

NATIONAL INSTITUTE OF TECHNOLOGY WARANGAL



B.Tech. in

BIOTECHNOLOGY

SCHEME OF INSTRUCTION AND SYLLABI

(Effective from 2021-22)

DEPARTMENT OF BIOTECHNOLOGY



Vision and Mission of the Institute
National Institute of Technology Warangal

VISION

Towards a Global Knowledge Hub, striving continuously in pursuit of excellence in Education, Research, Entrepreneurship and Technological services to the society

MISSION

- Imparting total quality education to develop innovative, entrepreneurial and ethical future professionals fit for globally competitive environment.
- Allowing stake holders to share our reservoir of experience in education and knowledge for mutual enrichment in the field of technical education.
- Fostering product-oriented research for establishing a self-sustaining and wealth creating centre to serve the societal needs.

Vision and Mission of the Department
Department of Biotechnology

VISION

To become a global centre of excellence for quality education, research, technological services and entrepreneurship in emerging areas of biotechnology.

MISSION

- Providing quality education in pursuit of knowledge that establishes a strong foundation for understanding the developments in the rapidly advancing field of biotechnology through research and instruction.
- Promoting scientific discovery and development in diversified fields of biotechnology through a fusion between engineering and life sciences.
- Fostering relationships with institutes of higher learning and research, alumni and industries.



Department of Biotechnology:

Brief about the Department:

The Department of Biotechnology was established in the year 2006 with B. Tech program in Biotechnology with an intake of 60 candidates. The Department also offers an M. Tech program and PhD program in Biotechnology. At present, there are 20 highly motivated and experienced faculty members in the Department carrying out academic and research in key areas of Biotechnology including Bioenergy and Environment, Cellular and Omics Research, Bioinformatics and Computational Biology.

The Department has state of the art and dedicated undergraduate, postgraduate and research laboratories with an assortment of sophisticated equipment. The faculty in the Department have completed several externally funded research projects and at present many research projects are ongoing funded by DBT/DST/CSIR, Govt. of India. The Department has collaboration with premier research institutes in India to transform research outcomes into integrated commercial technologies.

List of Programs offered by the Department:

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

Note: Refer to the following weblink for Rules and Regulations of B.Tech. program:
https://www.nitw.ac.in/media/uploads/2021/08/27/btech_rules-and-regulations-2021-22.pdf



B. Tech. – Biotechnology
Program Educational Objectives

PEO-1	Apply academic knowledge and professional investigational skills in basic mathematics, life sciences, computational and other courses to find solutions for societal problems overlapping the biotechnology domain.
PEO-2	Implement biotechnology projects to enhance the standards of the society and environment.
PEO-3	Investigate the concerns related to food, energy, environment, biosafety and bioethics.
PEO-4	Exhibit exemplary soft skills, managerial and leadership skills.
PEO-5	Continue lifelong learning in the biotechnology domain for individual growth and also for the betterment of the society.

Program Articulation Matrix

PEO	PEO1	PEO2	PEO3	PEO4	PEO-5
Mission Statements					
1	3	2	2	2	3
2	3	3	2	2	3
3	2	3	2	3	3

1-Slightly; 2-Moderately; 3-Substantially

**B. Tech. – Biotechnology****Program Outcomes**

PO-1	Engineering knowledge: Apply the knowledge of mathematics, science, and engineering fundamentals, and biotechnology to the solution of complex engineering problems
PO-2	Problem analysis: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences
PO-3	Design/Development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations
PO-4	Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions
PO-5	Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex biotechnology activities with an understanding of the limitations
PO-6	The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice
PO-7	Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development
PO-8	Ethics: Apply ethical principles and commit to professional ethics, responsibilities, and norms of the engineering practice.
PO-9	Individual and teamwork: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO-10	Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO-11	Project management and Finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments
PO-12	Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.



Program Specific Outcomes

PSO-1	Design solutions for real world biotechnological problems and analyze their complexities.
PSO-2	Develop interfaces among subsystems of biotechnology.
PSO-3	Analyze large biological data samples to solve biotechnological problems

**SCHEME OF INSTRUCTION****B. Tech. Biotechnology – Course Structure****I - Year, I – Semester**

S. No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1	MA134	Matrix Theory, Calculus and Ordinary Differential Equations	3	0	0	3	BSC
2	CY131	Chemistry	3	0	2	4	BSC
3	EC131	Basic Electronics Engineering	3	0	0	3	ESC
4	ME131	Basic Mechanical Engineering	3	0	0	3	ESC
5	ME134	Workshop Practice	0	1	2	2	ESC
6	HS132	English for Technical Communication	2	0	2	3	HSC
7	IC001	Induction Program (MNC 1) *	0	0	0	0	MNC
8	IC101	EAA (MNC 2) *	0	0	2	0	MNC
Total			14	1	8	18	

I - Year, II – Semester

S. No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1	MA184	Integral Calculus and Laplace Transforms	3	0	0	3	BSC
2	PH186	Engineering Physics	3	0	2	4	BSC
3	CS181	Problem Solving and Computer Programming	3	0	2	4	ESC
4	EE131	Basic Electrical Engineering	3	0	0	3	ESC
5	ME132	Engineering Graphics	1	0	4	3	ESC
6	BT151	Bioprocess Calculations	3	0	0	3	PCC
7	IC151	EAA (MNC 3) *	0	0	2	0	MNC
Total			16	1	10	20	

* MNC weblink: https://www.nitw.ac.in/media/uploads/2021/10/22/mnc_1st-year.pdf

Note: BSC – Basic Science Courses
ESC –Engineering Science Courses
PCC – Professional Core Courses
PEC – Professional Elective Courses
OEC – Open Elective Courses
HSC – Humanities and Social Science Courses
MNC – Mandatory Non-credit Courses

**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	MA235	Transforms, Complex Variables and Partial Differential Equations	3	0	0	3	BSC
2	BT201	Biochemical Thermodynamics	3	0	0	3	PCC
3	BT202	Microbiology	3	0	0	3	PCC
4	BT203	Biochemistry	3	0	0	3	PCC
5	BT204	Biocomputing	3	0	2	4	PCC
6		Elective – 1	3	0	0	3	PEC
7	CY231	Academic Laboratory Safety Practices	1	0	0	1	BSC
8	BT205	Microbiology and Biochemistry Laboratory	0	0	4	2	PCC
Total			19	0	6	22	

II - Year, II – Semester

S. No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1	MA288	Numerical Methods and Series Solutions	3	0	0	3	BSC
2	BT251	Transport Phenomena in Bioprocess Systems	3	0	2	4	PCC
3	BT252	Enzyme Technology	3	0	0	3	PCC
4	BT253	Cell Biology	3	0	0	3	PCC
5	BT254	Molecular Biology	3	0	0	3	PCC
6	BT255	Bioinformatics	3	0	0	3	PCC
7		Elective – 2	3	0	0	3	PEC
8	BT256	Cell Biology and Molecular Biology Laboratory	0	0	4	2	PCC
9	IC251	MNC 4 *	0	0	0	0	MNC
Total			21	0	6	24	

* MNC weblink: https://www.nitw.ac.in/media/uploads/2021/10/22/mnc_2nd-year.pdf

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**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	BT301	Bioprocess Engineering	3	0	2	4	PCC
2	BT302	Biological Reaction Engineering	3	0	0	3	PCC
3	BT303	Genetic Engineering	3	0	0	3	PCC
4	BT304	Immunology	3	0	0	3	PCC
5	BT305	Structural Biology	3	0	0	3	PCC
6		Elective – 3	3	0	0	3	PEC
7	BT306	Genetic Engineering and Immunology Laboratory	0	0	4	2	PCC
8	SM338	Engineering Economics and Accountancy	3	0	0	3	HSC
Total			21	0	6	24	

III - Year, II – Semester

S. No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1	BT351	Bioseparations Technology	3	0	2	4	PCC
2	BT352	Animal and Plant Biotechnology	3	0	0	3	PCC
3	BT353	Biostatistics	3	0	0	3	PCC
4	BT354	Analytical Biotechnology	2	0	2	3	PCC
5	BT355	Systems Biology	3	0	0	3	PCC
6		Elective – 4	3	0	0	3	PEC
7		Open Elective – I #	3	0	0	3	OEC
8	IC351	MNC 5 *	0	0	0	0	MNC
Total			19	0	6	22	

* MNC weblink: https://www.nitw.ac.in/media/uploads/2021/10/22/mnc_3rd-year.pdf

OEC weblink: https://www.nitw.ac.in/media/uploads/2021/10/22/open-elective-1_vi-sem.pdf

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OEC – Open Elective Courses
HSC – Humanities and Social Science Courses
MNC – Mandatory Non-credit Courses

**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	CH431	Bioprocess Engineering Economics	3	0	0	3	ESC
2	BT401	Modelling Simulation and Optimization of Bioprocesses	2	0	2	3	PCC
3	BT402	Bioprocess Instrumentation and Control	3	0	2	4	PCC
4	BT403	Computational Methods in Drug Discovery	3	0	2	4	PCC
5		Open Elective – II #	3	0	0	3	OEC
6	BT449	Summer Internship / EPICS	-	-	-	2	PCC
Total			14	0	6	19	

IV - Year, II – Semester

S. No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1		Elective – 5	3	0	0	3	PEC
2		Elective – 6	3	0	0	3	PEC
3	BT498	Seminar	1	0	0	1	SEM
4	BT499	Project Work @	0	0	8	4	PW
Total			7	0	6	11	

OEC weblink: https://www.nitw.ac.in/media/uploads/2021/10/22/open-elective-2_vii-sem.pdf

@ **NOTE: Refer to the following link for the guidelines to prepare dissertation report:**
https://www.nitw.ac.in/media/uploads/2021/08/27/ug_project-report-format_55vW5pL.pdf

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PEC – Professional Elective Courses
OEC – Open Elective Courses
HSC – Humanities and Social Science Courses
MNC – Mandatory Non-credit Courses

Note: Students can complete the Summer Internship / EPICS during any summer however, the grades will be reflected only in the IV year I semester grade sheet.



Credits in Each Semester									
Cat. Code	Sem-I	Sem-II	Sem-III	Sem-IV	Sem-V	Sem-VI	Sem-VII	Sem-VIII	Total
BSC	7	7	4	3	0	0	0	0	21
ESC	8	10	0	0	0	0	3	0	21
PCC	0	3	15	18	18	16	13	0	83
PEC	0	0	3	3	3	3	0	6	18
OEC	0	0	0	0	0	3	3	0	6
HSC	3	0	0	0	3	0	0	0	6
MNC	YES	YES	YES	YES	YES	YES	0	0	0
Project	0	0	0	0	0	0	0	4	4
Seminar	0	0	0	0	0	0	0	1	1
Total	18	20	22	24	24	22	19	11	160

Program Elective Courses

Elective-1 (II Year, I Semester)		
S. No.	Course Code	Course
1	BT211	Process Engineering Principles
2	BT212	Biodiversity and Conservation
3	BT213	Data Structures and Algorithms
Elective-2 (II Year, II Semester)		
S. No.	Course Code	Course
1	BT261	Unit Operations
2	BT262	Genetics
3	BT263	Biophysics
Elective-3 (III Year, I Semester)		
S. No.	Course Code	Course
1	BT311	Biocatalysis and Biotransformations
2	BT312	Food Biotechnology
3	BT313	Cancer Biology
Elective-4 (III Year, II Semester)		
S. No.	Course Code	Course
1	BT361	Biopolymer Technology
2	BT362	Cultivation of Mushroom and Biofertilizer Production
3	BT363	Advanced Bioinformatics
Elective-5 and 6 (IV Year, II Semester)		
S. No.	Course Code	Course
1	BT461	Biofuels Engineering
2	BT462	Neurobiology
3	BT463	Genomic Data Analysis
4	BT464	Principles of Biosafety, Bioethics & Intellectual Property Rights
5	BT5162	Pharmaceutical Biotechnology
6	BT5165	Machine Learning
7	BT5169	Advanced Biomaterials Engineering
8	BT5170	Medical Biotechnology



9	BT5171	Nanotechnology for Medicine and Healthcare
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DETAILED SYLLABUS

B. Tech. – Biotechnology



Course Code MA134	MATRIX THEORY, CALCULUS AND ORDINARY DIFFERENTIAL EQUATIONS	Credits 3-0-0: 3
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Pre-Requisites: None

Course Outcomes:

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

CO1	Solve the consistent system of linear equations
CO2	Apply orthogonal and congruent transformations to a quadratic form
CO3	Find the maxima and minima of multivariable functions
CO4	Solve arbitrary order linear differential equations with constant coefficients
CO5	Apply the concepts in solving physical problems arising in engineering

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

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 and congruent transformation; properties of complex matrices - Hermitian, skew-Hermitian and unitary matrices

Differential Calculus: Taylor's theorem with remainders; Taylor's and Maclaurin's expansions; asymptotes; curvature; curve tracing; functions of several variables - 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

Ordinary Differential Equations: Geometric interpretation of solutions of first order ODE $y' = f(x, y)$; exact differential equations; integrating factors; orthogonal trajectories; 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...

Learning Resources:

Text Books:

- Advanced Engineering Mathematics, R. K. Jain and S. R. K. Iyengar, Narosa Publishing House, 2016, 5th Edition.



2. Advanced Engineering Mathematics, Erwin Kreyszig, John Wiley and Sons, 2015, 8thEdition.
3. Calculus and Analytic Geometry, George B. Thomas and Ross L. Finney, Pearson, 2020, 9thEdition.

Reference Books:

1. Advanced Engineering Mathematics, Dennis G. Zill, Jones & Bartlett Learning, 2018, 6thEdition.
2. Higher Engineering Mathematics, B. S. Grewal, Khanna Publishers, 2012, 42ndEdition.



Course Code: CY131	CHEMISTRY	Credits 3-0-0: 3
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Pre-Requisites: None

Course Outcomes:

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

CO1	Understand the basic concept of chemistry involved in the biomolecules, physical chemistry, spectroscopic techniques and analytical methods for biomolecules analysis.
CO2	Utilize the spectroscopic methods in characterizing the biomolecules
CO3	Develop analytical methods for qualitative and quantitative analysis of biomolecules
CO4	Design biomimetic or biological important materials based on the concepts of biodegradable polymers and nano-materials.
CO5	Select a suitable methodology for the estimation of metal content, iodine content, active chlorine or hardness of water
CO6	Analyze acids, bases, redox compounds, etc. using instrumental methods

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Thermo chemistry: Heat of reaction, types of heats of reaction, Kirchhoff's equation, laws of thermo chemistry, bond energy and bond enthalpy.

Nano materials and Biological Applications: Introduction, classification, properties, introduction, nanotechnology applications, material self-assembly, molecular vs material self-assembly, synthesis - top down and bottom up, synthesis, properties & potential applications of carbon nanotubes, fullerenes and graphene, nano-catalysis.

Spectroscopic Methods of Analysis: UV-Vis absorption spectroscopy, Infrared spectroscopy, NMR spectroscopy.

Polymer Chemistry: Polymers introduction, classification, polymerization types, mechanism of addition polymerization, preparation and properties.

Chemistry of Biology: Elements in biology, oxygen transport and storage-myoglobin, hemoglobin Bohr's effect, chemistry of elements in medicine, chelation therapy, cancer treatment, anti-arthritis drugs, contributions of individual elements to biological systems. biomimetic chemistry: weak interactions in chemistry and biology, proximity effect in organic chemistry and molecular recognition, chemistry of the living cells, analogy between biochemical and organic reaction. chemistry of biomolecules: amino acids – structure,



properties, classes, stereochemistry, peptide bond synthesis, peptide secondary structures, chemistry of enzymes: catalytic triad, enzyme inhibition and drug design, enzyme in organic chemistry, antibody catalyzed organic reactions, chemistry of nucleic acids: history of sugars, bases, and nucleic acids, hydrogen bonded base pairs and double helix, DNA intercalators.

Bioanalytical Methods: Fluorescence, chemiluminescence, bioluminescence, basics of thin layer chromatography, column chromatography, gas chromatography (GC) and HPLC, electrophoresis.

Laboratory: Any of the twelve experiments will be performed from the given list:

1. Introduction: standardization procedure. understanding the redox process, electron transfer, importance of qualitative and quantitative analysis
2. Estimation of Hematite: understanding the importance on purity of ore, % of metal content (for Fe)
3. Hardness of water: understanding the of metal complexes, multi dentate ligands importance of purity of ground water, (EDTA method; complexometry)
4. Preparation of nanomaterials: understanding the importance of nanomaterials, their preparation and characterization using FT-IR
5. pHmetry: concept of pH, instrumentation, calibration, determination of the concentrations by instrumental methods
6. Conductometry: concept of conductivity, importance of conductivity
7. Potentiometry: determination of the redox potential of the reaction
8. Colorimetry: analysis of phosphate from soft drinks using volumetry/colorimetry importance of Beers and Lamberts law
9. Photochemical experiment: chemistry of blue print, importance of visible light and its application for a redox process, importance of coloring agent
10. Preparation of bakelite / polypyrrole: concepts of organic reactions and application for organic material preparation
11. Corrosion experiment: concept of corrosion, importance of corrosion agents
12. Adsorption experiment: understanding phenomena of adsorption and absorption
13. Analysis of a drug: importance of the purity, concentrations of a drug molecule
14. Preparation of red azo-dye/Aspirin/Fe(acac). concepts of organic reactions and application
15. Glucose estimation by volumetric titration
16. Separation of compounds using TLC/Chromatography technique
17. Ion-exchange chromatography with example
18. Separation of leaf pigments by paper chromatography

Learning Resources:

Text Books:

1. Engineering Chemistry, Shashi Chawla, Dhanpat Rai & Co. 2017.
2. Organic Spectroscopy, William Kemp, Macmillan Education, Limited, 2017.
3. Lehninger Principles of Biochemistry, David L. Nelson, Michael M. Cox, W. H. Freeman, 2006, 9th Edition.
4. Introductory Chemistry laboratory manual: Concepts and Critical Thinking, Charles Corwin, Pearson Education, 2012.
5. Investigating Chemistry: Laboratory Manual, David Collins, Freeman & Co., 2006.



