intermolecular forces in biological systems, stabilizing forces in proteins, lipids and nucleic acids.

**Unit II**

**Basics of Molecular Structure:** Bond length, bond angle, torsion angle and non-covalent interactions – molecular structure and internal energy – energy minimization of small molecules – types of energy minimization- empirical representation of molecular energies – use of force fields and the molecular mechanics method –discussion of global energy minimum –molecular visualization tools.

**Unit III**

**Simulation Techniques:** Stochastic and deterministic simulations, molecular dynamics and Monte Carlo simulation- definition and types of model building- Velocity, Verlet leapfrog algorithm, periodic boundary conditions, generating ab initio and template-based models, applications of molecular dynamics simulations.



**Text Books:**

1. Atkins' Physical Chemistry, Peter Atkins and Julio De Paula, Oxford University Press, 2018, 11<sup>th</sup> Edition.
2. Molecular Modelling-Principles and Applications, Andrew R. Leach, Pearson Education, 2009, 2<sup>nd</sup> Edition

**Reference Books:**

1. Understanding Molecular Simulation, From Algorithms to Applications. Frenkel & Smith, Elsevier, Academic Press, 2002, 2<sup>nd</sup> Edition.
2. Molecular and Cellular Biophysics, Meyer B Jackson, Cambridge University Press, 2010, 1<sup>st</sup> Edition.
3. Molecular Modelling for Beginners, Alan Hinchliffe, Wiley Publishers, 2008, 2<sup>nd</sup> Edition.



<b>BT3161</b>	<b>BIODIVERSITY AND CONSERVATION</b>	<b>DEC</b>	<b>3-0-0</b>	<b>3 Credits</b>
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**Pre-Requisites:** None

**Course Outcomes:**

At the end of the course the student will be able to:

<b>CO1</b>	Comprehend the diversity among microbes, plants animals
<b>CO2</b>	Realize hotspots and endangered species
<b>CO3</b>	Identify endemic and threatened species for conservation
<b>CO4</b>	Understand the functioning of conservation organizations and their activities

**Course Articulation Matrix:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
<b>CO1</b>	1	2	-	-	-	-	3	2	-	3	-	2	-	-	1
<b>CO2</b>	-	-	-	-	-	2	1	2	-	-	-	-	-	-	-
<b>CO3</b>	-	3	-	-	-	1	-	-	-	-	-	-	-	-	-
<b>CO4</b>	-	-	-	-	-	-	-	-	3	-	-	3	3	-	-

1 - Slightly; 2 - Moderately; 3 – Substantially

**Syllabus:**

**Unit I**

**Introduction to Biodiversity:** Biodiversity: definition, levels, organization, uses, and valuing biodiversity genetic diversity: nature and origin of genetic variation, measuring genetic diversity variation, wild relatives of cultivated/domesticated/cultured organisms (plants/animals/microbes). Species diversity: concept of species, measurement of species diversity, global distribution of species richness, ecosystem diversity - terrestrial and aquatic ecosystems, centers of mega diversity and hotspots, biodiversity vs. biotechnology, DNA barcoding.

**Unit II**

**Biodiversity Loss and Conservation:** Concept and characteristics of plant community, methods of studying vegetation, Raunkiaer's classification of life forms, biological spectrum, plant succession, concept of climax and climax communities, biodiversity conservation, principles and rationale, ex-situ and in-situ conservation strategies including sperm/seed banks, cryopreservation, embryo collection and freezing, creation of parks, wildlife sanctuaries, botanical gardens.

**Unit III**

**Importance of Biodiversity:** Endemic and threatened plant species of India, importance of biodiversity in Indian context, global animal diversity, a bird's eye view of animal kingdom, domesticated animal diversity and wild animal resources of India, a brief account of diversity in aquatic life, Introduction to Hardy-Weinberg Law.



## Unit IV

**Conservation Organizations and Activities:** Brief account of the conservation organizations and their activities-CI, WWF, UNEP, FAO, IUCN, international agreements on biodiversity conservation-CBD, CITES, IPCC, UNFCCC, RAMSAR, biodiversity related to traditional knowledge, biopiracy, Nagoya Protocol, Intellectual Property Rights and biodiversity.

### Text Books:

1. An Advanced Textbook on Biodiversity: Principles and Practice, K.V. Krishnamurthy, Oxford & IBH Publishing, 2018, 2<sup>nd</sup> Edition.
2. Biodiversity and Biotechnology. Ray S., Ray A.K. New Central book Agency, 2010, 3<sup>rd</sup> Edition.

### Reference Books:

1. Biodiversity: An Introduction. Gaston, K.J, Spicer J.I. Blackwell Publishing Company, 2004, 1<sup>st</sup> Edition.



<b>BT3231</b>	<b>INDUSTRIAL BIOTECHNOLOGY</b>	<b>DEC</b>	<b>3-0-0</b>	<b>3 Credits</b>
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**Prerequisites:**

- i. BT2021 Microbiology
- ii. BT1021 Bioprocess Calculations

**Course Outcomes:**

At the end of the course the student will be able to

<b>CO1</b>	Understand the use of living cells in industry
<b>CO2</b>	Understand the commercial production processes in the biotechnology industry
<b>CO3</b>	Understand and apply the industrial level production processes for economically valuable products
<b>CO4</b>	Develop the bioprocess for production of industrial products

**Course Articulation Matrix:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
<b>CO1</b>	2	3	1	1	-	2	3	1	-	-	-	-	3	1	2
<b>CO2</b>	1	3	1	1	-	2	2	1	-	-	-	-	3	2	1
<b>CO3</b>	2	2	3	1	2	2	2	1	-	-	-	-	3	3	1
<b>CO4</b>	1	2	3	3	3	3	2	1	-	-	1	1	2	3	3

1 - Slightly; 2 - Moderately; 3 – Substantially

**Syllabus:****Unit I**

Introduction to industrial biotechnology, Outline of industrial biotechnological process. Production of biomass, primary and secondary metabolites: Commercial production of Organic Acids and bulk organics (ethanol). Commercial production of Antibiotics, Extra cellular polysaccharides (Xanthan Gum), Pigments (Shikonin).

**Unit II**

Microbial production of industrial enzymes: glucose isomerase, cellulase, lipases, amylase, protease, Production of Fermented Foods, Single Cell Protein.

**Unit III**

Commercial production of recombinant therapeutic proteins, Microbial Transformations (Steroids), Transformation of steroids and sterols, Transformation of non-steroidal compounds, Applications of bioconversions. Screening strategies for new products.

**Text Books:**

1. Okafor, N. (2007). *Modern industrial microbiology and biotechnology* (1<sup>st</sup> ed.) Science Publishers.
2. Stanbury, P., Whitaker, A., & Hall, S. J. (2016). *Principles of fermentation technology* (3<sup>rd</sup> ed.). Butterworth-Heinemann.



<b>BT3241</b>	<b>NANOBIOTECHNOLOGY</b>	<b>DEC</b>	<b>3-0-0</b>	<b>3 Credits</b>
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**Prerequisites:**

- i. PH1011 Engineering Physics
- ii. CY1011 Engineering Chemistry

**Course Outcomes:**

At the end of the course the student will be able to:

<b>CO1</b>	Understand the basic principles of nanotechnology
<b>CO2</b>	Understand physical, chemical and biological methods for synthesis of nano Materials
<b>CO3</b>	Apply the concepts of nanotechnology for biosensors
<b>CO4</b>	Apply the concepts of nanotechnology for drug delivery and gene therapy.

**Course Articulation Matrix:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
<b>CO1</b>	2	1	-	2	-	2	-	-	-	-	-	-	3	1	-
<b>CO2</b>	1	2	-	2	2	1	-	-	-	-	-	-	3	-	-
<b>CO3</b>	2	1	1	2	2	-	-	-	1	-	-	-	3	-	-
<b>CO4</b>	3	1	-	1	1	-	1	-	-	-	-	-	-	-	-

1 - Slightly; 2 - Moderately; 3 – Substantially

**Syllabus:**

**Unit I**

Introduction to Nanotechnology: Top down and bottom up approaches- Nanobiotechnology, Types of nanomaterials: Nanoparticles, Nanowires, Nanotubes, Thin films and Multilayers, Properties of Nanomaterials, Biomolecules as Nanostructures, Molecular Motors.

**Unit II**

Methods of preparation of nanomaterials (Physical, chemical and Biological), Nanoparticle synthesis using microbes, characterization techniques of nanomaterial: Electron microscopy, Atomic force microscopy, Photon correlation spectroscopy, X-ray diffraction analysis, Thermogravimetric analysis. Functionalization of nanomaterials for biological applications.

**Unit III**

Applications of nanomaterials in optical biosensors and fluorescence nanomaterial for imaging, quantum dots, Nanomaterials in electrochemical biosensors, Nanomaterials for other biological and environmental applications.



## Unit IV

Nanostructures for drug delivery, Nanovesicles; Nanospheres; Nano capsules, Magnetic nanoparticles; Nanocarriers; Dendrimers, Concepts, Targeting, Routes of delivery and advantages, Drug-Photodynamic therapy, Nanomaterials targeted drug delivery. Recent trends in nanobiotechnology. Nanotoxicology

### Text Books:

1. Ratner, M., & Ratner, D. (2003). *Nanotechnology – a gentle introduction to the next big idea* (1st ed.), Pearson education.
2. Niemeyer, C. M., & Chad A. Mirkin, C. A. (2004). *Nanobiotechnology: Concepts, applications and perspectives* (1st ed.). John Wiley & Sons.
3. Foster, L. E. (2005). *Nanotechnology - science, innovation and opportunity*. Person Education



<b>BT3251</b>	<b>FOOD BIOTECHNOLOGY</b>	<b>DEC</b>	<b>3-0-0</b>	<b>3 Credits</b>
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**Pre-Requisites:**

- i. BT2021 Microbiology
- ii. BT2011 Biochemistry

**Course Outcomes:**

At the end of the course the student will be able to:

<b>CO1</b>	Understand the components and nutritional value of food
<b>CO2</b>	Understand the concepts of fermented food production process
<b>CO3</b>	Understand the food processing methods and regulations

**Course Articulation Matrix:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
<b>CO1</b>	-	3	-	-	-	3	2	1	1	1	2	3	3	-	2
<b>CO2</b>	-	-	1	3	1	3	2	2	2	1	2	2	2	3	2
<b>CO3</b>	1	2	3	3	2	2	1	3	2	2	1	2	2	2	2

1 - Slightly; 2 - Moderately; 3 – Substantially

**Syllabus:****Unit I**

Food biochemistry and microbiology: Components of food: carbohydrates, proteins, fats, vitamins, minerals, Antinutrients; Balanced diet; Prebiotics; Probiotics; Phytonutraceuticals; Nutraceuticals Vs Pharmaceuticals; Microbial Spoilage: food, milk and milk products, meat and meat products; Bacterial pathogens and Non-bacterial pathogens; food preservation.

**Unit II**

Production of fermented food: Overview of diverse fermented foods; Starter cultures in food industry; Production process of selected fermented foods (Soya sauce, Sauerkraut, Peanut milk, Idly, Beer, Wine, Yogurt, Cheese, Sausages); Concept of SCP, mushrooms, food yeasts, algal protein, GM foods; bio-fortification, food additives, food sweeteners and colours. Limit of Pesticide in Food item, Hazardous effect of Food additives

**Unit III**

Food processing methods and regulations: Product development; Processing techniques; Toxicology studies; clinical trials associate with product development; Hygiene and sanitation in food sector; Concepts of GMP, GHP and GLP; Food Laws and Organizations: Food Safety Standards Rules & Regulations, 2011, FSSAI regulation, Essential commodities Act; International Organizations: EFSA, FDA, FAO.



**Text Books:**

1. Lee, B. H. (2015). *Fundamentals of food biotechnology* (2nd ed.), Wiley-Blackwell.
2. Jay, J. M., Loessner, M. J., & Golden, D. A. (2005). *Modern food microbiology* (7th ed.). Springer.
3. Green, P. J. (2002). *Introduction to food biotechnology* (1st ed.) CRC Press. Shetty, K., Paliyath, G., Pometto, A., & Levin, R. E. (2005). *Food biotechnology* (2nd ed.), CRC Press.



<b>BT3261</b>	<b>BIOREACTOR DESIGN AND ANALYSIS</b>	<b>DEC</b>	<b>2-0-0</b>	<b>2 Credits</b>
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**Pre-Requisites:**

- i. BT1021 Bioprocess Calculations
- ii. BT2101 Biological Reaction Engineering

**Course Outcomes:**

At the end of the course the student will be able to:

<b>CO1</b>	Understand the general consideration of various types of bioreactors and their design
<b>CO2</b>	Design batch, fed batch and continuous bioreactors for enzymes and cells
<b>CO3</b>	Understand the non-ideality and model selection
<b>CO4</b>	Understand the concept of scale up and scale down

**Course Articulation Matrix:**

	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>	<b>PO7</b>	<b>PO8</b>	<b>PO9</b>	<b>PO10</b>	<b>PO11</b>	<b>PO12</b>	<b>PSO1</b>	<b>PSO2</b>	<b>PSO3</b>
<b>CO1</b>	3	2	2	1	-	-	-	-	-	-	-	-	3	2	-
<b>CO2</b>	2	2	3	2	-	1	-	1	-	-	-	-	3	2	-
<b>CO3</b>	2	2	3	2	2	1	-	1	-	-	-	-	3	2	-
<b>CO4</b>	3	2	3	2	2	-	-	-	-	-	-	-	3	3	-

1 - Slightly; 2 - Moderately; 3 – Substantially

**Syllabus:**

**Unit I**

**Introduction:** Overview of submerged liquid fermentation process (SLF) and Solid-state fermentation (SSF), General design information; Mechanical design of reactors, heat transfer and mass transfer equipment; Design considerations for maintaining sterility of process streams and process equipment; Piping and instrumentation.

**Unit II**

**Overview on various Reactor Types:** Bioreactors for microbial (bacteria and fungi), plant and animal cultivation, Photobioreactors for algal cell cultivation, Bioreactors for immobilized cell cultivation and solid state fermentation.

Batch reactor- calculation of batch time, quantitative evaluation of batch processes, continuous flow bioreactors- CFSTR including chemostat and turbidostat, mean residence time, washout condition; recycle bioreactors; combination of bioreactors; fed-batch cultivation. Mechanical design of bioreactors based OTR and OUR, Safety aspects of reactor design.

**Unit III**

**Non-ideal behavior in bioreactors:** Non-ideal parameters, models for non-ideal flow including single parameter and multi parameters; transient behavior- characterization of transient state, stability analysis including inhibition systems; phase plane and bifurcation analyses.



## Unit V

**Scale up and scale down:** Effect of scale-up on oxygenation, mixing, sterilization, pH, temperature, inoculum development, nutrient availability and supply; Bioreactor scale up strategies: constant power consumption per volume, mixing time, impeller tip speed (shear), mass transfer coefficients; Scale down; Process economics.

### Text Books:

1. Panda, T. (2011). *Bioreactors analysis and design* (1st ed.). Tata McGraw Hill.
2. Schuegerl, K. (1987). *Bioreaction engineering (Vol I)*. John Wiley and Sons.
3. Ghose, T. K. (1990). *Bioprocess computations for biotechnology (Vol I)*. Pearson Education.
4. McDuffie, N. G. (1991). *Bioreactor design fundamentals* (1st ed.). Butterworth-Heinemann.
5. Ravi, R., Vinu, R., & Gummadi, S. N. (2017). *Chemical and biochemical reactors and reaction engineering, Volume 3A*, Coulson and Richardson's chemical engineering (4th ed.). Butterworth-Heinemann.
6. Asenjo, J. A., & Merchuk, J. C. (1994). *Bioreactor system design* (1st ed.). CRC Press.



<b>BT3271</b>	<b>ENZYME TECHNOLOGY</b>	<b>DEC</b>	<b>2-0-0</b>	<b>2 Credits</b>
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**Pre-Requisites:**

- i. BT2011 Biochemistry
- ii. BT2101 Biological Reaction Engineering

**Course Outcomes:**

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

<b>CO1</b>	Understand basics and principles of enzyme technology
<b>CO2</b>	Understand concepts of enzyme kinetics and inhibition
<b>CO3</b>	Understand the immobilization techniques and their industrial applications
<b>CO4</b>	Comprehend the strategies for production of industrial enzymes and their applications.

