CURRICULUM & SYLLABI

B.Tech. BIOTECHNOLOGY

Effective from AY: 2024-25



NATIONAL INSTITUTE OF TECHNOLOGY WARANGAL

WARANGAL, TELANGANA

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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
Biotechnology

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

MISSION
- Providing a quality education in pursuit of knowledge that establishes a strong foundation for understanding 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.

Program: 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 / Mission Statements	PEO-1	PEO-2	PEO-3	PEO-4	PEO-5
Providing a quality education in pursuit of knowledge that establishes a strong foundation for understanding developments in the rapidly advancing field of biotechnology through research and instruction	3	2	2	2	3
Promoting scientific discovery and development in diversified fields of Biotechnology through a fusion between engineering and life sciences.	3	3	2	2	3
Fostering relationships with institutes of higher learning and research, alumni and industries	2	3	2	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Program: B.Tech. Biotechnology

Program Outcomes

PO-1	**Engineering knowledge**: Apply the knowledge of mathematics, science, 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 modeling 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 and responsibilities and norms of the engineering practice.
PO-9	**Individual and team work:** 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.

CURRICULUM
B.Tech. Biotechnology

1st Semester

S.No.	Code	Course Title	L-T-P	Credits
1	MA1161	Linear Algebra, Calculus and Ordinary Differential Equations	3-0-0	3
2	CY1161	Engineering Chemistry	3-0-2	4
3	EE1161	Basic Electrical & Electronics Engineering	3-0-0	3
4	BT1101	Design Thinking	0-1-4	3
5	ME1161	Engineering Drawing	1-0-4	3
6	EE1263	Basic Electrical & Electronics Engineering Lab	0-1-2	2
7	IC1101	EAA-I (Games & Sports / Yoga & Wellness)	0-0-0	0
			Total Credits	**18**

2nd Semester

S.No.	Code	Course Title	L-T-P	Credits
1	MA1162		3-0-0	3
2	PH1161	Engineering Physics	3-0-2	4
3	CS1101	Programming and Data Structures	3-0-0	3
4	BT1161	Biology for Engineers	2-0-0	2
5	HS1161	English for Technical Communication	2-0-2	3
6	BT1102	Bioprocess Calculations	3-0-0	3
7	CS1103	Programming and Data Structures Lab	0-1-2	2
8	IC1102	EAA-II (Games & Sports / Yoga & Wellness)	0-0-0	0
			Total Credits	**20**

3rd Semester

S.No.	Code	Course Title	L-T-P	Credits
1	BT1201	Biocomputing	3-0-0	3
2	BT1203	Biochemical Thermodynamics	3-0-0	3
3	BT1205	Microbiology	3-0-0	3
4	BT1207	Biochemistry	3-0-0	3
5	BT1209	Biostatistics	3-0-0	3
6	BT1211	Microbiology Lab	0-1-2	2
7	BT1213	Biochemistry Lab	0-1-2	2
		Total Credits		**19**

4th Semester

S.No.	Code	Course Title	L-T-P	Credits
1	MA1261	Fourier Series, Partial Differential Equations and Complex Variables	3-0-0	3
2	BT1202	Biological Reaction Engineering	3-0-0	3
3	BT1204	Bioinformatics	3-0-2	4
4	BT1206	Cell Biology	3-0-0	3
5	BT1208	Molecular Biology and Genetics	4-0-0	4
6	BT1210	Biocomputing Lab	0-1-2	2
7	BT1212	Cell Biology and Molecular Biology Lab	0-1-2	2
		Total Credits		**21**

5th Semester

S.No.	Code	Course Title	L-T-P	Credits
1	MS1262	Business Essentials for Engineers	3-0-0	3
2	BT1301	Bioprocess Engineering	3-0-0	3
3	BT1303	Genetic Engineering	3-0-0	3
4	BT1305	Immunology	3-0-0	3
5	BT13XX	Professional Elective - I	3-0-0	3
6	BT1381	Fractal Course – I	1-0-0	0.5
7	BT1307	Bioprocess and Bioreaction Engineering Lab	0-1-2	2
8	BT1309	Genetic Engineering and Immunology Lab	0-1-2	2
		Total Credits		**19.5**

6th Semester

S.No.	Code	Course Title	L-T-P	Credits
1	BT1302	Downstream Processing	3-0-2	4
2	BT1304	Bioprocess Instrumentation and Control	3-0-0	3
3	BT13XX	Professional Elective – II	3-0-0	3
4	BT13XX	Professional Elective – III	3-0-0	3
5	BT1306	Product Development	0-1-4	3
6	BT1382	Fractal Course – II	1-0-0	0.5
7	BT1308	Bioprocess Instrumentation and Control Lab	0-1-2	2
8	BT1310	Computational Methods in Drug Discovery Lab	0-1-2	2
		Total Credits		**20.5**

7th Semester

S.No.	Code	Course Title	L-T-P	Credits
1	BT1401	Modelling Simulation and Optimization of Bioprocesses	3-0-0	3
2	BT14XX	Professional Elective – IV	3-0-0	3
3	BT14XX	Professional Elective – V	3-0-0	3
4	BT14XX	Open Elective - I	2-0-0	2
5	BT1403	Modelling Simulation and Optimization of Bioprocesses Lab	0-0-2	1
6	BT1405	Instrumentation Methods in Biotechnology Lab	0-0-2	1
7	BT1489	Seminar & Technical Writing	0-0-0	2
8	BT1491	Short Term Industrial / EPICS / Research Experience	0-0-0	2
9	BT1495	Minor Project	0-0-0	2
		Total Credits		**19**

8th Semester

S.No.	Code	Course Title	L-T-P	Credits
1	BT14XX	Professional Elective – VI	3-0-0	3
2	BT14XX	Professional Elective – VII	3-0-0	3
3	BT14XX	Professional Elective – VIII	3-0-0	3
4	BT1498	Major Project	0-0-0	6
		Total Credits		**15**

Professional Elective Courses:

Professional Elective - I		
S.No.	**Code**	**Course Title**
1	BT1321	Industrial Biotechnology
2	BT1323	Biodiversity and Conservation
3	BT1325	Biological Programming

Professional Elective - II, III		
S.No.	**Code**	**Course Title**
1	BT1322	Biophysics
2	BT1324	Enzyme Technology
3	BT1326	Biomaterials Engineering
4	BT1328	Plant Biotechnology
5	BT1330	Unit Operations in Biotechnology
6	BT1332	Advanced Bioinformatics

Professional Elective - IV, V		
S.No.	**Code**	**Course Title**
1	BT1421	Genomic Data Analysis
2	BT1423	Structural Biology
3	BT1425	Cancer Biology
4	BT1427	Transport Phenomena in Bioprocess Systems
5	BT1429	Molecular Pathogenesis
6	BT1431	Systems Biology

Professional Elective - VI, VII, VIII		
S.No.	**Code**	**Course Title**
1	BT1422	Environmental Biotechnology
2	BT1424	Protein Engineering
3	BT1426	Metabolic Engineering
4	BT1428	Biosensors
5	BT1430	Nanobiotechnology
6	BT1432	Animal Biotechnology

7	BT1434	Pharmaceutical Biotechnology
8	BT1436	Analytical Biotechnology
9	BT1438	Biosafety, Bioethics & IPR

Basic Science Courses

S.No.	Code	Course Title	L-T-P	Credits
1	MA1161	Linear Algebra, Calculus and Ordinary Differential Equations	3-0-0	3
2	CY1161	Engineering Chemistry	3-0-2	4
3	MA1162	Integral and Vector Calculus, Laplace and Fourier Transforms	3-0-0	3
4	PH1161	Engineering Physics	3-0-2	4
5	MA1261	Fourier Series, Partial Differential Equations and Complex Variables	3-0-0	3

Engineering Science Courses

S.No.	Code	Course Title	L-T-P	Credits
1	EE1161	Basic Electrical & Electronics Engineering	3-0-0	3
2	ME1161	Engineering Drawing	1-0-4	3
3	BT1101	Design Thinking	0-1-4	3
4	EE1263	Basic Electrical & Electronics Engineering Lab	0-1-2	2
5	CS1101	Programming and Data Structures	3-0-0	3
6	BT1161	Biology for Engineers	2-0-0	2
7	CS1103	Programming and Data Structures Lab	0-1-2	2

Humanities and Social Science Courses

S.No.	Code	Course Title	L-T-P	Credits
1	HS1161	English for Technical Communication	2-0-2	3
2	MS1262	Business Essentials for Engineers	3-0-0	3

The Overall Credit Structure

Course Category	Credits
Basic Science	17
Engineering Science	18
Humanities and Social Sciences	6
Program Core	72
Professional Elective	24
Open Elective	2
Seminar and Technical Writing	2
Minor Project	2
Short Term Industrial / EPICS/ Research Experience	2
Fractal Course	1
Major Project	6
Total Graded Credit Requirement	**152**

Minor in Biotechnology:

Code	Course Title	L-T-P	Credits
BT1M01	Essential Biochemistry	2-0-2	3
BT1M02	Foundations in Cell Biology	2-0-2	3
BT1M03	Principles of Bioprocess Engineering	2-0-2	3
BT1M04 / BT1M06	Elements of Bioseparations Technology / Systems Biology for Engineers	2-0-2	3
BT1M05 / BT1M07	*In silico* Drug Discovery / Introductory Modelling Simulation and Optimization of Bioprocesses	2-0-2	3
		Total	**15**

Honors in Biotechnology:

Code	Course Title	L-T-P	Credits
BT1H01	Nutrigenomics	3-0-0	3
BT16004	Biomaterials and Tissue Engineering	3-0-0	3
BT1H02	Agricultural Biotechnology	3-0-0	3
BT16021	Recombinant DNA Technology	3-0-0	3
BT16025	Bioeconomy and Biorefineries	3-0-0	3
		Total	**15**