Reference Books:

1. P. Atkins and Julio de Paula, Physical Chemistry, Freeman & Co. 8thEdition, 2017.
2. Atkins and Shriver, Inorganic Chemistry, Oxford University Press, 4thEdition, 2008
3. Clayden, Greaves, Warren and Wothers, Organic Chemistry, Oxford University Press, 2014.
4. Physical Chemistry, Peter Atkins, Julio de Paula, James Keeler, Oxford University Press, 2018.
5. Paula Bruce, Organic Chemistry, Pearson Education, 2013, 8thEdition,



Course Code: EC131	BASIC ELECTRONIC ENGINEERING	Credits 3-0-0: 3
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Pre-Requisites: None

Course Outcomes:

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

CO1	Comprehend the characteristics of semiconductor devices, and operational amplifiers
CO2	Understand the principles of working of amplifiers
CO3	Understand and design of simple combinational and basics of sequential logic circuits
CO4	Understand the principles of electronic measuring instruments and transducers
CO5	Understand the basic principles of electronic communication

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Electronics Systems: Introduction to electronics, review of p-n junction operation, diode applications, Zener diode as regulator.

Transistor and Applications: Introduction to transistors, BJT Characteristics, biasing and applications, simple RC coupled amplifier and frequency response. FET and MOSFET characteristics and applications.

Feedback in Electronic Systems: Open loop and closed loop systems, negative and positive feedback, merits and demerits, principles of LC and RC oscillators.

Integrated Circuits: Operational amplifiers – characteristics and linear applications

Digital Circuits: Number systems and logic gates, combinational logic circuits, flip-flops, counters and shift registers, data converters, analog to digital and digital to analog converters (ADC/DAC's), introduction to microprocessors and microcontrollers.

Laboratory Measuring Instruments: Principles of digital multi-meters, cathode ray oscilloscopes (CRO's).

Electronics Instrumentation: Measurement, Sensors, principles of LVDT, strain gauge and thermocouples, introduction to data acquisition system.

Principles of Communication: Need for modulation, definitions of various modulation and



demodulation techniques, AM radio transmitter and receiver, brief understanding of FM and mobile communications.

Learning Resources:

Text Books:

1. Basic Electronics & Linear Circuits, Bhargava N N, Kulshreshtha D C, Gupta S C, Tata McGraw Hill, 2013, 2ndEdition.
2. Digital Computer Electronics, Albert Malvino, Jerald Brown, McGraw-Hill Education, 1992, 3rdEdition.
3. Electronic Communication Systems, George Kennedy, Bernard Davis, Tata McGraw Hill, reprint 2009, 4thEdition.
4. Modern Electronic Instrumentation and Measurement Techniques, Albert D. Helfrick, William D. Cooper, Prentice Hall India, 2011.

Reference Books:

1. Electronic Devices and circuits, Salivahanan S, Suresh Kumar N, McGraw Hill Education, 2017, 4thEdition.
2. Electronics: A Systems Approach, Neil Storey, Prentice Hall, 2009, 4thEdition.



Course Code: ME131	BASIC MECHANICAL ENGINEERING	Credits 3-0-0:3
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Pre-Requisites: None

Course Outcomes:

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

CO1	Identify materials for engineering applications
CO2	Describe the functions and operations of conventional, NC, CNC and 3D printing methods of manufacturing.
CO3	Select a power transmission system for a given application.
CO4	Understand the concepts of thermodynamics and functions of components of a power plant.
CO5	Understand basics of heat transfer, refrigeration, internal combustion engines and automobile engineering.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Engineering Materials: Introduction to engineering materials, classification and properties. manufacturing processes: castings - patterns & molding, hot working and cold working.

Metal Forming Processes: Extrusion, drawing, rolling, forging, welding - arc welding & gas welding, soldering, brazing.

Machine Tools: Lathe - types - operations, problems on machining time calculations, drilling M/c - types - operations, milling M/c - types - operations - up & down milling, shaping M/c - operations- quick return mechanism, planer M/c.- operations-shaper Vs planer, grinding M/c- operations. introduction to NC/CNC machines, 3D printing

Power Transmission: Transmission of power, belt drives, gears and gear trains -simple problems.

Fasteners and Bearings: Fasteners - types and applications, bearings - types and selection thermodynamics: energy sources - conventional/renewable, Thermodynamics - system, state, properties, thermodynamic equilibrium, process & cycle, zeroth law of thermodynamics, work & heat, first law - cyclic process, change of State, Cp, Cv, limitations of first law, thermal reservoirs, heat engine, heat pump/refrigerator, efficiency/COP, second law, PMM2, Carnot cycle, entropy - T-S and P-V diagrams.

Thermal Power Plant: Layout of thermal power plant & four circuits - Rankine cycle, T-S & P-V diagrams, boilers - Babcock & Wilcox, Cochran boilers, comparison of fire tube & water tube



boilers, steam turbines - impulse Vs. reaction, compounding - pressure & velocity compounding, condensers - jet condenser and surface condenser; cooling towers.

I.C. Engines: 2-Stroke & 4-Stroke engines, P-v diagram; S.I. engine, C.I. engine, differences

Refrigeration: Vapor compression refrigeration cycle - refrigerants, desirable properties of refrigerants

Heat Transfer: Modes of heat transfer, thermal resistance concept, composite walls & cylinders, and overall heat transfer coefficient - problems

Automobile Engineering: Layout of an automobile, transmission, clutch, differential, internal expanding shoe brake

Learning Resources:

Text Books:

1. Elements of Mechanical Engineering, M.L. Mathur, F.S. Mehta and R.P. Tiwari, R.S. Vaishwnar, Jain Brothers, New Delhi, 2008.
2. Basic Mechanical Engineering, Praveen Kumar, Pearson Education, India, 2013.

Reference Books:

1. Engineering Heat Transfer-Gupta & Prakash, New Chand Bros. New Delhi, 2010.
2. Workshop Technology (vol. 1 & 2)-BSRaghuvanshi, Dhanpath Rai & Sons, New Delhi.
3. Manufacturing Technology Volume I: Foundry, Forming and Welding, P.N. Rao, TMH 2019, 5th Edition.



Course Code: ME134	WORKSHOP PRACTICE	Credits 0-1-2: 2
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Pre-Requisites: None

Course Outcomes:

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

CO1	Identify the hand tools and instruments to perform corresponding trades
CO2	Practice on manufacturing of components using workshop trades including fitting, sheet metal, carpentry, foundry and welding
CO3	Identify and apply suitable tools for machining processes including facing, turning, taper turning, grooving, chamfering, thread cutting, knurling and tapping.
CO4	Apply basic electrical engineering knowledge for house wiring practice

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Demonstration of safety practices and precautions to be observed in workshop.

Fitting Trade: Demonstration and practice of fitting tools, preparation of T-shape, dovetail joint, disassembling and reassembling of tail stock, bench vice etc.

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 same diameter and with reducer for different diameters.

Machine shop: Demonstration and practice on lathe machine, preparation of work pieces involving facing, plane turning, step turning, groove cutting, chamfering, taper turning, knurling and parting operations.

House Wiring: Demonstration and practice on electrical tools, wiring and earthing, exercises on staircase wiring & go down wiring.

Power Tools: Demonstration and practice on power tools and safety practices.

Foundry Trade: Demonstration and practice on molding tools and processes, preparation of green sand molds for solid and split patterns, demonstration of sweep molding process.

Welding Shop: Demonstration and practice on arc welding and gas welding, preparation of lap joint and butt joint.

Sheet metal: Demonstration of and practice on sheet metal tools, practice on preparing required shapes from a sheet using appropriate tools.

Learning Resources:

Text Books:



1. Basic Workshop Technology: Manufacturing Process, Felix W.; Independently Published, 2019.
2. Workshop Processes, Practices and Materials; Bruce J. Black, Routledge publishers, 2015.5th Edition.
3. Engineering Practices Laboratory Manual, Ramesh Babu.V., VRB Publishers Private Limited, Chennai, 2014, revised Edition.
4. Wiring Estimating, Costing and Contracting; Soni P.M. & Upadhyay P.A.; AtulPrakashan, 2021, 1st Edition.

Reference Books:

1. A Course in Workshop Technology Vol I. & II, B.S. Raghuwanshi, Dhanpath Rai & Co., 2015.
2. Elements of Workshop Technology, Vol. I & Vol. II by S. K. Hajra Choudhury & Others, Media Promoters and Publishers, Mumbai. 2007, 14th Edition
3. Engineering Practices Lab Manual; T.Jeyapoovan, Vikas Pub, 2008, 4th Edition.

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>).



Course Code: HS132	ENGLISH FOR TECHNICAL COMMUNICATION	Credits: 2-0-2: 3
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Pre-Requisites: None

Course Outcomes:

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

CO1	Understand basic grammar principles
CO2	Write clear and coherent passages
CO3	Write effective letters for job application and complaints
CO4	Prepare technical reports and interpret graphs
CO5	Enhance reading comprehension
CO6	Comprehend speech sounds, stress and intonation

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Grammar Principles: (Correction of sentences, concord) and vocabulary building (synonyms and antonyms) idioms and phrasal verbs - patterns of use and suggestions for effective employment in varied contexts, effective sentence construction - strategies for bringing variety and clarity in sentences- removing ambiguity - editing long sentences for brevity and clarity.

Reported Speech:- Contexts for use of reported speech - its impact on audiences and readers- active and passive voice- reasons for preference for passive voice in scientific English, paragraph writing: definition of paragraph and types- features of a good paragraph - unity of theme- coherence- linking devices- direction- patterns of development, note-making - definition- the need for note-making - its benefits - various note formats- like tree diagram, block or list notes, tables, etc...

Letter-Writing: Its importance in the context of other channels of communication- qualities of effective letters-types -personal, official, letters for various purposes- emphasis on letter of application for jobs - cover letter and resume types -examples and exercises, reading techniques: definition- skills and sub-skills of reading- skimming and scanning - their uses and purposes- examples and exercises.

Reading Comprehension: - reading silently and with understanding- process of comprehension- types of comprehension questions, features of technical English - description of technical objects and process, report-writing- definition- purpose -types- structure- formal and informal reports- stages in developing report- proposal, progress and final reports- examples and exercises, book reviews- oral and written review of a chosen novel/play/movie-



focus on appropriate vocabulary and structure - language items like special vocabulary and idioms used.

Language Laboratory- English sound system -vowels, consonants, diphthongs, phonetic symbols- using dictionary to decode phonetic transcription-- received pronunciation, its value and relevance- transcription of exercises.

Stress and Intonation: –Word and sentence stress - their role and importance in spoken English, intonation in spoken English -definition, patterns of intonation- –falling, rising, etc.- use of intonation in daily life-exercises, introducing oneself in formal and social contexts- role plays- their uses in developing fluency and communication in general, oral presentation - definition- occasions- structure- qualities of a good presentation with emphasis on body language and use of visual aids, listening comprehension -challenges in listening, good listening traits, some standard listening tests- practice and exercises, debate/ group discussions-concepts, types, do's and don'ts- intensive practice.

Learning Resources:

Text Books:

1. English for Engineers and Technologists (Combined Edition Vol.1&2) Orient Black Swan, 2010, 2nd Edition.
2. Effective Technical Communication, Ashraf M. Rizvi, Tata McGraw-Hill, 2006, 1st Edition.

Reference Books:

1. Technical Communication: Principles and Practice, Meenakshi Raman & Sangeetha Sharma, Oxford University Press, 2011, 2nd Edition.

Software:

1. Clear Pronunciation – Part-1 Learn to Speak English
2. Clear Pronunciation – Part-2 Speak Clearly with Confidence
3. Study Skills
4. English Pronunciation



Course Code: MA184	INTEGRAL CALCULUS AND LAPLACE TRANSFORMS	Credits: 3-0-0: 3
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Pre-Requisites: MA134

Course Outcomes:

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

CO1	Analyze improper integrals
CO2	Evaluate multiple integrals in various coordinate systems
CO3	Apply the concepts of gradient, divergence and curl to formulate engineering problems
CO4	Convert line integrals into surface integrals and surface integrals into volume integrals
CO5	Apply Laplace transforms to solve physical problems arising in engineering

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

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.

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; Stoke's theorem; Gauss Divergence theorem.

Laplace Transforms: Laplace transforms; inverse Laplace transforms; properties of Laplace transforms; Laplace transforms of unit step function, impulse function, periodic function; convolution theorem; applications of Laplace transforms - 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.

Learning Resources:

Text Books:

1. Advanced Engineering Mathematics, R. K. Jain and S. R. K. Iyengar, Narosa Publishing House, 2016, 5th Edition
2. Advanced Engineering Mathematics, Erwin Kreyszig, John Wiley and Sons, 2015, 8th Edition



3. Calculus and Analytic Geometry, George B. Thomas and Ross L. Finney, Pearson, 2020, 9thEdition

Reference Books:

1. Advanced Engineering Mathematics, Dennis G. Zill, Jones & Bartlett Learning, 2018, 6thEdition
2. Higher Engineering Mathematics, B. S. Grewal, Khanna Publishers, 2012, 42ndEdition.



Course Code: PH186	ENGINEERING PHYSICS	Credits: 3-0-2:4
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Pre-Requisites: None

Course Outcomes:

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

CO1	Apply the concept of wave and particle duality of radiant energy in solving problems.
CO2	Understand the applications of lasers in electrical engineering.
CO3	Understand the utility of different materials for engineering applications.
CO4	Apply the concepts of interference, diffraction, and polarization in engineering measurements and determine acceptance angle and numerical aperture of an optical fiber
CO5	Make use of lasers and optical instruments for experimentation.
CO6	Demonstrate quantum nature of radiation using photoelectric effect.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Quantum Mechanics: Concepts and experiments that led to the discovery of quantum nature, Heisenberg uncertainty principle; Schrodinger time independent and time dependent wave equations, the free particle problem - particle in an infinite and finite potential well, quantum mechanical tunneling. MB, BE and FD distributions.

Wave and Quantum Optics: Interference and Diffraction: Concept of interference and working of Fabry-Perot interferometer and its application as wavelength filter, multiple beam diffraction and working of diffraction, gratings, application of grating as wavelength splitter.

Polarization Devices: Principles, working and applications of wave plates, half shade polarimeter, polariscope, isolators and liquid crystal displays.

Lasers: Basic theory of laser, concept of population inversion and construction and working of He-Ne, Nd-YAG, CO₂ lasers, LED, white light LED, semiconductor laser, holography and NDT.

Optical Fibers: Structure, types, features, light guiding mechanism and applications in communications and sensing.



Solar Cells: Solar spectrum, photovoltaic effect, materials, structure and working principle, I-V characteristics, power conversion efficiency, quantum efficiency, emerging PV technologies, applications.

Magnetic and Dielectric Materials: Magnetic materials and superconductors: Introduction - Weiss theory of ferromagnetism, properties, domains, Curie transition, hard and soft magnetic materials, spinel ferrites, structure, classification, applications, Meissner effect, type-I and type-II superconductors, applications.

Dielectric Materials: Introduction to dielectrics, dielectric constant, polarizability, properties and types of insulating materials, polarization mechanisms in dielectrics(qualitative), frequency and temperature dependence of polarization, dielectric loss Clausius-Mossotti Equation(qualitative)dielectric breakdown, applications.

Functional and Nano Materials: Functional materials: fiber reinforced plastics, fiber reinforced metals, surface acoustic wave materials, bio-materials, high temperature materials and smart materials properties and applications.

Nanomaterials: Introduction, classification, properties, different methods of preparation and applications.

Laboratory:

1. Determination of wavelength of sodium light using Newton's rings.
2. Determination of wavelength of He-Ne laser – metal scale.
3. Measurement of width of a narrow slit using He- Ne laser.
4. Determination of specific rotation of cane sugar by Laurent half-shade polarimeter.
5. Determination of capacitance by using R-C circuit.
6. Determination of resonating frequency and bandwidth by LCR circuit.
7. Measurement of half-life of radioactive source using GM Counter.
8. Diffraction grating by normal incidence method.
9. Measurement of numerical aperture of optical fiber.

Learning Resources:

Text Books:

1. Fundamentals of Physics by Halliday, Resnic and Walker, John Wiley, 2011, 9th Edition.
2. Concepts of Modern Physics, Arthur Beiser, Shobhit Mahajan, S. Rai Choudhury, McGraw Hill Publications, 2009, 6th Edition,
3. Physics Laboratory Manual by Physics Department, NIT Warangal, 2021.

Reference Books:

1. Optics, Ajoy K Ghatak, Tata McGraw Hill, 2017, 6th Edition.
2. Solid State Physics, S O Pillai, New Age Publishers, 2018, 8th Edition.
3. Understanding Lasers An Entry-Level Guide, by Jeff Hecht, Wiley Publications, 2018, 4th Edition.
4. Practical Physics by G.L. Squire, Cambridge University press, 2001, 4th Edition.
5. Engineering Physics Practical, S.K. Gupta, Krishna Prakashan Publications, 2010, 9th Edition.

Online Resources:



1. <https://nptel.ac.in/courses/122/107/122107035/>
2. Amrita Virtual labs <https://vlab.amrita.edu/>



Course Code: CS181	PROBLEM SOLVING AND COMPUTER PROGRAMMING	Credits: 3-0-2: 4
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Pre-Requisites: None

Course Outcomes:

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

CO1	Design algorithms for solving simple mathematical problems including computing, searching and sorting.
CO2	Compare and contrast algorithms in terms of space and time complexity to solve simple mathematical problems.
CO3	Explore the internals of computing systems to suitably develop efficient algorithms.
CO4	Examine the suitability of data types and structures to solve specific problems.
CO5	Apply control structures to develop modular programs to solve mathematical problems.
CO6	Apply object-oriented features in developing programs to solve real world problems.
CO_L1	Design and test programs to solve mathematical and scientific problems.
CO_L2	Develop and test programs using control structures.
CO_L3	Implement modular programs using functions.
CO_L4	Develop programs using classes.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO2	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO3	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO4	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO5	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO6	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO_L1	1	1	-	-	3	-	-	-	-	-	-	1	-	2	2
CO_L2	1	1	-	-	3	-	-	-	-	-	-	1	-	2	2
CO_L3	1	1	-	-	3	-	-	-	-	-	-	1	-	2	2
CO_L4	1	1	-	-	3	-	-	-	-	-	-	1	-	2	2

1 - Slightly; 2 - Moderately; 3 – Substantially

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: Basics of C++, 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.