**Course Articulation Matrix:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
<b>CO1</b>	1	-	-	1	-	-	-	-	-	-	-	-	2	-	-
<b>CO2</b>	2	-	-		-	-	-	-	-	-	-	-	2	-	-
<b>CO3</b>	1	-	-	1	1	-	-	-	-	-	-	-	-	2	-
<b>CO4</b>	1	3	2	3	-	-	-	-	-	-	-	-	1	3	2

1 - Slightly; 2 - Moderately; 3 – Substantially

**Syllabus:**

**Unit I**

Introduction to Enzymes: General introduction, Nomenclature and Classification of enzymes, Biological Roles, Activation energy, Coenzymes, Cofactors, Prosthetic group, Metalloenzymes, Enzyme activity, Specificity and Selectivity, Identification of binding and catalytic sites.

**Unit II**

Mechanism of Enzyme Action (Activity & Specificity). Enzyme Characterization. Sequential reactions and ping-pong reactions. Multienzyme complex and multifunctional enzymes, Enzyme inhibition: Reversible (competitive, uncompetitive, and mixed) and irreversible, Allosteric regulation of enzyme activity.

**Unit III**

Enzyme immobilization: Enzymes in free and immobilized forms, stabilization of soluble enzymes; Principles & techniques of immobilization, Immobilized enzyme reactions; Damkohler number, Analysis of mass transfer effects, Analysis of film and Pore diffusion effects, Calculation of effectiveness factors of immobilized enzyme systems, Design of enzyme electrodes, Enzyme embedding.

**Unit IV**

Applications of enzymes: Enzymes for industrial processes and manufacture of commercial products, Industrial Enzymes: Proteases, Lipases, Carbohydrate active enzymes, Nucleic acidenzymes, artificial enzymes, Applications of enzymes in food industry, detergents, energy, waste treatment, pharmaceutical (amylase, collagenase), medical and analytical purpose.



**Text Books:**

1. Palmer, T., & Bonner, P. (2007). *Enzymes: Biochemistry, biotechnology, clinical chemistry* (2nd ed.). Woodhead Publishing.
2. Buchholz, K., Kasche, V., & Bornscheuer, U. T. (2012). *Biocatalysts and enzyme technology* (2nd ed.). Wiley Publishing
3. Copeland, R. A. (2000). *Enzymes: A practical introduction to structure, mechanism, and data analysis* (2nd ed.). Wiley–VCH.



<b>BT3281</b>	<b>PROTEIN ENGINEERING</b>	<b>DEC</b>	<b>2-0-0</b>	<b>2 Credits</b>
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**Pre-Requisites:** None

**Course Outcomes:**

At the end of the course the student will be able to:

<b>CO1</b>	Explain protein structural organization, functions and applications of biologically and industrially important proteins, recombinant proteins, and DNA binding proteins.
<b>CO2</b>	Perform protein sequence alignment, and explain techniques to determine the three dimensional structure of unknown proteins using X-ray crystallography, NMR, etc.
<b>CO3</b>	Produce recombinant proteins, purify isolated proteins and recombinant proteins, perform peptide sequencing (by Edmans degradation, etc) in order to locate the amino acid positions, map the proteins for amino acid change
<b>CO4</b>	Chemically synthesize peptides by SPPS, design peptides and carry out peptide modification chemically and by directed evolution for enhanced thermal stability and catalytic efficiency.

**Course Articulation Matrix:**

	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>	<b>PO7</b>	<b>PO8</b>	<b>PO9</b>	<b>PO10</b>	<b>PO11</b>	<b>PO12</b>	<b>PSO1</b>	<b>PSO2</b>	<b>PSO3</b>
<b>CO1</b>	1	-	-	1	-	-	-	-	-	-	-	-	2	-	-
<b>CO2</b>	2	-	-		-	-	-	-	-	-	-	-	2	-	-
<b>CO3</b>	1	-	-	1	1	-	-	-	-	-	-	-	-	2	-
<b>CO4</b>	1	3	2	3	-	-	-	-	-	-	-	-	1	3	2

1 - Slightly; 2 - Moderately; 3 – Substantially

**Syllabus:**

**Unit I**

Introduction to proteins and peptides: Methods for protein isolation and purification, Industrial applications of protein engineering, Multiple sequence alignment, data bank scanning, pattern matching; sequence structure comparison, Mass spectroscopy and analysis of protein expression, Techniques of protein structure determination and prediction, Primary structure, Peptide mapping, Peptide sequencing-Edman degradation method, Secondary structures-Alpha turn, beta sheets, coilcoiled, hair pin, Tertiary structures- Domains, folding, denaturation and renaturation.

**Unit II**

Methods to determine 3D structures, Quaternary structure: Modular nature, formation of complexes. Post translational modifications, Structure functional relationship of DNA binding proteins, prokaryotic and eukaryotic transcription factors: Zn fingers, Helix-turn-helix motifs, leucine Zippers, DNA polymenrases, Membrane proteins and receptors, bacteriorhodopsin, epidermal growth factor and insulin receptors, and their interaction with effectors, protein phosphorylation, immunoglobulins, enzymes: serine proteases, ribonuclease, lysozyme.



### Unit III

Design and synthesis of peptides, methods to alter primary structure of proteins-specific modification, change of amino acid by DNA mutation, multiple substitution, chimeric proteins, Thermostability of proteins, Enhancement of catalytic activity of enzymes by protein engineering, Recombinant insulin, de novo protein design.

#### Text Books:

1. D. Voet and J.G. Voet, Biochemistry, 3rd Edn., John Wiley & Sons Inc., 2004.
2. T. E. Creighton, Protein Function: A Practical Approach, 1st Edn., Oxford University Press, 2004.
3. C. Branden and J. Tooze, Introduction to Protein Structure, 2nd Edn., Garland Science, 1999.
4. S. J. Park and J. R. Cochran, Protein Engineering and Design, 1st Edn., CRC press, 2009



<b>BT3341</b>	<b>BIOPROCESS CONTROL AND INSTRUMENTATION</b>	<b>DEC</b>	<b>3-0-0</b>	<b>3 Credits</b>
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**Pre-Requisites:**

- i. BT1021 Bioprocess Calculations

**Course Outcomes:**

At the end of the course the student will be able to:

<b>CO1</b>	Understand various bioprocess instrumentation and their dynamic behavior
<b>CO2</b>	Understand the closed loop control system and its components
<b>CO3</b>	Analyze stability of feedback control system

**Course Articulation Matrix:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
<b>CO1</b>	3	2	3	3	2	-	-	-	1	1	2	2	2	3	2
<b>CO2</b>	3	3	3	3	3	-	-	-	1	1	2	2	3	3	2
<b>CO3</b>	3	2	3	2	3	-	-	-	1	1	1	1	2	2	2

1 - Slightly; 2 - Moderately; 3 – Substantially

**Syllabus:**

**Bioprocess Instrumentation:** Temperature, pH, Level, Flow, load, agitation, flow, Pressure, exit gas analysers, DO sensors, Dielectric spectroscopy, sensors for substrate (glucose, metal ions) and biomass. Response of First order systems: Transfer Function, Transient Response, Forcing Functions and Responses. Physical examples of First and second order systems: Examples of First order systems, Linearization, Transportation Lag.

**Control Systems:**

Control Systems: Strategies for Bioprocess Control - Description of different control strategies and their control structures. Components of a Control System, Block Diagram Development of Block Diagram, Controllers and Final Control Elements. Closed loop Transfer functions: Standard Block-Diagram Symbols, Transfer Functions for Single-Loop Systems and Multi-loop Systems. Transient response of simple control systems: Servo Problem, Regulatory Problem

**Controllers:** Proportional, Proportional-Integral, PID Controllers, Cascade Control, Model Predictive Control, Neural Network-Based Control, Fuzzy Logic-Based Control, Model Based Control, Soft Sensor-Based Control- case studies. PAT Based Control Strategies (Spectrophotometry: UV-Vis, FT-IR, Raman, SLS, Fluorescence) Automation in Biomanufacturing, SCADA (supervisory control and data acquisition) controller Ziegler-Nichols Controller Settings. Stability: Routh Test, Root Locus.

**Frequency Response:** Introduction, Substitution Rule, Bode Diagrams. Control system



designbased on frequency response: Bode and Nyquist Stability Criterion, Gain and Phase Margins.

**Text Books:**

1. Coughanowr, D., & Leblanc, S. (2009). *Process systems analysis and control* (3rd ed.).McGraw-Hill.
2. Eckman, D. P. (1985). *Industrial Instrumentation*. Wiley.
3. Shuler, M. L., Kargi, F., & DeLisa, M. (2017). *Bioprocess engineering: Basic concepts* (3rd ed.). Pearson.
4. Bailey, J. E., & Ollis, D. F. (2006). *Biochemical engineering fundamentals* (2nd ed.).McGraw-Hill.
5. Ghosh, T. (2004). *Biotechnology and bioprocess engineering: Proceedings, VII International biotechnology symposium*. Delhi.
6. Stephanopoulos, G. (2015). *Chemical process control*. Pearson India



<b>BT3351</b>	<b>BIOPROCESS DESIGN AND ECONOMICS</b>	<b>DEC</b>	<b>3-0-0</b>	<b>3 Credits</b>
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**Pre-Requisites:**

- i. BT1021 Bioprocess Calculations

**Course Outcomes:**

At the end of the course the student will be able to:

<b>CO1</b>	Understand the principles of bioprocess plant design
<b>CO2</b>	Understand the design concepts of bioreactor
<b>CO3</b>	Design various unit operations of bioindustries

**Course Articulation Matrix:**

	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>	<b>PO7</b>	<b>PO8</b>	<b>PO9</b>	<b>PO10</b>	<b>PO11</b>	<b>PO12</b>	<b>PSO1</b>	<b>PSO2</b>	<b>PSO3</b>
<b>CO1</b>	3	3	3	1	3	-	1	-	-	-	-	2	2	1	1
<b>CO2</b>	3	2	3	-	-	-	-	-	-	-	-	-	2	1	-
<b>CO3</b>	3	3	3	-	3	-	-	-	-	-	-	3	3	2	1

1 - Slightly; 2 - Moderately; 3 – Substantially

**Syllabus:****Unit I**

Bioprocess Plant design and Economics- Introduction, Objectives, Design estimate of life cycle of a product

**Unit II**

Economics analysis of Bioprocess plants- Bio-manufacturing of industrial bioproducts (organic acids, alcohols, ketones, amino acids, antibiotics, vitamins, enzymes, proteins, SCP etc.), Bioproducts recovery (primary, intra & extracellular, intermediates), final purification, operation integration, Components of Cost estimate, Process flow sheets, Material & Energy balances, Equipment sizing, Equipment cost and design methods, Cost estimates (Capital, Manufacturing, fixed & Overhead), Profitability Analysis, Case studies for Penicillin & Recombinant protein production, etc.

**Unit III**

Process scheduling and analysis, Simulation in SuperPro designer for Process analysis and economic evaluation of bioproducts (Citric acid, Insulin, Therapeutic proteins etc.)

**Text Books:**

1. Clark, D. S., & Blanch, H. W. (1997). *Biochemical engineering* (2nd ed.). CRC Press.
2. Harrison, R. G., Todd, P., Rudge, S. R., & Petrides, D. P. (2015). *Bioseparations science and engineering* (2nd ed.). Oxford University Press.
3. Mahajani, V. V., & Umarji, S. B. (2016). *Joshi's process equipment design* (5th ed.). Trinity Press.
4. Green, D. W., & Southard, M. Z. (2019). *Perry's chemical engineers' handbook*



(9th ed.). McGraw-Hill Education.

5. Asenjo, J. A., & Merchuk, J. C. (1994). *Bioreactor system design* (1st ed.). CRC Press.
6. Couper, J. R., Penney, W. R., Fair, J. R., & Stanley M. Walas, S. M. (2010) *Chemical process equipment: Selection and design* (3rd ed.). Elsevier.
7. Henley, E. J., & Kumamoto, H. (1985). *Designing for Reliability and Safety Control*. Prentice Hall



<b>BT3361</b>	<b>BIOFUEL TECHNOLOGY</b>	<b>DEC</b>	<b>3-0-0</b>	<b>3 Credits</b>
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**Pre-Requisites:**

- i. BT2011 Biochemistry

**Course Outcomes:**

At the end of the course the student will be able to:

<b>CO1</b>	Identify potential biomass sources and differentiate various generations of biofuels
<b>CO2</b>	Understand the production process of various biofuels
<b>CO3</b>	Apply the concept of strain engineering for biofuel production
	Understand bio refinery concepts and forecast the entrepreneurial opportunities

**Course Articulation Matrix:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
<b>CO1</b>	3	2	2	3	2	2	3	3	2	-	-	3	3	3	1
<b>CO2</b>	3	3	3	2	3	2	3	3	2	-	2	3	3	3	3
<b>CO3</b>	3	3	3	2	3	2	1	3	-	-	3	2	2	3	3
<b>CO4</b>	3	3	3	2	3	1	2	3	3	-	3	2	3	3	3

1 - Slightly; 2 - Moderately; 3 – Substantially

**Syllabus:****Unit I**

Introduction: Global Scenario of energy production and fossil fuel depletion and its hazardous effects, oil economy, Renewable energy, alternative sources, National Biofuel Policy and law, basic concepts about biomass derived energy, potential biomass feedstocks including energy crops, biomass Types and their formation: photosynthesis, chemistry and composition of biomass

**Unit II**

Biomass conversion to Biofuels: An overview, first generation, second generation and advance biofuels, Biomass conversion technologies and Pretreatment methods, Thermal, chemical and biological conversions, Biomass to liquid fuels. Biomass degrading enzymes and microorganisms.

**Unit III**

Bioethanol and Biodiesel production; Bioethanol production from lignocellulosic feedstocks, algae and sea weeds. Lignocellulose-Based Chemical Products, Genetic and metabolic engineering of bacteria and yeast for bioethanol production. Strain engineering for ethanol and inhibitor tolerance. Biodiesel: Vegetable oils and chemically processed biofuels, Biodiesel composition and production processes, Fischer-Tropsch Diesel: Chemical Biomass-to Liquid Fuel Transformations. Algae biomass, Technical challenges in biodiesel production.



## Unit IV

Biorefining: Biomass to Biogas, Bio hydrogen and bioelectrochemical systems such as Microbial fuel cell, Microbial desalination cell. Energy recovery from waste, Concept of Bio refinery, techno-economic analyses of biofuel conversion technologies, Entrepreneurial Opportunities in Bioenergy.

### Text Books:

1. Demirbas, A. (2009). *Biofuels: Securing the planet's future energy needs* (1st ed.). Springer.
2. Gupta, V., Tuohy, M., Kubicek, C., Saddler, J., & Xu, F. (2013). *Bioenergy research: Advances and applications* (1st ed.). Elsevier.
3. Dahiya, A. (2015). *Bioenergy: Biomass to biofuels* (1st ed.). Academic Press.
4. Gupta, V. K., & Tuohy, M. G. (2013). *Biofuel technologies - recent developments* (1st ed.). Springer.
5. Shimizu, K. (2017). *Metabolic regulation and metabolic engineering for biofuel and biochemical production* (1st ed.). CRC Press.
6. Mousdale, D. M. (2008). *Biofuel - biotechnology, chemistry, and sustainable development* (1st ed.). CRC Press.
7. M. Drapcho, John N. Walker, and Nathaniel G (2008). *Biofuels Engineering Process Technology*, McGraw-Hill
8. Nelson, V. C., & Starcher, K. L. (2016). *Introduction to bioenergy* (1st ed.). CRC Press



<b>BT3371</b>	<b>METABOLIC REGULATION AND ENGINEERING</b>	<b>DEC</b>	<b>2-0-0</b>	<b>2 Credits</b>
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**Pre-Requisites:**

- i. BT2011 Biochemistry
- ii. BT2101 Biological Reaction Engineering

**Course Outcomes:**

At the end of the course the student will be able to:

<b>CO1</b>	Understand the overview of cellular metabolism and its regulation
<b>CO2</b>	Understand regulatory mechanisms involved in biosynthesis of metabolites
<b>CO3</b>	Apply the concept of auxotrophic mutations for the synthesis of metabolites
<b>CO4</b>	Understand the pathway manipulation and apply the modeling tools for metabolic engineering

**Course Articulation Matrix:**

	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>	<b>PO7</b>	<b>PO8</b>	<b>PO9</b>	<b>PO10</b>	<b>PO11</b>	<b>PO12</b>	<b>PSO1</b>	<b>PSO2</b>	<b>PSO3</b>
<b>CO1</b>	3	3	-	2	-	-	-	-	-	-	-	-	3	2	2
<b>CO2</b>	3	-	-	3	-	2	-	-	-	-	-	-	3	2	2
<b>CO3</b>	3	-	-	3	-	2	-	-	-	-	-	-	3	3	3
<b>CO4</b>	2	2	3	2	-	-	-	3	1	3	-	-	3	3	3

1 - Slightly; 2 - Moderately; 3 – Substantially

**Syllabus:**

**Metabolism and Regulations** – Overview of cellular metabolism – Different models for cellular reactions, induction – Jacob Monod model and its regulation, Differential regulation by isoenzymes, Feedback regulation.