SYLLABI

B.Tech. Biotechnology

1st Semester

MA1161 **3-0-0 (3)**

Linear Algebra, Calculus and Ordinary Differential Equations

Pre-Requisites: **None**

Course Outcomes:

CO-1	Understand to solve the consistent system of linear equations
CO-2	Apply orthogonal transformations to a quadratic form
CO-3	Determine the series expansion of a given function
CO-4	Explore the properties of functions of several variables
CO-5	Solve arbitrary order linear differential equations

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3
CO-1	3	3	1	2	1	–	–	–	–	–	–	–	1	1	1
CO-2	3	3	1	2	1	–	–	–	–	–	–	–	–	–	1
CO-3	3	3	1	2	1	–	–	–	–	–	–	–	1	–	1
CO-4	3	3	1	2	1	–	–	–	–	–	–	–	–	–	–
CO-5	3	3	1	2	1	–	–	–	–	–	–	–	2	1	1

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Linear Algebra: Vector space, Subspace, Examples, Linear span, Linear independence and dependence, Basis, Dimension, Extension of a basis of a subspace, Intersection and sum of two subspace, Examples. Linear transformation, Kernel and Range of a linear map, Rank-Nullity Theorem (without proof). Rank of a matrix, Row, and column spaces, Solvability of the system of linear equations, Inner product spaces, Orthogonal basis, Gram-Schmidt orthogonalization process. Eigenvalues, Eigenvectors, and properties Caley-Hamilton Theorem (without proof) and applications, diagonalization of a matrix, diagonalization by similarity, and orthogonal transformations.

Differential Calculus: Taylor's theorem with remainders; Taylor's and Maclaurin's expansions; Functions of several variables – continuity, differentiability, partial derivatives, Euler's theorem, change of variables, Jacobians, Functional dependence; Maxima andminima of functions of several variables (2 and 3 variables) - Lagrange's method of multipliers.

Ordinary Differential Equations: First order differential equations - Basic definitions, Geometric interpretation of solutions of first-order ODE $y' = f(x, y)$, Exact differential equations, Integrating factors, Linear equation, Reducible to linear form: Bernoulli's equations; Orthogonal trajectories; Higher order linear differential equations with constant coefficients - Cauchy-Euler and Legendre's differential equations, Method of variation of parameters - System of linear differential equations; Applications to physical problems.

Learning Resources:

Text Books:

1. Howard Anton and Chris Rorres, Elementary Linear Algebra with Supplementary Applications, John Wiley & Sons, 2014, 11th Edition
2. George B. Thomas and Ross L. Finney, Calculus and Analytic Geometry, Pearson, 2020, 9th Edition

3. Erwin Kreyszig, Advanced Engineering Mathematics, John Wiley and Sons, 2015, 8th Edition

Reference Books:

1. Dennis G. Zill, Advanced Engineering Mathematics, Jones & Bartlett Learning, 2018, 6th Edition
2. R. K. Jain and S. R. K. Iyengar, Advanced Engineering Mathematics, Narosa Publishing House, 2016, 5th Edition

CY1161 **3-0-2 (4)**

Engineering Chemistry

Pre-Requisites: **None**

Course Outcomes:

CO-1	Understand the basic concepts of chemistry relevant to materials
CO-2	Apply electrochemical concepts for energy harvesting, conversion and storage
CO-3	Analyze the properties of materials for various applications
CO-4	Comprehend the concepts of instrumentation principles, Spectroscopy and procedures involved in characterization of materials
CO-5	To analyze the metal contents from the ores by understanding the redox process
CO-6	To determine the rate of corrosion by a redox reaction and understand the concept of adsorption

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3
CO-1	3	–	–	–	–	–	–	–	–	–	–	–	–	2	–
CO-2	3	–	–	–	–	–	–	–	–	–	–	–	2	2	1
CO-3	3	2	–	–	–	–	–	–	–	–	–	–	2	2	1
CO-4	3	–	–	–	–	–	–	–	–	–	–	–	2	2	1
CO-5	3	3	3	–	2	–	2	–	–	–	–	–	1	1	–
CO-6	3	3	3	–	2	2	–	–	–	1	–	–	1	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Chemical Kinetics and Thermodynamics: Order of a Reaction, Theories of Reaction Rates. Homogeneous and Heterogeneous Catalysis. Thermodynamic variables, Laws of Thermodynamics, Thermodynamic Relationships and Applications.

Electrochemistry and Energy Systems: Introduction to Electrochemistry, Nernst's law and its applications. Batteries, fuel cell and photo-electrochemical systems. Corrosion and its prevention.

Transition Metal Chemistry and Organometallic Chemistry: Bonding in transition metal complexes; Crystal field and MO Theories, Jahn-Teller effect. Properties of Coordination complexes; Metal Carbonyls, EAN and 18-electron rule, Ligands and hapticity; Type of reactions: Oxidative addition, Reductive elimination, Migratory insertion, Hydrogenation, Hydro formylation, Monsanto process and Wacker process.

Engineering Materials: Inorganic and Organic Semiconductors, Magnetic materials, Liquid crystals, Superconductors, Photo conducting Materials and conducting polymers.

Chromatographic and Spectroscopic Methods: Liquid Chromatographic and Gas Chromatographic methods. UV-VIS, spectroscopy, Infrared spectroscopy, NMR spectroscopy.

List of Experiments:

1. Standardization $KMnO_4$ solution.
2. Estimation of metal content in an ore.
3. Estimation of Calcium in milk powder by complexometry.
4. Extraction and identification of DNA from green peas/onions.
5. Estimation of iodine in iodized common salt.

6. Blue printing of an object by photochemical reaction.
7. Kinetics of acid hydrolysis of methyl acetate.
8. Determination of acid strength in citrus fruit.
9. Verification of Beer-Lambert Law and estimation of concentration of food color.
10. Evaluation of E^o values of $Zn|Zn^{2+}$ and $Cu|Cu^{2+}$ Electrodes and measure the emf by constructing the Daniel cell.
11. Estimation of phosphoric acid in soft drinks by pH metry.
12. Separation of natural pigments from mixture using paper chromatography.
13. Determination of efficiency of a corrosion inhibitor.
14. Verification of Freundlich adsorption isotherm.
15. Preparation of a polymer and its analysis.
16. Estimation of active pharmaceutical ingredient in a drug.

Learning Resources:

Text Books:

1.Shashi Chawla, A Text Book of Engineering Chemistry, Danpathrao & Co. Publications, 2007, 6th India reprint Edition
2. Ashutosh Kar, Text Book of Engineering Chemistry, ED-Tech Publications, 2018
3. William Kemp, Organic Spectroscopy, Macmillan Education Limited, 2017
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. Michael F. Ashby/David R.H. Jones, Engineering Materials, Elsevier Science, 2012
2. V. Raghava, Material Science and Engineering, PHI Learning, 2015
3. J.M. Martin, Materials for Engineering, Elsevier Science, 2006
4. Peter Atkins, Julio de Paula, James Keeler, Physical Chemistry, Oxford University Press, 2018

EE1161 **3-0-0 (3)**

Basic Electrical & Electronics Engineering

Pre-Requisites: **None**

Course Outcomes:

CO-1	Analyze DC & AC circuits and determine power & power factor
CO-2	Understand the specifications of electrical machines
CO-3	Identify the type of electrical machines for a given application
CO-4	Analyze basic electronic circuits and estimate the illumination requirements

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3
CO-1	3	3	2	2	2	2	1	1	1	1	2	1	–	–	–
CO-2	3	3	2	2	2	2	1	1	1	1	2	1	–	–	–
CO-3	3	3	2	2	2	2	1	1	1	1	2	1	–	1	–
CO-4	3	3	2	2	2	2	1	1	1	1	2	1	1	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

DC Circuits: Kirchhoff's Voltage and Current Laws, Superposition Theorem, Star-Delta Transformations. **AC Circuits:** Complex representation of Impedance, Phasor diagrams, Power & Power Factor, Solution of 1-Phase Series & Parallel Circuits.

Single Phase Transformers: Principle of Operation of a Single-Phase Transformer, EMF Equation, Phasor Diagram, Equivalent Circuit of a 1-Phase Transformer, Determination of Equivalent circuit parameters, calculation of Regulation & Efficiency of a Transformer.

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 of 3-Phase Induction Motor & Applications, Principle of Operation of Alternator- EMF equation.

Illumination: Terminology, Laws of illumination and Luminance, Luminaries, LED Lighting (Qualitative). **Electric Heating**: Principles of resistance heating, induction heating and dielectric heating. (Qualitative). **Electronic Devices & Circuits:** P-type and N-Type semiconductors, P-N junction diode and its I-V characteristics, Single-phase Half-wave and Full wave rectifiers. Bipolar Junction Transistor-operation and CE, CC & CB configurations, Static Characteristics of SCR-MOSFET- IGBT.

Sensors & Transducers: Thermocouple, Thermistor, Resistance Temperature Detector, Hall effect and Piezoelectric Transducers (Qualitative Treatment only)

Electrical Measuring Instruments: Moving Coil & Moving iron ammeters & voltmeters. Wattmeter's (Qualitative).

Electronics Measurements: Principle of Operation of Digital Multi Meter & Cathode Ray Oscilloscope.