Laboratory:

1. Programs on conditional control constructs.
2. Programs on loops (while, do-while, for).
3. Programs using user defined functions and library functions.
4. Programs on arrays, matrices (single and multi-dimensional arrays).
5. Programs using pointers (int pointers, char pointers).
6. Programs on structures.
7. Programs on classes and objects.

Learning Resources:

Text Books:

1. Walter Savitch, "Problem Solving with C++", Pearson, 2014, 9th Edition.

Reference Books:

1. Cay Horstmann, Timothy Budd, "Big C++", Wiley, 2009, 2nd Edition.
2. R.G. Dromey, "How to solve it by Computer", Pearson, 2008.



Course Code: EE131	BASIC ELECTRICAL ENGINEERING	Credits: 3-0-0: 3
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Pre-Requisites: None

Course Outcomes:

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

CO1	Analyze electric and magnetic circuits.
CO2	Identify the type of electrical machines for a given application.
CO3	Understand the ratings of electrical apparatus.
CO4	Identify meters for measuring electrical quantities

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

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

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

Magnetic Circuits: Fundamentals and solution of magnetic circuits, concepts of self and mutual inductances, coefficient of coupling.

Single Phase Transformers: Principle of operation, EMF equation, phasor diagram, equivalent circuit, determination of equivalent circuit parameters, calculation of regulation and efficiency.

DC Machines: Principle of operation, classification, EMF and torque equations, characteristics of generators and motors, speed control methods.

AC Machines: 3-Phase induction motor, principle of operation, torque, speed characteristics, slip-ring induction motor, introduction to synchronous machine (qualitative), applications of electrical machines.

Electrical Measuring Instruments: Moving coil and moving iron ammeters, voltmeters, wattmeter, digital multimeter (qualitative).

Electric Heating: Principles of resistance heating, induction heating and dielectric heating. (qualitative).



Learning Resources:

Text Books:

1. Electrical & Electronic Technology, Edward Hughes, Pearson Education, 2016, 12th Edition.
2. Electrical Engineering Fundamentals, Vincent Del Toro, Pearson Education, 2015, 2nd Edition.
3. Electrical Machinery - Theory, Performance & Applications, P.S. Bimbhra, Khanna Publishers 2014, 7th Edition.
4. Basic Electrical Engineering, V N Mittle and Arvind Mittal, Tata McGraw Hill, 2005, 2nd Edition.

Reference Books:

1. Basic Electrical Engineering, U Bakshi & A. Bakshi, Technical Publications, 2019, 1st Edition.
2. Principles of Electrical & Electronics Engineering, V. K Mehtha, S. Chand Publications, New Delhi, 2010, 3rd Edition.
3. Electrical Machines, A Fitzgerald, Charles Kingsley, Stephen Umans, McGraw Hill Education, 2017, 6th Edition.
4. Electric Machinery, Stephen.J.Chapman, McGraw Hill International Edition, 2017, 4th Edition.

Online Resources:

1. <https://nptel.ac.in/courses/108/108/108108076/>



Course Code: ME132	ENGINEERING GRAPHICS	Credits: 0-1-4: 3
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Pre-Requisites: None

Course Outcomes:

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

CO1	Apply BIS standards and conventions while drawing lines, printing letters and showing dimensions.
CO2	Classify the systems of projection with respect to the observer, object and the reference planes.
CO3	Construct orthographic views of an object when its position with respect to the reference planes is defined in CAD environment
CO4	Analyse the internal details of an object through sectional views in CAD environment.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	1	-	1	2	-	-	-	-	-	-	1	-	2	-
CO2	1	1	-	1	2	-	-	-	-	-	-	1	-	2	-
CO3	1	1	-	1	2	-	-	-	-	-	-	1	-	2	-
CO4	11	1	-	1	2	-	-	-	-	-	-	1	-	2	-

11 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:1

Introduction: Drawing instruments and their uses, types of lines, lettering, general rules for dimensioning, geometrical constructions using instruments. (conventional)

Orthographic Projection: Methods of projection, principles of orthographic projection, first angle versus third angle of projection, six views of an object, conventions. (conventional)

Projection of Points: Projections of points when they are situated in different quadrants. (Conventional)

Projections of Lines: Projections of a line parallel to one of the reference planes and inclined to the other, line inclined to both the reference planes, traces. (Conventional)

Fundamentals of AutoCAD: Introduction to Auto-CAD, DRAW tools, MODIFY tools, TEXT, DIMENSION, PROPERTIES (AutoCAD)

Projections of Planes: Projections of a plane perpendicular to one of the reference planes and inclined to the other, oblique planes. (AutoCAD)

Projections of Solids: Projections of solids whose axis is parallel to one of the reference planes and inclined to the other, axis inclined to both the planes. (AutoCAD)

Section of Solids: Sectional planes, Sectional views –prism, pyramid, cylinder and cone, true shape of the section. (AutoCAD)



Learning Resources:

Text Books:

1. Engineering Graphics, N.D. Bhatt and V.M. Panchal, Charotar Publishers, 2016, 53rdEdition.

ReferenceBooks:

1. Engineering Drawing, Agarwal, B, McGraw Hill Education, 2015, 2ndEdition.
2. AutoCAD 2017 for Engineers & Designers,Sham Tickoo, Dreamtech Press, 2017, 23rd Edition.



Course Code: BT151	BIOPROCESS CALCULATIONS	Credits: 3-0-0: 3
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Pre-Requisites: None

Course Outcomes:

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

CO1	Understand the material and energy balances of bioprocesses
CO2	Perform material and energy balances on biochemical processes/equipment without and with reactions
CO3	Perform unsteady state material and energy balances
CO4	Draw the flow diagram and solve the problems involving recycle, purge and bypass in a process or unit
CO5	Calculate balances on reactive processes

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction: Drawing steady-state material balances, general material balance equations; procedure for material balance calculations; material balances involving multiple sub-systems; simplifications for steady state processes without chemical reaction; material balance problems with chemical reactions.

Material Balance for Various Unit Operations: Concept of limiting; excess reactants; fractional conversion; percentage of conversion; percentage yield; excess air calculations; material balances involving simultaneous equations; material balances involving recycle; by-pass; and purge streams; stoichiometry of microbial growth and product formation, recycle by-pass and purge, material balances involving recycle; by-pass; and purge streams, uses of recycle and purge streams, problems involving recycle and purge streams.

Steady-State Energy Balances: General energy balance equations; enthalpy calculation procedures; enthalpy change in non-reactive processes; steam tables; procedure for energy balance calculations without reaction; energy balance worked examples without reaction; enthalpy change due to reaction. Solving simultaneous material and energy balances, heat of reaction for processes with biomass production; energy balance equation for cell culture; fermentation energy balances worked examples.

Unsteady-State Material and Energy Balances: Unsteady-state material and energy balance equations; solving differential equations; unsteady-state mass balances; unsteady-state energy balances; unsteady-state material and energy balances on non-reactive process; heat of mixing and solution; balances on reactive processes; integrated balances.



Learning Resources:

Text Books:

1. Principles and Calculations in Chemical Engineering, David M. Himmelblau, Prentice Hall India, 2003, 6thEdition.
2. Stoichiometry, Bhatt B.I, and Vora S.M, Tata McGraw-Hill, 2005, 4thEdition.

Reference Books:

1. Chemical Processes Principles (Part-1): Material and Energy Balances, O.A. Hougen, K.M. Watson, and R.A. Ragatz, Asia Publication House, 2001, 2ndEdition.



Course Code: MA235	TRANSFORMS, COMPLEX VARIABLES AND PARTIAL DIFFERENTIAL EQUATIONS	Credits: 3-0-0: 3
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Pre-Requisites: MA184

Course Outcomes:

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

CO1	Obtain the Fourier series for a given function
CO2	Find the Fourier transform of a function and Z-transform of a sequence
CO3	Determine the solution of a PDE by variable separable method
CO4	Understand the use of complex variables in engineering problems
CO5	Evaluate real integrals using functions of complex variables

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Fourier Series: Expansion of a function in Fourier series for a given range, half range sine and cosine expansions.

Fourier Transforms: Fourier transformation and inverse transforms, sine, cosine transformations and inverse transforms, simple illustrations.

Z-Transforms: Z- transform and Inverse Z-transforms, properties, convolution theorem, simple illustrations.

Partial Differential Equations: Method of separation of variables, solution of one-dimensional wave equation, one dimensional heat conduction equation and two-dimensional steady state heat conduction equations with illustrations.

Complex Variables: Analytic function - Cauchy Riemann equations, harmonic functions, conjugate functions, complex integration, line integrals in complex plane, Cauchy's theorem (simple proof only), Cauchy's integral formula - Taylor's and Laurent's series expansions - zeros and singularities, residues - residue theorem, use of residue theorem to evaluate the real integrals of the type $\int_0^{2\pi} f(\cos \theta, \sin \theta) dx$, $\int_{-\infty}^{\infty} f(x) dx$ without poles on real axis

Learning Resources:

Text Books:

1. Advanced Engineering Mathematics, R. K. Jain and S. R. K. Iyengar, Narosa Publishing House, 2016, 5thEdition
2. Advanced Engineering Mathematics, Erwin Kreyszig, John Wiley and Sons, 2015, 8thEdition



Reference Books:

1. Advanced Engineering Mathematics, Dennis G. Zill, Jones & Bartlett Learning, 2018, 6thEdition
2. Complex Variables and Applications, James W. Brown and Ruel V. Churchill, McGraw-Hill, 2009, 8thEdition



Course Code: BT201	BIOCHEMICAL THERMODYNAMICS	Credits: 3-0-0:3
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Pre-Requisites: BT121

Course Outcomes:

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

CO1	Understand the laws of thermodynamics
CO2	Apply power and refrigeration cycles for bioprocesses
CO3	Understand the degrees of freedom, phase and chemical reaction equilibria
CO4	Calculate thermodynamic parameters for biochemical reactions
CO5	Differentiate between ideal and non-ideal solutions

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Concepts in Engineering Thermodynamics: First Law of thermodynamics and other basic concepts, calculation of work, energy and property changes in reversible processes, second law of thermodynamics, thermodynamics of flow process, thermodynamic properties of fluids, volumetric properties of real gases, Maxwell's relationships and their applications, residual properties, estimation of thermodynamic properties using equation of state, power cycles and refrigeration cycles.

Solution Thermodynamics: Partial properties, concepts of chemical potential and fugacity, ideal and non-ideal solutions, Gibbs – Duhem equation, excess properties of mixture; activity coefficients, activity coefficient correlations.

Phase and Chemical Reaction Equilibria: Criteria for phase equilibrium, vapor – liquid equilibrium calculations for binary mixtures, liquid –liquid equilibria and solid-liquid equilibria, introduction to chemical reaction equilibrium, equilibrium criteria for homogeneous chemical reactions; evaluation of equilibrium constant and effect of pressure and temperature on equilibrium constant; calculation of equilibrium conversions and yields for single and multiple chemical reactions.

Biochemical Thermodynamics: Energetics of metabolic pathways; energy coupling (ATP & NADH) stoichiometry and energetic analysis of cell growth and product formation–elemental balances, degree of reduction concepts; available-electron balances; yield coefficients; thermodynamics of microbial growth.; oxygen consumption and heat evolution in aerobic cultures; thermodynamic efficiency of growth, energy balance equation for free cell culture; reaction thermodynamics. pH dependence of a biochemical reaction, unfolding of a protein as a function of temperature.



Learning Resources:

Text Books:

1. Introduction to Chemical Engineering Thermodynamics, J.M. Smith, H.C. van Ness and M.M. Abbott, McGraw Hill, 2005, 7th Edition.
2. Biochemical, and Engineering Thermodynamics, Stanley I. Sandler, Wiley, 2006, 4th Edition.

Reference Books:

1. Kinetics and Energetics in Biotechnology, J.A Roels, Elsevier, 2003, 1st Edition.
2. Thermodynamics: Applications of Mathematica, Robert A. Alberty, Wiley-Interscience, 2007, 1st Edition.

Online Resources:

1. <https://nptel.ac.in/courses/104/101/104101084/>
2. <https://www.youtube.com/watch?v=HogpLHsh6Lc>



Course Code: BT202	MICROBIOLOGY	Credits: 3-0-0:3
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Pre-Requisites: None

Course Outcomes:

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

CO1	Understand cellular ultra-structure of prokaryotes and eukaryotes
CO2	Select the optimum environmental factors for microbial growth
CO3	Analyze the outcome of genetic variations in microbes
CO4	Evaluate the impact of viruses on the physiology of animals, plants and microbes
CO5	Understand the biology of fungi and protists and their importance
CO6	Apply the knowledge of microbial interactions in bioremediation

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction to the world of Microbes: Spontaneous generation versus biogenesis of microorganisms - germ theory of disease –Koch's postulates. prokaryotic and eukaryotic microbes, cell structures—internal and external, functions of cellular components. principle of light microscope.

Microbial Nutrition and Growth: Microbial nutrition—macro elements and microelements. growth factors, uptake of nutrients. preparation of culture media—types and different formulations. isolation of pure culture of microbes—different methods. microbial growth curve—effects of environmental factors. control of microbial growth by physical and chemical agents. antibiotics

Microbial Genetics and Viruses: Microbial genetics—DNA as genetic material. spontaneous mutation. horizontal gene transfer methods—conjugation, transformation and transduction. viruses—general characteristics, cultivation techniques. Baltimore classification, bacteria, animal and plant viruses

Diverse Types of Microbes and Applications: Fungi, algae and protozoa: yeasts and molds, characteristics, morphology, reproduction and physiology of fungi - occurrence, characteristics of algae, biological and economic importance, lichens, morphology, reproduction and physiology of protozoa. applied microbiology: microbial interactions, biogeochemical roles of microorganisms, wastewater treatment procedures.

Learning Resources:



Text Books:

1. Prescott's Microbiology, Willey, J. M., Sandman, K. M. and Wood, D. H. McGraw Hill Education. 2020. 11th Edition.

Reference Books:

1. Brock Biology of Microorganisms, Michael T. Madigan, Kelly S. Bender, Daniel H. Buckley, W. Matthew Sattley and David A. Stahl, Pearson, 2017, 15th Edition.
2. Ananthanarayan and Paniker's Textbook of Microbiology, Ananthanarayan, R and Paniker, C. K. J. Orient Longman Pvt. Ltd. 2020. 11th Edition.

Online Resources:

1. <https://microbiologyonline.org/index.php>
2. <https://microbe.net/resources/m>



Course Code: BT203	BIOCHEMISTRY	Credits: 3-0-0:3
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Pre-Requisites: None

Course Outcomes:

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

CO1	Identify the structure and functions of biomolecules
CO2	Understand complex biochemical pathways and metabolism
CO3	Interpret biochemical reactions of proteins, carbohydrates and nucleic acids with organic and inorganic solvents
CO4	Estimate and separate biomolecules using chromatography and electrophoresis
CO5	Determine the kinetic parameters of enzymatic reactions

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction: Facts of life, water: the medium of life, pH, acids, bases, buffers, weak bonds and covalent bonds, introduction to bioenergetics.

Molecules of Life: Amino acids and peptides: classification of amino acids, structure and properties of amino acids, peptide bond and peptide proteins: structure and classification of proteins. primary structure, secondary structure, tertiary structure and quaternary structure, aggregated proteins, structural importance in function, denaturation and renaturation. nucleic acids: structure of nucleic acids, structure of DNA, specialized secondary structures, principle kinds of RNA and their structures, carbohydrates: structure and functions of carbohydrates and glycoproteins. lipids: structure of fats and oils, phospholipids, membrane lipids, vitamins: introduction, classification and functions of vitamins, disease of vitamins deficiency.

Metabolism: Metabolism: glycolysis, gluconeogenesis, and the pentose phosphate pathway, the citric acid cycle, amino acid oxidation, oxidative phosphorylation and photophosphorylation, DNA metabolism, RNA metabolism, protein metabolism, analytical techniques in biochemistry for small molecules and macro- molecules for quantification.

Enzymes and Enzyme Kinetics: Enzymes as biological catalysts, classification, examples of enzymes catalyzed reactions, Michaelis–Menten approach to enzyme kinetics, and mechanism of enzyme action.

Learning Resources:

Text Books:

1. Lehninger Principles of Biochemistry, David L. Nelson, Michael M. Cox, W. H. Freeman



- and Company, 2017, 7th Edition.
2. Biochemistry, Reginald H. Garrett, Charles M. Grisham, Cengage Learning, 2017, 6th Edition.
 3. Practical Biochemistry: Principles and Techniques, Keith Wilson and John Walker, Cambridge University Press, 2000, 5th Edition.

Reference Books:

1. Harpers Illustrated Biochemistry, Victor Rodwell, David Bender, Kathleen M. Botham, Peter J. Kennelly and P. Anthony Weil, Tata McGraw – Hill, 2015, 30th Edition.
2. Biochemistry, Jeremy M. Berg, John L. Tymoczko, Gregory J. Gatto, Jr., and Lubert Stryer, Macmillan, 2015, 8th Edition.

Online Resources:

1. <https://nptel.ac.in/courses/104/105/104105076/>
2. <https://vlab.amrita.edu/?sub=3&brch=63>



Course Code: BT204	BIOCOMPUTING	Credits: 3-0-2:4
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Pre-Requisites: CS181

Course Outcomes:

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

CO1	Understand the scripting language procedures
CO2	Apply the programming structures, file handling and file management to develop programs
CO3	Develop basic programs in Python
CO4	Apply the basics of SQL to create database

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction to Python: Introduction to python, history of python, python features, python development tools, writing python program, values and variables; numeric values, expressions, variables; legal variables, assigning values to variables, operators; arithmetic, assignment, comparison, logical and bitwise. data types; numbers, Boolean, strings.

Functions and Flow Statements: Sequence overview, common sequence operations, indexing, slicing, adding sequences, multiplication, length, minimum, and maximum, lists: python's workhorse, the list function, basic list operations, list methods, tuples: immutable sequences, the tuple function, basic tuple operations. control flow statements: simple if statement, if/else statement, if/elif statement, nested if statement, conditional expressions, while loop, for loop, continue and break statements.

Strings and Files Handling: Exception handling, try, except statement, functions; built-in functions, commonly used modules. strings; creating and storing strings, the str () function, basic string operations, string comparison, concatenation split, join, slice, formatting strings. files, creating and opening text files, reading and writing data and csv file concepts.