**Regulation of primary and secondary metabolites:** Amino acid synthesis pathways and its regulation at enzyme level and whole cell level, Alteration of feedback regulation, Limiting accumulation of end products. Regulation of secondary metabolite pathways, precursor effects, prophase, idiophase relationship, Catabolite regulation by passing control of secondary metabolism, producers of secondary metabolites, and applications of secondary metabolites.

**Regulation on enzyme expression:** Strain selection, Genetic improvement of strains, Gene dosage, metabolic pathway manipulations to improve fermentation, Feedback repression, Catabolite Repression, optimization, and control of metabolic activities.

**Pathway manipulations:** The modification of existing - or the introduction of entirely new – metabolic pathways.



**Modeling of Metabolic pathway and flux analysis:** Metabolic Flux and Control Analysis, Modelling of metabolic networks. KEGG pathway and Flux analysis

**Text Books:**

1. Wang, D. I. C., Lilly, M. D., Humphrey, A. E., Dunnill, D., Demain, A. L. (2005). *Fermentation and enzyme technology* (1st ed.; Reprint). John Wiley & Sons.
2. Stephanopoulos, G. N., Aristidou, A. A. & Nielsen, J. (1998). *Metabolic engineering principles and methodologies*. Academic Press.
3. Smolke, C. (2009). *The metabolic pathway engineering handbook: Tools and applications* (1st ed.). CRC Press.
4. Prof. Pinaki Sar, Prof. Amit Ghosh, Metabolic Engineering, NPTEL Course, [https://onlinecourses.nptel.ac.in/noc24\\_bt29/preview](https://onlinecourses.nptel.ac.in/noc24_bt29/preview)  
[https://onlinecourses.nptel.ac.in/noc21\\_bt18/preview](https://onlinecourses.nptel.ac.in/noc21_bt18/preview)



<b>BT3381</b>	<b>BIOPHARAMCEUTICAL TECHNOLOGY</b>	<b>DEC</b>	<b>2-0-0</b>	<b>2 Credits</b>
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**Pre-Requisites:**

- i. BT2021 Microbiology
- ii. BT2011 Biochemistry
- iii. BT2031 Cell Biology

**Course Outcomes:**

At the end of the course the student will be able to:

<b>CO1</b>	Understand the different forms of drugs and their delivery
<b>CO2</b>	Understand the pharmacodynamics and pharmacokinetics of drugs
<b>CO3</b>	Classify biopharmaceutical and their manufacturing process
<b>CO4</b>	Apply recombinant DNA technology for the production biopharmaceuticals

**Course Articulation Matrix:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
<b>CO1</b>	2	1	2	1	-	3	2	1	-	-	-	3	3	2	3
<b>CO2</b>	2	3	3	2	3	1	-	1	-	-	-	1	3	1	2
<b>CO3</b>	2	3	3	3	2	2	2	1	-	-	-	1	3	-	2
<b>CO4</b>	2	3	3	3	2	2	2	2	2	2	2	3	3	3	3

1 - Slightly; 2 - Moderately; 3 – Substantially

**Syllabus:****Unit I**

History and definition of drugs, Sources of drugs: plants, animals, microbes and minerals, concepts of drug dosage of solid, semi-solid, liquid, aerosol, tablets and capsules, routes of drug administration, controlled and sustained drug delivery, Biomaterials for drug delivery, liposome mediated drug delivery.

**Unit II**

Pharmacodynamics and pharmacokinetics of drugs, Absorption, Distribution of drugs, Biotransformation and bioavailability of drugs, Dose-response relationships, mechanism of action of drug, theory of drug-receptor, compartment modeling, half-life of drug, Apparent volume, Renal-Plasma clearance, Total-body clearance.

**Unit III**

Biopharmaceutical products and their importance, manufacture of tablets, compressed tablets wet and dry granulation; slugging or direct compression direct compression, coating of pills, capsules, parental solution, oral liquids, ointment, Laxatives, Analgesics, non-steroidal contraceptives, analytical and testing methods used in drug manufacture, packing techniques; quality management; Good manufacturing practices.FDA guidelines/regulatories



## Unit IV

Immunomodulating drugs, Biological Hormones: insulin, glucagon, human growth hormone, gonadotrophins, human growth hormone, Cytokines, Interferons, Tumor Necrosis Factor (TNF), transgenic animals and plants, recombinant DNA technology, phage based production, artificial cell therapy, vaccine technology, nanobodies and its application in biopharmaceutical industry.

### Text Books:

1. Walsh, G. (2003). *Biopharmaceuticals: Biochemistry and biotechnology* (2nd edn.). JohnWiley and Sons.
2. Brunton, L. L., Hilal-Dandan, R., & Knollmann, B. C. (2018). *Goodman & Gilman's the pharmacological basis of therapeutics* (13th ed.). McGraw-Hill Education.
3. Primrose, S. B., Tywman, R. M., & Old, R. W. (2001). *Principles of gene manipulation* (6th edition). Blackwell Publishing Company.



<b>BT3391</b>	<b>OMICS TECHNOLOGIES</b>	<b>DEC</b>	<b>2-0-0</b>	<b>2 Credits</b>
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**Pre-Requisites:** None

**Course Outcomes:**

At the end of the course the student will be able to:

<b>CO1</b>	Understand the basics of genomics and transcriptomics
<b>CO2</b>	Understand the methods and approaches involved in proteomics and metabolomics
<b>CO3</b>	Understanding the principles and methods of data integration from different OMICS technologies

**Course Articulation Matrix:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
<b>CO1</b>	3	3	3	3	-	1	-	-	-	-	-	-	3	-	-
<b>CO2</b>	3	3	3	2	-	1	-	-	-	-	-	-	3	-	-
<b>CO3</b>	3	3	3	3	-	-	-	-	-	-	-	-	3	-	-

1 - Slightly; 2 - Moderately; 3 – Substantially

**Syllabus:**

**Unit I**

Overview and general principles: Omics domains: Genomics, Proteomics, and Metabolomics, Genomics: Introduction to genome structure, DNA microarray, whole genome sequencing, Concept of next generation sequencing technology, Large scale genome sequencing strategies, Transcriptomics (RNA sequencing) & analysis of transcriptomic data, Concepts and principles of genome annotation, reference genome sequence, integrated genomic maps, gene expression profiling; identification of SNPs.

**Unit II**

Proteomics: Mass spectrometry – ionization methods (MALDI, electrospray), mass analyzers, fragmentation, intact protein analysis, protease digestion, peptide mass fingerprinting, tandem mass spectrometry, Introduction to quantitative proteomics- Differential proteomics, post- translational modifications. Computational methods for identification of polypeptides from mass spectrometry Protein arrays: basic principles, bioinformatics-based tools for analysis of proteomics data. Protein-protein interaction, Surface plasmon resonance.

**Unit III**

Metabolomics: Metabolomics-an overview, Analytical techniques for metabolomics; Mass spectrometry in metabolomics, Metabolic pathway analysis; Metabolomics data analysis - case studies- workflow for lipidomic, NMR based metabolomics.



## Unit IV

OMICS and Big Data management: Big data industry standards, Data acquisition, cleaning, omics sciences

### Text Books:

1. Primrose, S. B., & Twyman, R. M. (2002). *Principles of genome analysis and genomics* (3rd ed.). Wiley-Blackwell
2. Liebler, D. C. (2002). *Introduction to Proteomics – Tools for the new biology* (1st ed.). Humana Press.
3. Pevsner, J. (2015). *Bioinformatics and functional genomics* (3rd ed.). Wiley-Blackwell.
4. Mount, D. W. (2004). *Bioinformatics: Sequence and genome analysis* (2nd ed.). CSHL Press.



<b>BT4431</b>	<b>BIOPROCESS MODELLING AND SIMULATION</b>	<b>DEC</b>	<b>3-0-0</b>	<b>3 Credits</b>
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**Pre-Requisites:**

- i. BT1021 Bioprocess calculations
- ii. BT 3201 Upstream processing
- iii. BT 3301 Downstream processing

**Course Outcomes:**

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

<b>CO1</b>	Understand the Modelling Principles
<b>CO2</b>	Develop model equations for microbial growth and enzyme kinetics
<b>CO3</b>	Understand and analyze for bioreactor modelling and control
<b>CO4</b>	Simulate biological kinetics and processes

**Course Articulation Matrix:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
<b>CO1</b>	3	2	3	1	-	-	-	-	2	1	-	1	2	1	1
<b>CO2</b>	3	2	3	2	3	-	-	1	2	-	-	1	3	1	2
<b>CO3</b>	3	1	3	2	-	-	-	1	2	-	2	1	2	2	2
<b>CO4</b>	3	2	3	2	2	-	-	1	2	2	2	1	3	3	3

**Syllabus:****Unit I**

Introduction: Modelling principles, Classification of models, use of models for understanding, design and optimization of bioreactors, simulation tools. Formulation of balance equations, types of mass balance equations, balancing procedure, Component balances for reacting systems, Stoichiometry, elemental balancing, yield coefficient concept.

**Unit II**

Modeling of bioprocess: Type of kinetic models; Mathematical representation of bioprocess; Modeling of microbial cell growth, substrate uptake and product production, Substrate inhibition and product inhibition, Dynamic simulation of batch, fed-batch, steady and transient culture, Modelling of enzyme kinetics, kinetics of enzyme action (mmkinet), lineweaverburkplot (lineweav). Determination of  $k_La$  using - sulfite oxidation reaction and dynamic method.

**Unit III**

Optimization, Validation and Sensitivity Analysis: Data smoothing and analysis; Numerical Integration techniques; Numerical optimization of bioprocess using mathematical models. Parameter estimation; Parameter sensitivity analysis; Statistical validity

**Unit IV**

Simulations of biological processes: batch fermentation (bat ferm), chemostat



fermentation (chemo), fed batch fermentation (fed bat), repeated fed batch culture (rep fed), steady-state chemostat(chemostat), variable volume fermentation (varvol and varvold), penicillin fermentation using elemental balancing (penferm), fluidized bed recycle reactor (fbr). Introduction to MATLAB programming.

### Unit V

Simulation of biomanufacturing: Introduction to SuperPro Designer, registration of compounds, Selection of unit operation and connections, Simulations of manufacturing of few metabolites.

### Text Books:

1. Heinzle, E., Dunn, I. J., Ingham, J., & Přenosil, J. E. (2021). Biological reaction engineering: Dynamic modelling fundamentals with simulation examples (3rd ed.). Wiley-VCH.
2. Harrison, R. G., Todd, P., Rudge, S. R., & Petrides, D. P. (2015). Bioseparations science and engineering (2nd ed.). Oxford University Press.
3. Leigh, J. R. (1987). Modeling and control of fermentation processes. Peter Peregrinus. Ltd.
4. Sablani, S. S., Datta, A. K., Rahman, M. S., & Mujumdar, A. S. (2006). Hand book of food and bioprocess modelling techniques (1st ed.). CRC Press. Lesk, A. M. (2014).
5. Arthur M. Lesk. (2014) Introduction to bioinformatics (4th ed.) Oxford University Press.
6. Doran, P. M. (2012). *Bioprocess engineering principles* (2nd ed.). Academic Press.



<b>BT4441</b>	<b>DRUG DESIGN AND DEVELOPMENT</b>	<b>DEC</b>	<b>3-0-0</b>	<b>3 Credits</b>
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**Pre-Requisites:**

- i. BT3311 Bioinformatics

**Course Outcomes:**

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

<b>CO1</b>	Understand the concept of structure-function relationship of lead molecules in drug discovery
<b>CO2</b>	Understand the target identification in drug discovery
<b>CO3</b>	Apply proteomics and genomics techniques in drug discovery and design process
<b>CO4</b>	Apply computational approaches for drug design

**Course Articulation Matrix:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
<b>CO1</b>	1	2	2	2	2	2	-	-	1	0	-	1	3	2	-
<b>CO2</b>	-	3	3	3	3	1	-	-	1	-	1	-	3	2	-
<b>CO3</b>	-	2	2	3	3	2	-	-	1	0	-	-	3	-	2
<b>CO4</b>	-	2	3	3	3	3	2	-	1	0	1	1	3	-	3

1 - Slightly; 2 - Moderately; 3 – Substantially

**Syllabus:**
**Unit I**

Economic importance of drug discovery, Stages of drug discovery, Phases in drug discovery, identification, validation and diversity of drug targets, Structure and function of different targets enzymes, ion channels and receptors. Molecular recognition in Ligand - Protein Binding. Structure – Based and Ligand – Based Drug Design. Functional selectivity of receptors.

**Unit II**

Stereochemistry in Drug Design, Peptides and Peptidomimetics. Bonded and non - bonded interactions, Drug delivery systems for proteins and peptides with special reference to oral & nasal routes. Delivery consideration of Biotechnological products: Stability profile, Barriers to peptides and protein delivery, Delivery of protein and peptide drugs, Site specific protein modification, Toxicity profile characterization (ADMET-SAR).

**Unit III**

High-Throughput Screening, Lipinski rule of 5, Pharmacogenomics, Proteomics, Array technology and Recombinant DNA technology of drugs. Disease targets for gene therapy. Monoclonal antibodies for diseases such as Diabetes, Cancer and neurodegenerative disorders. Study of pharmacokinetics and pharmacodynamics of the ligands.



## Unit IV

Computational approaches for the quantification of Molecular diversity and design of compound libraries, physicochemical concept of in drug design. History of QSAR, 2D-QSAR; 3D-QSAR, descriptors of QSAR, Tools and techniques of QSAR, Parameters Used in QSAR, Applications of QSAR, 3D pharmacophore hypothesis, PKPD model, Molecular Dynamics simulations, AI-ML model

### Text Books:

1. Stromgaard, K., Krogsgaard-Larsen, P., & Madsen, U. (2017). *Textbook of drug design and discovery* (5th ed.). CRC Press.
2. Raymond G. Hill and Duncan Richards (2020), *Drug Discovery and Development: Technology in Transition*, Elsevier
3. Giersiefen, H., Hilgenfeld, R., & Hillisch, A. (2003). *Modern methods of drug discovery* (1st ed.). Birkhäuser Basel.
4. Knablein, J. (2005). *Modern biopharmaceuticals: Design, development and optimization* (1st ed.). Wiley-Blackwell.
5. Leach, A. R. (2001). *Molecular modeling: Principles and applications* (2nd ed.). Pearson Publications.
6. Kourounakis, P. N. (1994). *Advanced drug design and development: A medicinal chemistry approach* (1st ed.). Taylor and Francis.



<b>BT4451</b>	<b>SYSTEMS BIOLOGY</b>	<b>DEC</b>	<b>3-0-0</b>	<b>3 Credits</b>
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**Pre-Requisites:**

- i. BT 2031 Cell biology
- ii. BT 2081 Molecular Biology and Genetics
- iii. BT 2101 Biological Reaction Engineering

**Course Outcomes:**

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

<b>CO1</b>	Understand basic, advanced principles of systems biology and biological networks
<b>CO2</b>	Understand networks behaviour and emergent properties of biological networks/ systems
<b>CO3</b>	Understand why systems level studies are essential in biology through case study based examples
<b>CO4</b>	Apply kinetics principles to develop systems level mathematical models in biology

**Course Articulation Matrix:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
<b>CO1</b>	3	2	3	3	-	1	-	1	-	-	-	-	3	1	-
<b>CO2</b>	3	3	3	3	-	-	-	2	-	-	-	-	3	-	2
<b>CO3</b>	3	3	3	3	3	-	-	-	-	-	-	-	3	-	2
<b>CO4</b>	3	2	3	2	3	1	-	-	-	-	1	1	3	1	2

1 - Slightly; 2 - Moderately; 3 – Substantially

**Syllabus:**

**Unit I**

**Systems biology-fundamentals:** Introduction to systems biology; high throughput experimental techniques: gene array, protein array, two-hybrid systems; model formulation based on enzyme kinetics, Michaelis-Menten kinetics, mass actions kinetics, Hill equation, steepness, threshold phenomenon, ultrasensitivity, steady state, dynamic and stochastic models in system biology.