Learning Resources:

Text Books:

1. Edward Hughes, Electrical & Electronic Technology, Pearson Education, 2016, 12th Edition
2. Vincent Del Toro, Electrical Engineering Fundamentals, Pearson Education, 2015, 2nd Edition
3. V. K Mehtha, Principals of Electrical & Electronics Engineering, S. Chand Publications, New Delhi, 2010, 3rd Edition
4. V N Mittle and Arvind Mittal, Basic Electrical Engineering, Tata McGraw Hill, 2005, 2nd Edition

Reference Books:

1. Millman & Halkias, Integrated Electronics - Analog and Digital Circuit and Systems, Tata McGraw-Hill Education, 2017, 2nd Edition
2. U Bakshi & A. Bakshi, Basic Electrical Engineering, Technical Publications, 2019, 2019-Edition
3. A Fitzgerald, Charles Kingsley, Stephen Umans, Electrical Machines, McGraw Hill Education, 2017, 6th Edition
4. Stephen. J. Chapman, Electric Machinery, McGraw Hill International Edition, 2017, 4th Edition
5. P.S. Bimhbra, Electrical Machinery - Theory, Performance & Applications, Khanna Publishers 2014, 7th Edition

Other Suggested Readings:

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

ME1161 **1-0-4 (3)**

Engineering Drawing

Pre-Requisites: **None**

Course Outcomes:

CO-1	Apply BIS standards and conventions while drawing Lines, printing Letters and showing Dimensions
CO-2	Classify the systems of projection with respect to the observer, object and the reference planes
CO-3	Construct orthographic views of an object when its position with respect to the reference planes is defined
CO-4	Analyze the internal details of an object through sectional views
CO-5	Develop 3D Isometric View from 2D orthographic views

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3
CO-1	1	1	1	–	–	–	1	1	3	3	–	–	–	1	–
CO-2	1	1	1	–	–	–	1	1	3	3	–	–	–	1	–
CO-3	1	1	1	–	–	–	1	1	3	3	–	–	–	1	–
CO-4	1	1	1	–	–	–	1	1	3	3	–	–	–	1	–
CO-5	1	1	1	–	–	–	1	1	3	3	–	–	–	1	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

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)**

Isometric Views: Isometric axes, Isometric lines, Isometric Planes, Isometric scale, Isometric Views, Isometric projections. **(AutoCAD)**

Learning Resources:

Text Books:

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

Reference Books:

1. B. Agarwal, Engineering Drawing, McGraw Hill Education, 2015, 2nd Edition
2. S. Tickoo, Auto CAD 2017 for Engineers & Designers, Dreamtech, 2016, 23rd Edition

BT1101 **1-0-4 (3)**

Design Thinking

Pre-Requisites: **None**

Course Outcomes:

CO-1	Identify user needs
CO-2	Define problems to stimulate ideation
CO-3	Ideate on problems to propose solutions by working collaboratively
CO-4	Test aspects of proposed solutions
CO-5	Improve solutions by gaining user feedback

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3
CO-1	2	2	2	3	3	3	2	2	3	3	2	3	3	2	2
CO-2	2	2	2	3	3	3	2	2	3	3	2	3	3	2	2
CO-3	2	2	2	3	3	3	2	2	3	3	2	3	3	2	2
CO-4	2	2	2	3	3	3	2	2	3	3	2	3	3	2	2
CO-5	2	2	2	3	3	3	2	2	3	3	2	3	3	2	2

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction to Engineering: “Engineering” as a vehicle for social and economic development; impact of science/engineering our day to day lives; process of engineering a product; various career options.

Introduction and identifying the need: Understanding the unique needs of the user - empathize - define - ideate - prototype - test. Case Studies - Develop appreciation for the design process and its application in specific settings (Guest lectures, Videos, Field visits, Interplay lectures of design-based movies).

Problem Formulation: Framing a problem statement neutrally using adequate checks. Case studies.

Concept Generation: Generate multiple concepts using various creativity tools and thinking styles.

Prototyping: Select from ideas and make quick prototypes (mock-ups) using available material.

Evaluation: Iterative process of ideation, prototyping and testing-Take the mock-ups to users for feedback and iterate process till users feel delighted.

Activities:

Some of the activities which are undertaken as a part of this course include:

- Field Visits
- Case Studies on innovation, failures etc.
- Guest lecture
- Group Discussions
- Presentation by student
- Experiential learning workshops

Learning Resources:

Reference Books:

1. Andrew Pressman, Design Thinking: A guide to creative problem solving for everyone, Routledge Taylor and Francis group, 2019, 1st Edition
2. Tim Brown, Change by Design: How Design Thinking Transforms Organizations and Inspires Innovation, Harper Business, 2019
3. George E. Dieter, Linda C. Schmidt, Engineering Design, McGraw-Hill Education, 2019, 5th Edition
4. Ulrich, K., Eppinger, S. and Yang, M., Product design and development, 2020, 7th Edition

Other Suggested Readings:

1. https://www.arvindguptatoys.com/
2. https://honeybee.org/
3. https://dschool.stanford.edu/resources/getting-started-with-design-thinking
4. https://designthinking.ideo.com/

EE1263 **0-1-2 (2)**

Basic Electrical & Electronics Engineering Lab

Pre-Requisites: **None**

Course Outcomes:

CO-1	Select the range of apparatus based on the ratings of DC machines, transformers and induction machines
CO-2	Understand the operation of KVL, KCL and Superposition theorems applied to simple DC circuits
CO-3	Determine equivalent circuit parameters of transformers by conducting OC and SC tests
CO-4	Evaluate the performance of DC machines & its braking methods
CO-5	Evaluate the performance of AC machines and Transformers

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3
CO-1	3	3	3	2	2	2	2	1	2	3	1	1	–	–	–
CO-2	3	3	3	2	1	2	1	1	2	3	1	1	–	–	–
CO-3	3	3	3	1	1	2	1	1	2	3	1	1	–	–	–
CO-4	3	3	3	1	1	2	2	1	2	3	1	1	1	1	–
CO-5	3	3	3	1	1	2	2	1	2	3	1	1	1	1	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

List of Laboratory Experiments:

1. Electrical verification of Kirchhoff's voltage and current laws.
2. Verification of superposition theorem.
3. Calculation of the power factor and power in a Single phase series *RL* circuit.
4. No load test on a DC machine.
5. Load test on a DC shunt generator.
6. Speed control of a DC shunt motor.
7. Determination of equivalent circuit parameters of a single phase transformer.
8. Determination of efficiency and regulation of a single phase transformer.
9. Direct load test on a single phase transformer.
10. Direct Load test on a three phase induction motor.
11. Static Characteristics of Transistors.
12. Half wave and Full-Wave Rectifiers With R-Load.
13. Static Characteristics of MOSFET.
14. Static Characteristics of SCR.

Learning Resources:

Text Books:

1. M. E. VanValken Burg, Network Analysis, PHI, 2015, 3rd Edition
2. William H. Hayt, Jack Kemmerly, Steven M. Durbin, Engineering Circuit Analysis, Tata McGraw-Hill, 2013, 8th Edition

Reference Books:

1. M. L. Soni and J.C. Gupta, A Course in Electrical Circuit Analysis, Dhanpat Rai & Co. (P), 2001
2. G.K Mittal & Ravi Mittal, Network Analysis, Khanna Publications, 2003, 14th Edition
3. Gopal G Bhise, Prem R Chadha &Durgesh C. Kulshreshtha Gopal, Engineering Network Analysis and Filter Design, Umesh Publications, 2012
4. S.R. Paranjothi, Electric Circuit Analysis, New Age International Pub., 2002
5. U Bakshi & A. Bakshi, Basic Electrical Engineering, Technical Publications, 2019, 2019-Edition
6. V. K Mehtha, Principals of Electrical & Electronics Engineering, S. Chand Publications, New Delhi, 2010, 3rd Edition

Other Suggested Readings:

1. https://nptel.ac.in/courses/108/104/108104139/
2. https://nptel.ac.in/courses/108/102/108102097/
3. https://nptel.ac.in/courses/108/108/108108076/

2nd Semester

MA1162 **3-0-0 (3)**

Integral and Vector Calculus, Laplace and Fourier Transforms

Pre-Requisites: MA1161

Course Outcomes:

CO-1	Analyze improper integrals for extracting certain properties of beta and gamma integrals
CO-2	Evaluate multiple integrals in different coordinate systems
CO-3	Apply the concepts of gradient, divergence and curl of scalar and vector point functions to formulate engineering problems
CO-4	Convert line integrals into area integrals and surface integrals into volume integrals
CO-5	Apply Laplace transforms to solve physical problems arising in engineering

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3
CO-1	3	3	1	2	1	–	–	–	–	–	–	–	–	1	–
CO-2	3	3	1	2	1	–	–	–	–	–	–	–	–	1	–
CO-3	3	3	1	2	1	–	–	–	–	–	–	–	–	1	1
CO-4	3	3	1	2	1	–	–	–	–	–	–	–	–	1	–
CO-5	3	3	1	2	1	–	–	–	–	–	–	–	1	2	1

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Integral Calculus: Improper integrals; Beta and Gamma functions, and their properties; Differentiation under integral sign, Evaluation of double and triple integrals; Areas and Volumes, Change of order of integration; 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 operator; Parametrization of curves and surfaces; Line, surface and volume 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, impulse and periodic functions; 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.

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

Learning Resources:

Text Books:

1. George B. Thomas and Ross L. Finney, Calculus and Analytic Geometry, Pearson, 2020, 9th Edition
2. Dennis G. Zill, Advanced Engineering Mathematics, Jones & Bartlett Learning, 2018, 6th Edition

Reference Books:

1. Maurice D. Weir, Joel Hass and Christopher Heil, Thomas' Calculus: Early Transcendentals, Pearson, 2014, 13th Edition
2. Erwin Kreyszig, Advanced Engineering Mathematics, John Wiley and Sons, 2015, 8th Edition
3. R. K. Jain and S. R. K. Iyengar, Advanced Engineering Mathematics, Narosa Publishing House, 2016, 5th Edition

PH1161 **3-0-2 (4)**

Engineering Physics

Pre-Requisites: **None**

Course Outcomes:

CO-1	Examine the concepts of Interference, diffraction, polarisation to solve engineering problems
CO-2	Assess the technological applications of lasers and optical fibers
CO-3	Apply the quantum mechanical principles for solving engineering problems
CO-4	Understand the basics of nanomaterials and their engineering applications
CO-5	Demonstrate the production, detection and applications of ultrasonics

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3
CO-1	3	3	1	2	–	–	–	–	–	–	–	–	3	2	–
CO-2	3	3	2	2	–	–	–	–	–	–	–	–	3	2	–
CO-3	3	3	2	2	–	–	–	–	–	–	–	–	3	2	–
CO-4	3	3	2	2	–	–	–	–	–	–	–	–	3	2	–
CO-5	3	3	2	2	–	–	–	–	–	–	–	–	3	2	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Interference: Principle of Superposition, Coherence and Coherent Sources, Production of Coherent Light, Young's Double Slit Experiment, Concept of interference, Newton's Rings, working of Michelson Interferometer, Fabry-Perot Interferometer, and its application as wavelength filter.