SQL Programming: introduction to SQL, role of SQL, SQL features and benefits, creation of simple database, retrieving data, summarizing data, adding data to the database, deleting data, updating the database, protecting data, SQL basics; statements, names, table names, column names, data types, constants, numeric constants, string constants, date and time constants, symbolic constants, built-in functions, missing data (null values), execution of queries.

Laboratory: Program to perform arithmetic calculations in python, program to find the length of the given sequence, program to reverse and concatenation of the given sequence, program to complement and reverse complement of DNA sequence, program to calculate GC



content in the given DNA sequence, program to translate DNA into protein sequence, program for creating table to demonstrate simple biological application, program for creation of bio-data base with fields (accession number, gene name, protein name, expression system, sequence length), program for record manipulations such as deletion, modification, addition and counting the record.

Learning Resources:

Text Books:

1. Introduction to python programming, Gowrishankar S, Veena A, CRC Press, 2019, 1stEdition.
2. Beginning Python, Magnus Lie Hetland, Apress, 2008, 1stEdition.
3. SQL: The Complete Reference, James R Groff, Paul N. Weinberg and Andy Opperl, McGraw-Hill Education, 2009, 3rdEdition.

Reference Books:

1. Python for Bioinformatics, Jason M. Kinser, Jones and Bartlett Publishers, 2020, 1st Edition.
2. Hands-On Database: An Introduction to Database Design and Development, Steve Conger, Pearson Education, Inc., 2012, 3rd Edition.
3. SQL: The Complete Reference, Paul Weinberg, James Groff, Andrew Opperl, McGraw Hill, 2010, 3rd Edition.

Online Resources:

1. <https://www.w3schools.com/>
2. <https://nptel.ac.in/noc/courses/106/>



Course Code: CY231	ACADEMIC LABORATORY SAFETY PRACTICES	Credits 1-0-0:1
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Pre-Requisites: None

Course Outcomes:

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

CO1	Understand individual's responsibility for safety in laboratory
CO2	Identify chemical hazards in the laboratory
CO3	Use personal protective equipment
CO4	Identify safety equipment and follow emergency response
CO5	Practice standard laboratory practices

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Chemical Safety: Being safe in the laboratory, individuals responsibility for safety in laboratories, personal protective equipment (PPE), laboratory protocols, guide to chemical hazards: toxicity, flammability, corrosivity, reactivity., recognizing chemical hazards: sources of information, recommended laboratory techniques: working with chemicals, apparatus, and equipment, safety equipment and emergency response: fires, chemical contamination on skin, clothing, and eyes, other personal injury, chemical spills, web as a source of safety information.

Biosafety: Risk assessment, personal protection requirements, laboratory physical space requirements, stock culture requirements, standard laboratory practices, training, documentation, practices, guidelines in microbiology laboratories.

Learning Resources:

Text Books:

1. Safety in Academic Chemistry Laboratories, (Best practices for I and II year university students), American Chemical Society, 2017, 8thEdition.

Reference Books:

1. Guidelines for Biosafety in Teaching Laboratories, Jeffrey J. Byrd, Robert A. Maxwell, Heather M. Townsend, Elizabeth A. B. Emmert, ASM Press, 2019, 1stEdition.
2. Laboratory Biosafety Manual, WHO, World Health Organization, 2004, 3rdEdition.



Course Code: BT205	MICROBIOLOGY & BIOCHEMISTRY LAB	Credits: 0-0-4:2
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Pre-Requisites: BT202, BT203

Course Outcomes:

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

CO1	Estimate the concentration of biological macromolecules
CO2	Identify and characterize biological macromolecules
CO3	Separate biomolecules using chromatography and electrophoresis
CO4	Conduct biochemical reactions of proteins, carbohydrates and nucleic acids with organic and inorganic solvents
CO5	Isolate microbial pure culture from environmental sample and characterize using appropriate staining technique
CO6	Optimize the environmental conditions for optimum growth of microbes

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Microbiology Laboratory:

1. Media preparation—solid and liquid
2. Pure culture techniques—incubating, streaking and spreading
3. Microbial growth characteristics—growth curve
4. Gram's staining
5. Isolation of pure culture from environmental samples—serial dilution and membrane filter technique
6. Effects of physical and chemical agents on microbial growth
7. Delbruck's fluctuation test
8. Determination of bacteriophage titer value by pluck assay

Biochemistry Laboratory:

1. Qualitative analysis of carbohydrates, amino acids and proteins.
2. Quantitative estimation of protein by Biuret method and Lowry method.
3. Quantitative estimation of reducing sugars by DNS method.
4. Quantitative estimation of total sugars by anthrone method.
5. Quantitative estimation of DNA by diphenylamine method.
6. Quantitative estimation of RNA by orcinol method.
7. Determination of absorption maxima (λ_{max}).



8. Estimation of nucleic acids and protein purity by spectrometric analysis.
9. Quantitative estimation of protein and nucleic acids concentration by UV-absorption method.
10. Effect of substrate concentration and determination of Michaelis–Menten parameters V_{max} & K_m .
11. Separation of amino acids by thin layer chromatography
12. Determination of molecular weight of a protein by SDS-PAGE.

Learning Resources:

Text Books:

1. Biochemistry Laboratory Manual, Pallab Basu, Academic Publishers, 2018, 3rd Edition.
2. Laboratory Manual in Biochemistry, J. Jayaraman, New age International, 2011, 1st Edition.
3. Microbiology Lab manual, Department of Biotechnology, NIT Warangal, 2021.

Reference Books:

1. Harpers Illustrated Biochemistry, Victor Rodwell, David Bender, Kathleen M. Botham, Peter J. Kennelly and P. Anthony Weil, Tata McGraw – Hill, 2015, 30th Edition.

Online Resources:

1. <https://vlab.amrita.edu/?sub=3&brch=63>



Course Code: MA288	NUMERICAL METHODS AND SERIES SOLUTIONS	L-T-P: Cr 3-0-0:3
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Pre-Requisites: MA235

Course Outcomes:

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

CO1	Interpret an experimental data using interpolation / curve fitting
CO2	Solve algebraic / transcendental equations and ordinary differential equations numerically
CO3	Apply multi-step methods in solving ordinary differential equations
CO4	Understand the Sturm-Liouville problems in obtaining the series solutions for ordinary differential equations
CO5	Use properties of Bessel and Legendre functions

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Numerical Methods: Curve fitting by the method of least squares, fitting of (i) straight line(ii) second degree parabola (iii) exponential curves - Gauss-Seidal iteration method to solve a system of equations - numerical solution of algebraic and transcendental equations by Regula-Falsi method and Newton-Raphson's method - 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, 4thorder Runge-Kutta method for solving first order ordinary differential equations; multi-step methods for solving ODE – solution of BVP using finite difference method.

Series Solutions: Sturm-Liouville problems, series solution of Bessel and Legendre's differential equations - Bessel function of first kind, recurrence formulae, generating function, orthogonality of Bessel functions - Legendre polynomial, Rodrigue's formula, generating function, recurrence formula, orthogonality of Legendre polynomials.

Learning Resources:

Text Books:

1. Advanced Engineering Mathematics, R. K. Jain and S. R. K. Iyengar, Narosa Publishing House, 2016, 5thEdition
2. Advanced Engineering Mathematics, Erwin Kreyszig, John Wiley and Sons, 2015,



8thEdition

Reference Books:

1. Special Functions for Scientists and Engineers, W. W. Bell, Dover Publications, 2004, 1stEdition
2. Higher Engineering Mathematics, B. S. Grewal, Khanna Publishers, 2012, 42ndEdition



Course Code: BT251	TRANSPORT PHENOMENA IN BIOPROCESS SYSTEMS	Credits: 3-0-2:4
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Pre-Requisites: BT201

Course Outcomes:

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

CO1	Understand laws in momentum transfer, types of fluids, viscosity and measurement
CO2	Comprehend power requirement for Newtonian and Non-Newtonian fluids
CO3	Realize the mechanisms of heat transfer in a bioprocess operation
CO4	Recognize diffusion properties, film theory concepts and mass transfer between various states
CO5	Comprehend the role of oxygen transfer in growth and metabolism of the cells.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Momentum Transfer-I: 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, factors affecting broth viscosity (cell concentration, cell morphology, osmotic pressure, product and substrate concentration), velocity distribution in laminar flow and turbulent flow.

Momentum Transfer-II: Equation of change for isothermal system (equation of continuity, equation of motion), interphase transport in isothermal systems (friction factors for flow in tubes and in packed columns) mixing, mixing mechanism, power requirements in un-gassed Newtonian and Non-Newtonian fluids, gassed fluids, interaction between cell and turbulent Eddies, operating conditions for turbulent shear damage, macroscopic balances-mass, momentum and mechanical energy balances.

Heat Transfer: Thermal conductivity and the mechanisms of energy transport- measurement of thermal conductivity, Fourier's law, steady state conduction, analogy between heat and momentum transfer, temperature distribution with more than one independent variables-heating in a semi-infinite and finite slab, temperature distribution in turbulent flow-reference to stirred tank reactor, relationship between heat transfer, cell concentrations and stirring conditions.

Mass Transfer: Diffusivity, theory of diffusion, analogy between mass heat and momentum transfer, role of diffusion in bioprocessing, film theory, concentration distribution with more than one independent variable unsteady diffusion, boundary layer theory, concentration distribution in turbulent flow-corrosion equation, definition of binary mass transfer coefficients,



transfer coefficients at high mass transfer rates-boundary layer theory, penetration theory, convective mass transfer, liquid-solid mass transfer, liquid-liquid mass transfer, gas-liquid mass transfer.

Oxygen Transfer: Oxygen uptake in cell cultures, factors affecting cellular oxygen demand, oxygen transfer from gas bubbles to aerobic culture, oxygen transfer in fermenters, bubbles factors affecting oxygen transport sparging, stirring, medium properties, antifoam agents, temperature, mass transfer correlations, measurements of kLa -oxygen balance method, dynamic method.

Laboratory: Determination of viscosity of the fluid, illustration of different fluid flow using Reynolds experiment, verification of Bernoulli's principle, determination of head losses due to friction in pipe lines, determination of thermal conductivity of metal rod, heat transfer through composite wall, heat transfer in natural convection, emissivity measurement apparatus, double pipe heat exchanger, vaporizing efficiency using steam distillation, diffusivity of a vapor in air, batch distillation.

Learning Resources:

Text Books:

1. Transport Phenomena, R. B. Bird, W. E. Stewart and E. N. Lightfoot, John Wiley, 2006, 2nd Edition.
2. Bioprocess Engineering Principles, Pauline M. Doran, Academic Press, 2012, 2nd Edition

Reference Books:

1. Biochemical Engineering, Harvey W. Blanch and Douglas S. Clark, CRC Press, 2014, 3rd Edition.
2. Bioprocess Engineering: Basic concepts, Michael L. Shuler, Fikret Kargi and Matthew De Lisa, Prentice Hall, 2017, 3rd Edition.



Course Code: BT252	ENZYME TECHNOLOGY	Credits: 3-0-0:3
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Pre-Requisites: BT201, BT203

Course Outcomes:

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

CO1	Understand basic principles of enzyme mechanism
CO2	Apply enzyme kinetics with and without inhibitors
CO3	Demonstrate the immobilization techniques and their potential applications
CO4	Identify techniques for isolation, purification of industrially important enzymes
CO5	Apply principles of enzyme technology in order to develop an efficient enzymatic process

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction: Nomenclature and classification of enzymes, types of specificity, active sites, enzyme-substrate interaction, lock and key mechanism, induced fit mechanism and transition state hypotheses, enzyme function and general mechanism.

Enzyme Kinetics: Basic concepts of bioenergetics, factors affecting the rates of chemical reactions, enzyme kinetics, Michaelis-Menten equation, measurement of K_m and V_{max} , kinetics of multi-substrate reaction, 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.

Immobilized Enzymes: Use of enzymes in free solution and associated problems; stabilization of soluble enzymes; objectives of enzyme immobilization, principles & techniques of immobilization, immobilized enzyme reactions; analysis of mass transfer effects on kinetics of immobilized enzyme reactions, analysis of film and pore diffusion effects on kinetics of immobilized enzyme reactions, calculation of effectiveness factors of immobilized enzyme systems.

Production and Application of Enzymes: Sources of industrial enzymes (natural & recombinant), strategies of isolation and purification of new enzymes from different sources, large-scale industrial enzyme production, downstream processing, modification of enzymes, methods in enzyme engineering, site directed mutagenesis, applications of enzymes for industrial processes and manufacture of commercial products, industrial enzymes, proteases, lipases, carbohydrate active enzymes, nucleic acid enzymes, applications of enzymes in food industry, detergents, energy, waste treatment, pharmaceutical, medical and analytical



purpose.

Learning Resources:

Text Books:

1. Enzymes Biochemistry, Biotechnology, Clinical chemistry, Palmer, T., Bonner, P., Wood Head Publishing, 2008, 2nd Edition.
2. Biochemical Calculations: How to Solve Mathematical Problems in General Biochemistry, Irwin H. Segel, Wiley India Pvt. Ltd, 2010, 2nd Edition.

Reference Books:

1. Biocatalysts and Enzyme Technology, Klaus Buchholz, Volker Kasche, Uwe Theo Bornscheuer, Wiley Publishing, 2012, 2nd Edition
2. Enzymes- A Practical Introduction to Structure, Mechanism and data analyses, Copeland, R. A, WILEY–VCH, 2012, 2nd Edition
3. Biochemical Engineering, H. W. Blanch and D. S. Clark, Marcel, Dekker Inc., 1996, 2nd Edition

Online Resources:

1. <https://nptel.ac.in/courses/102/102/102102033/>



Course Code: BT253	CELL BIOLOGY	Credits: 3-0-0:3
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Pre-Requisites: BT202, BT203

Course Outcomes:

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

CO1	Understand the cell theory and cellular compartmentalization
CO2	Distinguish the structure and function of the cell organelles and membrane.
CO3	Compare and contrast the events of cell cycle and its regulation.
CO4	Summarize the definition, sources and applications of stem cells.
CO5	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
CO1	-	-	-	1	-	2	-	2	-	-	-	1	3	-	-
CO2	-	-	-	1	-	2	-	2	-	-	-	2	3	-	-
CO3	-	-	-	2	-	1	-	2	-	-	-	2	3	-	-
CO4	-	-	-	2	-	1	-	1	-	-	-	2	3	-	-
CO5	-	-	-	2	-	2	-	1	-	-	-	1	3	-	-

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction to the Cell: Discovery of cells, cell theory; unity and diversity of cells, cells under the microscope, different classes of cells; prokaryotic cell, eukaryotic cell, structure and function of intracellular organelles, endomembrane system.

Cell Membranes: The structure of cell membranes, membrane lipids, phospholipid bilayer, fluid mosaic model of membrane structure, membrane proteins, integral membrane proteins, peripheral membrane proteins, transmembrane proteins, transport across cell membranes, permeability of phospholipid bilayers, channel and carrier proteins, passive transport, active transport, role of cell membrane in maintaining homeostasis.

Cell Regulation: Cell cycle, mitosis, meiosis, cell cycle checkpoint, molecular mechanics of cell cycle, role of cyclin dependent kinases in controlling the cell cycle, general principles of cell signaling, types of extracellular signal molecules, types of cell surface receptors, same signal molecule different responses, intracellular receptors, intracellular signaling proteins as molecular switches, signaling by protein phosphorylation and GTP-binding proteins.

Cancer and Stem Cells: Introduction to stem cells, embryonic stem cell, adult stem cell, pluripotent stem cells, stem cell differentiation, applications of stem cells, cell cycle and cancer, characteristics of cancer cells, types of tumors, causes and prevention of cancer.



Learning Resources:

Text Books:

1. The Cell: A Molecular Approach, Geoffrey M. Cooper and Robert E Hausman, Oxford University press, 2015, 7thEdition.
2. Molecular Biology of the Cell, Bruce Alberts, Alexander D. Johnson, Julian Lewis, David Morgan, Martin Raff, Keith Roberts, Garland Science, 2015, 6thEdition.

Reference Books:

1. Cell and Molecular Biology, Karp, G., Iwasa, J., Marshall, W. Wiley press 2019, 9thEdition

Online Resources:

1. The Cell, An Image Library (<http://www.cellimagelibrary.org/home>)
2. The Hidden Life of the Cell (<https://www.dailymotion.com/video/x1f26gz>)



Course Code: BT254	MOLECULAR BIOLOGY	Credits: 3-0-0:3
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Pre-Requisites: BT202, BT203

Course Outcomes:

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

CO1	Understand the structure of nucleic acids and proteins and their interactions.
CO2	Explain the mechanisms of the central dogma of life.
CO3	Analyze the molecular mechanisms of gene regulation in prokaryotes and eukaryotes.
CO4	Identify the importance of epigenetic controls on gene expression.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Genome Anatomies and DNA Replication: Anatomy of eukaryotic genome, unusual chromosomal types, eukaryotic organelle genomes, anatomy of prokaryotic genome. genome replication: DNA replication mechanisms, issues relevant to genome replication, topological problem, diverse function of DNA topoisomerase, genetic recombination, DNA repair processes.

Transcription: Initiation of transcription, first step in gene expression, accessing genome, assembly of transcription initiation complexes of prokaryotes and eukaryotes, regulation of transcription initiation. RNA processing: processing of mRNAs, synthesis and processing of non-coding RNAs, process of pre-RNA by chemical modification, turnover of mRNAs.

Translation: Role of tRNA and ribosome in protein synthesis, initiation of translation, translation elongation, termination of translation, regulation of translation, post translational processing of proteins.

Gene Regulation: regulation of gene expression in eukaryotes and prokaryotes, epigenetics and gene regulation, gene regulation by RNA interference, gene regulation in development and evolution, concept of operon structure. mechanisms of control of lac and trp operons.

Learning Resources:

Text Books:

1. Molecular Biology of the Cell, Bruce Alberts, Garland Science, 2007, 5th Edition.
2. Molecular Biology of the Gene, James D. Watson, Tania A. Baker, Stephen P. Bell, Alexander Gann, Michael Levine, Richard Losick, Pearson Education, 2017, 7th Edition.