**Unit II**

**Molecular networks and cellular behavior:** Emergent properties of biological networks; complexity, adaptability, bistability, robustness and evolvability; introduction to network motifs, elements of transcription networks, dynamics and response time of simple gene regulation, autoregulation, feed forward loops (FFLs), temporal expression programs and global structure

**Unit III**

Case studies, computations tools and applications : Signal transduction networks, E. coli chemotaxis network, infection model, robustness patterning in development- morphogen profiles, fruit fly patterning, threshold and negative feedback loop in rhythmic processes (oscillations) of complex biological system, Computational tools and software packages, Synthetic biology: building and analyzing synthetic networks, systems pharmacology.



**Text books:**

1. Uri Alon (2007) , Introduction to Systems Biology, Chapman and Hall/CRC
2. Zoltan Szallasi, Jörg Stelling, Vipul Periwai, (2007),
3. Systems Modeling in Cellular Biology: From Concepts to Nuts and Bolts, Prentice Hall of India
4. Eberhard O. Voit (2000), Computational Analysis of Biochemical Systems, Cambridge University Press
5. Voit, E. (2017). *A first course in systems biology* (2nd ed.). Taylor and Francis.



<b>BT4461</b>	<b>ANIMAL BIOTECHNOLOGY</b>	<b>DEC</b>	<b>2-0-0</b>	<b>2 Credits</b>
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**Pre-Requisites:**

- i. BT2031 Cell Biology

**Course Outcomes:**

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

<b>CO1</b>	Understand the basics of animal cell culture
<b>CO2</b>	Characterize the animal cell using biochemical and molecular biology techniques
<b>CO3</b>	Apply the principles of genetic engineering to modify animal cell for research and industrial use
<b>CO4</b>	Demonstrate the importance of genetically engineered animal models for applications in drug development and disease research

**Course Articulation Matrix:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
<b>CO1</b>	3	1	3	3	2	-	-	-	1	1	1	3	3	3	1
<b>CO2</b>	3	3	3	3	2	-	1	3	2	-	2	3	3	3	3
<b>CO3</b>	3	3	3	2	1	-	2	2	2	-	2	3	3	3	2
<b>CO4</b>	3	3	3	3	3	1	1	3	2	1	2	3	3	3	3

1 - Slightly; 2 - Moderately; 3 – Substantially

**Syllabus:**

**Unit I**

Introduction to animal biotechnology: Historical background, advantages and limitations, General Safety Measures, Aseptic Techniques, Risk Assessment. Cryopreservation. Media for culturing cells and tissues: natural and defined media; serum free and serum-based media. Isolation of Cells and Tissues, primary and secondary cell cultures, development and maintenance of cell lines.

**Unit II**

Characteristics of animal cells: Morphological, Nucleic acid (DNA and RNA), Enzyme Activity, Antigenic Markers. Animal cell transformation: Immortalization, Aberrant Growth, Tumorigenicity. Transformation Assay, Cell counting, Cell Proliferation and Viability assay.

**Unit III**

Application of animal cell cultures: Recombinant protein production and purification; Testing of drugs: Clinical trials and methods, Vaccine production. Embryonic cell culture and development, In vitro fertilization, Animal Breeds, Transgenic Animal Production: Microinjection method, retroviral vector method; and applications of transgenic animals: Animal cloning, Knock-out and knock-in animals

**Unit IV**

Animal models in disease research: animal models for tuberculosis, neurodegenerative



disorders, and cancer research, Hybridoma Technology, Embryonic Stem Cell method Ethical Issues and concerns.

**Text Books:**

1. Butler, M. (2003). *Animal cell culture and technology* (2nd ed.). Taylor & Francis.
2. Freshney, R. I. (2010). *Culture of animal cells: A manual of basic technique and specialized applications* (6th ed.). John Wiley & Sons.
3. Pörtner, R. (2007). *Animal cell biotechnology: Methods and protocols* (2nd ed.). HumanaPublishers.
4. Ashish Verma, Anchal Singh, *Animal Biotechnology: Models in Discovery and Translation*, Academic Press, 2019, 2nd Edition



<b>BT4471</b>	<b>STEM CELL TECHNOLOGY</b>	<b>DEC</b>	<b>2-0-0</b>	<b>2 Credits</b>
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**Pre-Requisites:**

- i. BT2031 Cell Biology

**Course Outcomes:**

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

<b>CO1</b>	Classify different stem cells
<b>CO2</b>	Evaluate the handling of stem cells
<b>CO3</b>	Demonstrate the importance of stem cells in treatment

**Course Articulation Matrix**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
<b>CO1</b>	3	1	3	3	2	-	-	-	1	1	1	3	3	3	1
<b>CO2</b>	3	3	3	3	2	-	1	3	2	-	2	3	3	3	3
<b>CO3</b>	3	3	3	2	1	-	2	2	2	-	2	3	3	3	2

1 - Slightly; 2 - Moderately; 3 – Substantially

**Syllabus:****Unit I**

Stem Cells: Definition, classification and sources, Properties and application of embryonic stem cells, Cell adhesion – Extracellular matrix, In vitro cell proliferation, Induced pluripotent stem cells.

**Unit II**

Maintenance of Cells: Biology and characterization of cultured cells, Maintenance and management of cell lines, Scale-up of animal cells in culture, Scale-up of anchorage dependent cells and suspension cultures: Cell isolation and selection; cell preservation

**Unit III**

Role of stem cells in treatment: treatment of autoimmune diseases, neurodegenerative diseases, cancer treatment.

**Text Books:**

1. Robert Lanza, Anthony Atala, Essentials of Stem Cell Biology, 2013, 3rd Edition
2. David Gottlieb, Stem Cell Biology, Cold Spring Harbor, 2002



<b>BT4481</b>	<b>TISSUE ENGINEERING</b>	<b>DEC</b>	<b>2-0-0</b>	<b>2 Credits</b>
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**Pre-Requisites:**

- i. BT2031 Cell Biology

**Course Outcomes:**

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

<b>CO1</b>	Understand the basic concept of Tissue engineering
<b>CO2</b>	Evaluate the cellular growth at lab to form tissues or organ
<b>CO3</b>	Demonstrate the role of tissue engineering applications

**Course Articulation Matrix**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
<b>CO1</b>	3	1	3	3	2	-	-	-	1	1	1	3	3	3	1
<b>CO2</b>	3	3	3	3	2	-	1	3	2	-	2	3	3	3	3
<b>CO3</b>	3	3	3	2	1	-	2	2	2	-	2	3	3	3	2

1 - Slightly; 2 - Moderately; 3 – Substantially

**Syllabus :****Unit I**

Introduction to Tissue engineering Definitions, basic principles History and scope. Introduction to Biomaterials and scaffolds (Biomaterials. metals, ceramics, polymers (synthetic and natural). Biodegradable materials, native matrix. Criteria of modifying biomaterials as TE scaffold. Design principles

**Unit II**

Growth and Differentiation, Animal cell biology, organization of cells into tissues, tissue microenvironment, 3D organization, cell migration and angiogenesis, Cell sources: Stem cells. basic principles, embryonic stem cells, induced pluripotent stem cells. Scaffold fabrication Techniques: Electrospinning, 3D bioprinting, Decellularize and Stereolithography.

**Unit III**

Wound healing, Basic immunology, response of body to foreign materials, Transplantation of engineered cells and tissues. Clinical Applications of TE: Skin and Nerve Regeneration, Heart Valves and Blood, Musculoskeletal Tissue Engineering: Bone and Cartilage, Urinary Tissues/Organs, Central Nervous System Regeneration, Cardiovascular regeneration.

**Text Books:**

1. Robert Lanza, Robert Langer, Joseph P. Vacanti, (2020), Principles of Tissue Engineering, 5th Edition , Academic Press (Elsevier)
2. Bernhard O. Palsson, Sangeeta N. Bhatia (2004)., Tissue Engineering, Pearson publications



<b>BT4491</b>	<b>ENVIRONMENTAL BIOTECHNOLOGY</b>	<b>DEC</b>	<b>3-0-0</b>	<b>3 Credits</b>
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**Prerequisites:**

- i. BT2021 Microbiology
- ii. BT2091 Unit operations

**Course Outcomes:**

At the end of the course the student will be able to

<b>CO1</b>	Understand the biological processes for wastewater treatment
<b>CO2</b>	Understand the biological approaches for solid and hazardous waste management
<b>CO3</b>	Understand the principle and types of bioremediation
<b>CO4</b>	Apply the concepts of biotechnology for metal extraction and remediation

**Course Articulation Matrix:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
<b>CO1</b>	2	2	3	2	1	3	2	-	-	-	-	1	2	-	-
<b>CO2</b>	2	2	2	-	-	2	2	-	-	-	-	1	2	-	-
<b>CO3</b>	2	2	-	-	-	3	2	-	-	-	-	1	2	-	-
<b>CO4</b>	2	2	2	-	-	2	2	-	-	-	-	1	2	-	-

1 - Slightly;

2 - Moderately;

3 – Substantially

**Syllabus:****Unit I**

Overview of domestic and industrial waste. Biological Treatment of Wastewater: Introduction – wastewater characteristics and microbial aspects of treatment; Bioreactor systems - activated sludge process, aerated lagoons, trickling filters, Fluidized bed reactor, UASB. Biological removal of nutrients. Micro-pollutants in wastewater, Detection and removal of micropollutants (pesticides, pharmaceuticals and personal care products).

**Unit II**

Solid waste management: Nature and composition of municipal solid waste. Basic concept of landfill for waste disposal. Biological methods of solid waste management – aerobic (microbial composting and vermicomposting) and anaerobic (anaerobic digestion) methods. Hazardous waste: Introduction, characteristics and management of waste.

**Unit III**

Bioremediation: Introduction - constraints and priorities of Bioremediation. Engineering strategies employed for microbial bioremediation: in situ and ex situ strategies. Phytoremediation – introduction and mechanisms. Case study of bioremediation.



## Unit IV

Metal Biotechnology: Microbial remediation of heavy metals: fundamental concepts of microbial transformation, accumulation and immobilization of metals. Bioleaching - Introduction, microorganism involved in bioleaching, bioleaching mechanisms, examples of bioleaching, Biological recovery of metals from e-waste.

### Text Books:

1. Rittmann, B. E., & McCarty P. L. (2003). Environmental biotechnology: principles and applications (1st ed.). Tata McGraw-Hill Education.
2. Metcalf & Eddy, Inc. (2003). Waste water engineering treatment and reuse (4th ed.). McGraw Hill Education. Worrell, W. A., & Vesilind, P. A., & Ludwig, C. (2012). Solid waste engineering (2nd ed.). Cengage Learning.
3. Maulin, S. P. (2020). Microbial bioremediation & biodegradation (1st ed.). Springer.
4. Natarajan, K. A. (2018). Biotechnology of metals: principles, recovery methods and environmental concerns (1st ed.). Elsevier.
5. Kanaujiya, D. K., Paul, T., Sinharoy, A., & Pakshirajan, K. (2019). Biological treatment processes for the removal of organic micropollutants from wastewater: a review. Current pollution reports, 5(3), 112-128.



<b>BT4501</b>	<b>BIOMATERIALS</b>	<b>DEC</b>	<b>3-0-0</b>	<b>3 Credits</b>
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**Prerequisites:**

- i. BT2011 Biochemistry,
- ii. BT2021 Microbiology;
- iii. BT2031 Cell Biology

**Course Outcomes:**

At the end of the course the student will be able to

<b>CO1</b>	Classify and understand the properties of biomaterials
<b>CO2</b>	Understand the concept of biocompatibility
<b>CO3</b>	Demonstrate the concept of Biodegradation biomaterial
<b>CO4</b>	Understand the concepts for developing new materials for tissue engineering and bio-implant applications

**Course Articulation Matrix:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
<b>CO1</b>	2	-	2	-	-	-	-	-	-	-	-	-	3	2	2
<b>CO2</b>	3	1	-	3	-	-	-	-	-	-	-	-	3	2	2
<b>CO3</b>	2	2	3	3	-	-	-	-	-	2	-	-	3	2	3
<b>CO4</b>	2	3	3	2	-	2	2	-	-	2	-	-	3	3	3

1 - Slightly; 2 - Moderately; 3 – Substantially

**Syllabus:**

**Unit I**

Introduction to basic concepts of Materials Science; Salient properties of important material classes; Property requirement of biomaterials. Classes of materials in medicine.

**Unit II**

Concept of biocompatibility; Structure and properties of biological cells & tissues; cell material interactions and host reaction to biomaterials and evaluation; Assessment of biocompatibility of biomaterials, in vitro biochemical assays (cellular adhesion, cellular viability using MTT osteogenic differentiation using ALP assay).

**Unit III**

Degradation of Materials in Biological environment: Biodegradation of Biodegradable Polymeric Biomaterials, Degradative Effects of the Biological Environment on Metals and Ceramics, Pathological Calcification of Biomaterials

**Unit IV**

Applications of Biomaterials in Functional Tissue Engineering, Bone Tissue Engineering, Cartilage Tissue Engineering, Blood Vessel Tissue Engineering, Heart Valve Tissue



Engineering and Skin Tissue engineering. Design concept of developing new materials for bio-implant applications Electrospinning, Freeze Drying, decellularization and 3D bioprinting. Ethical and legal Issues in Biomaterials and Medical Devices.

**Text Books:**

1. Buddy D. Ratner (2014), Biomaterials Science: An Introduction to Materials in Medicine 3rd Edition, Academic Press.
2. Sujatha V. Bhat (2010), Biomaterials, 2nd Edition , Narosa Publishing house.
3. Fredrick H. (1993), Silver Medical Devices and Tissue engineering: An integrated approach 1st edition , chapman and Hall Publications.
4. Jonathan Black (1992), Biological Performance of Materials: Fundamentals of Biocompatibility, Marcel Dekker, Inc., New York and Basel.
5. J.M. Davis (1994), Basic Cell Culture: A Practical Approach, IRL Press, Oxford University Pres, New York,.
6. Mithe, Ritchie and Karihalo (2003), Comprehensive structural integrity, Vol.9: Bioengineering , Elsevier Academic Press, 2003.



<b>BT4511</b>	<b>FERMENTATION TECHNOLOGY</b>	<b>DEC</b>	<b>3-0-0</b>	<b>3 Credits</b>
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**Pre-Requisites:**

- i. BT1021 Bioprocess calculations
- ii. BT 3201 Upstream processing
- iii. BT 3301 Downstream processing

**Course Outcomes:**

At the end of the course the student will be able to

<b>CO1</b>	Understand the chronological development of the fermentation industry
<b>CO2</b>	Understand working principle of various Bioreactors
<b>CO3</b>	Understand stoichiometry of cell growth and product formation
<b>CO4</b>	Calculate stoichiometric coefficients, Yield coefficients
<b>CO5</b>	Understand the batch culture, Continuous culture, Multistage system, Feedback system
<b>CO6</b>	Model solid state Fermentation

**Course Articulation Matrix:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
<b>CO1</b>	3	-	1	1	-	1	-	-	-	-	-	-	3	1	2
<b>CO2</b>	2	-	3	-	-	-	-	-	1	-	-	-	3	2	1
<b>CO3</b>	2	-	1	-	-	-	-	-	-	-	-	-	3	3	1
<b>CO4</b>	2	-	1	-	-	-	-	-	-	-	-	-	2	3	3
<b>CO5</b>	-	-	3	2	-	-	-	-	-	-	-	-	1	1	2
<b>CO6</b>	-	-	2	-	3	-	-	-	-	-	-	-	2	2	3

1 - Slightly;

2 - Moderately;

3 – Substantially

**Syllabus:**
**Unit I**

Introduction to fermentation technology: Interaction between Chemical Engineering. Introduction to fermentation processes, the chronological development of the fermentation industry, the component parts of a fermentation process, Microbial culture selection for fermentation processes.

**Unit II**

Gaden's Fermentation classification, Design and operation of fermenters, Basic concepts for selection of a reactor, Rheology of fermenter, Scale up of Bioreactor.