Diffraction: Definition and types of Diffractions, Huygen's Principle and types of wave fronts, types of Diffraction, Single Slit Diffraction, Double Slit Diffraction, Diffraction Grating, Derivation of Resolving Power and Dispersive Power, Rayleigh's Criterion and applications.

Polarization: Introduction to Polarization, Production of Polarized Light by Reflection and Refraction, Phenomenon of Double Refraction, Construction and Working of Nicol's Prism, Half-Wave and Quarter Waveplates, Representation of Different Polarized Lights, Optical Activity, Practical Applications of Polarized Light, Construction and Working of Laurent's Half Shade Polarimeter and Engineering Applications.

Lasers & Optical Fibers: Basic theory of Laser, Fundamentals of lasers, Einstein Coefficients, Characteristics of Laser Pumping Mechanisms; Basic Components of Laser System, 2-Level, 3-Level and 4-Level Systems, Construction and working of He-Ne, Nd-YAG, and semiconductor diode Lasers and Engineering Applications of Lasers. Basic Principle of Optical Fiber, Derivation-Numerical Aperture and Acceptance Angle, Types of Optical Fibers (Step and Graded Index, Single Mode and Multimode), Applications in Communications and Sensors.

Quantum Mechanics: Concepts and experiments that led to the discovery of Quantum Nature, de Broglie hypothesis of matter waves, 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 tunnelling and applications.

Nanomaterials: Introduction and importance of Nanomaterials, classification (0D, 1D, 2D and 3D) of nanomaterials, properties of nanomaterials, carbon-based nanomaterials, synthesis of nanomaterials, top-down and bottom-up approaches, characterization of nanomaterials, Engineering Applications of Nanomaterials.

Ultrasonics: Production, detection, and applications of ultrasonics.

List of Experiments:

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 Numerical aperture, loss, Acceptance angle of optical fiber.
6. Determination of plank constant by photo electric effect.
7. Determination of I – V characteristics of photo diode.
8. Diffraction grating by normal incidence method.
9. Determination of capacitance by using R-C circuit.
10. Determination of resonating frequency and bandwidth by LCR circuit.
11. Strain Gauge.
12. Dielectric constant measurements.
13. Determination of carrier concentration, charge by using Hall effect experiment.
14. Study of I-V characteristics of Solar Cell.
15. Determination of velocity of ultrasonic waves and adiabatic compressibility of liquids using ultrasonic interferometer.

Learning Resources:

Text Books:

1. Halliday, Resnic and Walker, Fundamentals of Physics, John Wiley, 2011, 9th Edition
2. Arthur Beiser, Shobhit Mahajan, S. Rai Choudhury, Concepts of Modern Physics, McGraw Hill Publications, 2009, 6th Edition
3. Shatendra Sharma, Jyotnsa Sharma, Engineering Physics, Pearson Education, 2018
4. Sulabha K. Kulkarnl, Nanotechnology: principles and practices, Springer Publications, 2018, 3rd Edition
5. G.L. Squire, Practical Physics, Cambridge University press, 2001, 4th Edition

Reference Books:

1. Ajoy K. Ghatak, Optics, Tata McGraw Hill, 2017, 6th Edition
2. Jeff Hecht, Understanding Lasers An Entry-Level Guide, Wiley Publications, 2018, 4th Edition
3. M.N. Avadhanulu, P.G. Khirsagar, A Textbook of Engineering Physics, 2011, 9th Edition
4. Hugh D. Young, Roger A. Freedman, University Physics with modern physics, Pearson Education, 2014
5. B. Rogers, J Adams and S. Pennathur, Nanotechnology the whole story, CRC Press, 2013
6. Dr. S.K. Gupta Krishna, Engineering Physics Practical, Prakashan Publications, 2010, 9th Edition

Other Suggested Readings:

1. https://nptel.ac.in/courses/122/107/122107035/

CS1101 **3-0-0 (3)**

Programming and Data Structures

Pre-Requisites: **None**

Course Outcomes:

CO-1	Design algorithms for solving simple mathematical problems including computing, searching and sorting
CO-2	Compare and contrast algorithms in terms of space and time complexity to solve simple mathematical problems
CO-3	Explore the internals of computing systems to suitably develop efficient algorithms
CO-4	Examine the suitability of data types and structures to solve specific problems
CO-5	Apply control structures to develop modular programs to solve mathematical problems
CO-6	Understand the concept of Abstract Data Types and use in real time applications

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3
CO-1	3	1	1	1	2	1	–	–	–	–	–	3	3	3	3
CO-2	2	1	2	1	2	3	–	–	–	–	–	3	3	2	2
CO-3	1	2	2	2	2	1	–	–	–	–	–	3	3	2	2
CO-4	2	2	2	2	2	2	–	–	–	–	–	2	3	2	1
CO-5	2	2	3	1	2	2	–	–	–	–	–	2	3	2	2
CO-6	2	2	3	2	2	2	–	–	–	–	–	2	3	2	2

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Fundamentals of 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, Number systems and data representation.

Elements of C++ programming language: Data types, constants, and variables, expressions and assignment statements, input and output statements, conditional and branch statements: If-else, Switch-case constructs, iteration statements: while, do-while, for, Arrays – Single and Multi-Dimensional Arrays, strings. Bit-wise operations.

Functions and Recursion: Modular approach for solving real time problems, user defined functions, library functions, parameter passing - call by value, call by reference, return values, passing arrays as parameters to functions Recursion.

Structures and Classes: Declaration, member variables, member functions, access modifiers, function overloading, Problems on Complex numbers, Date, Time, Large Numbers.

Pointers and Files: Introduction to pointers and dynamic allocation, String processing, File operations-create, read and write.

Searching and sorting: Linear and binary search, selection sort, bubble sort, insertion sort, merge sort, quick sort.

Data structures: Abstract Data Types (ADTs) - Stack ADT- Array-Based Implementation of Stack - Applications, Queue ADT - Array-Based Implementation – Applications.

Learning Resources:

Text Books:

1. Walter Savitch, Problem Solving with C++, Pearson, 2018, 10th Edition
2. Cay Horstmann, Timothy Budd, Big C++, Wiley, 2009, 2nd Edition
3. R.G. Dromey, How to solve it by Computer, Pearson, 2008
4. Mark Allen Weiss, Data Structures and Algorithm Analysis in C++, Pearson Education, 2006, 3rd Edition

BT1161 **2-0-0 (2)**

Biology for Engineers

Pre-Requisites: **None**

Course Outcomes:

CO-1	Realize the significance of biomolecules for sustaining life
CO-2	Identify the difference between unicellular to multi-cellular organisms
CO-3	Understand heredity, variation and central dogma of life
CO-4	Apply the concepts of biology for engineering the cell

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3
CO-1	3	2	2	–	–	2	2	–	–	2	–	3	3	3	3
CO-2	3	2	2	–	–	2	–	–	–	–	–	3	3	3	3
CO-3	3	2	2	–	–	2	–	–	–	–	–	3	3	3	3
CO-4	3	3	2	2	1	2	2	1	–	2	–	3	3	3	3

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Molecules of Life: Chemical basis of life, Proteins, Nucleic acids, Carbohydrates, Lipids, Membranes and First cell, Inside the cell, Cell cycle and Division.

Information processing in living system: Central dogma, Concept of Gene, Genetic code, Transcription, Translation, Biological signal transduction, Quorum sensing and Biofilm formation.

Biomolecular machines and motors: Cytoskeletal motor proteins, ATP synthase, Cell motility.

Applied Biotechnology: Biocomputing, Synthetic biology, Biosensors, Biomedical instrumentation in disease diagnosis, Biomimicry, Biomechanics, Biomaterials, Nanobiotechnology, Industrial and Environmental Biotechnology, Biosafety and Bioethics.