Reference Books:

1. Genomes 4, T. A. Brown, Garland Science, 2017, 4th Edition.
2. Molecular Biology, David Freifelder, Narosa Publishing House, 2004, 2nd Edition

Online Resources:

1. https://onlinecourses.swyam2.ac.in/cec20_ma13/preview



Course Code: BT255	BIOINFORMATICS	Credits: 3-0-0:3
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Pre-Requisites: BT203

Course Outcomes:

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

CO1	Recall significant advances in historical timeline of bioinformatic developments
CO2	Identify, locate and retrieve specific records from various biological databases
CO3	Predict concealed signatures in RNA and Protein sequences
CO4	Construct virtual 3D models of protein structures
CO5	Analyze healthcare data with bioinformatic tools

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction: A brief history of bioinformatics, the origins, paradigm shift from protein to DNA analysis, parallel advances in biology and computer science, genomics and the information superhighway, high-throughput bioinformatics, present and future perspectives.

Sequence Databases: Scientific publications and archives: media, content, access and presentation, biological sequence databases, information retrieval from biological databases, assessing pairwise sequence similarity: BLAST and FASTA.

Genome and Sequence Analysis: Genome browsers, genome annotation, predictive methods using RNA sequences, predictive methods using protein sequences, multiple sequence alignments, molecular evolution and phylogenetic analysis.

Structural Bioinformatics: Secondary structural elements (SSE), DSSP, prediction of SSEs, template based and template free prediction of 3D structure of proteins, 3D structure refinement and validation.

Translational Bioinformatics: Translational bioinformatics in healthcare, past, present and future, databases describing the genetics of human health, prediction and characterization of impactful genetic variants from sequence, informatics and precision medicine, electronic health record systems, viroinformatics for viral diseases: tools and databases.

Learning Resources:

Text Books:

1. Bioinformatics, Andreas D. Baxevanis, Gary D. Bader, David S. Wishart, Wiley, 2019, 4th Edition.



2. Introduction to Bioinformatics, Arthur M. Lesk, Oxford University Press, 2019, 5th Edition.

Reference Books:

1. Essential Bioinformatics, JinXiong, Cambridge University Press, 2006, 1st Edition.
2. Translational Bioinformatics in Healthcare and Medicine, Khalid Raza, Nilanjan Dey, Elsevier Science, 2020, 1st Edition.

Online Resources:

1. <https://academic.oup.com/bib/article/20/6/1981/5066445>
2. <http://bcb.unl.edu/yyin/teach/PBB2015/The%20origins%20of%20bioinformatics.pdf>



Course Code: BT256	CELL BIOLOGY AND MOLECULAR BIOLOGY LAB	Credits: 0-0-4:2
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Pre-Requisites: BT253, BT254

Course Outcomes:

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

CO1	Operate a microscope to observe slides and correctly identify different cell types.
CO2	Differentiate cellular structures using different microscopic techniques.
CO3	Isolate nucleic acids and proteins from biological samples.
CO4	Estimate the quality and quantity of nucleic acids using gel-electrophoresis and Spectrophotometer.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Cell Biology Laboratory: Demonstration of microscopes, determining the cell concentration using hemocytometer, smear preparation and staining (bacteria, animal and plant cells), cell division – mitosis, microscopic determination of cell viability using membrane permeability assay, fluorescent labelling and microscopic detection of cellular components (direct and indirect labelling).

Molecular Biology Laboratory: Isolation of plasmid by alkaline lysis method, isolation of genomic DNA from bacteria by high salt method, molecular weight determination of nucleic acid, DNA elution from agarose gel, isolation of genomic DNA from plant tissue, isolation of RNA from yeast, isolation of proteins from mammalian cells and quantification of proteins.

Learning Resources:

Text Books:

1. Laboratory Investigations in Cell and Molecular Biology, Allyn A. Bregman, Wiley, 2001, 4th Edition.
2. Molecular Cloning: A laboratory manual, Joseph Sambrook and David Russell, CSHL press, 2004, 3rd Edition.

Reference Books:

1. Genomes 4, T. A. Brown, Garland Science, 2017, 4th Edition.



Online Resources:

1. The Cell, An Image Library (<http://www.cellimagelibrary.org/home>)
2. The Hidden Life of the Cell (<https://www.dailymotion.com/video/x1f26gz>)



Course Code: BT301	BIOPROCESS ENGINEERING	Credits: 3-0-2:4
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Pre-Requisites: BT251

Course Outcomes:

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

CO1	Understand the roles and responsibilities of a bioprocess engineer
CO2	Comprehend sterilization techniques and estimate the sterilization time
CO3	Understand the rheology of fermentation fluids and determine the power requirement in bioreactors
CO4	Develop the design equations for bioreactors and calculate the oxygen demand for cell growth.
CO5	Understand the scale up concepts for bioprocesses
CO6	Identify sensors and instruments needed for measurement and control

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction to Bioprocessing: Role of a bioprocess engineer, kinetics of microbial growth, substrate utilization and product formation; simple structured models, design of fermentation media.

Sterilization: Media sterilization; kinetics of thermal death of cells & spores, design of batch and continuous thermal sterilization, sterilization of air and filter design, radiation and chemical sterilization.

Batch, Fed-Batch and Continuous Processes: Operation of batch, continuous and fed-batch processes and industrial applications, comparison of batch, fed-batch and continuous processes.

Rheology of Fermentation Fluids: Newtonian and non-Newtonian fluids, aeration and agitation, power requirement for gassed and un-gassed systems, time calculation for mixing.

Mass Transfer in Bioreactors: Theories of mass transfer, metabolic oxygen demand, measurement of K_La , Maximum cell concentration.

Instrumentation in Bioreactors: On-line and off-line measurement various types of microbial and enzyme reactors, bioreactor considerations for animal cell culture and plant cell culture, fermentation: structured and unstructured models, optimization of fermentation media.



Laboratory:

1. Effect of Enzyme concentration on kinetics of invertase enzyme
2. Measurement of cell biomass concentration
3. Effect of Substrate concentration on kinetics of invertase enzyme
4. Yogurt fermentation
5. Effect of pH on kinetics of invertase enzyme
6. Effect of Temperature on kinetics of invertase enzyme

Learning Resources:

Text Books:

1. Bioprocess Engineering Principles. By Paulin M. Doran. Elsevier Science & Technology Books, 2008, 2nd Edition.
2. Biochemical Engineering Fundamentals, Second Edition, James E. Bailey, David F. Ollis. Mc Graw Hill, 2004, 2nd Edition.
3. Bioprocess Engineering Basic Concepts 2nd Edition, Michael Shuler, Fikret Kargi. Prentice-Hall India, 2006, 2nd Edition.

Reference Books:

1. Bioprocess Engineering: Kinetics, Mass Transport, Reactors and Gene Expression by Wolf. R. Vieth. A Wiley-Inter science Publication, 2009, 1st Edition.
2. Principles of fermentation technology, P F Stanbury and A Whitaker, Pergamon press, 2005, 3rd Edition.

Online Resources:

1. <https://www.kgi.edu/news/what-is-bioprocess-engineering/>
2. <https://www.labmanager.com/big-picture/bioprocessing-overview-and-trends/the-basics-of-bioprocess-engineering-25963>



Course Code: BT302	BIOLOGICAL REACTION ENGINEERING	Credits: 3-0-0:3
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Pre-Requisites: BT251

Course Outcomes:

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

CO1	Understand the kinetics and mechanism of chemical and biochemical reactions
CO2	Classify bioreactors and estimate Monod's parameters
CO3	Design batch, continuous flow, and fed batch reactors for enzymatic reactions
CO4	Develop models for bioreactors and structured models for microbial growth
CO5	Understand scale up concepts for bioreactors

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction: From bioprocess design to system biology, types of reaction, order of reaction, the effect of temperature on reaction rate. rate equations and reaction mechanisms; interpretation of batch reactor data, constant volume batch reactor, integral method of analysis of data for reversible and irreversible reactions.

Bioreactor Systems: Definitions, differences and similarities between chemical and bioreactors; classification of bioreactors; reactor configurations; description of a conventional bioreactor with all aspects; design and construction criteria of a bioreactor; residence time distributions, concentration, and temperature distributions; models of non-ideal reactors, imperfect mixing.

Design of Bioreactors: Design of bio-reactors with volumetric isotropy, design equations for enzyme reactors, batch growth of microorganisms, design equation of a plug flow reactor; design of CSTR with washout concept; stirred tank reactors with recycle of biomass; continuous stirred tank fermenter in series without and with recycle of biomass; estimation of kinetic parameters; role of mixing in industrial bio-reactions.

Modeling of Growth Kinetics and Design of Fermentation Processes: Model structure and complexity, a general structure for kinetic models, unstructured growth kinetics, simple structured models, mechanistic models, morphologically structured models, the stirred tank bioreactor, plug flow reactor, dynamic analysis of continuous stirred tank bioreactors, large scale processes.



Learning Resources:

Text Books:

1. Bioreaction Engineering Principles, Jens Nielsen, John Villadsen, Gunnar Lidén, Kluwer Academics /Plenum publishers, 2002, 2nd Edition.
2. Bioprocess Engineering Principles, Paulin M. Doran, Elsevier Science & Technology Books, 2013, 2nd Edition.

Reference Books:

1. Chemical Reaction Engineering, Octave Levenspiel, A Wiley- interscience Publication, 2004, 3rd Edition.
2. Biochemical Engineering Fundamentals, James E. Bailey, David F. Ollis, Mc Graw Hill, 1986, 2nd Edition.

Online Resources:

1. <https://nptel.ac.in/courses/102/105/102105064/#>
2. <https://nptel.ac.in/courses/103/105/103105054/>



Course Code: BT303	GENETIC ENGINEERING	Credits: 3-0-0:3
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Pre-Requisites: BT203, BT254

Course Outcomes:

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

CO1	Discuss the basic and advanced techniques in genetic engineering.
CO2	Select the appropriate host and vector system for cloning and expression.
CO3	Employ the cloning strategies to produce recombinant molecules.
CO4	Understand the DNA sequencing technology and gene modification approaches.
CO5	Apply genetic engineering principles for biotechnological and biomedical applications.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Basic Techniques: Agarose gel electrophoresis, nucleic acid blotting southern, western and northern blotting, PCR, competent cell preparation, transformation of *E. coli*, advanced techniques in gene expression and analysis: RT-PCR, Real-Time PCR, microarray, genome editing tools.

Cutting and Joining DNA Molecules: Various restriction enzymes, ligases, cloning vectors, plasmids and phage vectors, cosmids, phasmids and other advanced vectors for recombinant protein production and purification, animal and plant vector; introducing DNA into bacterial cells, cloning in bacteria, animal and plant cells, advance techniques of gene transfer, recombinant clone selection, heterogeneous gene expression, transient and inducible expression system.

Genomic Libraries and Sequencing: DNA and cDNA library preparation, cloning strategies for library preparation, screening of libraries, sequencing: DNA sequencing, concept of next generation sequencing technology, whole genome sequencing, analyzing sequence data, mapping and identification coding and non-coding gene, transgenic animals and plants, molecular pharming.

Learning Resources:

Text Books:



1. Principles of gene manipulation, Old RW and Primrose SB. BlackWell Scientific Publications, 2013, 7thEdition.
2. Molecular Cloning: A Laboratory Manual, Michael R. Green, Joseph Sambrook, Cold Spring Harbor Laboratory Press, 2013, 4th Edition.

Reference Books:

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



Course Code: BT304	IMMUNOLOGY	Credits: 3-0-0:3
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Pre-Requisites: BT203, BT253, BT254

Course Outcomes:

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

CO1	Summarize the overall concept of the human immune system.
CO2	Explain different cells and organs involved in the human immune system.
CO3	Recognize effectors molecules fight against infectious diseases.
CO4	Design monoclonal antibodies to diagnose infectious diseases.
CO5	Understand the concept of immunization.
CO6	Relate the role of the immune system in organ transplantation, autoimmune disorders and Cancer.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction to Immune System: Innate and adaptive immunity, cells and components of immune system, primary and secondary lymphoid organs: structure and functions.

Immunoglobulins: Immunogen, haptens and adjuvants, epitope, immunoglobulin isotypes: structure and functions, monoclonal antibodies: hybridoma technology and applications, recombinant and chimeric antibodies, humanized and bispecific antibodies, immunotoxins, polyclonal antibodies, abzymes, antigen-antibody interactions: agglutination, precipitation, immunodiffusion, ELISA, Immunoelectrophoresis, RIA, ELISPOT.

Organization and Expression of Immunoglobulin Genes: Antibody diversity, somatic variation theory, germ line theory, Tonegawa's bombshell, immunoglobulin genes rearrange, immunoglobulin light chain (kappa, lambda) and heavy chain rearrangement, immunoglobulin class switching, B-cell maturation, T-cell development, antigen processing and presentation, general organization and inheritance of the MHC, MHC structure and functions, MHC-peptide interaction, B-cell activation by TI and TD antigens, T-cell activation: CTL-mediated cytotoxic responses.

Tolerance and Immunity: Complement system, hypersensitivity reactions, overview of the induction and functions of cytokines, signal transduction mediated by cytokine receptors, therapeutic uses of cytokines, cytokine-related diseases, immunological tolerance, autoimmune disorders, transplantation, graft rejection and immunosuppressive therapy, vaccine development, types of vaccines, tumor immunology.



Learning Resources:

Text Books:

1. Kuby Immunology, Jenni Punt, Sharon Stranford, Patricia Jones, Judith A Owen, 2018, 8th Edition.
2. Cellular & Molecular Immunology, Abul Abbas, Andrew Lichtman, Shiv Pillai, 2021, 10th Edition.

Reference Books:

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

Online Resources:

1. <https://www.nature.com/nri/>
2. <https://www.frontiersin.org/journals/immunology>
3. <https://onlinelibrary.wiley.com/journal/1600065x>



Course Code: BT305	STRUCTURAL BIOLOGY	Credits: 3-0-0:3
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Pre-Requisites: BT201, BT203

Course Outcomes:

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

CO1	Determine the hierarchy in protein structures and structure-function relationship
CO2	Understand techniques involved in determining the structure of a biomolecules
CO3	Illustrate the role of computers to visualize the crystal structures
CO4	Identify the need of computer-based simulations
CO5	Apply molecular dynamics simulations to study molecular systems

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Structure Function Relationship: Protein architecture; motifs and domains of protein structures; conformational analysis, protein folding, bonds and energies in macromolecules, covalent, ionic, coordinate, hydrophobic and van der Waals interactions, enzymes, active sites of enzymes, enzyme-ligand interaction.

Basics of Macromolecular Crystallography: X-ray diffraction and Bragg equation, scattering factor, structure factor expression, phase problem and methods for phase determination, structure determination of macromolecules by crystallography technique.

Nuclear Magnetic Resonance (NMR) and Cryo-Electron Microscopy: Advantages and disadvantages of X-ray, NMR and Cryo-EM, thermodynamics and kinetics of protein crystallization, structural genomics project.

RCSB -Visualization of Macromolecules: Introduction to molecular dynamics simulation, need of simulation in studying biology, building realistic atomistic model, size and times scale of macromolecular movements, case studies on structure-based drug designing and protein engineering.

Learning Resources:

Text Books:

1. Introduction to Protein Structure, Branden C. I., and Tooze J., Taylor and Francis, 2001 2nd Edition,
2. Introduction to Protein Architecture: The Structural Biology of Proteins, 2014, Lesk A. M., Oxford University Press; 4th revised Edition.



Reference Books:

1. Biochemistry, Voet, D, Voet, J. G., and Pratt C. W., John Wiley and Sons. 2016, 5th Edition.
2. Biochemistry, Berg J, M., Stryer L., Tymoczko J, Gatto G. WH Freeman & Co, 2019, 9th Edition
3. Proteins, Structure and Molecular Properties, Creighton. T.E., W.H. Freeman and Co, 1993, 2nd Edition
4. Introduction to Macromolecular Crystallography, McPherson, A., Wiley Blackwell, 2009, 2nd Edition.
5. Principles of Protein X-Ray Crystallography, Drenth, J., Springer, 2007, 3rd Edition.
6. Crystallography Made Crystal Clear, Rhodes, G., Academic Press, 2006, 3rd Edition.

Online resources:

1. <https://nptel.ac.in/courses/102/107/102107086/>



Course Code BT306	GENETIC ENGINEERING & IMMUNOLOGY LABORATORY	Credits: 0-0-4:2
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Pre-Requisites: BT303, BT304

Course Outcomes:

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

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

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1	1	1	-	2	1	1	-	1	-	3	2	-	-
CO2	2	3	3	3	1	2	1	2	-	3	-	2	3	1	-
CO3	2	3	3	3	1	2	-	2	2	3	-	2	2	1	1
CO4	2	3	3	3	1	2	-	-	-	3	-	2	2	-	1
CO5	2	3	3	3	1	2	1	2	2	3	-	2	2	1	-
CO6	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 and ligation
4. PCR primer designing and PCR
5. Analysis of gene sequence for cloning and restriction mapping

Immunology Laboratory:

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



Learning Resources:

Text Books:

1. Molecular cloning: A Laboratory Manual, Joseph Sambrook and David Russell, CSHL Press, 2004, 3rd Edition.
2. David Wild, The Immunoassay Handbook: Theory and Applications of Ligand Binding, ELISA and Related Techniques, Elsevier Science, 2013, 4th Edition.

Reference Books:

1. Kuby Immunology, Jenni Punt, Sharon Stranford, Patricia Jones, Judith A Owen, 2018, 8th Edition.

Online Resources:

1. <https://www.frontiersin.org/journals/immunology>



Course Code: SM338	ENGINEERING ECONOMICS AND ACCOUNTANCY	Credits: 3-0-0:3
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Pre-Requisites: None

Course Outcomes:

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

CO1	Understand time value of money for effective resource utilization and investment.
CO2	Understand business and economic environment at national level.
CO3	Prepare financial statements of a company and appreciate importance of accounting.
CO4	Apply cost concepts to control costs at operational level.
CO5	Develop effective presentation skills with special emphasis on contemporary topics

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Methods of Economic Analysis Capital Budgeting Techniques: Time value of money, various methods of economic analysis (pay back, ARR, NPV, IRR and benefit cost ratio), methods of depreciation (straight line, sum of the years digit method, declining balance method, annuity method, sinking fund method).

Introduction to National Income National Income: Definition, circular flow, various concepts and methods of estimation, limitations and advantages.

Inflation: Meaning, CPI and WPI, theories of inflation and measures to control inflation.

Economic Policy of 1991: Economic policy of 1991, introduction and amendments in various economic policies by the Central Government (Current Affairs)

Financial Statements: Accounting principles, procedure, double entry system, journal, ledger, trial balance, cashbook preparation of trading and profit and loss account, balance sheet.