**Unit III**

Batch culture, Continuous culture, Multistage system, Feedback systems, Comparison of batch and continuous culture in industrial process, Biomass productivity, Metabolite



productivity Continuous brewing, Continuous culture and biomass production, Comparison of batch and continuous culture investigative tools, Fed-batch culture, Variable volume fed-batch culture, Fixed volume fed-batch culture, Cyclic fed-batch culture, Application of fed-batch culture, Examples of the use of fed-batch culture

#### **Unit IV**

Production of industrially important microbial products - Case studies: Production of beer, alcohol, enzymes, S.C.P and antibiotics from industrial strains

#### **Text Books:**

1. Bailey, J.E. and Ollis D.F., Biochemical Engineering Fundamentals, Mcgraw Hill Higher Education; 2nd edition, 2001
2. Stanbury, P.E., Whitaker, A., Hall, S., Principles of Fermentation Technology 2nd edition, Butterworth-Heinemann, 2002
3. Pirt, S. J., Principles of Microbe and Cell Cultivation. Wiley, John & Sons, Reprint, 2005
4. Moo-Young, M., Comprehensive Biotechnology, Vol. 1–4, Pergamon Press, Reprint, 2004



<b>BT4521</b>	<b>BIOSAFETY AND IPR</b>	<b>DEC</b>	<b>3-0-0</b>	<b>3 Credits</b>
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**Pre-Requisites:**

- i. BT2021 Microbiology
- ii. BT3231 Industrial Biotechnology

**Course Outcomes:**

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

<b>CO1</b>	Understand the basics of biosafety, bioethics and IPR
<b>CO2</b>	Role of biosafety committees in risk assessment and management
<b>CO3</b>	Review international agreements and protocols for biosafety
<b>CO4</b>	Analyze the procedures involved in patent filing and licensing

**Course Articulation Matrix:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
<b>CO1</b>	2	-	-	-	-	3	3	-	-	2	-	-	3	2	3
<b>CO2</b>	2	-	-	-	-	3	3	-	-	2	-	-	3	2	3
<b>CO3</b>	2	-	-	-	-	3	3	-	-	2	-	-	3	-	3
<b>CO4</b>	2	-	-	-	-	3	3	-	-	2	-	-	3	-	3

1 - Slightly;

2 - Moderately;

3 – Substantially

**Syllabus:**
**Unit I**

Introduction to Biosafety: Historical Background, Introduction to Biological Safety Cabinets, Primary Containment for Biohazards, Biosafety Levels, Bioethics: Necessity of bioethics, Origin and Evolution of ethics into bioethics, Ethical reasoning and the justification of moral beliefs, Different paradigms of bioethics - National and International.

**Unit II**

Definition of GMOs & LMOs, Roles of Institutional Biosafety Committee, RCGM, GEAC etc. for GMO applications in food and agriculture, Environmental release of GMOs; Risk Analysis; Risk Assessment; Risk management and communication, Regulatory Framework for Pharmaceutical Supply Chain: Ensuring biosafety in production, distribution, and quality control of pharmaceutical products.

**Unit III**

Overview of National Regulations and relevant International Agreements including Cartagena Protocol. Agreements and Treaties, History of GATT & TRIPS Agreement, Madrid Agreement; Hague Agreement, WIPO Treaties; Budapest Treaty; PCT, **Geographical Indications and Trade Secrets**: Definition, importance, and examples, Protection of trade secrets under TRIPS and other treaties.

**Unit IV**

Indian Patent Act 1970 & recent amendments. Introduction to Patents; Types of patent



applications: Ordinary, PCT, Conventional, Divisional and Patent of Addition, Specifications: Provisional & complete. Patent databases- Patent filing procedures, Time frame & cost; Status of patent applications filed, Precautions while patenting – disclosure/non-disclosure, Financial assistance for patenting, Patent licensing and agreement, Patent infringement, **Designs and Copyrights:** Protection of industrial designs, Basics of copyright law in biotechnology, Distinction between patents and copyrights.

**Text Books:**

1. Fleming, D. O., & Hunt, D. A. (2021). Biological safety: Principles and practices (5th ed.). ASM Press.
2. Mueller, Janice M. Aspen Treatise for Patent Law. Aspen Publishing, 2024.
3. Kankanala, K. C. (2007). Genetic patent law and strategy (1st ed.). Manupatra Publishers.
4. Jecker, N. A. S., Jonsen, A. R., & Pearlman, R. A. (2007). Bioethics: An introduction to history, methods, and practice (2nd ed.). Jones and Bartlett Publishers.
5. Traavik, T. & Ching, L. L. (2007). Biosafety first: Holistic approaches to risk and uncertainty in genetic engineering and genetically modified organisms. Tapir Academic Press.
6. US Government. (2004). 21st Century Complete Guide to Biosafety and Biosecurity. Progressive Management.
7. Bare Act. (2007). Indian Patent Act 1970 Acts & Rules. Universal Law Publishing.
8. Steinbock, B. (2009). The oxford handbook of bioethics (1st ed.). Oxford University Press.



<b>BT4531</b>	<b>ENTREPRENEURSHIP IN BIOTECHNOLOGY</b>	<b>DEC</b>	<b>3-0-0</b>	<b>3 Credits</b>
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**Pre-Requisites:**

- i. BT2021 Microbiology
- ii. BT3231 Industrial Biotechnology

**Course Outcomes:**

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

<b>CO1</b>	Understand the scope, importance of biotechnology and allied fields.
<b>CO2</b>	Role of entrepreneurship in economic development of industry.
<b>CO3</b>	Learnt to do Market survey and assessment
<b>CO4</b>	Preparation of Business Plan; learn Forms of business organization/ownership.
<b>CO5</b>	Case study of any top three Biotechnology Companies (start up, various stages in establishment, .etc.,)

**Course Articulation Matrix:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
<b>CO1</b>	1	-	-	-	-	-	-	-	-	1	1	-	1	2	-
<b>CO2</b>	-	-	2	2	1	1	2	1	2	2	3	1	-	1	1
<b>CO3</b>	-	1	-	-	-	-	1	-	1	1	1	3	-	1	-
<b>CO4</b>	-	-	2	2	1	-	1	2	1	2	1	1	-	2	1
<b>CO5</b>	1	1	2	1	2	1	2	-	1	1	2	1	1	1	2

**Syllabus:**

**Unit I**

Introduction to Biotechnology & Applications: Biotechnology – definition, history, thrust areas of biotechnology; Elements of Bio-Process Engineering; Biotech Industries; Basic concepts of GLP, GMP and FDA; Scope and Importance of Biotechnology and allied fields.

**Unit II**

Introduction to Bio-entrepreneurship: Definition of Bio entrepreneurship, traits of an entrepreneur; Copyright, Patents, trademark, plant breeders and farmers’ rights, biodiversity related issues; Biopiracy, International and Indian business policies with the focus on Bio and Pharmaceutical products.

**Unit III**

Entrepreneur and Entrepreneurship: Introduction; Entrepreneur and Entrepreneurship; Role of entrepreneurship in economic development; Entrepreneurial competencies and motivation; Institutional Interface for Small Scale Industry/Enterprises.

**Unit IV**

Planning a Small Scale Enterprises: Opportunity Scanning and Identification; Creativity and product development process; Market survey and assessment; choice of technology and selection of site. Financing new/small enterprises; Techno Economic Feasibility Assessment; Preparation of Business Plan; Forms of business



organization/ownership. Case study of any top three Biotechnology Companies (startup, various stages in establishment, .etc., Biocon: Evolution of India's Biotech Giant, Bharat Biotech: Innovations and Challenges, From Startup to Global Leader)

**Text books:**

1. Karoly Nikolich and Sergey Musatov(2014), *Bioentrepreneurship: From Research to Business*, Springer
2. Patzelt, Holger, Brenner, Thomas (Eds.). Handbook of Bioentrepreneurship. Springer, 2008.
3. G.G. Meredith, R.E.Nelson and P.A. Neek, The Practice of Entrepreneurship, ILO, 1982.
4. James Mawson and Neil Jain (2016), *Entrepreneurial Finance in Biotech and Life Sciences*, Elsevier
5. Dr. Vasant Desai, Management of Small Scale Enterprises, Himalaya Publishing House, 2004.
6. A Handbook for New Entrepreneurs, Entrepreneurship Development Institute of India, Ahmedabad, 1988.
7. Bruce R Barringer and R Duane Ireland, Entrepreneurship: Successfully Launching New Ventures, 3rd ed., Pearson Edu., 2013.
8. Swati Agarwal, Sonu Kumari, and Supriya Khan, Bioentrepreneurship and Transferring Technology into Product Development, IGI Global, 2021.



<b>BT4541</b>	<b>BIOSENSORS</b>	<b>DEC</b>	<b>3-0-0</b>	<b>3 Credits</b>
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**Pre-Requisites:**

- i. EE1601 Basic Electrical and Electronics Engineering
- ii. BT2101 Biological Reaction Engineering

**Course Outcomes:**

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

<b>CO1</b>	Understand biosensing and transducing techniques
<b>CO2</b>	Understand principles of linking cell components and biological pathways with energy transduction, sensing and detection
<b>CO3</b>	Demonstrate appreciation for the technical limits of performance of biosensor
<b>CO4</b>	Apply principles of engineering to develop bioanalytical devices and design of biosensors

**Course Articulation Matrix:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
<b>CO1</b>	3	2	2	-	1	2	-	-	-	-	1	1	2	-	-
<b>CO2</b>	3	2	2	-	1	2	-	-	-	-	1	1	2	1	-
<b>CO3</b>	3	2	2	2	1	2	-	-	-	-	2	1	3	2	-
<b>CO4</b>	3	2	2	3	1	2	2	-	-	-	2	1	3	2	2

1 - Slightly;

2 - Moderately;

3 – Substantially

**Syllabus:**
**Unit I**

General principles: A historical perspective; Signal transduction; Physico-chemical and biological transducers; Sensor types and technologies, Definitions and Concepts Terminology and working vocabulary; Main technical definitions: calibration, selectivity, sensitivity, reproducibility, detection limits, response time.

**Unit II**

Physico-chemical transducers: Electrochemical transducers (amperometric, potentiometric, conductimetric); optical transducers (absorption, fluorescence, SPR); Thermal transducers; piezoelectric transducers, Quantitative sensors, Multi response biosensors.

**Unit III**

Biosensor Engineering: Methods for biosensors fabrication, self-assembled monolayers, screen printing, photolithography, micro-contact printing, MEMS. Engineering concepts for mass production, Case study on sensor development (Continuous Glucose Monitoring sensor)

**Unit IV**



Application of modern sensor technologies: Clinical chemistry; Test-strips for glucose monitoring; Urea determination; Implantable sensors for long-term monitoring; wearable biosensors; Environmental monitoring; Technological process control; Food quality control; Forensic science benefits; Problems & limitations. Paper-Based Sensors, 3D-Printed Sensors, Microfluidic Sensors, Lab-on-a-Chip (LoC) Devices.

**Text Books:**

1. Donald G. Buerk, Biosensors: Theory and Applications, CRC Press, 2009.
2. Mustafa Kemal Sezgintürk , Commercial Biosensors and Their Applications: Clinical, Food, and Beyond, 1st Edn, Elsevier, 2020
3. Alice Cunningham, Introduction to Bioanalytical Sensors, John Wiley & Sons, 1998.
4. Brian R. Eggins, Chemical Sensors and Biosensors, John Wiley & Sons, 2003.
5. Rene Lalauze, Chemical Sensors and Biosensors, 1st Edn, Wiley-ISTE, 2013



## Open Elective Courses

BT2071	BIOLOGY FOR ENGINEERS	OEC	3-0-0	3 Credits
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**Pre-requisites:** None

**Course Outcomes:**

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

<b>CO1</b>	Realize the significance of biomolecules for sustaining life
<b>CO2</b>	Identify the difference between unicellular to multi-cellular organisms
<b>CO3</b>	Understand the central dogma of life and gene regulation
<b>CO4</b>	Analyze and understand the concepts of biology for engineering the cell

**Course Articulation Matrix:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
<b>CO1</b>	2	3	3	1	-	-	-	-	-	-	-	-	-	2	-
<b>CO2</b>	2	3	3	1	-	-	-	-	-	-	-	-	-	2	-
<b>CO3</b>	2	3	3	1	-	-	-	-	-	-	-	-	-	2	-
<b>CO4</b>	2	3	3	1	-	-	-	-	-	-	-	-	-	2	-

1 - Slightly; 2 - Moderately; 3 – Substantially

**Syllabus:****Unit I**

**Introduction:** Importance of biology to engineers, Molecules of life: Water and Carbon, Evolution and origin of life, Darwins theory, Diversity of life, Chemical basis of life, Nucleic acids, Amino acids and Proteins, Carbohydrates, Lipids and Membranes.

**Unit II**

**Cell structure and function:** Prokaryotic, Eukaryotic cell and Virus, Sub cellular organelles and their functions, Regulation of cellular metabolism: Cellular respiration and Fermentation, Photosynthesis, Cell division (differences between mitosis and meiosis), Mendel's Law and Patterns of inheritance.

**Unit III**

**Gene structure and expression:** Difference between prokaryotic and eukaryotic gene structure, DNA replication, Transcription, RNA processing and Translation, Control of gene expression (lac operon).

**Unit IV**

**Applications of Biology in Engineering:** Genetic engineering (microbe, plant and animal



cells for improvement), Industrial Biotechnology (Primary and Secondary metabolites), Environmental engineering, Biopharmaceuticals, Tissue engineering, Biomaterials, Stem cell engineering, Biosensors, Bioinformatics.

**Text Books:**

1. Quillin, Allison Scott Freeman, Kim Quillin and Lizabeth Allison, Biological Science, Pearson Education India, 2016.
2. Reinhard Renneberg, Viola Berkling and Vanya Loroeh, Biotechnology for Beginners, Academic Press, 2017.



<b>BT3171</b>	<b>ENVIRONMENTAL TECHNOLOGY</b>	<b>OEC</b>	<b>3-0-0</b>	<b>3 Credits</b>
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**Pre-requisites:** None

**Course Outcomes:**

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

<b>CO1</b>	Understand the importance of water quality and treatment of wastewater
<b>CO2</b>	Understand the types of solid waste and their management
<b>CO3</b>	Understand the fundamental aspects of air pollution and its control
<b>CO4</b>	Apply biological methods for remediation of contaminated soil

**Course Articulation Matrix:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
<b>CO1</b>	2	2	3	1	-	2	3	1	-	-	1	2	3	-	-
<b>CO2</b>	2	2	3	1	-	2	3	1	-	-	1	2	3	-	-
<b>CO3</b>	2	2	3	1	-	2	3	1	-	-	1	2	3	-	-
<b>CO4</b>	3	3	3	1	-	2	3	-	-	-	1	2	3	-	-

1 - Slightly; 2 - Moderately; 3 – Substantially

**Syllabus:**

**Unit I**

Introduction of environmental technology, Water quality and control – Sources of water pollution, Water quality standards for potable water, Health effects of water pollutants, Fundamentals of water treatment process; wastewater characterization, Fundamentals of wastewater treatment (primary, secondary and tertiary treatment). Ecodesign, waste generation over technology development.

**Unit II**

Solid and hazardous Waste Management: Municipal Solid waste management - Sources and classification. Management and methods of processing of waste. Hazardous waste management – sources, classification, treatment and disposal methods. Plastic waste – sources and types, management practices. Microfibres, Microplastics, nanoplastics and its impact on environment, E-waste management, Nuclear waste management.

**Unit III**

Air pollution and control: Sources, classification and health effects, Air quality standards, control of air pollution. Techniques for air pollution control - cyclones, wet dust scrubbers and fabric filters for particulate matter, gas absorption, Biological control of gaseous pollutants.

**Unit IV**

**Bioremediation of contaminated sites:** Introduction, engineering strategies of bioremediation: site characterization, *in situ* and *ex situ* strategies. Phytoremediation – introduction and mechanisms of phytoremediation, Nanoremediation, Waste valorization.



**Text Books:**

1. Garg, S. K. (1999). Water supply engineering – environmental engineering (Vol.I). Khanna Publishers.
2. Metcalf & Eddy, Inc. (2003). Waste water engineering treatment and reuse (4th ed.). McGraw Hill Education.
3. Masters, G. M., & Ela, W. P. (2007). Introduction to Environmental Engineering and Science (3rd ed.), Pearson Education.
4. Rittmann, B. E., & McCarty P. L. (2003). Environmental biotechnology: principles and applications (1st ed.). Tata McGraw-Hill Education.
5. Hale, R. C., Seeley, M. E., La Guardia, M. J., Mai, L., & Zeng, E. Y. (2020). A global perspective on microplastics. *Journal of Geophysical Research: Oceans*, 125(1), e2018JC014719.