Learning Resources:

Text Books:

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

HS1161 **2-0-2 (3)**

English for Technical Communication

Pre-Requisites: English proficiency above B1 level as per the CEFR (Common European Framework of Reference) for languages

Course Outcomes:

CO-1	Understand and apply principles of technical communication to interact effectively in diverse environments
CO-2	Analyze complex technical documents to extract and synthesize key information
CO-3	Employ reported speech, active and passive voice in engineering and scientific contexts to compile technical reports
CO-4	Demonstrate use of English speech sounds, stress, and intonation in day-to-day situations, conversations, and interactions
CO-5	Interpret technical data presented in the form of graphs, pie charts, and diagrams
CO-6	Critique and provide constructive feedback on peer communication performances and written works

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3
CO-1	–	–	–	–	–	2	–	–	3	3	–	3	1	1	1
CO-2	–	–	–	–	–	–	–	–	3	3	–	3	1	1	2
CO-3	–	–	–	–	–	–	–	–	3	3	–	3	–	–	–
CO-4	–	–	–	2	–	–	–	–	3	3	–	3	–	–	–
CO-5	–	–	–	–	–	–	–	–	3	3	–	3	–	2	–
CO-6	–	–	–	–	–	–	–	–	3	3	–	3	–	–	–

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Grammar Principles & Effective Sentence Construction: Correction of Sentences and Concord, - Vocabulary Building, - Synonyms and Antonyms, - Idioms and Phrasal Verbs: Patterns of Use and Suggestions for Effective Employment in Varied Contexts, - Technical Vocabulary (Jargons and Registers),- 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, - Impact on Audiences and Readers, - Active and Passive Voice, - Reasons for Preference for Passive Voice in Scientific English

Reading Techniques: Definition and Importance, - Skills and Sub-Skills of Reading, - Skimming and Scanning: Uses and Purposes, Examples and Exercises, - Reading Comprehension, - Reading Silently and with Understanding, - Process of Comprehension, - Types of Comprehension Questions

Writing- Paragraph & Letter: Definition of Paragraph and Types, - Features of a Good Paragraph, - Unity of Theme, - Coherence, - Linking Devices, - Direction, - Patterns of Development. - Importance in the Context of Other Channels of Communication, - Qualities of Effective Letters, - Types of Letters, - Official Letters, - Letters for Various Purposes, - Letters of Application for Jobs, - Cover Letter and Resume Types, - Letters for Internship/Fellowship, - Writing Statements of Purpose (SOPs), - Examples and Exercises

Mechanics of Writing: Principles of a Technical Report, - Know Your Audience, Purpose, and Length of Report, - Understand the Cornerstones of a Presentation, - Define Various Purposes of Presentations and Plan the Correct Structure, - Writing Clear Sentences and Paragraphs, - Removing Jargon,

Redundancy, and Wordiness, - Kinds of Graphics and Their Messages, - Suitability for Placement in Graphic Representation.

Reviews: Oral and Written Review of a Chosen Novel/Play/Movie, - Review of Scientific Articles and Science Fiction, - Focus on Appropriate Vocabulary and Structure, - Use of Special Vocabulary and Idioms

Language laboratory:

1. **English Sound System** -vowels, consonants, Diphthongs, phonetic symbols- using dictionary to decode phonetic transcription- Received Pronunciation, its value and relevance- transcription.
2. **Stress and Intonation** –word and sentence stress - their role and importance in spoken English- Intonation in spoken English -definition, -use of intonation in daily life-exercises.
3. **Introducing oneself in formal and social contexts**- Role plays. - their uses in developing fluency and communication in general.
4. **Oral presentation** - definition- occasions- structure- qualities of a good presentation with emphasis on body language and use of visual aids.
5. **Listening Comprehension**- Challenges in listening, good listening traits, some standard listening tests- practice and exercises.
6. **Debate/ Group Discussions**-concepts, types, Do's and don'ts- intensive practice, Guided writing practice with examples, drafting – the mindset to avoid writer's block, Checking your own reports and presentations, Giving and receiving constructive feedback.

Text Books:

1. English for Engineers and Technologists (Combined Edition, Vol. 1 and 2), Orient Blackswan, 2010
2. Ashraf, M Rizvi, Effective Technical Communication, Tata McGraw-Hill, 2006
3. Meenakshi Raman and Sangeetha Sharma, Technical Communication: Principles and Practice, Oxford University Press, 2011, 2nd Edition
4. Tan, Zhongchao. Academic Writing for Engineering Publications: A Guide for Non-native English Speakers, Springer, 2022

Reference Books:

1. Markel, Mike, and Stuart A. Selber. Technical Communication, Bedford/St. Martin's, 2017
2. Strunk, William, Jr., and E.B. White, The Elements of Style, Longman, 2000, 4th Edition
3. Olsen, Leslie A., and Thomas N. Huckin, Technical Writing and Professional Communication, McGraw-Hill, 1991, 2nd Edition
4. Turabian, Kate L, A Manual for Writers of Research Papers, Theses, and Dissertations, University of Chicago Press, 2018, 9th Edition
5. Seely, John, The Oxford Guide to Writing and Speaking, Oxford University Press, 2004
6. Murphy, Raymond, English Grammar in Use, Cambridge University Press, 2019, 5th Edition
7. Pinker, Steven, The Sense of Style: The Thinking Person's Guide to Writing in the 21st Century, Viking, 2014

Other Suggested Readings:

1. Zinsser, William, On Writing Well: The Classic Guide to Writing Nonfiction, HarperCollins, 2006, 7th Edition
2. Williams, Joseph M and Joseph Bizup, Style: Lessons in Clarity and Grace, Pearson, 2016, 12th Edition
3. Einsohn, Amy and Marilyn Schwartz, The Copyeditor's Handbook: A Guide for Book Publishing and Corporate Communications, University of California Press, 2019, 4th Edition
4. Alley, Michael, The Craft of Scientific Writing, Springer, 2018, 4th Edition
5. Hofmann, Angelika H, Scientific Writing and Communication: Papers, Proposals, and Presentations, Oxford University Press, 2016, 3rd Edition

BT1102 **3-0-0 (3)**

Bioprocess Calculations

Pre-Requisites: **MA1161**

Course Outcomes:

CO-1	Understand the material and energy balances of bioprocesses
CO-2	Perform material and energy balances on biochemical processes/equipment without and with reactions
CO-3	Perform unsteady state material and energy balances
CO-4	Draw the flow diagram and solve the problems involving recycle, purge and bypass in a process or unit
CO-5	Calculate balances on reactive processes

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3
CO-1	3	–	2	–	–	3	3	–	3	–	–	–	3	–	–
CO-2	–	–	3	2	–	–	1	–	1	–	–	–	3	2	–
CO-3	–	–	3	2	–	–	1	–	1	–	–	–	3	–	–
CO-4	3	–	3	–	–	–	–	–	–	2	–	–	3	3	–
CO-5	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, 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. Himmelblau, D.H, Basic Principles and Calculations in Chemical Engineering, Prentice Hall India, 2003, 6th Edition
2. Bhatt B.I, and Vora S.M, Stoichiometry, Tata McGraw-Hill, 2005, 4th Edition

Reference Books:

1. Hougen, O.A, Watson, K.M and Ragatz R.A, Chemical Processes Principles (Part-1): Material and Energy Balances, Asia Publication House, 2001, 2nd Edition
2. Pauline M. Doran, Bioprocess Engineering Principles, Elsevier, 2005, South Asia Edition

Other Suggested Readings:

1. Basic calculations & equations – Bioprocessing Explained (home.blog)
2. NPTEL: Chemical Engineering - NOC: Material & Energy Balance Computations
3. FM_GOPSONS.qxd (beeindia.gov.in)

CS1103 **0-1-2 (2)**

Programming and Data Structures Lab

Pre-Requisites: **None**

Course Outcomes:

CO-1	Design and test programs to solve mathematical and scientific problems
CO-2	Develop and test programs using control structures
CO-3	Implement modular programs using functions
CO-4	Develop programs using classes
CO-5	Develop ADT for stack and queue applications

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3
CO-1	3	2	2	1	2	1	–	–	–	–	–	–	3	3	3
CO-2	1	1	2	1	2	2	–	–	–	–	–	–	3	3	2
CO-3	1	2	3	2	2	1	–	–	–	–	–	–	3	3	2
CO-4	2	2	2	2	2	3	–	–	–	–	–	–	2	3	2
CO-5	2	2	2	2	2	3	–	–	–	–	–	–	2	3	2

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

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.
8. Programs of Stack and Queue.

Learning Resources:

Text Books:

1. Walter Savitch, Problem Solving with C++, Pearson, 2014, 9th Edition
2. Cay Horstmann, Timothy Budd, Big C++, Wiley,2009, 2nd Edition
3. R.G. Dromey, How to solve it by Computer, Pearson, 2008
4. Mark Allen Weiss, Data Structures and Algorithm Analysis in C++, Pearson Education, 2006, 3rd Edition

3rd Semester

BT1201 **3-0-0 (3)**

Biocomputing

Pre-Requisites: **MA1161, MA1162, CS1101, BT1161**

Course Outcomes:

CO-1	Understand the scripting language procedures
CO-2	Apply the programming structures, file handling and file management to develop programs
CO-3	Develop basic programs in Python
CO-4	Apply the basics of SQL to create database
CO-5	Apply the Biocomputing knowledge for any given biological problem

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3
CO-1	3	3	3	2	3	2	–	1	2	1	3	3	3	3	3
CO-2	2	2	2	3	3	2	–	1	2	3	3	3	3	3	3
CO-3	3	3	3	3	3	3	–	2	3	3	3	3	3	3	3
CO-4	3	3	3	3	3	3	–	2	3	3	3	3	3	3	3
CO-5	3	3	3	3	3	3	–	2	3	3	3	3	3	3	3

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

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.

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.

Learning Resources:

Text Books:

1. Gowrishankar S, Veena A, Introduction to python programming, CRC Press, 2019, 1st Edition
2. Magnus Lie Hetland, Beginning Python, Apress, 2008, 1st Edition

3. James R Groff, Paul N. Weinberg and Andrew J. Oppel, SQL: The Complete Reference, McGraw-Hill Education, 2010, 3rd Edition

Reference Books:

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

Other Suggested Readings:

1. https://nptel.ac.in/noc/courses/106/

BT1203 **3-0-0 (3)**

Biochemical Thermodynamics

Pre-Requisites: **None**

Course Outcomes:

CO-1	Understand the laws of thermodynamics
CO-2	Apply power and refrigeration cycles for bioprocesses
CO-3	Understand the degrees of freedom, phase and chemical reaction equilibria
CO-4	Calculate thermodynamic parameters involved in biochemical reactions
CO-5	Differentiate between ideal and non-ideal solutions

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3
CO-1	3	2	1	1	1	1	1	–	–	–	–	–	3	2	–
CO-2	3	2	3	–	1	–	–	–	–	–	–	–	2	1	–
CO-3	3	2	1	–	–	–	–	–	–	–	–	–	1	–	–
CO-4	3	2	1	2	–	1	–	–	–	–	–	–	1	1	–
CO-5	3	1	3	–	–	–	1	–	–	–	–	–	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: 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.