Application of Cost Concepts: Cost concepts, breakeven analysis, meaning and its application and limitations, preparation of cost sheet.

Presentations / group discussions on current topics.

Learning Resources:

Text Books:

1. Modern Economic Theory, K KDewett& M H Navalur, S. Chand Publishing, 2006, 1st



Edition.

2. Indian Economy: Problems of Development and Planning, MK Agrawal, AN Agrawal, New Age International, 2014, 1st Edition.

ReferenceBooks:

1. Accounting Part-I, S.P. Jain, K.L. Narang, Kalyani Publishers, 2019 Reprint.
2. Cost Accounting, M.N. Arora, Vikas Publishing House, 2013, 1st Edition.



Course Code: BT351	BIOSEPARATIONS TECHNOLOGY	Credits: 3-0-2:4
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Pre-Requisites: BT203, BT301

Course Outcomes:

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

CO1	Understand separation techniques used in downstream process
CO2	Design and optimize downstream processes
CO3	Describe the requirements for successful operation of downstream processes
CO4	Analyze the principles of major unit operations used in downstream processing

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Scope of Bioseparations Technology: Importance of bioseparations technology in biotechnology, characteristics of products, criteria for selection of bio-separation techniques, economics of bioseparations in biotechnology, cost-cutting strategies.

Recovery of Intracellular Products: Cell disruption methods – physical methods (osmotic shock, grinding with abrasives, solid shear, liquid shear) – chemical methods (alkali, detergents) – enzymatic methods cell disruption by homogenizer-mechanism, Bead mill disruption-operating process design considerations, scale up.

Solid- Liquid Separation: Centrifugation: principles of centrifugation, various centrifuges; basket centrifuge, tabular centrifuge, disc-bowl centrifuge, membrane separation processes, basic principles of membrane separation, different types of membranes, criteria for selection of membranes.

Chromatography: Principles of chromatographic separation methods, different types of chromatographic methods, ion – exchange chromatography, gel chromatography, affinity chromatography etc... applications in bio-processing, electrophoresis of proteins, isoelectric focusing, protein precipitation, dialysis; extraction and freeze drying.

Laboratory: Extraction of intracellular proteins by cell disruption methods, centrifugation methods, precipitation methods, dialysis, lyophilization, ion exchange chromatography, gel filtration chromatography, affinity chromatography, tangential filtration methods, NATIVE electrophoresis, storage methods for isolated products.

Learning Resources:

Text Books:

1. Bioseparations: Downstream Processing for Biotechnology, Paul A. Belter, Wiley-Blackwell, 2008.



2. Bioseparations: Principles and Techniques, Sivasankar, Prentice Hall India Learning Private Limited, 2010.
3. Downstream Process Technology, Prasad, Prentice Hall India Learning Private Limited, 2010.

Reference Books:

1. Product Recovery in Bioprocess technology, BIOTOL series, Butterworth –Heinemann, 2010.
2. Principles of Downstream processing, by Ronald J. Lee, Wiley Publications, 2007.
3. Downstream Processing of Proteins: Methods and Protocols, Mohamed A. Desai, Humana Press, 2012.

Online Resources:

1. <https://onlinelibrary.wiley.com/doi/10.1002/elsc.201600033>



Course Code: BT352	ANIMAL AND PLANT BIOTECHNOLOGY	Credits: 3-0-0:3
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Pre-Requisites: BT253, BT254

Course Outcomes:

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

CO1	Comprehend the elementary techniques in culture of animal cells.
CO2	Explain the role of transgenic animals in recombinant product production.
CO3	Describe various plant tissue culture techniques
CO4	Comprehend the methods for plant propagation and germplasm preservation
CO5	Explain the conventional and molecular marker breeding, hardening techniques

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction to Animal Cell Culture: Historical background of animal cell culture, essential equipment, general laboratory practices, aseptic techniques, culture media: 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, cryopreservation.

Applications of Animal Biotechnology: Reproductive technologies, recombinant vaccine technologies, overview of transgenic animal technology, transgenic animal production strategies, importance and applications of transgenic animals, recombinant products, knockout model systems and their applications, ethical issues in animal biotechnology.

Introduction to Plant Tissue Culture: History, scope and perspectives of plant cell, tissue and organ culture, role of micro and macro nutrients, vitamins and carbon source in tissue culture, media preparation- pH, temperature, solidifying agents, slant preparations, maintenance of cultures, environmental conditions, explants characteristics, micropropagation and its applications, types, stages, establishment of propagated plants, micropropagation for large scale multiplication of crop plants, forest trees, medicinal plants and ornamentals, germplasm preservation- definition, importance and methods, *insitu* and *exsitu* conservation, centers of germplasm preservation in India.

Culture Techniques, Hardening and Applications: Explants selection, sterilization and inoculation; various media preparations; MS, B5, SH PC L-2; callus and cell suspension culture, hardening- hardening stages, role of poly house, net house, compost, chemical fertilizer, cocopit and soil in hardening. androgenic haploids and its applications, embryo rescue, embryo culture protoplast isolation, somatic hybrids and cybrids.



Learning Resources:

Text Books:

1. Animal Biotechnology: Models in Discovery and Translation, Ashish Verma, Anchal Singh, Academic Press, 2014, 2nd Edition.
2. Plant Tissue Culture: Theory and Practice, Bhojwani. S.S. &Razdan. M.K. Elsevier Science Publishers, New York. 1998, 1st Edition.
3. Introduction to Plant Biotechnology, Chawla. H.S. Oxford & IBH. 2000, 1st Edition.
4. Biotechnology: Secondary Metabolites, Ramawat. K.G.&Merillon. J. M. Science Pub., Netherlands. 2007, 2nd Edition.

Reference Books:

1. Animal Cell Culture & Technology, Michael Butler, Garland Science, 2003, 2nd Edition.
2. An Introduction to Plant Tissue Culture, Razdan. M.K., Oxford & IBH Publishing, 2019, 3rd Edition.

Online Resources:

1. <https://nptel.ac.in/courses/102/103/102103016/>
2. https://onlinecourses.nptel.ac.in/noc20_me04/preview



Course Code: BT353	BIostatISTICS	Credits: 3-0-0:3
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Pre-Requisites: None

Course Outcomes:

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

CO1	Understand the mathematical basis and foundations of probability and statistics
CO2	Apply statistical methods to solve biological problems
CO3	Apply the statistical principles to design the research experiments.
CO4	Apply basic and modern statistical methods to analyze the big data in biology and clinical data

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction to Biostatistics and Organization of Data: Data type, graphical and pictorial presentation of data, measures of central tendency and dispersion, sampling techniques, sample size, coefficient of variation, means error, relative error, precision and accuracy.

Probability Distribution and Statistical Inference: Introduction to probability, Bayes' theorem, probability distributions, binomial distribution, poisson distribution, normal distribution. parametric and non-parametric tests: testing hypothesis, types of errors, tests of significance based on normal distribution, data characteristics and nonparametric procedures, chi square test, sign test, Wilcoxon sign rank test, Wilcoxon rank sum test, ANOVA, linear and multiple regression and correlation, method of least squares, significance of correlation and regression, test of significance for correlation coefficients.

Experimental Design: General principles of experimental design, randomization, double-blind and double-dummy techniques, completely randomized and Latin square designs, factorial design, crossover and parallel designs, case studies.

Statistics in Data Analytics: Application of statistics in genetics, introduction to big data analytics, data analytics lifecycle: discovery, data preparation, model planning, model building, communicating results, operationalize.

Learning Resources:

Text Books:

1. Biostatistics: A Foundation for Analysis in the Health Sciences, Daniel Wayne W., John Wiley & Sons, 2008, 9th Edition.
2. Fundamentals of Biostatistics, Rosner Bernard, Brooks/Cole, 2011, 7th Edition.



Reference Books:

1. Intuitive Biostatistics, Motulsky H, Oxford University Press, 2009, 2nd Edition.
2. Data Science and Big Data Analytics. Discovery, Analyzing, Visualizing and Presenting Data, EMC Education Services, John Wiley & Sons, 2017.

Online Resources:

1. [Statistics for Biologists, https://www.nature.com/collections/qghhqm/](https://www.nature.com/collections/qghhqm/)



Course Code: BT354	ANALYTICAL BIOTECHNOLOGY	Credits 2-0-2:3
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Pre-Requisites: BT203

Course Outcomes:

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

CO1	Understand basics of bioanalysis and bioassays
CO2	Comprehend principles and types of bioanalytical instruments
CO3	Describe various spectrometry and microscopy techniques
CO4	Select appropriate chromatographic techniques
CO5	Apply bioanalytical techniques learnt in characterization of biomolecules

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction: Protein extraction and quantitation, protein manipulation in solution, modern approaches in bioanalysis and bioassays, radioisotope techniques, concepts, GM and scintillation counter, autoradiography, RIA, applications in biological sciences.

Imaging Techniques: Principles, construction, working and applications of -microscopy, bright and dark-field, phase contrast, fluorescence microscopy, confocal microscopy; atomic force microscopy; scanning tunneling microscopy, electron microscopy: TEM and SEM.

Spectrometric Techniques: UV-Visible spectrometry, fluorescence spectrometry, IR spectrometry, CD spectrometry, Fourier transform infrared spectrometry (FTIR), liquid chromatography–mass spectrometry (LCMS), gas chromatography–mass spectrometry (GCMS), atomic absorption spectrometry (AAS), inductively coupled plasma mass spectrometry (ICPMS), inductively coupled plasma optical emission spectrometry (ICP-OES)

Advanced Techniques: Next generation sequencing (NGS), multiplex fluorescent *in situ* hybridization (m FISH), comparative genome hybridization (CGH), spectral karyotyping (SKY), matrix-assisted laser desorption ionization time-of-flight (MALDI-TOF), flow cytometry - fluorescence-activated cell sorting (FACS), differential scanning calorimetry (DSC), electro chemical workstation (potentiostat /galvanostat).

Demonstration: Fluorescence spectrometry, IR spectrometry, CD spectrometry, Fourier transform infrared spectrometry (FTIR), SEM, XRD and NMR.



Learning Resources:

Text Books:

1. Principles and Techniques of Biochemistry and Molecular Biology, Wilson K and Walker J, Cambridge University Press, 2005, 6th Edition.

Reference Books:

1. Spectroscopy, D. L. Pavia, G. M. Lampman, G. S. Kriz, J. R. Vyvyan, Cengage Learning, 2007, 1st Edition.
2. Principles of Instrumental Analysis, Douglas A. Skoog, F. James Holler, Stanley R. Crouch, Cengage Learning, 2016, 7th Edition.
3. Instrumental methods of analysis, Willard, Merit, Dean and Settle, CBS publishers, 2018, 7th Edition.
4. Methods in Modern Biophysics, B Notting, Springer, 2010, 3rd Edition.
5. Proteins and Proteomics: A Laboratory Manual, R.J. Simpson, CSHL press, 2003, 1st Edition.
6. Molecular Cloning: A Laboratory Manual, J. Sambrook and D. W. Russell, CSHL (Cold Spring Harbor Laboratory) Press, 2001, 3rd Edition.
7. Fundamental Laboratory Approaches for Biochemistry and Biotechnology, A. J. Ninfa and D. P. Ballou, Wiley, 2009, 2nd Edition.
8. Bioanalytics - Analytical Methods and Concepts in Biochemistry and Molecular Biology, Joachim W. Engels, Friedrich Lottspeich, Wiley, 2018, 1st Edition.

Online Resources:

1. <https://nptel.ac.in/courses/102/103/102103044/>
2. <https://nptel.ac.in/courses/103/108/103108100/>



Course Code: BT355	SYSTEMS BIOLOGY	Credits 3-0-0:3
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Pre-Requisites: BT203

Course Outcomes:

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

CO1	Understand basic, advanced principles of systems biology and biological networks applications
CO2	Understand networks behavior and emergent properties of biological networks/systems
CO3	Apply kinetics principles to develop systems level mathematical models in biology
CO4	Create predictive mathematical models of biological interaction networks to explore their emergent behavior
CO5	Draw insights form systems level models/ studies for biotechnological and biomedical applications

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

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, ultra-sensitivity, steady state, dynamic and stochastic models in system biology.

Molecular Networks to Cellular Behavior: Emergent properties of biological networks; complexity, adaptability, biostability, robustness and evolvability; introduction to network motifs, elements of transcription networks, dynamics and response time of simple gene regulation, auto regulation, feed forward loops (FFLs), temporal expression programs and global structure.

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, systems biology and artificial intelligence.

Systems Models and Simulation (Hands on): Dynamics of a simple gene regulation, Dynamics of small interaction network with coupled ODE, Bi-stable switch and multi-stability, Dynamics of circadian rhythm and limit cycle, Dynamics of MOTIFs, Pattern formation using



PDE. Dynamics of prey-predatory model, Dynamics of SIR model and disease spread.

Learning Resources:

Text Books:

1. Introduction to Systems Biology, Uri Alon, Chapman and Hall / CRC Mathematical and Computational Biology, 2007, 1st Edition.
2. Systems Modeling in Cellular Biology: From Concepts to Nuts and Bolts, Zoltan Szallasi, JörgSterling, Vipul Periwal, Prentice Hall of India, 2007, 1st Edition.

Reference Books:

1. Computational Analysis of Biochemical Systems, Eberhard O. Voit, Cambridge University Press, 2000, 1st Edition.
2. An Introduction to computational Systems Biology: System-level modelling of cellular networks. CRC press, Taylor and Francis Group, 2021, 1st Edition.

Online Resources:

1. <https://nptel.ac.in/courses/102/106/102106068/>
2. <https://www.ibiology.org/bioengineering/challenges-in-synthetic-biology/>



Course Code: CH431	BIOPROCESS ENGINEERING ECONOMICS	Credits 3-0-0:3
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Pre-Requisites: None

Course Outcomes:

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

CO1	Analyze alternative processes and equipment for manufacturing a product
CO2	Determine costs involved in process plants
CO3	Perform economic analysis and optimum design of processes
CO4	Evaluate project profitability

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction: Chemical engineering plant design, overall design consideration, practical considerations in design, engineering ethics in design.

General Design Considerations: Health and safety hazards, loss prevention, environmental protection, plant location, plant layout, plant operation and control.

Process Design Development: Development of design database, process creation, process design criteria, process flow diagram (PFD), equipment design specifications. flow sheet synthesis and development: general procedure, process information, functions diagram, flow sheet synthesis, software use in process design.

Cost and Asset Accounting: General accounting procedure, balance sheet and income statements.

Analysis of Cost Estimation: Cash flow for industrial operations, factors affecting investment and production costs, capital investments, fixed capital and working capital, estimation of capital investment, cost indices, estimation of total cost, gross profit, net profit and cash flow, cost scaling factors, net present value analysis.

Interest and Insurance: Interest, simple interest, compound interest, nominal and effective interest rates, continuous interest, costs of capital, time value of money, annuity, cash flow patterns, income taxes, present worth, future worth, taxes and insurance.

Depreciation: Depreciable investments, methods for calculating depreciation.

Profitability Analysis: Profitability standards, costs of capital, minimum acceptable rate of return, methods of calculating profitability, rate of return on investment, payback period, net return, discounted cash flow rate of return, net present worth, payout period, alternative investments, replacements.



Optimum Design and Design Strategy: Defining the optimization problem, selecting an objective function, structural optimization, parametric optimization, variable screening and selection, optimization applications.

Bioprocess Economics: Introduction to bioprocess economics, scaleup and scale down issues, facility design aspects of bioprocess economics.

Learning Resources:

Textbooks:

1. Plant Design and Economics for Chemical Engineers, Peters M.S., K.D. Timmerhaus and R.E. West, McGraw Hill, 2011, 5thEdition.
2. Analysis, Synthesis and Design of Chemical Processes, Turton R., R.C. Baile, W.B. Whiting, J. A. Shaeiwitz, PHI, New Delhi, 2011, 3rdEdition.

Reference Books:

1. Product and Process Design Principles: Synthesis, Analysis, and Evaluation, Seider W.D., J.D. Seader, D.R. Lewin, Wiley, 2004, 2ndEdition.
2. Chemical Process Equipment: Selection and Design, James R. Couper, W. Roy Penny, James R. fair, Stanley M. Walas, Elsevier Butterworth-Heinemann, 2012.
3. Engineering Economics, R. Panneerselvam, Prentice Hall India, 2013.

Online Resources:

1. <https://nptel.ac.in/courses/103/105/103105166/>



Course Code: BT401	MODELLING, SIMULATION AND OPTIMIZATION OF BIOPROCESSES	Credits 2-0-2:3
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Pre-Requisites: BT301, BT302

Course Outcomes:

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

CO1	Understand modeling principles
CO2	Formulate balance equations
CO3	Analyze batch, semi continuous / fed batch operation
CO4	Develop enzyme and growth kinetic models
CO5	Comprehend bioreactor modeling
CO6	Develop models for biological systems

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction to Modeling: - Modeling principles, use of models for understanding, design and optimization of bioreactors, concepts of models, types of models., use of models in bioprocess.

Classification of Models: Mathematical model, Physical models, static and dynamic models, analytical and mathematical models, linear and nonlinear models, stable and unstable models, steady state and transient models, descriptive and normative models, distributed lag model, mechanistic models, structured and unstructured models, segregated and unsegregated models

Approaches for Model Development: Mass balance models, formulation of balance equations, types of mass balance equations, balancing procedure, continuous stirred tank bioreactor, tubular reactor, component balances for reacting systems, constant volume continuous stirred tank reactor, semi-continuous reactor with volume change, steady-state oxygen balancing in fermentation, bioreactor modeling, biomass productivity, modeling of tubular plug flow bioreactors, simulation examples of biological reaction, processes using Berkeley Madonna, batch fermentation, chemostat fermentation, fed batch fermentation, kinetics of enzyme action, repeated fed batch culture

Bioprocess Modeling using SuperPro Designer: Flow sheeting of the bioprocess using SuperPro designer, design of various bioreactors using SuperPro designer, case studies of bioprocess optimization.



Learning Resources:

Text Books:

1. Bioreactors: Analysis and Design, Panda, Tapobrata, McGraw-Hill Education, 2011, 1st Edition.
2. Biological Reaction Engineering: Dynamic Modeling Fundamentals with Simulation Examples, I. J. Dunn, E. Heinzle, J. Ingham, J. E. Pfenosil, WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim, 2003, 1st Edition.