<b>BT3291</b>	<b>BIOENERGY AND BIOFUEL</b>	<b>OEC</b>	<b>3-0-0</b>	<b>3 Credits</b>
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**Pre-requisites:** None

**Course Outcomes:**

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

<b>CO1</b>	Classify feedstocks for generation of bioenergy
<b>CO2</b>	Understand various bioenergy production processes
<b>CO3</b>	Understand various biofuels and technology involved in their production
<b>CO4</b>	Understand the concepts of biological production of hydrogen

**Course Articulation Matrix:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
<b>CO1</b>	3	2	2	1	2	2	3	3	2	-	-	3	3	2	1
<b>CO2</b>	3	3	3	2	3	2	3	3	2	-	2	3	3	3	3
<b>CO3</b>	3	3	3	2	3	2	1	3	-	-	3	2	2	3	3
<b>CO4</b>	3	3	3	2	3	1	2	3	-	-	2	2	3	3	3

1 - Slightly; 2 - Moderately; 3 – Substantially

**Syllabus:**

**Unit I**

**Introduction:** Classification of energy based on sources, bio-based energy, bioenergy types, Biopower, Bioheat, Biofuels, advanced liquid fuels, drop-in fuels, Syngas, biohydrogen, biobased products. Feedstocks: Conventional and dedicated biomass feedstock. Residual Feedstocks: Agricultural wastes, forestry wastes, farm waste, organic components of residential, commercial, institutional and industrial waste. Biofuel –an sustainable alternative.

**Unit II**

**Bioconversion processes:** Thermochemical processes, Direct Combustion, Pyrolysis, Gasification; Biochemical conversion – hydrolysis, enzyme and acid hydrolysis, fermentation, anaerobic digestion; other techniques: trans-esterification

**Unit III**

**Biofuels:** First generation biofuels, Second generation biofuels, third generation biofuels; Pros and cons of Biofuels, Algal biofuels, Cyanobacteria and producers of biofuels, Biodiesel composition and production processes, Bioethanol, Biomethane, biobutanol, Engineering aspects of biofuels, Economics of biofuels

**Unit IV**

**Biohydrogen:** Bioproduction of gases, Production of H<sub>2</sub> by photosynthetic organisms,



Emergence of the hydrogen economy, Microbial Fuel Cells and other technological advancements. Bioenergy in electric vehicles, Biomaterials for energy storage.

**Text Books:**

1. Brown, R. C., & Brown, T. R. (2014). Biorenewable resources: Engineering new products from agriculture (2nd ed.). Wiley-Blackwell.
2. Soetaert, W., & Vandamme, E. J. (2009). Biofuels (1st ed.). Wiley.
3. Klass, D. L. (1998). Biomass for renewable energy, fuels and chemicals (1st ed.). Academic press.
4. Nelson, V. C., & Starcher, K. L. (2016). Introduction to bioenergy (1st ed.). CRC Press.
5. Dahiya, A. (2015). Bioenergy: Biomass to biofuels (1st ed.). Academic Press



<b>BT4401</b>	<b>ETHICS AND IPR</b>	<b>OEC</b>	<b>3-0-0</b>	<b>3 Credits</b>
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Pre-Requisites: None

**Course Outcomes:**

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

<b>CO1</b>	Understand the concept of engineering ethics
<b>CO2</b>	Understand the agreements, treaties and the procedures involved in patent filing
<b>CO3</b>	Analyze the databases and formalities pertaining to patent agreements

**Course Articulation Matrix:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
<b>CO1</b>	2	-	-	-	-	3	3	-	-	2	-	-	3	2	3
<b>CO2</b>	2	-	-	-	-	3	3	-	-	2	-	-	3	-	3
<b>CO3</b>	2	-	-	-	-	3	3	-	-	2	-	-	3	-	3

1 - Slightly; 2 - Moderately; 3 – Substantially

**Syllabus:**

**Unit I**

Engineering Ethics :Senses of 'Engineering Ethics' – Variety of moral issues – Types of inquiry

– Moral dilemmas – Moral Autonomy – Kohlberg's theory – Gilligan's theory – Consensus and Controversy – Models of professional roles - Theories about right action – Self-interest – Customs and Religion – Uses of Ethical Theories.

**Unit II**

Agreements and Treaties, History of GATT & TRIPS Agreement, Madrid Agreement; Hague Agreement, WIPO Treaties; Budapest Treaty; PCT, Indian Patent Act 1970 & recent amendments, Introduction to Patents; Types of patent applications: Ordinary, PCT, Conventional, Divisional and Patent of Addition, Specifications: Provisional & complete

**Unit III**

Patent databases- Patent filing procedures, Time frame& cost; Status of patent applications filed, Precautions while patenting – disclosure/non-disclosure, Financial assistance for patenting , Patent licensing and agreement, Patent infringement, Introduction to Copyrights and Trademarks, Trade Secrets and Geographical Indications (GIs), Case Studies in Patents and IPR (e.g., Tesla's open-source patents, Apple vs. Samsung lawsuits).

**Text Books:**

1. Martin, M. W., & Schinzinger, R. (2005). Ethics in engineering (4th ed.). McGraw Hill Higher Education.
2. Govindarajan, M., Natarajan, S., & Senthil Kumar, V. S. (2004). Engineering ethics. PHI Learning.
3. Wadhera, B. L. (2010). Law relating to intellectual property (5th ed.). Universal Law



Publishing.

4. Bansal, P. (2015). IPR handbook for pharma students and researchers. Pharma Med Press.
5. K.D. Sibley, The Law & Strategy of Biotechnology Patents, Butterworth-Heinemann, 1994
6. Mueller, Janice M. Aspen Treatise for Patent Law. Aspen Publishing, 2024



<b>BT4411</b>	<b>BIOSENSOR TECHNOLOGY</b>	<b>OEC</b>	<b>3-0-0</b>	<b>3 Credits</b>
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**Pre-Requisites:**

- i. EE1601 Basic Electrical and Electronics Engineering

**Course Outcomes:**

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

<b>CO1</b>	Understand biosensing and transducing techniques
<b>CO2</b>	Understand principles of linking cell components and biological pathways with energy transduction, sensing and detection
<b>CO3</b>	Demonstrate appreciation for the technical limits of performance of biosensor
<b>CO4</b>	Apply principles of engineering to develop bioanalytical devices and design of biosensors

**Course Articulation Matrix:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
<b>CO1</b>	3	2	2	-	1	2	-	-	-	-	1	1	2	-	-
<b>CO2</b>	3	2	2	-	1	2	-	-	-	-	1	1	2	1	-
<b>CO3</b>	3	2	2	2	1	2	-	-	-	-	2	1	3	2	-
<b>CO4</b>	3	2	2	3	1	2	2	-	-	-	2	1	3	2	2

1 - Slightly; 2 - Moderately; 3 – Substantially

**Syllabus:****Unit I**

General principles: A historical perspective; Signal transduction; Physico-chemical and biological transducers; Sensor types and technologies, Definitions and Concepts Terminology and working vocabulary; Main technical definitions: calibration, selectivity, sensitivity, reproducibility, detection limits, response time.

**Unit II**

Physico-chemical transducers: Electrochemical transducers (amperometric, potentiometric, conductimetric); optical transducers (absorption, fluorescence, SPR); Thermal transducers; piezoelectric transducers, Quantitative sensors, Multi response biosensors.

**Unit III**

Biosensor Engineering: Methods for biosensors fabrication, self-assembled monolayers, screen printing, photolithography, micro-contact printing, MEMS. Engineering concepts for mass production, Case study on sensor development (Continuous Glucose Monitoring sensor)

**Unit IV**

Application of modern sensor technologies: Clinical chemistry; Test-strips for glucose monitoring; Urea determination; Implantable sensors for long-term monitoring; wearable biosensors; Environmental monitoring; Technological process control; Food quality control;



Forensic science benefits; Problems & limitations. Paper-Based Sensors, 3D-Printed Sensors, Microfluidic Sensors, Lab-on-a-Chip (LoC) Devices.

**Text Books:**

1. Donald G. Buerk, Biosensors: Theory and Applications, CRC Press, 2009.
2. Mustafa Kemal Sezgintürk , Commercial Biosensors and Their Applications: Clinical, Food, and Beyond, 1st Edn, Elsevier, 2020
3. Alice Cunningham, Introduction to Bioanalytical Sensors, John Wiley & Sons, 1998.
4. Brian R. Egdins, Chemical Sensors and Biosensors, John Wiley & Sons, 2003.
5. Rene Lalauze, Chemical Sensors and Biosensors, 1st Edn, Wiley-ISTE, 2013

**MINOR DEGREE PROGRAM**

<b>BT2031</b>	<b>CELL BIOLOGY</b>	<b>PCC</b>	<b>3-0-0</b>	<b>3 Credits</b>
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Prerequisites: Nil

**Course Outcomes:**

At the end of the course the student will be able to:

<b>CO1</b>	Understand the cell theory and cellular compartmentalization
<b>CO2</b>	Understand the structure and function of the plasma membrane and cell organelles
<b>CO3</b>	Understand the molecular mechanisms of cell cycle and signal transduction
<b>CO4</b>	Understand the significance of apoptosis in cellular regulation and relate the importance of cell cycle on cancer development

**Course Articulation Matrix:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
<b>CO1</b>	3	-	-	1	1	-	-	-	-	-	-	-	2	-	-
<b>CO2</b>	3	-	-	1	1	-	-	-	-	-	-	-	3	-	-
<b>CO3</b>	3	-	-	1	1	-	-	-	-	-	-	-	3	-	-
<b>CO4</b>	2	2	-	1	-	-	-	-	-	-	-	-	3	-	-

1 - Slightly; 2 - Moderately; 3 – Substantially

**Syllabus:****Unit I**

**Cell structure and function:** Discovery of cells & Basic properties of cell, Cell theory; Cell complexity, Different classes of cells; Prokaryotic & Eukaryotic cell. Intracellular Compartments: Structure and functions of Nucleus and cell organelles, Extra cellular matrix, Cell-cell communication, integrins.

**Unit II**

**Cell Membrane and cell division:** Introduction to cell membrane components, phospholipid bilayers, membrane transport systems ( active, passive and facilitated). Cell division: Molecular Mechanics of Mitosis & Meiosis, Checkpoint cell cycle control, Activation and control of cyclin dependent kinase activity.

**Unit III**

**Cell signaling:** Intracellular signaling and types of signal receptors, Signal Transduction by hormones-Steroid / Peptide hormones, Concept of Secondary messengers, cAMP, cGMP, Protein Kinases, G Proteins, Receptors & Non-receptors associated tyrosine kinases, Protein kinase receptors (calmodulin, RAS, RAF, MAPK), Cytokine receptor-JAK-STAT signaling pathway.



## Unit IV

**Cell differentiation:** Cancer biology basics, Characteristics of Cancer Cells, Types of Tumors, Molecular Basis of Cancer-Proto oncogene, Tumor Suppressor gene. Concepts of Apoptosis, Necrosis, Ubiquitin Proteasome Pathway, Autophagy and Mitophagy, Aging and Senescence, Therapeutic interventions of uncontrolled cell growth, Stem cell and its application.

### Text Books:

1. Alberts, B., Johnson, A., Lewis, J., Morgan, D., Raff, M., Roberts, K., & Walter, P. (2014).
2. *Molecular biology of the cell* (6th ed.). Garland Science.
3. Cooper, G. M., & Hausman, R. E. (2015). *The cell: A molecular approach* (7th ed.). Oxford University Press.
4. Nelson, D. L., & Cox, M. M. (2017). *Lehninger principles of biochemistry* (7th ed.). WH Freeman.
5. Rodwell, V. W., Bender, D. A., Botham, K. M., Kennelly, P. J., & Weil, P. A. (2015). *Harper's illustrated biochemistry* (30th ed.). McGraw-Hill Education



<b>BT2111</b>	<b>ANALYTICAL METHODS IN BIOTECHNOLOGY</b>	<b>PCC</b>	<b>3–0–0</b>	<b>3 Credits</b>
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**Prerequisites:**

- i. PH1011 Engineering Physics
- ii. CY1011 Engineering Chemistry
- iii. BT2011 Biochemistry

**Course Outcomes:**

At the end of the course the student will be able to:

<b>CO1</b>	Understand the basics of bioanalysis and types of bioanalytical instruments
<b>CO2</b>	Apply spectroscopic techniques for characterization of biomolecules
<b>CO3</b>	Select the appropriate chromatographic technique for bioanalysis

**Course Articulation Matrix:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
<b>CO1</b>	3	-	-	1	3	-	-	3	-	-	-	-	3	-	-
<b>CO2</b>	3	-	-	2	3	-	-	3	-	-	-	-	3	3	-
<b>CO3</b>	3	-	-	1	3	-	-	2	-	-	-	-	3	1	-

1 - Slightly; 2 - Moderately; 3 – Substantially

**Syllabus:****Unit I**

**Introduction, Modern approaches in Bioanalysis and Bioassays, Microscopy Techniques-** Dark-field, Phase contrast, Fluorescence, Confocal, Polarization microscopy; SPM, AFM, Electron microscopy: TEM & SEM.

**Unit II**

**Radioisotope techniques-** Basic concepts, GM and scintillation counter, autoradiography, RIA, Applications in biological science.

**Molecular Spectroscopic techniques:** Basic concepts and experimental methods of UV- Visible spectroscopy, Fluorescence spectroscopy, CD spectroscopy, NMR, X-ray, Mass spectroscopy, atomic absorption spectroscopy (AAS, inductively coupled plasma emission (ICP/AES), Fourier transform infrared spectrometry (FTIR).

**Unit III**

**Advanced chromatographic techniques—** Mass Spectrometry – various ionization methods – EI, CI, ESI, MALDI-TOF, HRMS. Gas Chromatography (GC) with detectors— electron capture (ECD), flame ionization (FID), and mass spectrometry (MS), Liquid chromatography with mass spectroscopy (LC-MS), high-performance thin layer chromatography (HPTLC).



## Unit IV

**Advanced Techniques:** Next-generation sequencing (NGS), multiplex fluorescent in situ hybridization (m-FISH), comparative genome hybridization (CGH), flow cytometry-fluorescence-activated cell sorting (FACS)

### Text Books:

1. Wilson, K., & Walker, J. (2005). *Principles and techniques of biochemistry and molecular biology* (6th ed.). Cambridge University Press.
2. Pavia, D. L., Lampman, G. M, Kriz, G. S., & Vyvyan, J. R. (2015). *Introduction to spectroscopy* (5th ed.). Cengage Learning.
3. Skoog, D. A., Holler, F. J., & Crouch, S. R. (2018). *Principles of instrumental analysis* (7<sup>th</sup> ed.). Cengage Learning



<b>BT3231</b>	<b>INDUSTRIAL BIOTECHNOLOGY</b>	<b>DEC</b>	<b>3-0-0</b>	<b>3 Credits</b>
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**Prerequisites:**

- i. BT2021 Microbiology
- ii. BT1021 Bioprocess Calculations

**Course Outcomes:**

At the end of the course the student will be able to

<b>CO1</b>	Understand the use of living cells in industry
<b>CO2</b>	Understand the commercial production processes in the biotechnology industry
<b>CO3</b>	Understand and apply the industrial level production processes for economically valuable products
<b>CO4</b>	Develop the bioprocess for production of industrial products

**Course Articulation Matrix:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
<b>CO1</b>	2	3	1	1	-	2	3	1	-	-	-	-	3	1	2
<b>CO2</b>	1	3	1	1	-	2	2	1	-	-	-	-	3	2	1
<b>CO3</b>	2	2	3	1	2	2	2	1	-	-	-	-	3	3	1
<b>CO4</b>	1	2	3	3	3	3	2	1	-	-	1	1	2	3	3

1 - Slightly; 2 - Moderately; 3 – Substantially

**Syllabus:****Unit I**

Introduction to industrial biotechnology, Outline of industrial biotechnological process. Production of biomass, primary and secondary metabolites: Commercial production of Organic Acids and bulk organics (ethanol). Commercial production of Antibiotics, Extra cellular polysaccharides (Xanthan Gum), Pigments (Shikonin).

**Unit II**

Microbial production of industrial enzymes: glucose isomerase, cellulase, lipases, amylase, protease, Production of Fermented Foods, Single Cell Protein.