Learning Resources:

Text Books:

1. J.M. Smith, H.C. van Ness, M.M. Abbott, Swihart, M. T, Introduction to Chemical Engineering Thermodynamics, McGraw Hill, 2018, 8th Edition

2. Stanley I. Sandler, Chemical, Biochemical, and Engineering Thermodynamics, Wiley, 2006, 4th Edition

Reference Books:

1. Robert A. Alberty, Biochemical Thermodynamics: Applications of Mathematica Wiley-Interscience, 2007, 1st Edition
2. Urs von Stockar, Biothermodynamics: The role of thermodynamics Biochemical Engineering, CRC Press, 2013, 1st Edition

Other Suggested Readings:

1. https://nptel.ac.in/courses/102106082

BT1205 **3-0-0 (3)**

Microbiology

Pre-Requisites: None

Course Outcomes:

CO-1	Understand cellular ultrastructure of prokaryotes and eukaryotes
CO-2	Select the optimum environmental factors for microbial growth
CO-3	Analyze the outcome of genetic variations in microbes
CO-4	Evaluate the impact of viruses on the physiology of animals, plants and microbes
CO-5	Understand the biology of fungi and protists and their importance
CO-6	Apply the knowledge of microbial interactions in bioremediation

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3
CO-1	3	–	–	1	–	2	–	–	–	–	–	1	2	–	–
CO-2	3	–	2	–	–	1	2	–	–	–	–	2	1	2	–
CO-3	3	1	–	2	–	1	1	–	–	–	–	2	2	–	–
CO-4	3	1	–	3	–	2	1	–	–	–	–	1	1	–	–
CO-5	3	–	1	–	–	1	2	–	–	–	–	2	2	–	–
CO-6	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—macroelements 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 their 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. Willey, J. M., Sandman, K. M. and Wood, D. H, Prescott's Microbiology, McGraw Hill Education, 2020, 11th Edition

Reference Books:

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

Other Suggested Readings:

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

BT1207 **3-0-0 (3)**

Biochemistry

Pre-Requisites: **BT1161**

Course Outcomes:

CO-1	Identify the structure and functions of biomolecules
CO-2	Understand complex biochemical pathways and metabolism
CO-3	Interpret biochemical reactions of proteins, carbohydrates and nucleic acids with organic and inorganic solvents
CO-4	Estimate and separate biomolecules using chromatography and electrophoresis
CO-5	Determine the kinetic parameters of enzymatic reactions

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3
CO-1	3	3	3	2	1	2	1	–	–	–	–	2	3	1	3
CO-2	3	2	2	3	1	3	3	1	–	–	–	2	3	1	3
CO-3	3	3	3	3	2	2	3	3	1	1	1	2	3	1	3
CO-4	3	3	3	3	3	2	3	3	1	1	1	2	3	1	3
CO-5	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: 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. David L. Nelson, Michael M. Cox, Lehninger Principles of Biochemistry, W. H. Freeman and Company, 2017, 7th Edition

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

Reference Books:

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

Other Suggested Readings:

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

BT1209 **3-0-0 (3)**

Biostatistics

Pre-Requisites: None

Course Outcomes:

CO-1	Understand the mathematical basis and foundations of probability and statistics
CO-2	Apply statistical methods to solve biological problems
CO-3	Apply the statistical principles to design the research experiments
CO-4	Apply basic and modern statistical methods to analyze the big data in biology and clinical data

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3
CO-1	3	–	–	–	3	–	–	–	–	1	–	2	3	–	–
CO-2	3	–	–	–	–	–	–	–	2	–	–	1	3	–	–
CO-3	3	1	–	–	2	–	–	2	–	1	–	1	3	–	–
CO-4	3	2	–	–	3	–	–	2	–	–	–	1	3	2	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction to biostatistics and organization of data: Data type, graphical and pictorial presentation of data, measurers 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, 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, cross over and parallel designs, case studies with biological data.

Statistics in Data Analytics: Application of statistics in biological data analysis, Introduction to Big data analytics, data analytics lifecycle: discovery, data preparation, model planning, model building, communicate results, operationalize.

Learning Resources:

Text Books:

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

Reference Books:

1. Motulsky H, Intuitive Biostatistics, 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

Other Suggested Readings:

1. Statistics for Biologists, https://www.nature.com/collections/qghhqm/

BT1211 **0-1-2 (2)**

Microbiology Lab

Pre-Requisites: **None**

Course Outcomes:

CO-1	Estimate the concentration of biological macromolecules
CO-2	Identify and characterize biological macromolecules
CO-3	Separate biomolecules using Chromatography and Electrophoresis
CO-4	Conduct biochemical reactions of proteins, carbohydrates and nucleic acids with organic and inorganic solvents

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3
CO-1	2	3	–	2	–	–	1	3	–	–	–	–	–	–	–
CO-2	–	–	1	–	–	1	–	–	1	1	–	–	2	–	–
CO-3	–	3	–	–	3	–	–	3	–	–	2	–	–	1	–
CO-4	2	–	–	–	–	2	2	–	–	–	–	1	–	–	1

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

1. Media preparation—solid and liquid.
2. Pure culture techniques—Inoculating, 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.

Learning Resources:

Text Books:

1. Lab manual Microbiology

BT1213 **0-1-2 (2)**

Biochemistry Lab

Pre-Requisites: **None**

Course Outcomes:

CO-1	Estimate the concentration of biological macromolecules
CO-2	Identify and characterize biological macromolecules
CO-3	Separate biomolecules using Chromatography and Electrophoresis
CO-4	Conduct biochemical reactions of proteins, carbohydrates and nucleic acids with organic and inorganic solvents

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3
CO-1	2	3	–	2	–	–	1	3	–	–	–	–	–	–	–
CO-2	–	–	1	–	–	1	–	–	1	1	–	–	2	–	–
CO-3	–	3	–	–	3	–	–	3	–	–	2	–	–	1	–
CO-4	2	–	–	–	–	2	2	–	–	–	–	1	–	–	1

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

1. Qualitative analysis of Carbohydrates, amino acids & proteins.
2. Quantitative estimation of protein by Biuret method & 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 (λmax).
8. Estimation of Nucleic acids & 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 Vmax & Km.
11. Separation of amino acids by Thin layer chromatography, Determination of molecular weight of a protein by SDS-PAGE.

Learning Resources:

Text Books:

1. Pallab Basu, Biochemistry Laboratory Manual, Academic Publishers, 2018, 3rd Edition
2. J. Jayaraman, Laboratory Manual in Biochemistry, New age International, 2011, 1st Edition

Reference Books:

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

Other Suggested Readings:

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

4th Semester

MA1261 **3-0-0 (3)**

Fourier Series, Partial Differential Equations and Complex Variables

Pre-Requisites: MA1162

Course Outcomes:

CO-1	Obtain the Fourier series for a given function
CO-2	Classify the PDE
CO-3	Determine the solution of a PDE by variable separable method
CO-4	Understand and use of complex variables
CO-5	Evaluate a real definite integral

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3
CO-1	2	3	1	2	1	–	–	–	–	–	–	–	–	2	1
CO-2	3	2	1	2	1	–	–	–	–	–	–	–	–	–	–
CO-3	2	3	1	3	1	–	–	–	–	–	–	–	–	–	–
CO-4	3	2	1	2	1	–	–	–	–	–	–	–	–	2	1
CO-5	3	3	1	3	1	–	–	–	–	–	–	–	–	2	1

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Fourier Series: Introduction and basic definitions; Expansion of a function in Fourier series for a given range; Half range sine and cosine expansions.

Partial Differential Equations: Classification of higher order partial differential equations; Method of separation of variables - Solution of one-dimensional wave equation, one-dimensional heat conduction equation and two-dimensional steady state heatconduction equation 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) and 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 definite integral of the type $\int_0^{2\pi} f(cos\theta,\ sin\theta)d\theta$ and $\int_{-\infty}^{\infty} f(x)dx$. Concept of conformal mapping with simple illustrations.

Learning Resources:

Text Books:

1. Dennis G. Zill, Advanced Engineering Mathematics, Jones & Bartlett Learning, 2018, 6th Edition
2. Erwin Kreyszig, Advanced Engineering Mathematics, John Wiley and Sons, 2015, 8th Edition
3. James Ward Brown and Ruel V. Churchill, Complex Variables and Applications, McGraw Hill Education, 2009, 9th Edition

Reference Books:

1. R. K. Jain and S. R. K. Iyengar, Advanced Engineering Mathematics, Narosa Publishing House, 2016, 5th Edition
2. M.D. Rai Singhania, Ordinary and Partial Differential Equations, S. Chand and Co., 2024, 20th Edition

BT1202 **3-0-0 (3)**

Biological Reaction Engineering

Pre-Requisites: **BT1102, BT1203**

Course Outcomes:

CO-1	Understand the kinetics and mechanism of chemical and biochemical reactions
CO-2	Classify bioreactors and estimate Monod's parameters
CO-3	Design batch, continuous flow, and fed batch reactors for enzymatic reaction
CO-4	Understand scale up concepts for bioreactor
CO-5	Understand bioprocess plant design and process economics

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3
CO-1	–	–	–	1	3	–	–	–	1	–	–	–	3	–	–
CO-2	–	–	–	1	3	–	–	–	2	–	–	–	3	1	1
CO-3	–	–	–	1	3	–	–	–	–	–	–	–	3	–	2
CO-4	–	–	–	2	3	–	–	–	2	–	–	–	3	3	3
CO-5	–	–	–	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. microbial growth rate equations; 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.

Bioprocess Plant Design: General design information, mass and energy balance, flow sheeting, materials of construction for bioprocess plants, specification and design of heat and mass transfer equipment used in bioprocess industries, utilities for biotechnology production plants, bioprocess economics and safety considerations.