Reference Books:

1. Modeling and Control of fermentation Processes, J.R. Leigh, Peter Peregrinus, London, 2000, 1st Edition.
2. Hand book of food and bioprocess modeling techniques, Syam S. Sablani, Taylor & Francis Group, LLC, 2006, 1st Edition.

Online Resources:

1. <http://38.100.110.143/model/index.html>
2. <https://www.youtube.com/watch?v=qAMhDOFdW3g>
3. https://www.youtube.com/watch?v=OhFot_I_x8
4. <https://www.youtube.com/watch?v=cSUPrSkemqo>



Course Code: BT402	BIOPROCESS INSTRUMENTATION AND CONTROL	Credits: 3-0-2:4
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Pre-Requisites: BT301, BT302

Course Outcomes:

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

CO1	Understand the principles of instrumentation and control engineering
CO2	Analyze different components of a control loop
CO3	Analyze stability of feedback control systems
CO4	Analyze biological regulation and control system
CO5	Examine the model analysis and simulations

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Instrumentation and Control Basic Concepts, Examples: Bioprocess instrumentation, temperature, pH, level, flow, pressure, DO sensors, 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: 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 and Controllers: Transient response of simple control systems, servo problem, regulatory problem, controllers, proportional, proportional-integral, PID controllers. Ziegler-Nichols controller settings, stability: Routh test for stability, root locus.

Introduction to Frequency Response: Substitution rule, Bode diagrams, control system design based on frequency response, Bode and Nyquist stability criterion, gain and phase margins.

Laboratory: Interacting and non-interacting liquid level system, time constant estimation of liquid in glass thermometer, heat transfer dynamics in a stirred tank, computer-controlled flow process analyzer (P, PD, PID controls) levels process analyzer, pressure analyzer, temperature process analyzer, computer-controlled heat exchanger, example model analysis and simulation, regulation of glucose insulin system, respiratory control system, cardiac control system, control analysis in systems and synthetic biology, control analysis in drug delivery systems.



Learning Resources:

Text Books:

1. Process Systems Analysis and Control. Coughanowr D R., LeBlanc SE., McGraw-Hill, 2009, 3rd Edition.
2. Physiological control systems. Analysis, simulation, and estimation. Michael C K Khoo. Wiley, 2018, 2nd Edition.

Reference Books:

1. Control of Biological and Drug-Delivery Systems for Chemical, Biomedical and Pharmaceutical Engineering, Laurent Simon. Wiley, 2013, 1st Edition.

Online Resources:

1. <https://nptel.ac.in/courses/103/101/103101142/>
2. <https://engineeringmedia.com/>



Course Code: BT403	COMPUTATIONAL METHODS IN DRUG DISCOVERY	Credits 3-0-2:4
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Pre-Requisites: BT255, BT305

Course Outcomes:

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

CO1	Understand structure-function relationship of lead molecules in drug discovery process
CO2	Understand the process of target identification in drug discovery
CO3	Apply proteomics and genomics techniques in drug-discovery and design process
CO4	Understand the drug delivery systems
CO5	Design new drugs using computational methods

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Insights into the Drug Design Process: Drug design process for a known protein target – structure-based drug design process, finding initial hits, compound refinement, ligand-based drug design process, finding initial hits using online/offline software.

Stereochemistry in Drug Design: Peptides, peptidomimetics, bonded and non - bonded interactions, drug delivery systems for proteins, peptides with special reference to oral and nasal routes, delivery consideration of biotechnological products, stability profile, barriers to peptides, protein delivery, delivery of protein and peptide drugs, toxicity profile characterization, druggable targets.

Computational Approaches: Quantification of molecular diversity and design of compound libraries, physicochemical concept of in drug design, QSAR, 2D-QSAR; 3D-QSAR, descriptors of QSAR, tools and techniques of QSAR, parameters used in QSAR, applications of QSAR, 3D pharmacophore hypothesis.

Introduction to Docking: Scoring functions, docking process – protein preparation, building the ligand, setting the bounding box, running docking calculations, molecular docking software and their utilities in drug design, high-throughput screening.

Laboratory: Design and 2D sketching of ligand/drug, introduction to protein structure and visualization tools, generation and preparation of 3D optimized structure of ligand and receptor for docking, docking of receptor-ligand and analysis of results, docking of protein-protein and analysis of results, estimation of binding free energy of ligands and receptor, introduction to molecular dynamics simulation methods, introduction to molecular dynamics analysis methods.



Learning Resources:

Text Books:

1. Textbook of Drug Design and Discovery, PovlKrogsgaard-Larsen, Ulf Madsen, Kristian Stromgaard, CRC Press, 2017, 5th Edition.
2. Modern Methods of Drug Discovery, Gerhard Edwin Seibold, Alexander Hillisch, Rolf Hilgenfeld, Birkhauser, 2003, 1st Edition.

Reference Books:

1. Molecular Modelling for Beginners, Alan Hinchliffe, Wiley & Sons Ltd. 2008, 2nd Edition.
2. Advanced Drug Design and Development: A medicinal Chemistry Approach. Kourounakis Taylor and Francis, 1994, 1st Edition.
3. Computational medicinal chemistry for drug discovery, Patrick Bultinck, Marcel Dekker, CRC Press, 2004, 1st Edition.
4. Modern Biopharmaceuticals: Design, Development and Optimization. JorgKnablein, Wiley – VCH, 2005, 1st Edition.
5. Molecular Modelling, Principles & Applications, Andrew R. Leach, Addison Wesley Longman, Singapore, 1996, 1st Edition.
6. Molecular Modelling and Simulation – An interdisciplinary Guide, Schlick, Tamar, Springer, 2010, 1st Edition.
7. David C Young: Computational Drug Design (A guide for computational and medicinal chemists) Wiley & Sons, Inc., New Jersey, USA, 2009, 1st Edition.

**Professional Elective Courses**

Course Code: BT211	PROCESS ENGINEERING PRINCIPLES	Credits 3-0-0:3
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Pre-Requisites: None

Course Outcomes:

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

CO1	Understand the process engineering principles for biochemical engineer
CO2	Identify various process mathematical methods for bioprocess engineering
CO3	Understand the process heat transfer methods used in bioprocess
CO4	To evaluate the economics of process industries reflecting current economic criteria

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction: Introduction to process engineering, process flow sheeting, process variable identification, component and overall material balances, and process design.

Process Mathematical Methods: Introduction to numerical methods in biochemical engineering processes, Stoichiometric relationships, ideal and real gas behavior.

Process Heat Transfer: Fundamentals of heat transfer, modes of heat transfer, conduction, convection and radiation heat transfer, boiling and condensation, evaporation, and heat exchanger analysis.

Process Plant Design and Economics: Economic and optimization issues relevant to investment, product-cost estimation, and profitability analysis.

Learning Resources:**Text Books:**

1. Introduction to process engineering and design, Shuchen B. Thakore and Bharat I. Bhatt, McGraw Hill Education, 2017 1st Edition.
2. Bioprocess Engineering, K Clarke, Woodhead Publishing, 2013 1st Edition.

Reference Books:

1. Principles of process engineering, S.M. Henderson, Robert L Perry and J.H. Young, 1997 1st Edition.
2. Bioprocess engineering principles, Pauline M. Doran, Elsevier, 2012, 2nd Edition.

Online Resources:



1. <https://nptel.ac.in/courses/103/103/103103165/>
2. <https://nptel.ac.in/courses/103/103/103103039/>



Course Code: BT212	BIODIVERSITY AND CONSERVATION	Credits 3-0-0:3
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Pre-Requisites: None

Course Outcomes:

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

CO1	Comprehend the diversity among microbes, plants and animals
CO2	Realize hotspots and endangered species
CO3	Identify endemic and threatened species for conservation
CO4	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
CO1	1	2	-	-	-	-	3	2	-	3	-	2	-	-	1
CO2	-	-	-	-	-	2	1	2	-	-	-	-	-	-	-
CO3	-	3	-	-	-	1	-	-	-	-	-	-	-	-	-
CO4	-	-	-	-	-	-	-	-	3	-	-	3	3	-	-

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

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.

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.

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.

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.



Learning Resources:

Text Books:

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

Reference Books:

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

Online Resources:

1. <https://nptel.ac.in/courses/102/104/102104068/>



Course Code: BT213	DATA STRUCTURES AND ALGORITHMS	Credits 3-0-0:3
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Pre-Requisites: CS181

Course Outcomes:

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

CO1	Understand data structures and algorithms
CO2	Comprehend linear data structures
CO3	Differentiate nonlinear data structures
CO4	Perform searching, sorting and hashing techniques

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Linear Data Structures – List: Introduction to algorithm and data structures, introduction, algorithms, asymptotic notation, introduction to data structures, types of data structures, data structure operations, arrays: introduction, types of arrays, representation of one-dimensional array in memory, array traversal, insertion and deletion, sorting and searching, realizing matrices using two dimensional arrays, matrix operations, linked lists, introduction, linked-lists -basic concept, linked-list implementation, type of linked lists, circular linked list, doubly linked list.

Linear Data Structures – Stacks and Queues: Stacks, introduction, stacks, stacks operations, stack implementation, queues, introduction, queues -basic concept, queue operations, queue operations, queue implementation, circular queues, priority queues, double ended queues.

Nonlinear Data Structures – Trees: Introduction, basic concept, binary tree, binary tree representation, binary tree traversal, binary search tree, tree variants.

Nonlinear Data Structures – Graphs: Introduction, basic concept, graph terminology, graph implementation, shortest path algorithm, graph traversal.

Searching, Sorting and Hashing Techniques: Sorting and searching, introduction, sorting techniques, searching techniques.

Learning Resources:

Text Books:

1. Data Structures, E Balagurusamy, McGraw Hill; 1st Edition, 2020, 1st Edition.

Reference Books:



1. Data Structures, R. Venkatesan, S. Lovelyn Rose, Wiley, 2019, 2ndEdition.
2. Data Structures and Algorithms Made Easy: Data Structures and Algorithmic Puzzles, Narasimha Karumanchi, career monk publications, 2016, 1stEdition.



Course Code: BT261	UNIT OPERATIONS	Credits 3-0-0:3
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Pre-Requisites: None

Course Outcomes:

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

CO1	Understand various unit operations involved in bioprocess industry.
CO2	Describe fluid flow operation and its measurement.
CO3	Identify heat transfer equipment for bioprocessing
CO4	Comprehend the unit operation equipment involved in bioseparations
CO5	Relate appropriate unit operation techniques in bioprocessing

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Fluid Flow Operation: Characteristics of fluid, measurement of fluid viscosity, rotating cylinder viscometer, falling sphere viscometer, capillary tube viscometer, Saybolt and Redwood viscometer, measurement of flow rate and velocity - Pitot tube and Pitot-static probe, variable head meters, variable area meters, current meters, positive displacement meters, electromagnetic meters.

Mechanical Operation: Size reduction: crushing, grinding, pulverizing; mechanical separation, filtration, settling, sedimentation, screening, flotation.

Solid-Liquid Operations: Adsorption equilibria – batch and fixed bed adsorption; drying mechanism-drying curves time of drying; batch and continuous dryers, extraction, co-current and counter current extraction, leaching principles-single stage and multiple stage leaching.

Learning Resources:

Text Books:

1. Unit Operations of Chemical Engineering, W.L McCabe, J.C. Smith and P. Harriott, McGraw Hill, 1993, 7th Edition.

Reference Books:

1. Transport Processes and Separation Processes Principles, Christie J Geankoplis, Prentice Hall, 2003, 4th Edition.
2. Transport Phenomena, R. B. Bird, W. E. Stewart and E. N. Lightfoot, John Wiley, 2006, 2nd Edition.
3. Chemical Engineering, Coulson, J.M. and J.F. Richardson, Butterworth - Heinemann,



1991, 4th Edition.

Online Resources:

1. <https://nptel.ac.in/content/storage2/courses/101103004/pdf/mod7.pdf>



Course Code: BT262	GENETICS	Credits 3-0-0:3
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Pre-Requisites: None

Course Outcomes:

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

CO1	Understand Mendelian inheritance and deviations from Mendelism.
CO2	Comprehend concepts of chromosomal inheritance, linkage and crossing over.
CO3	Study chromosomal aberrations and mutations.
CO4	Describe the basics of human molecular genetics and their applications.
CO5	Clarify the theory of population and evolutionary genetics.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Physical Basis of Heredity: Basic law of inheritance, deviations of Mendel's ratios due to gene interaction, epistasis, concept of alleles, dominance, and complementation test.

Linkage, Recombination and Gene Mapping Methods: Chromosomal theory of heredity, concept of linkage, crossing over and mapping to genes by recombination frequency, linkage of genes on the X chromosome, linkage maps, sex influence and sex-limited traits, sex linked disorders in human beings.

Mutation and Extra Chromosomal Inheritance: Change in chromosome number and structure, mutation, maternal inheritance, inheritance of mitochondrial and chloroplast genes, transposable elements.

Human Molecular Genetics and Application: Pedigree analysis, genetic disorders, human gene therapy; DNA profiling; genome engineering – CRISPR/CAS9 system for cleaving DNA molecules.

Population and Evolutionary Genetics: Allele frequency, natural selection, random genetic drift, genetic variation in natural population, molecular evolution, speciation.

Learning Resources:

Text Books:

1. Principles of Genetics, D. Peter Snustad, Michael J. Simmons, Wiley, 2016, 7th Edition.
2. Genetics, Strickberger M.W., Prentice Hall India, 2008, 3rd Edition.
3. Human molecular genetics, Tom Strachan, Andrew P. Read, CRC Press, 2019, 5th Edition.



Reference Books:

1. Genetics A conceptual approach, Benjamin A Pierce, W. H. Freeman and co., 2017, 6thEdition.
2. Principles of genetics, Robert H. Tamarin, McGraw-Hill Company, 2001, 7thEdition.

Online Resources:

1. <https://nptel.ac.in/noc/courses/noc19/SEM1/noc19-bt05/>



Course Code: BT263	BIOPHYSICS	Credits 3-0-0:3
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Pre-Requisites: BT203

Course Outcomes:

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

CO1	Define ergocity in a system and concept of ensembles
CO2	Understand forces involved in biological systems
CO3	Illustrate difference between quantum and molecular mechanics
CO4	Identify stochastic and deterministic simulation techniques
CO5	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
CO1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO2	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO3	2	-	-	-	-	-	-	-	-	-	-	-	-	1	-
CO4	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CO5	-	2	-	-	2	-	-	-	-	-	-	-	-	2	-

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

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.

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.

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.

Learning Resources:

Text Books:

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



Reference Books:

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

Online Resources:

1. <https://nptel.ac.in/courses/115/101/115101121/>



Course Code: BT311	BIOCATALYSIS AND BIOTRANSFORMATIONS	Credits 3-0-0:3
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Pre-Requisites: BT203

Course Outcomes:

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

CO1	Understand the progression of biotransformation
CO2	Describe the classification of enzymes
CO3	Comprehend the applications of biocatalysis
CO4	Review commonly used enzyme preparations
CO5	Demonstrate the methods used for enzyme immobilization

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction: History of industrial biotransformations, biocatalysis, advantages and limitations of biocatalysis.

Enzymes: Enzyme classification, nomenclature, classes, enzyme properties, commonly used enzyme preparations, isolated enzymes vs. whole cell systems, immobilization; modified and artificial enzymes. mechanistic aspects of enzyme catalysis, coenzymes, enzyme sources, retrosynthetic biocatalysis, optimization of biocatalysis.

Biocatalytic Applications: Hydrolytic reactions, mechanistic and kinetic aspects, reduction reactions, oxidation reactions, addition and elimination reactions, transfer reactions, halogenation and dehalogenation reactions.

Analytical Techniques: Specialized techniques, biotransformation at industrial scale, quantitative analysis of industrial biotransformation.

Learning Resources:

Text Books:

1. Industrial Biotransformations, Andreas Liese, Karsten Seelbach, Christian Wandrey, Wiley-VCH; 2006, 2nd Edition.
2. Biotransformations in Organic Chemistry: A Textbook, Kurt Faber, Springer; 2011, 6th Edition.

Reference Books:

1. Biocatalysis: Fundamentals and Applications, Andreas S. Bommarius, Bettina R, Wiley-VCH; 2004, 1st Edition.



Online Resources:

1. https://nptel.ac.in/content/syllabus_pdf/104105032.pdf
2. <https://nptel.ac.in/courses/102/102/102102033/>



Course Code: BT312	FOOD BIOTECHNOLOGY	Credits 3-0-0:3
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Pre-Requisites: None

Course Outcomes:

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

CO1	Explain the components and nutritional value of foods
CO2	Describe nutraceuticals and their impact on health
CO3	Identify microbes that preserve and spoil foods
CO4	Comprehend various fermentation processes in food industry
CO5	List out various industrial production processes and quality measures

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction to Food Biotechnology: Components of food: carbohydrates, proteins, fats, nutrition: balanced diet, food pyramid, essential amino acids, fatty acids, vitamins, minerals, anti-nutrients, nutrition deficiency diseases, protein energy malnutrition, scurvy, rickets, beriberi, hypocalcemia, osteomalacia, vitamin K deficiency, pellagra, xerophthalmia.

Nutraceuticals Vs Pharmaceuticals: Nutraceuticals vs pharmaceuticals, prebiotics, probiotics, lactose intolerance, micronutrients, nuts and grains, phyto-nutraceuticals, bio-fortification, life style disorders: diabetes, ischemic heart disease, stroke, peripheral arterial disease, congenital heart disease and need of personalized nutrition.

Food Processing: Microorganisms in food processing and their characteristics, sources, use of enzymes in food industry, sources, production of single cell protein and application in food industry, genetically modified food, vegetables, fruits, fishes, fermented food, industrial production and preservation of fermented foods, dairy products, cheeses, yogurt and acidophilus milk, edible mushrooms and their cultivation.

Food Preservation and Processing: Food spoilage, bacterial agents of food borne illness - *Clostridium*, *Vibrio* and *Salmonella* species, nonbacterial agents of food borne illness – protozoa, algae, fungi, viruses, food preservation, role of chemicals in food preservation, meat and fish preservation, food additives, food sweeteners and colors, quality materials used in food processing (e.g.: Vinegar, acetic acid, citric acid, lactic acid), food quality and safety standards by European food safety authority (EFSA) and the United States Food and Drug Administration (USFDA).