**Unit III**

Commercial production of recombinant therapeutic proteins, Microbial Transformations (Steroids), Transformation of steroids and sterols, Transformation of non-steroidal compounds, Applications of bioconversions. Screening strategies for new products.

**Text Books:**

1. Okafor, N. (2007). *Modern industrial microbiology and biotechnology* (1<sup>st</sup> ed.) Science Publishers.
2. Stanbury, P., Whitaker, A., & Hall, S. J. (2016). *Principles of fermentation technology* (3<sup>rd</sup> ed.). Butterworth-Heinemann



<b>BT3341</b>	<b>BIOPROCESS CONTROL AND INSTRUMENTATION</b>	<b>DEC</b>	<b>3-0-0</b>	<b>3 Credits</b>
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**Pre-Requisites:** BT1021 Bioprocess Calculations

**Course Outcomes:**

At the end of the course the student will be able to:

<b>CO1</b>	Understand various bioprocess instrumentation and their dynamic behavior
<b>CO2</b>	Understand the closed loop control system and its components
<b>CO3</b>	Analyze stability of feedback control system

**Course Articulation Matrix:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
<b>CO1</b>	3	2	3	3	2	-	-	-	1	1	2	2	2	3	2
<b>CO2</b>	3	3	3	3	3	-	-	-	1	1	2	2	3	3	2
<b>CO3</b>	3	2	3	2	3	-	-	-	1	1	1	1	2	2	2

1 - Slightly; 2 - Moderately; 3 – Substantially

**Syllabus:**

**Bioprocess Instrumentation:** Temperature, pH, Level, Flow, load, agitation, flow, Pressure, exit gas analysers, DO sensors, Dielectric spectroscopy, sensors for substrate (glucose, metal ions) and biomass. Response of First order systems: Transfer Function, Transient Response, Forcing Functions and Responses. Physical examples of First and second order systems: Examples of First order systems, Linearization, Transportation Lag.

**Control Systems:**

Control Systems: Strategies for Bioprocess Control - Description of different control strategies and their control structures. Components of a Control System, Block Diagram Development of Block Diagram, Controllers and Final Control Elements. Closed loop Transfer functions: Standard Block-Diagram Symbols, Transfer Functions for Single-Loop Systems and Multi-loop Systems. Transient response of simple control systems: Servo Problem, Regulatory Problem

**Controllers:** Proportional, Proportional-Integral, PID Controllers, Cascade Control, Model Predictive Control, Neural Network-Based Control, Fuzzy Logic-Based Control, Model Based Control, Soft Sensor-Based Control- case studies. PAT Based Control Strategies (Spectrophotometry: UV-Vis, FT-IR, Raman, SLS, Fluorescence) Automation in Biomanufacturing, SCADA (supervisory control and data acquisition) controller Ziegler-Nichols Controller Settings. Stability: Routh Test, Root Locus.



**Frequency Response:** Introduction, Substitution Rule, Bode Diagrams. Control system design based on frequency response: Bode and Nyquist Stability Criterion, Gain and Phase Margins.

**Text Books:**

1. Coughanowr, D., & Leblanc, S. (2009). *Process systems analysis and control* (3rd ed.). McGraw-Hill.
2. Eckman, D. P. (1985). *Industrial Instrumentation*. Wiley.
3. Shuler, M. L., Kargi, F., & DeLisa, M. (2017). *Bioprocess engineering: Basic concepts* (3rd ed.). Pearson.
4. Bailey, J. E., & Ollis, D. F. (2006). *Biochemical engineering fundamentals* (2nd ed.). McGraw-Hill.
5. Ghosh, T. (2004). *Biotechnology and bioprocess engineering: Proceedings, VII International biotechnology symposium*. Delhi.
6. Stephanopoulos, G. (2015). *Chemical process control*. Pearson India


**MAJOR DEGREE PROGRAM**

<b>BT2031</b>	<b>CELL BIOLOGY</b>	<b>PCC</b>	<b>3–0–0</b>	<b>3 Credits</b>
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Prerequisites: Nil

**Course Outcomes:**

At the end of the course the student will be able to:

<b>CO1</b>	Understand the cell theory and cellular compartmentalization
<b>CO2</b>	Understand the structure and function of the plasma membrane and cell organelles
<b>CO3</b>	Understand the molecular mechanisms of cell cycle and signal transduction
<b>CO4</b>	Understand the significance of apoptosis in cellular regulation and relate the importance of cell cycle on cancer development

**Course Articulation Matrix:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
<b>CO1</b>	3	-	-	1	1	-	-	-	-	-	-	-	2	-	-
<b>CO2</b>	3	-	-	1	1	-	-	-	-	-	-	-	3	-	-
<b>CO3</b>	3	-	-	1	1	-	-	-	-	-	-	-	3	-	-
<b>CO4</b>	2	2	-	1	-	-	-	-	-	-	-	-	3	-	-

1 - Slightly; 2 - Moderately; 3 – Substantially

**Syllabus:**
**Unit I**

**Cell structure and function:** Discovery of cells & Basic properties of cell, Cell theory; Cell complexity, Different classes of cells; Prokaryotic & Eukaryotic cell. Intracellular Compartments: Structure and functions of Nucleus and cell organelles, Extra cellular matrix, Cell-cell communication, integrins.

**Unit II**

**Cell Membrane and cell division:** Introduction to cell membrane components, phospholipid bilayers, membrane transport systems ( active, passive and facilitated). Cell division: Molecular Mechanics of Mitosis & Meiosis, Checkpoint cell cycle control, Activation and control of cyclin dependent kinase activity.

**Unit III**

**Cell signaling:** Intracellular signaling and types of signal receptors, Signal Transduction by hormones-Steroid / Peptide hormones, Concept of Secondary messengers, cAMP, cGMP, Protein Kinases, G Proteins, Receptors & Non-receptors associated tyrosine kinases, Protein kinase receptors (calmodulin, RAS, RAF, MAPK), Cytokine receptor-JAK-STAT signaling pathway.



## Unit IV

**Cell differentiation:** Cancer biology basics, Characteristics of Cancer Cells, Types of Tumors, Molecular Basis of Cancer-Proto oncogene, Tumor Suppressor gene. Concepts of Apoptosis, Necrosis, Ubiquitin Proteasome Pathway, Autophagy and Mitophagy, Aging and Senescence, Therapeutic interventions of uncontrolled cell growth, Stem cell and its application.

### Text Books:

1. Alberts, B., Johnson, A., Lewis, J., Morgan, D., Raff, M., Roberts, K., & Walter, P. (2014).
2. *Molecular biology of the cell* (6th ed.). Garland Science.
3. Cooper, G. M., & Hausman, R. E. (2015). *The cell: A molecular approach* (7th ed.). Oxford University Press.
4. Nelson, D. L., & Cox, M. M. (2017). *Lehninger principles of biochemistry* (7th ed.). WH Freeman.
5. Rodwell, V. W., Bender, D. A., Botham, K. M., Kennelly, P. J., & Weil, P. A. (2015). *Harper's illustrated biochemistry* (30th ed.). McGraw-Hill Education



<b>BT2011</b>	<b>BIOCHEMISTRY</b>	<b>PCC</b>	<b>3-0-0</b>	<b>3 Credits</b>
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**Prerequisites:** CY1011 Engineering Chemistry

**Course Outcomes:**

At the end of the course the student will be able to:

<b>CO1</b>	Classify bio-molecules
<b>CO2</b>	Understand complex biochemical pathways within living cells
<b>CO3</b>	Understand the physiological functioning of the cells
<b>CO4</b>	Understand anabolic and catabolic metabolism
<b>CO5</b>	Understand the mechanism of enzymatic reactions

**Course Articulation Matrix:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
<b>CO1</b>	3	-	-	2	2	1	-	-	-	-	-	-	3	1	-
<b>CO2</b>	3	-	-	-	-	2	1	-	2	1	-	2	2	1	-
<b>CO3</b>	3	-	-	-	-	2	-	1	-	-	-	2	3	1	-
<b>CO4</b>	3	2	2	-	3	-	2	-	-	-	-	1	3	-	1
<b>CO5</b>	3	2	3	2	-	2	3	-	-	-	3	2	3	2	2

1 - Slightly; 2 - Moderately; 3 – Substantially

**Syllabus:**

**Unit I**

**Introduction to Biochemistry:** Chemical foundations of Biology - pH, acids, bases, buffers, weak bonds and covalent bonds. Carbohydrates: Structure, classification and functions of carbohydrates and glycoconjugates. Lipids: Structure of Fats and Oils, Phospholipids, membrane lipids.

**Unit II**

**Amino acids and Peptides:** Classification of amino acids, Structure and properties of amino acids, Peptide bond and peptides. Proteins: Structure and Classification of Proteins. Primary structure, Secondary structure, Tertiary structure and Quaternary structure, aggregated proteins, Structural importance in function, Denaturation and Renaturation.

**Unit III**

**Nucleic acids:** Structure of nucleic acids, Structure of DNA, specialized secondary structures, kinds of RNA and their structures.

**Unit IV**

**Vitamins:** Introduction, classification and functions of vitamins, disease of vitamins deficiency.

**Unit V**

**Metabolism:** Glycolysis, Gluconeogenesis, Pentose Phosphate Pathway, Citric Acid



Cycle, Oxidative Phosphorylation, Photosynthesis, Amino Acid Oxidation, DNA, RNA, Protein and Fatty acid metabolism.

**Text Books:**

1. Nelson, D. L., & Cox, M. M. (2017). Lehninger principles of biochemistry (7th ed.). WH Freeman.
2. Rodwell, V. W., Bender, D. A., Botham, K. M., Kennelly, P. J., & Weil, P. A. (2015). Harper's illustrated biochemistry (30th ed.). McGraw-Hill Education
3. Berg, J. M., Tymoczko, J. L., Gatto, G. J., & Stryer, L. (2015). Biochemistry (8th ed.). WH Freeman.



<b>BT2101</b>	<b>BIOLOGICAL REACTION ENGINEERING</b>	<b>PCC</b>	<b>3-0-0</b>	<b>3 Credits</b>
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**Prerequisites:**

- i. BT1021 Bioprocess calculations

**Course Outcomes:**

At the end of the course the student will be able to:

<b>CO1</b>	Understand the basics of reaction kinetics and reactor design
<b>CO2</b>	Understand the concept of enzyme kinetics and kinetics parameters estimation
<b>CO3</b>	Understand the modelling principles of microbial, substrate and product kinetics
<b>CO4</b>	Understand the concepts of ideal reactors and non-ideality

**Course Articulation Matrix:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
<b>CO1</b>	3	-	-	1	3	-	-	-	-	-	-	-	3	-	-
<b>CO2</b>	3	-	-	1	3	-	-	-	-	-	-	-	3	1	-
<b>CO3</b>	3	-	-	1	3	-	-	-	-	-	-	-	3	-	-
<b>CO4</b>	3	-	-	2	3	-	-	-	-	-	-	-	3	-	-

1 - Slightly; 2 - Moderately; 3 – Substantially

**Syllabus:**
**Unit I**

**Introduction to reaction kinetics:** Introduction to ideal reactor (batch and continuous reactors), performance equations, Levenspiel plot, elementary and non-elementary reactions, homogenous and heterogenous reactions, the effect of concentration and temperature on rate kinetics. Rate equations, concepts of molecularity, order, and mechanisms; Interpretation of batch reactor data, constant volume batch reactor, integral and differential methods

**Unit II**

**Enzyme kinetics:** Enzyme kinetics for single substrate reaction, Rapid equilibrium and Quasi steady approaches, model parameter estimation (Lineweaver–Burk, Eadie–Hofstee, Hanes–Wolf plots), Type of inhibitions (competitive, uncompetitive and non-competitive), substrate and product inhibition kinetics, immobilization and its kinetics

**Unit III**

**Microbial kinetics:** modelling of growth curve, balanced growth models, substrate utilization models - Monod equation and its modifications, unstructured and structured models, morphology-based models, product formation kinetics

**Unit IV**

**Ideal reactors and Non-ideality:** Batch and plug flow and CSTR reactors, non-ideality, RTD, concept of tracer studies, construction of C, E and F curves, selection of suitable reactor systems for multiple reactions, Models of non-ideal reactors.



**Text Books:**

1. Levenspiel, O. (1998). *Chemical reaction engineering* (3rd ed.). John Wiley and Sons.
2. Doran, P. M. (2012). *Bioprocess engineering principles* (2nd ed.). Academic Press.
3. Bailey, J. E., & Ollis, D. F. (1989). *Biochemical engineering fundamentals* (2nd ed.) McGraw Hill Education.
4. Ravi, R., Vinu, R., & Gummadi, S. N. (2017). *Chemical and biochemical reactors and reaction engineering, Volume 3A, Coulson and Richardson's chemical engineering* (4<sup>th</sup> ed.). Butterworth-Heinemann.
5. Nithya, M. & Seenivasan A. (2022). *Design and kinetics of homogenous biochemical reactors*. In *Bioprocess Engineering & Technology: Fundamentals, Upstream and Downstream Processing and Plant Design, Vol-II (Bioprocess Engineering and Technology: Upstream Process)*. CRC Press.



<b>BT2111</b>	<b>ANALYTICAL METHODS IN BIOTECHNOLOGY</b>	<b>PCC</b>	<b>3-0-0</b>	<b>3 Credits</b>
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**Prerequisites:**

1. PH1011 Engineering Physics
2. CY1011 Engineering Chemistry
3. BT2011 Biochemistry

**Course Outcomes:**

At the end of the course the student will be able to:

<b>CO1</b>	Understand the basics of bioanalysis and types of bioanalytical instruments
<b>CO2</b>	Apply spectroscopic techniques for characterization of biomolecules
<b>CO3</b>	Select the appropriate chromatographic technique for bioanalysis

**Course Articulation Matrix:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
<b>CO1</b>	3	-	-	1	3	-	-	3	-	-	-	-	3	-	-
<b>CO2</b>	3	-	-	2	3	-	-	3	-	-	-	-	3	3	-
<b>CO3</b>	3	-	-	1	3	-	-	2	-	-	-	-	3	1	-

1 - Slightly; 2 - Moderately; 3 – Substantially

**Syllabus:****Unit I**

**Introduction, Modern approaches in Bioanalysis and Bioassays, Microscopy Techniques-** Dark-field, Phase contrast, Fluorescence, Confocal, Polarization microscopy; SPM, AFM, Electron microscopy: TEM & SEM.

**Unit II**

**Radioisotope techniques-** Basic concepts, GM and scintillation counter, autoradiography, RIA, Applications in biological science.

**Molecular Spectroscopic techniques:** Basic concepts and experimental methods of UV- Visible spectroscopy, Fluorescence spectroscopy, CD spectroscopy, NMR, X-ray, Mass spectroscopy, atomic absorption spectroscopy (AAS, inductively coupled plasma emission (ICP/AES), Fourier transform infrared spectrometry (FTIR).

**Unit III**

**Advanced chromatographic techniques—** Mass Spectrometry – various ionization methods – EI, CI, ESI, MALDI-TOF, HRMS. Gas Chromatography (GC) with detectors— electron capture (ECD), flame ionization (FID), and mass spectrometry (MS), Liquid chromatography with mass spectroscopy (LC-MS), high-performance thin layer chromatography (HPTLC).



## Unit IV

**Advanced Techniques:** Next-generation sequencing (NGS), multiplex fluorescent in situ hybridization (m-FISH), comparative genome hybridization (CGH), flow cytometry-fluorescence-activated cell sorting (FACS)

### Text Books:

1. Wilson, K., & Walker, J. (2005). *Principles and techniques of biochemistry and molecular biology* (6th ed.). Cambridge University Press.
2. Pavia, D. L., Lampman, G. M, Kriz, G. S., & Vyvyan, J. R. (2015). *Introduction to spectroscopy* (5th ed.). Cengage Learning.
3. Skoog, D. A., Holler, F. J., & Crouch, S. R. (2018). *Principles of instrumental analysis* (7<sup>th</sup> ed.). Cengage learning



<b>BT2081</b>	<b>MOLECULAR BIOLOGY AND GENETICS</b>	<b>PCC</b>	<b>3-0-0</b>	<b>3 Credits</b>
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**Prerequisites:**

- i. BT2021 Microbiology
- ii. BT2011 Biochemistry

**Course Outcomes:**

At the end of the course the student will be able to:

<b>CO1</b>	Understand the genome structure and mechanism of DNA replication in prokaryotes and eukaryotes
<b>CO2</b>	Understand the molecular mechanisms of central dogma and gene regulation
<b>CO3</b>	Understand the population genetics , evolution and determine the recombinant frequencies

**Course Articulation Matrix:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
<b>CO1</b>	3	-	-	-	2	3	-	-	-	-	-	-	3	-	-
<b>CO2</b>	3	-	-	-	2	3	-	-	-	-	2	2	3	1	1
<b>CO3</b>	3	2	-	3	3	3	-	-	-	-	2	2	3	1	1

1 - Slightly; 2 - Moderately; 3 – Substantially

**Syllabus:****Unit I**

**Anatomy and Replication of genome:** Anatomy of Prokaryotic and Eukaryotic Genome. DNA Replication mechanisms, Genetic Recombination, transposons, Mutations and mutagenesis, DNA damage and repair mechanism.