Learning Resources:

Text Books:

1. Jens Nielsen, John Villadsen, Gunnar Lidén, Bioreaction Engineering Principles, Kluwer Academics /Plenum publishers, 2002, 2nd Edition

2. Paulin M. Doran, Bioprocess Engineering Principles, Elsevier Science & Technology Books, 2013, 2nd Edition

Reference Books:

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

Other Suggested Readings:

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

BT1204 **3-0-2 (4)**

Bioinformatics

Pre-Requisites: **BT1207**

Course Outcomes:

CO-1	Recall significant advances in historical timeline of bioinformatic developments
CO-2	Identify, locate and retrieve specific records from various biological databases
CO-3	Predict concealed signatures in RNA and Protein sequences
CO-4	Construct virtual 3D models of protein structures
CO-5	Analyze healthcare data with bioinformatic tools

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3
CO-1	1	2	–	2	3	–	–	–	–	–	–	1	1	2	3
CO-2	1	2	–	2	3	–	–	–	–	–	–	1	1	2	3
CO-3	1	2	–	2	3	–	–	–	–	–	–	1	1	2	3
CO-4	1	2	–	2	3	–	–	–	–	–	–	1	1	2	3
CO-5	1	2	–	2	3	–	–	3	–	–	–	1	1	2	3

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction: A brief history of bioinformatics, bioinformatics resources, databases and search tools at NCBI and UniProt. sequence analysis - sequence file formats, scoring matrices, pairwise sequence alignment, multiple sequence alignment, molecular evolution and phylogenetic analysis, Gene prediction and functional annotation.

Structure databases: Databases and search tools at PDB, secondary structural elements (SSE), DSSP, prediction of SSEs, template based and template free prediction of 3D structure of proteins, 3D structure visualization and validation.

Genomics: Introduction, genes and genomes, human genome in biology and medicine, sequencing technologies, evolutionary genomics, metagenomics and the microbial world, future of genomics.

List of Experiments:

1. Biological Databases: NCBI- GENBANK, PUBCHEM, UNIPROT, PDB, CATH, SCOP & KEGG.
2. Sequence Alignment Tools: Pairwise- BLAST, MSA- CLUSTAL OMEGA.
3. Phylogenetic Analysis: Tree Construction and Analysis.
4. Sketching and Visualization of small molecules - Biovia Discovery Studio.
5. Protein 3D structure visualization – Biovia Discovery Studio.
6. Protein Modelling – Biovia Discovery Studio.
7. Next Generation RNA Sequencing – Data visualization and analysis.
8. Meta genomics - Data visualization and analysis.

Learning Resources:

Text Books:

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

3. John M. Archibald, Genomics: A Very Short Introduction, OUP Oxford, 2018, Illustrated Edition
4. Bioinformatics Lab Manual

Reference Books:

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

Other Suggested Readings:

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

BT1206 **3-0-0 (3)**

Cell Biology

Pre-Requisites: **BT1205, BT1207**

Course Outcomes:

CO-1	Understand the cell theory and cellular compartmentalization
CO-2	Distinguish the structure and function of the cell organelles and membrane
CO-3	Compare and contrast the events of cell cycle and its regulation
CO-4	Summarize the definition, sources and applications of stem cells
CO-5	Relate the importance of cell cycle on cancer development

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3
CO-1	–	–	–	1	–	2	–	2	–	–	–	1	3	–	–
CO-2	–	–	–	1	–	2	–	2	–	–	–	2	3	–	–
CO-3	–	–	–	2	–	1	–	2	–	–	–	2	3	–	–
CO-4	–	–	–	2	–	1	–	1	–	–	–	2	3	–	–
CO-5	–	–	–	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.

Learning Resources:

Text Books:

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

Reference Books:

1. Karp, G., Iwasa, J., Marshall, Cell and Molecular Biology, W. Wiley Press, 2019, 9th Edition

Other Suggested Readings:

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

BT1208 **4-0-0 (4)**

Molecular Biology and Genetics

Pre-Requisites: BT1205, BT1207

Course Outcomes:

CO-1	Understand the mechanism of central dogma of molecular biology
CO-2	Explain the molecular mechanisms of gene expression, control, and regulation
CO-3	Comprehend the concept of Mendelian inheritance and deviations from Mendelism
CO-4	Describe the basics of human molecular genetics and evolutionary genetics

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3
CO-1	1	–	–	3	2	–	1	1	–	3	–	3	1	–	–
CO-2	1	–	1	3	2	–	1	1	–	–	–	3	2	–	1
CO-3	2	–	2	3	–	2	1	1	–	–	–	3	2	–	1
CO-4	2	–	–	3	–	–	1	2	–	–	–	3	2	–	1

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Genes in action: DNA, Genes and chromosomes, chromatin structure, DNA Replication-mechanism, topological constraints, end replication problem, DNA mutation and repair, homologous recombination, transposons.

Genes to proteins: Transcription- mechanism and regulation, transcription factors, splicing and RNA processing, genetic code, role of tRNA and ribosomes in translation, control, and regulation of translation, post translational modifications, regulation of gene expression.

Mendelism and Chromosomal theory: Principles of inheritance, deviation from mendelism, Linkage, Recombination and Gene Mapping Methods, Sex linkage, pedigree analysis. Mutation and Extra Chromosomal Inheritance**.** Change in chromosome number and structure, maternal inheritance.

Human Molecular Genetics and Evolutionary Genetics: Genetic disorders, human gene therapy; DNA profiling. Allele frequency, natural selection, random genetic drift, genetic variation in natural population, molecular evolution, speciation.

Plant Molecular genetics: Life cycle in plants, Techniques of plant transformation, defense response to stresses in plants.

Learning Resources:

Text Books:

1. Bruce Alberts, Molecular Biology of the Cell, Garland Science, 2014, 6th Edition
2. D. Peter Snustad, Michael J. Simmons, Principles of Genetics, Wiley, 2016, 7th Edition
3. Benjamin A Pierce, Genetics A conceptual approach, W. H. Freeman and Co, 2017, 6th Edition

Reference Books:

1. James D.Watson, Tania A. Baker, Stephen P. Bell, Alexander Gann, Michael Levine, Richard Losick, Molecular Biology of the Gene, Pearson Education, 2017, 7th Edition
2. Strickberger M.W., Genetics, Prentice Hall India, 2008, 3rd Edition

3. Robert H. Tamarin, Principles of genetics, McGraw-Hill Company, 2001, 7th Edition

Other Suggested Readings:

1. https://nptel.ac.in/noc/courses/noc19/SEM1/noc19-bt05/
2. https://onlinecourses.swayam2.ac.in/cec20_ma13/preview
3. https://archive.nptel.ac.in/courses/102/107/102107075/

BT1210 **0-1-2 (2)**

Biocomputing Lab

Pre-Requisites: **MA1161, MA1162, CS1103, BT1161**

Course Outcomes:

CO-1	Apply their programming skills to write and execute simple programs in python, perl and R
CO-2	Apply their programming skills to creating applications using variables, data types and control Structures
CO-3	Apply the concept of exception handling mechanism and to handle exceptions while programming
CO-4	Apply above techniques to solve given biological problems

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3
CO-1	3	3	3	3	1	–	–	–	2	1	1	1	3	1	–
CO-2	3	3	3	2	2	–	–	–	1	1	1	1	3	1	–
CO-3	3	3	3	2	2	–	–	–	1	1	1	1	3	1	–
CO-4	3	3	2	3	3	–	–	–	1	1	1	1	3	1	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

1. Creation of student database.
2. Database consist of roll number, name, subject code, marks etc.,
3. Finding out the total and average marks, result for each student table.
4. Record Manipulations such as Deletion, Modification, Addition and counting the record.
5. Programs to perform arithmetic calculations in python.
6. Creating table that demonstrates simple biological applications.
7. Creating table to demonstrate applications with biological sequences.
8. Program to find the length of the given sequence.
9. Program to reverse and concatenation of the given sequence.
10. Program to complement and reverse complement of DNA sequence.
11. Program to calculate GC content in the given DNA sequence.
12. Program to translate DNA into Protein Sequence.

Learning Resources:

Text Books:

1. C. J. Date, A. Kannan, Database Systems, Pearson Education Publication
2. Martin C Brown, Perl The Complete Reference, Tata McGraw Hill, 2001, 2nd Edition
3. Jason Kinser, Python for Bioinformatics, Jones and Bartlett Publishers, Sudbury, Massachusetts, 2009

BT1212 **0-1-2 (2)**

Cell Biology and Molecular Biology Lab

Pre-Requisites: BT1211, BT1213

Course Outcomes:

CO-1	Operate a microscope to observe slides and correctly identify different cell types
CO-2	Differentiate cellular structures using different microscopic techniques
CO-3	Isolate nucleic acids and proteins from biological samples
CO-4	Estimate the quality and quantity of nucleic acids using Gel-electrophoresis and Spectrophotometer

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3
CO-1	–	–	–	1	–	1	–	1	–	–	–	2	3	–	–
CO-2	–	–	–	2	–	1	–	1	–	–	–	2	3	–	–
CO-3	–	–	–	2	2	2	1	–	–	–	–	–	3	–	–
CO-4	–	–	1	3	2	1	–	–	–	–	–	–	3	–	–

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Cell Biology laboratory Experiments: 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& Indirect labelling).