Learning Resources:

Text Books:

1. Fundamentals of Food Biotechnology, B.H. Lee, John Wiley & sons Ltd, 2015, 1st Edition.
2. Introduction to Food Biotechnology, P. J. Green, CRC, 2002, 1st Edition.
3. Modern Food Microbiology, J. M. Jay, M. J. Loessner, and D. A. Golden, Springer, 2006, 7th Edition.

Reference Books:

1. Food Biotechnology, K. Shetty, G. Paliyath, A. Pometto, and R. E. Levin, CRC, 2005, 2nd Edition.
2. Food Biotechnology, SC Bhatia, Woodhead Publishing, 2013, 1st Edition.



Course Code: BT313	CANCER BIOLOGY	Credits 3-0-0:3
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Pre-Requisites: BT253

Course Outcomes:

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

CO1	Understand the cellular and molecular mechanisms of cancer.
CO2	Identify the factors that contribute to cancer development.
CO3	Appraise the various genetic and molecular changes normal cells undergo during transformation into malignant cancer cells.
CO4	Identify currently available therapeutic treatments for cancer

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Etiology of Cancer: Introduction to cancers, classification and characterization of cancers, causes of cancer, carcinogens, infectious agents as carcinogens, hallmarks of cancer, cancer genes: mutations and cancer development, two-hit hypothesis, hereditary cancer syndromes.

Molecular Basis of Cancer: Tumor viruses and oncogenes, tumor-suppressor genes, cell cycle checkpoints, defects in DNA repair and predispositions to cancer, p53 and apoptosis, telomeres in cancer, invasion and metastasis, molecular mechanism of metastasis, epithelial-mesenchymal transition, cancer epigenetics.

Survival Strategies of Cancer: Cancer cell signaling networks, role of immune system in cancer: inflammation, tumor associated macrophages, role of angiogenesis in cancer, stem cells and cancer: Wnt signaling, Hh signaling, cancer stem cells.

Diagnosis and Therapy: Cancer prevention: nutrients, energy metabolism of tumors, hormones and gene interactions, diagnosis of tumors: molecular diagnosis, molecular detection and classification; cancer vaccines, cancer therapy: conventional therapies, personalized and targeted therapies, immunotherapy, gene therapy, recent advances in anti-cancer therapies.

Learning Resources:

Text Books:

1. Introduction to Cancer Biology, Robin Hesketh, Cambridge University Press, 2012, 1stEdition.
2. Molecular Biology of Cancer: Mechanisms, Targets, and Therapeutics, Lauren Pecorino, Oxford University Press, 2012, 3rdEdition.



Reference Books:

1. The Biology of Cancer, Robert A Weinberg, New York: Garland Science, 2013, 2nd Edition.

Online Resources:

1. https://onlinecourses.swayam2.ac.in/aic20_ge02/preview
2. <https://www.cancer.gov/>



Course Code: BT361	BIOPOLYMER TECHNOLOGY	Credits 3-0-0:3
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Pre-Requisites: None

Course Outcomes:

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

CO1	Understand principles underlying manufacturing of biopolymers
CO2	Explain the characterization techniques and biodegradability properties of biopolymers
CO3	Identify the techniques for enhancing the mechanical strength of biopolymers
CO4	Explain the application biopolymers in diverse fields

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction to Biopolymers: Natural or biological polymers, protein-based polymers, carbohydrate-based polymers, polymers from renewable resources, advantages and limitations of biopolymers.

Manufacturing of Biopolymers and Processing: Chemical synthesis using petrochemical raw materials, chemical synthesis using bio-based feedstock, direct biosynthesis of biopolymers, modification of renewable feedstock, blending of biopolymers, compounding and additives, manufacture of bio composites, recycling.

Characterization and Testing of Biopolymers/ Biocomposite: Bulk analysis method (XRD, FTIR, DSC, TGA, etc...), Surface analysis techniques (SEM, TEM, AFM), mechanical properties of biopolymers.

Degradation of Biopolymers: Classes of biodegradable polymers, degradation mechanism, factor affecting degradation, measuring biodegradation of biopolymers.

Application of Biopolymers: Tissue engineering, film and composite coating, controlled release delivery systems, hydrocolloids and medicinal chemistry, agriculture and food security.

Learning Resources:

Text Books:

1. Biotechnology in Biopolymers Developments: Applications & Challenging Areas, Atul Tiwari and Ravi B. Srivastava, Smithers Rapra, 2012, 1st Edition.
2. Engineering Biopolymers-Markets, Manufacturing, Properties and Applications, Endres H.-J. and Siebert-Raths A., Hanser, 2011, 1st Edition.



Reference Books:

1. Handbook of biopolymers and biodegradable plastics: Properties, processing, and Applications, SinaEbnesajjad, Elsevier, 2013, 1st Edition.
2. Biosynthetic Polymers for Medical Applications, L. Poole-Warren, P. Martens and R. Green., Woodhead Publishing Series in Biomaterials, 2016, 1nd Edition.

Online Resources:

1. <https://nptel.ac.in/courses/103/106/105106205/>



Course Code: BT362	CULTIVATION OF MUSHROOM AND BIO-FERTILIZER PRODUCTION	Credits 3-0-0:3
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Pre-Requisites: None

Course Outcomes:

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

CO1	Understand mushroom morphology, cultivation and biofertilizer
CO2	Demonstrate bio-compositing technique for mushroom cultivation
CO3	Perform bio-composting for biofertilizer application
CO4	Appreciate the importance of self-employed and micro-entrepreneurship.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Mushroom Morphology and Classification: Edible and poisonous mushrooms, life cycle of basidiomycetes fungi, breeding and genetic improvement of mushroom strains, medicinal and nutritional value of mushrooms.

Mushroom Cultivation Techniques: Cultivation conditions for tropical and temperate countries, isolation, spawn production, growth media, spawn running and harvesting of mushrooms (*Volvariella* spp., *Pleurotus* spp., *Agaricus* spp., *Calocybe* spp., and *Lentinus* spp). Diseases / contamination; post-harvest technology: freezing, drying, freeze drying and canning.

Commercial Production of Mushroom Cultivation: Economics of the production of oyster mushroom, white mushroom and paddy straw mushroom cultivation, infrastructure facilities, expenditure on fixed assets, plant and machinery, cost of the project, interest and depreciation of the expenditure, cost of production and profit, micro-entrepreneurship in mushroom cultivation.

Composting Technique Methods: Introduction, history of composting, composting processes, microbiology of composting, fate of pathogens, ingredients in composting, various methods of composting: vermi-composting and home composting, steps in composting.

Bio-fertilizers and their Production: Introduction, microbes as bio-fertilizer, green manure, importance of macronutrients, bio-fertilizers vs chemical fertilizers; nitrogen fixers, types and examples; phosphate solubilizers, role of bacteria and mycorrhizae, mass cultivation and application of the bio-fertilizers: *Rhizobium*, *Azospirillum*, Cyanobacteria, Mycorrhizae, quality control, challenges and opportunities; bio-fertilizer micro-entrepreneurship.



Learning Resources:

Text Books:

1. Hand Book on Mushroom Cultivation, Nita Bahl, Vijay Primlani, Oxford & IBH Publishing, 2002 ,4th Edition.
2. Bio-fertilizers in Agriculture and Forestry. Subba Rao, N. S., India Book House, 1998, 1st Edition.

Reference Books:

1. The Biology and Cultivation of Edible Mushrooms. Chang, T.S. and Hayes, W.A. Academic Press,1978, 1stEdition.
2. Bio-fertilizers in Agriculture. Subba Rao, N. S., Oxford & IBH Publishing, 1988, 1stEdition.

Online Resources:

1. <https://nptel.ac.in/courses/102/104/102104068>
2. <https://freevidelectures.com/course/4678/nptel-industrial-biotechnology/54>



Course Code: BT363	ADVANCED BIOINFORMATICS	Credits 3-0-0:3
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Pre-Requisites: BT255

Course Outcomes:

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

CO1	Understand the importance of data mining approaches in mining high throughput data for knowledge discovery
CO2	Comprehend the sequence data acquisition and annotation methods for genome mapping and annotation
CO3	Utilize data submissions tools for submission of different types of biological data
CO4	Comprehend the databases available for metabolic diseases data analysis

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Data mining: introduction to data mining, text mining, transactional data, other kinds of data mining, Knowledge Discovery in Databases (KDD), web search engines, diversity of database types, data mining and society, efficiency and scalability. data warehouses, differences between operational database systems and data warehouses.

Sequence data acquisition and annotation methods: Protein sequencing, DNA sequencing, classical sequencing approaches, NGS sequencing methodology, various NGS platforms, contigs, chromosome and genome mapping, annotation of genomic data.

Data submission tools: sequence - BankIt, SPIN, WEBIN, Sequin, SAKURA. structure - ADIT, pdb_extract, AutoDep, EMDep, OneDep.

Metabolic Disease Databases: OMIM, KEGG, METAGENE, OMMBID, HMDB, Ramedis, BiGG, SYSTOMONAS, Reactome, HumanCyc, MetaCyc, drug database for inborn errors of metabolism (DDIEM).

Learning Resources:

Text Books:

1. Bioinformatics, Andreas D. Baxevanis, Gary D. Bader, David S. Wishart, Wiley, 2019, 4th Edition.
2. Introduction to Bioinformatics, Arthur M. Lesk, Oxford University Press, 2019, 5th Edition.

Reference Books:



1. Essential Bioinformatics, JinXiong, Cambridge University Press, 2006, 1st Edition.
2. Translational Bioinformatics in Healthcare and Medicine, Khalid Raza, Nilanjan Dey, Elsevier Science, 2020, 1st Edition.

Online Resources:

1. <https://academic.oup.com/bib/article/20/6/1981/5066445>
2. <http://bcb.unl.edu/yyin/teach/PBB2015/The%20origins%20of%20bioinformatics.pdf>



Course Code: BT461	BIOFUELS ENGINEERING	Credits 3-0-0:3
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Pre-Requisites: BT203, BT301

Course Outcomes:

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

CO1	Identify and select appropriate biomass sources for biofuels production
CO2	Comprehend the biochemical pathways associated with energy harvesting
CO3	Describe the production process of liquid, gaseous biofuels and bioelectricity
CO4	Apply bioreactor design strategies for efficient biofuel production
CO5	Appreciate the entrepreneurial opportunities in bioenergy

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction to Biofuels: Overview of biofuels, introduction to biorefinery, harvesting energy from biochemical reactions, national biofuel policy and law.

Liquid and Gaseous Biofuels: Biofuel feedstocks, biomass conversion technologies, ethanol production from different feed stocks, biodiesel production chemistry and thermodynamic aspects, drop-in biofuels, microbial engineering for biofuels production, biological production of hydrogen and methane, biomass gasification, pyrolysis and combustion.

Microbial Modeling and Bioreactor Design for Biofuels: Summary of microbial growth models, bioreactor operation and design for biofuel production, bioreactor design strategies.

Bioelectricity: Microbial fuel cells (MFC), fuel cell design and MFC performance, biopower production process, micro-entrepreneurial opportunities in bioenergy.

Learning Resources:

Text Books:

1. Biofuels Engineering Process Technology, Caye M. Drapcho; NhuậnPhúNghiem; Terry H. Walker, McGraw Hill: New York, 2020, 2nd Edition.
2. Bioenergy Biomass to Biofuels and Waste to Energy Second Edition, Anju Dahiya, Academic Press, 2020, 2nd Edition.

Reference Books:

1. Bioenergy Research: Advances and Applications, Vijai K. Gupta Elsevier B.V.



Netherlands, 2014, 1st Edition.

2. Introduction to Bioenergy (Energy and the Environment), Vaughn C. Nelson, Kenneth L. Starcher, CRC Press, 2011, 1st Edition.

Online Resources:

1. <https://nptel.ac.in/courses/102/104/102104057>



Course Code: BT462	NEUROBIOLOGY	Credits 3-0-0:3
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Pre-Requisites: None

Course Outcomes:

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

CO1	Understand neuronal architecture
CO2	Describe the underlying molecular mechanisms of neuron communication
CO3	Comprehend neuron characterization and differentiation
CO4	Understand the effects of pharmaceutical drugs on neurons
CO5	List out the human diseases related to the nervous system

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction to Nervous Systems: Central and peripheral nervous systems.

Neuro Anatomy–I: Structure and functions of neurons, synapse. their function, signals produced by neurons, sensors function, glial cells.

Neuro Anatomy–II: Molecular and cellular organization of neuronal differentiation, characterization of neuronal cells. neurophysiology, conduction of impulses by neurons, correlation of sensory functions.

Neuro Pharmacology: Pharmaceutical mediator, released by neurons. hormones and their effect on neuronal function. neurological disorders pathogenesis, genetic basis of neurological disorders.

Learning Resources:

Text Books:

1. Medical Neurobiology, Mason Peggy., Oxford University Press, 2017, 2nd Edition.

Reference Books:

1. Neurobiology, Mathews GaryG, Blackwell Science, 2001, 2nd Edition.
2. Neuro Biology, Gordon M. Shepherd, Oxford University Press, 1994, 3rd Edition.



Course Code: BT463	GENOMIC DATA ANALYSIS	Credits 3-0-0:3
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Pre-Requisites: None

Course Outcomes:

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

CO1	Identify the genomics technologies to generate different genomics data
CO2	Understand the use of different types of genomics data for biomedical applications
CO3	Apply the mathematical and statistical tools for analyzing the genomics data
CO4	Categorize human disease through genomics

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Genomics Data and Technology: Introduction to genomics and transcriptomics data, whole-genome sequencing, genomic data preprocessing, data scaling (TPM, FPKM, RSEM), mapping, RNA-Seq, copy number variation (CNV), alternative splicing, methylation data analysis, non-coding RNA, Expression quantitative trait loci (eQTL), Splicing Quantitative Trait Loci (sQTL), SNP and genome-wide association studies (GWS).

Statistics in Genomics Data Analysis: Variables in genomics data; statistical test: p-value; false discovery rate; hypergeometric test; chi-square test; fisher's exact test; regression analysis - ridge, lasso, elastic net; unsupervised and supervised learning techniques for multivariate data, confusion matrix, receiving operating curve.

Genomic Data in Phenotype Prediction: Concept of genotype and phenotype: omni-genic model; genomics relationship matrix (GRM), functional analysis of genomic data, cancer genomics, multi-omics approaches in phenotype prediction, genomics data to molecular network, case studies.

*Along with theory classes, hands-on sessions will be conducted.

Learning Resources:

Text Books:

1. Statistics and Data Analysis for Microarrays Using R and Bioconductor, by Sorin Draghici (Chapman & Hall/CRC Computational Biology Series Book 4), 2016, 2nd Edition.



2. Intuitive Biostatistics, Motulsky H, Oxford University Press, 2009, 2nd Edition.

Reference Books:

1. Bioinformatics for Geneticists: A Bioinformatics Primer for the Analysis of Genetic Data, Michael R. Barnes, Wiley, 2007, 2nd Edition.
2. Genome Data Analysis by Kim, Ju Han, Springer, 2019, 1st Edition.

Online Resources:

(Research articles):

1. Biological data sciences in genome research, Genome Research. 2015. 25: 1417-1422 (<https://genome.cshlp.org/content/25/10/1417.full>)
2. Genome-wide association studies of cancer: current insights and future perspectives. Nature Reviews Cancer 17, 692–704 (2017) (<https://www.nature.com/articles/nrc.2017.82>)
3. Statistical and integrative system-level analysis of DNA methylation data, Nature Reviews Genetics volume 19, pages129–147 (2018) (<https://www.nature.com/articles/nrg.2017.86>)



Course Code: BT464	PRINCIPLES OF BIOSAFETY, BIOETHICS & INTELLECTUAL PROPERTY RIGHTS	Credits 3-0-0:3
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Pre-Requisites: None

Course Outcomes:

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

CO1	Understand basic principles of biosafety and follow good laboratory practices
CO2	Identify design requirements of confinement facilities at different biosafety levels
CO3	Understand the societal and bioethical issues related to modern biotechnology.
CO4	List out the different forms of intellectual property rights
CO5	Comprehend international agreements and protocols for biosafety, bioethics and IPR

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction to Biosafety: Historical background, introduction to biological safety cabinets, primary containment for biohazards, biosafety levels, biosafety levels of specific microorganisms, recommended biosafety levels for infectious agents and infected animals, biosafety guidelines.

GMOs & LMOs: Roles of institutional biosafety committee (IBC), RCGM, GEAC, for GMO applications in food and agriculture, environmental release of GMOs, overview of national regulations and relevant international agreements – convention on biological diversity, Cartagena protocol.

Introduction to Intellectual Property Types: Patents, trademarks, copyright & related rights, industrial design, traditional knowledge, geographical indications, intellectual property as a factor in R&D; intellectual property of relevance to biotechnology.

Patents: Indian Patent Act and amendments, patents and concept of prior art, patent databases and patent search, invention in context of “prior art”, types of patent applications: ordinary, PCT, conventional, divisional and patent of addition, specifications: provisional and complete; precautions while patenting – disclosure / non-disclosure, patent licensing, patent infringement, patent ever-greening, case studies.

Agreements and Treaties: World Intellectual Property Organization (WIPO); Paris convention, Bernie convention, Budapest Treaty; Patent cooperation Treaty, (PCT). World Trade Organization, History of GATT and TRIPS agreement.

Bioethics: Historical background of modern bioethics, ethical principles and guidelines for research involving human subjects, Nuremberg code of bioethics, world medical council,



Declaration of Helsinki, National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research, and the essence of Belmont Report.

Learning Resources:

Text Books:

1. Biosafety in Microbiological and Biomedical Laboratories, Paul J. Meechan, Jeffrey Potts, CDC / NIH Publication, 2020, 6th Edition.

Reference Books:

1. World Intellectual Property Hand Book, WIPO Publication, 2004, 2nd Edition.
2. The Ethics of Research with Human Subjects, David B. Resnik, Springer International Publishing, 2018, 1st Edition.

Online Resources:

1. https://www.cdc.gov/labs/pdf/SF_19_308133-A_BMBL6_00-BOOK-WEB-final-3.pdf
2. https://www.wipo.int/edocs/pubdocs/en/intproperty/489/wipo_pub_489.pdf