**Unit II**

**Transcription and Translation:** Transcription Initiation and Regulation in Prokaryotes and Eukaryotes, Processing of mRNA, Non-coding RNAs (introns, miRNA, siRNA, snRNA). Prokaryotic and Eukaryotic translation, Post-translational processing of proteins. Gene regulation: Concept of operon structure. Mechanisms of Lac and Trp operons.

**Unit III**

**Population Genetics and Evolution:** Principles of Mendelian Law, Epistasis, Sex Determination and Linkage of Genes on the X Chromosome, Linkage maps, Crossing Over, Chromosomal mapping, Chromosome Variation (Number and Structure), Extra Chromosomal Inheritance, Epigenetics, Population Genetics, Selection and inheritance, Adaptive and neutral evolution, Genetic drift, Species and Speciation



**Text Books:**

1. Alberts, B., Johnson, A., Lewis, J., Morgan, D., Raff, M., Roberts, K., & Walter, P. (2014). *Molecular biology of the cell* (6th ed.). Garland Science.
2. Freifelder, D. (2004). *Molecular biology* (2nd ed.). Narosa Publishing House.
3. Brown, T. A. (2017). *Genomes 4* (4th ed.). Garland Science.
4. Watson, J. D., Baker, T. A., Bell, S. P., Gann, A., Levine, M., & Losick, R. (2008). *Molecular biology of the gene* (6th ed.). CSHL Press.
5. Strickberger, M.W. (2008). *Genetics* (3rd ed.). Prentice Hall of India.
6. Futuyma, D.J., 2017. Evolutionary biology today and the call for an extended synthesis. *Interface focus*, 7(5), p.20160145.



<b>BT3141</b>	<b>PLANT BIOTECHNOLOGY</b>	<b>DEC</b>	<b>3-0-0</b>	<b>3 Credits</b>
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**Prerequisites:**

- i. BT2011 Biochemistry
- ii. BT2081 Molecular Biology & Genetics
- iii. BT2031 Cell Biology
- iv. BT3212 Genetic engineering

**Course Outcomes:**

At the end of the course the student will be able to:

<b>CO1</b>	Comprehend the concepts of plant tissue culture techniques
<b>CO2</b>	Understand the technology of plant transformation
<b>CO3</b>	Understand in vitro techniques for production of plant secondary metabolites.
<b>CO4</b>	Understand the phytochemical production and assessment of transgenic plants

**Course Articulation Matrix:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
<b>CO1</b>	3	1	-	-	3	2	3	-	-	-	1	2	3	-	2
<b>CO2</b>	-	-	3	-	3	-	3	-	-	-	1	-	-	-	-
<b>CO3</b>	-	3	-	2	-	-	3	-	-	-	1	2	-	3	2
<b>CO4</b>	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-

1 - Slightly; 2 - Moderately; 3 – Substantially

**Syllabus:****Unit I**

Introduction to Plant Biotechnology, Plant agriculture: The impact of biotechnology, Special features and organization of Plant cells, Plant growth hormones: biosynthesis and signaling pathways, Physiology, Transpiration, Movement of water and ions.

**Unit II**

Plant Tissue Culture, Media, culture conditions, Callus, cell suspension culture, Anther, protoplast, embryo and meristem cultures, Totipotency, regeneration methods of plants in cultures, Somatic hybrids and cybrids, Applications of cell and tissue culture, Production of Secondary metabolites, Engineering considerations for the production of phytochemicals.

**Unit III**

Successful gene transfer mechanism, Direct and Indirect methods, Agrobacterium-mediated gene transfer, Applications of Transgenic plants, Insecticidal, herbicidal, and viral resistance, Other applications of Transgenic plants.



## Unit IV

Transgenic Plant Analysis, Initial screens, Definitive molecular characterization, Field Testing of Transgenic Plants, Environmental risk assessment, IPR in PBT.

### Text Books:

1. Sator, A., Scott, N. W., & Fowler, M. R. (2008). Plant biotechnology: The genetic manipulation of plants (2nd ed.). Oxford University Press.
2. Stewart, C. N. (2008). Plant biotechnology and genetics: Principles, techniques, and applications (2nd ed.). John Wiley and Sons.
3. Srivastava, P. S., Narula, A., & Srivastava, S. (2005). Plant biotechnology and molecular markers. Springer.
4. Chawla, H. S. (2020). Introduction to plant biotechnology (3rd ed.). Science Publishers.
5. Taiz, L. & Zeiger, E. (2010). Plant physiology (5th ed.). Oxford University Press.



<b>BT3251</b>	<b>FOOD BIOTECHNOLOGY</b>	<b>DEC</b>	<b>3-0-0</b>	<b>3 Credits</b>
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**Pre-Requisites:**

- i. BT2021 Microbiology
- ii. BT2011 Biochemistry

**Course Outcomes:**

At the end of the course the student will be able to:

<b>CO1</b>	Understand the components and nutritional value of food
<b>CO2</b>	Understand the concepts of fermented food production process
<b>CO3</b>	Understand the food processing methods and regulations

**Course Articulation Matrix:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
<b>CO1</b>	-	3	-	-	-	3	2	1	1	1	2	3	3	-	2
<b>CO2</b>	-	-	1	3	1	3	2	2	2	1	2	2	2	3	2
<b>CO3</b>	1	2	3	3	2	2	1	3	2	2	1	2	2	2	2

1 - Slightly; 2 - Moderately; 3 – Substantially

**Syllabus:****Unit I**

Food biochemistry and microbiology: Components of food: carbohydrates, proteins, fats, vitamins, minerals, Antinutrients; Balanced diet; Prebiotics; Probiotics; Phytonutraceuticals; Nutraceuticals Vs Pharmaceuticals; Microbial Spoilage: food, milk and milk products, meat and meat products; Bacterial pathogens and Non-bacterial pathogens; food preservation.

**Unit II**

Production of fermented food: Overview of diverse fermented foods; Starter cultures in food industry; Production process of selected fermented foods (Soya sauce, Sauerkraut, Peanut milk, Idly, Beer, Wine, Yogurt, Cheese, Sausages); Concept of SCP, mushrooms, food yeasts, algal protein, GM foods; bio-fortification, food additives, food sweeteners and colours. Limit of Pesticide in Food item, Hazardous effect of Food additives

**Unit III**

Food processing methods and regulations: Product development; Processing techniques; Toxicology studies; clinical trials associate with product development; Hygiene and sanitation in food sector; Concepts of GMP, GHP and GLP; Food Laws and Organizations: Food Safety Standards Rules & Regulations, 2011, FSSAI regulation, Essential commodities Act; International Organizations: EFSA, FDA, FAO.



**Text Books:**

1. Lee, B. H. (2015). *Fundamentals of food biotechnology* (2nd ed.), Wiley-Blackwell.
2. Jay, J. M., Loessner, M. J., & Golden, D. A. (2005). *Modern food microbiology* (7th ed.). Springer.
3. Green, P. J. (2002). *Introduction to food biotechnology* (1st ed.) CRC Press. Shetty, K., Paliyath, G., Pometto, A., & Levin, R. E. (2005). *Food biotechnology* (2nd ed.), CRC Press.



<b>BT3231</b>	<b>INDUSTRIAL BIOTECHNOLOGY</b>	<b>DEC</b>	<b>3-0-0</b>	<b>3 Credits</b>
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**Prerequisites:**

- i. BT2021 Microbiology
- ii. BT1021 Bioprocess Calculations

**Course Outcomes:**

At the end of the course the student will be able to

<b>CO1</b>	Understand the use of living cells in industry
<b>CO2</b>	Understand the commercial production processes in the biotechnology industry
<b>CO3</b>	Understand and apply the industrial level production processes for economically valuable products
<b>CO4</b>	Develop the bioprocess for production of industrial products

**Course Articulation Matrix:**

	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>	<b>PO7</b>	<b>PO8</b>	<b>PO9</b>	<b>PO10</b>	<b>PO11</b>	<b>PO12</b>	<b>PSO1</b>	<b>PSO2</b>	<b>PSO3</b>
<b>CO1</b>	2	3	1	1	-	2	3	1	-	-	-	-	3	1	2
<b>CO2</b>	1	3	1	1	-	2	2	1	-	-	-	-	3	2	1
<b>CO3</b>	2	2	3	1	2	2	2	1	-	-	-	-	3	3	1
<b>CO4</b>	1	2	3	3	3	3	2	1	-	-	1	1	2	3	3

1 - Slightly; 2 - Moderately; 3 – Substantially

**Syllabus:****Unit I**

Introduction to industrial biotechnology, Outline of industrial biotechnological process. Production of biomass, primary and secondary metabolites: Commercial production of Organic Acids and bulk organics (ethanol). Commercial production of Antibiotics, Extra cellular polysaccharides (Xanthan Gum), Pigments (Shikonin).

**Unit II**

Microbial production of industrial enzymes: glucose isomerase, cellulase, lipases, amylase, protease, Production of Fermented Foods, Single Cell Protein.

**Unit III**

Commercial production of recombinant therapeutic proteins, Microbial Transformations (Steroids), Transformation of steroids and sterols, Transformation of non-steroidal compounds, Applications of bioconversions. Screening strategies for new products.

**Text Books:**

1. Okafor, N. (2007). *Modern industrial microbiology and biotechnology* (1<sup>st</sup> ed.) Science Publishers.
2. Stanbury, P., Whitaker, A., & Hall, S. J. (2016). *Principles of fermentation technology* (3<sup>rd</sup> ed.). Butterworth-Heinemann



<b>BT3341</b>	<b>BIOPROCESS CONTROL AND INSTRUMENTATION</b>	<b>DEC</b>	<b>3-0-0</b>	<b>3 Credits</b>
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**Pre-Requisites:** BT1021 Bioprocess Calculations

**Course Outcomes:**

At the end of the course the student will be able to:

<b>CO1</b>	Understand various bioprocess instrumentation and their dynamic behavior
<b>CO2</b>	Understand the closed loop control system and its components
<b>CO3</b>	Analyze stability of feedback control system

**Course Articulation Matrix:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
<b>CO1</b>	3	2	3	3	2	-	-	-	1	1	2	2	2	3	2
<b>CO2</b>	3	3	3	3	3	-	-	-	1	1	2	2	3	3	2
<b>CO3</b>	3	2	3	2	3	-	-	-	1	1	1	1	2	2	2

1 - Slightly; 2 - Moderately; 3 – Substantially

**Syllabus:**

**Bioprocess Instrumentation:** Temperature, pH, Level, Flow, load, agitation, flow, Pressure, exit gas analysers, DO sensors, Dielectric spectroscopy, sensors for substrate (glucose, metal ions) and biomass. Response of First order systems: Transfer Function, Transient Response, Forcing Functions and Responses. Physical examples of First and second order systems: Examples of First order systems, Linearization, Transportation Lag.

**Control Systems:**

Control Systems: Strategies for Bioprocess Control - Description of different control strategies and their control structures. Components of a Control System, Block Diagram Development of Block Diagram, Controllers and Final Control Elements. Closed loop Transfer functions: Standard Block-Diagram Symbols, Transfer Functions for Single-Loop Systems and Multi-loop Systems. Transient response of simple control systems: Servo Problem, Regulatory Problem

**Controllers:** Proportional, Proportional-Integral, PID Controllers, Cascade Control, Model Predictive Control, Neural Network-Based Control, Fuzzy Logic-Based Control, Model Based Control, Soft Sensor-Based Control- case studies. PAT Based Control Strategies (Spectrophotometry: UV-Vis, FT-IR, Raman, SLS, Fluorescence) Automation in Biomanufacturing, SCADA (supervisory control and data acquisition) controller Ziegler-Nichols Controller Settings. Stability: Routh Test, Root Locus.



**Frequency Response:** Introduction, Substitution Rule, Bode Diagrams. Control system design based on frequency response: Bode and Nyquist Stability Criterion, Gain and Phase Margins.

**Text Books:**

1. Coughanowr, D., & Leblanc, S. (2009). *Process systems analysis and control* (3rd ed.). McGraw-Hill.
2. Eckman, D. P. (1985). *Industrial Instrumentation*. Wiley.
3. Shuler, M. L., Kargi, F., & DeLisa, M. (2017). *Bioprocess engineering: Basic concepts* (3rd ed.). Pearson.
4. Bailey, J. E., & Ollis, D. F. (2006). *Biochemical engineering fundamentals* (2nd ed.). McGraw-Hill.
5. Ghosh, T. (2004). *Biotechnology and bioprocess engineering: Proceedings, VII International biotechnology symposium*. Delhi.
6. Stephanopoulos, G. (2015). *Chemical process control*. Pearson India



<b>BT3311</b>	<b>BIOINFORMATICS</b>	<b>PCC</b>	<b>3–0–0</b>	<b>3 Credits</b>
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Prerequisites:

- i. BT2011 Biochemistry
- ii. BT2081 Molecular Biology & Genetics

### Course Outcomes:

At the end of the course the student will be able to:

<b>CO1</b>	Understand the biological sequences, algorithms for sequence alignments, and phylogenetic analysis.
<b>CO2</b>	Understand the types of biological databases available in the open-sourcedomain.
<b>CO3</b>	Perform the homology search and sequence evolution identification.
<b>CO4</b>	Understand the principles of protein structure and drug discovery.

### Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
<b>CO1</b>	3	-	-	1	3	-	-	2	-	-	-	-	3	1	2
<b>CO2</b>	3	-	-	1	3	-	-	2	-	-	-	-	3	1	-
<b>CO3</b>	3	-	-	1	3	-	-	2	-	-	-	-	3	1	2
<b>CO4</b>	3	-	-	2	3	-	-	2	-	-	-	-	3	-	-

1 - Slightly; 2 - Moderately; 3 – Substantially

### Syllabus:

#### Unit I

Introduction and Overview of Bioinformatics, Collecting and Storing Sequences in the Laboratory, Alignment of Pairs of Sequences, Introduction to Probability and Statistical Analysis of Sequence Alignments, Multiple Sequence Alignment, Sequence Database Searching for Similar Sequences.

Biological databases, Classification, database searching, Sequence Alignment: Pairwise and Multiple sequence Alignment, Sequence homology search.

#### Unit II

Phylogenetic trees, Phylogenetic Prediction, Prediction of RNA Secondary Structure, Gene Prediction and Regulation. Genome Analysis, Genome organization and evolution,

#### Unit III

Protein Classification and Structure Prediction, Structural bioinformatics in drug discovery, Molecular Docking- Rigid docking, flexible docking, manual Docking, docking based Screening, De novo Drug design, Virtual Screening Techniques-Drug likeness screening, Concept of Pharmacore mapping and pharmacophore-based Screening. Bioinformatics Programming Using Perl and Perl Modules

#### Unit IV



Introduction to Systems Biology, Computational Bioengineering, Introduction, Strategies in Bioengineering, Synthetic Biology, Design of Synthetic Systems, and Metabolic pathways

**Text books:**

1. Mount, D. W. (2004). *Bioinformatics: Sequence and genome analysis* (2nd ed.); CSHL Press.
2. Lesk, A. M. (2014). *Introduction to bioinformatics* (4th ed.) Oxford University Press.
3. Baxevanis, A. D. (2004). *Bioinformatics: A practical guide to the analysis of genes and proteins* (3rd ed.). Wiley-Interscience.
4. Leach, A. (2001). *Molecular modelling: Principles and applications* (2nd ed.). Prentice Hall.
5. Whitford, D. (2005). *Proteins: Structure and function* (1st ed.). Wiley.
6. Basant K. Tiwary (2022). *Bioinformatics and Computational Biology*. (1<sup>st</sup> ed.) Springer