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

Reference Books:

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

Other Suggested Readings:

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

5th Semester

MS1262 **3-0-0 (3)**

Business Essentials for Engineers

Pre-Requisites: **None**

Course Outcomes:

CO-1	Understand the basic concepts of management and its functions
CO-2	Apply the functions of management for taking effective decisions
CO-3	Analyze factors influencing management in competitive business environment
CO-4	Identify business opportunities and challenges
CO-5	Integrate functions of management for building a better organization

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3
CO-1	–	–	–	–	–	–	–	–	3	–	3	3	–	–	–
CO-2	–	–	–	–	–	–	–	–	2	–	3	3	3	–	3
CO-3	–	–	–	–	–	–	–	–	1	–	3	3	–	–	–
CO-4	–	–	–	–	–	–	–	–	1	–	2	2	–	2	2
CO-5	–	–	–	–	–	–	–	–	1	–	1	2	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction: The evolution of management theory, Business functions and their roles, Organizations and types, Levels of management, Types of markets and pillars of management- planning, organizing, leading and controlling.

People Management: Catalysts for organizational performance – Motivation & Leadership, Organization culture & Change, Human resource functions in a dynamic business environment and evolving dynamics in Industrial Relations.

Marketing Management: Nature and scope of marketing, Company's orientation towards market place, Importance of marketing concept, Marketing environment, 4p's of marketing, market segmentation, target market selection and positioning.

Financial Management: Financial accounting, Financial statements and analysis for decisions, Financial planning, Capital, Working capital, Capital structure and Sources of corporate finance, Investment decisions.

Project Management: Project screening and Selection, Techniques, Structuring concepts and Tools (WBS, OBS, and LRC, RACE). Project life cycle analysis. Appraisal of a project, Project Planning: Techniques, CPM, PERT- GAN - Time Cost Trade-off and Crashing Procedure, Project Monitoring: Monitoring Techniques and time control System, EVA Analysis

Quality & Strategy: Quality, Principles, Quality Awards, Standards of Quality culture, Quality metrics programs, Strategy, Vision and Mission, Porter's 5–forces, McKinsey's 7S Model, BCG Matrix, Competitive advantage - Value chain analysis & Resource based view.

Learning Resources:

Text Books:

1. Ronald J. Ebert, Ricky W. Griffin, Business Essentials, Pearson, 2019, 12th Edition

2. Harold Koontz, Heinz Weihrich, Mark V. Cannice, Essentials of Management, McGraw hill, 2020, 11th Edition

Reference Books:

1. G. Shainesh Philip Kotler, Kevin lane Keller, Alexander Chernev, Jagdish N. Sheth, Marketing Management, Pearson, 2022, 16th Edition
2. Dessler, G., & Varkkey, B, Human Resource Management, Pearson Education, 2024, 17th Edition
3. Prasanna Chandra, Financial Management: Theory & Practice, Mc Graw Hill, 2022, 11th Edition
4. Poornima M Charantimath, Total Quality Management, Pearson, 2022, 4th Edition
5. IM Pandey, Financial Management, Vikas Publications, 2021, 12th Edition
6. Jack R. Meredith, Mantel, Project Management - A Managerial Approach, John Wiley, 2021,11th Edition

Other Suggested Readings:

1. https://nptel.ac.in/courses/110106050
2. https://nptel.ac.in/courses/110105146
3. https://nptel.ac.in/courses/110105069
4. https://nptel.ac.in/courses/110104068
5. https://ocw.mit.edu/courses/15-535-business-analysis-using-financial-statements-spring-2003/
6. https://ocw.mit.edu/courses/15-810-marketing-management-fall-2010/

BT1301 **3-0-0 (3)**

Bioprocess Engineering

Pre-Requisites: BT1102, BT1205

Course Outcomes:

CO-1	Understand the role of a bioprocess engineer and the kinetics of the growth of microorganisms
CO-2	Comprehend different sterilization techniques for medium and air
CO-3	Apply the principles of fluid flow in bioprocessing systems
CO-4	Understand the applications of heat and mass transfer in bioprocesses
CO-5	Compare various types of bioreactors

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3
CO-1	2	3	3	3	–	–	–	–	–	–	–	–	3	–	–
CO-2	3	3	–	1	–	–	–	–	–	–	–	–	3	–	–
CO-3	2	2	2	2	–	–	–	–	–	–	–	–	3	–	–
CO-4	1	2	–	3	–	–	–	–	–	–	–	–	3	–	–
CO-5	1	3	1	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; Batch and continuous culture.

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.

Biofluid mechanics: Newtonian and non-Newtonian fluids, factors affecting broth viscosity, velocity distribution in laminar flow and turbulent flow, aeration and agitation, power requirement for gassed and un-gassed systems, Rate of mixing.

Bioprocess Heat Transfer: Modes of heat transfer, Steady-state and un-steady-state heat transfer, Heat transfer coefficients, Boiling and condensation heat transfer, Heat transfer equipment, Evaporation.

Mass Transfer in Bioreactors: Theories of mass transfer, Gas-Liquid mass transfer, Measurement of K_La, Oxygen transfer methodology, Maximum cell concentration.

Applications of bioreactors: On-line and off-line measurement in bioreactors, Various types of microbial and enzyme reactors.

Learning Resources:

Text Books:

1. Paulin M. Doran, Bioprocess Engineering Principles, Elsevier Science & Technology Books, 2008, 2nd Edition
2. James E. Bailey, David F. Ollis, Biochemical Engineering Fundamentals, Mc Graw Hill, 2004, 2nd Edition

3. Michael Shuler, Fikret Kargi, Bioprocess Engineering Basic Concepts, Prentice-Hall India, 2006, 2nd Edition

Reference Books:

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

Other Suggested Readings:

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

BT1303 **3-0-0 (3)**

Genetic Engineering

Pre-Requisites: BT1206, BT1208

Course Outcomes:

CO-1	Discuss the basic and advanced techniques in Genetic Engineering
CO-2	Select the appropriate host and vector system for cloning and expression
CO-3	Employ the cloning strategies to produce recombinant molecules
CO-4	Understand the DNA sequencing technology and gene modification approaches
CO-5	Apply genetic engineering principles for biotechnological and biomedical applications

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3
CO-1	3	2	–	2	1	–	–	1	–	–	–	–	3	1	2
CO-2	–	3	3	3	2	–	–	2	–	–	–	–	3	2	2
CO-3	–	3	3	3	2	–	–	–	–	–	–	–	3	1	1
CO-4	3	3	–	1	–	–	–	–	–	–	–	–	3	–	–
CO-5	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,* Advance Techniques in gene expression and analysis: RT-PCR, Real-Time PCR, microarray.

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

Reference Books:

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

BT1305 **3-0-0 (3)**

Immunology

Pre-Requisites: **BT1206, BT1208**

Course Outcomes:

CO-1	Summarize the overall concept of the human immune system
CO-2	Explain different cells and organs involved in the human immune system
CO-3	Recognize effectors molecules fight against infectious diseases
CO-4	Design monoclonal antibodies to diagnose infectious diseases
CO-5	Understand the concept of immunization
CO-6	Relate the role of the immune system in organ transplantation, autoimmune disorders and Cancer

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3
CO-1	1	1	1	2	–	1	–	–	–	–	–	3	3	2	–
CO-2	1	1	1	2	–	1	–	–	–	–	–	3	3	2	–
CO-3	1	1	1	2	–	1	–	–	–	–	–	2	3	2	1
CO-4	3	2	2	2	2	2	2	2	–	–	–	3	3	3	–
CO-5	3	2	2	2	2	2	2	2	–	–	–	3	3	3	2
CO-6	1	1	1	1	–	1	–	2	–	–	–	3	3	1	2

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.

Immunoglobulins: Immunogen, Hapten & 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, Immunodiffusion, ELISA, RIA, Immunohistochemistry, Flow cytometry.

Organization and Expression of Immunoglobulin genes: Antibody Diversity - Tonegawa's bombshell: Immunoglobulin genes rearrange, Immunoglobulin Light and Heavy chain rearrangement, Immunoglobulin Class Switching, B-cell and T-cell development, Antigen processing and presentation - MHC structure and functions, B-cell and T-cell activation.

Tolerance and Immunity: Complement system, Hypersensitivity reactions, Overview of the functions of cytokines, Signal transduction mediated by cytokine receptors, Therapeutic uses of cytokines, Cytokine-related diseases, Immunological tolerance, Autoimmune disorders, Transplantation, Graft rejection & Immunosuppressive Therapy, Types of Vaccines, Tumor Immunology.

Learning Resources:

Text Books:

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

3. Martin. F. Flajnik, Nevil J. Singh, Steven M. Holland, Paul's Fundamental Immunology, Lippincott Williams & Wilkins, 2023, 8th Edition

Reference Books:

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

Other Suggested Readings:

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

BT1381 **1-0-0 (0.5)**

Fractal Course I

Pre-Requisites: **None**

Course Outcomes:

CO-1	Acquire an in-depth understanding of the specific topic covered in the course, which could range from a particular technology, method, or recent advancement in Biotechnology
CO-2	Develop hands-on skills relevant to the course topic, such as using specific tools, software, or techniques
CO-3	Apply learned concepts to solve focused and practical engineering problems related to the course content
CO-4	Understand the interdisciplinary aspects and applications of the course to solve real-world industrial problems.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3
CO-1	3	3	3	–	–	–	–	–	–	–	–	–	1	2	3
CO-2	–	–	–	2	2	3	3	–	–	–	–	–	1	1	1
CO-3	–	–	3	2	2	–	–	–	–	–	–	–	1	1	1
CO-4	–	–	–	–	–	–	–	–	1	3	–	2	2	2	2

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

This one-week course aims to bridge the gap between academic learning and industry application / latest research developments, providing students with a comprehensive understanding of the Biotechnology field and enhancing their readiness for professional careers.

a. **Structure:** Lectures delivered by an expert from the Biotechnology Industry / R&D Organization / Academic Institution (SPARC Collaborators / Foreign Subject Experts in GIAN program / Adjunct Professors from Foreign Universities @ NITW).

b. **Content:** Topics covering current practices, case studies, technological advancements, and future trends.

c. **Interactive Sessions:** Q&A sessions, discussions, and case study analyses to foster interaction between students and the subject expert.

d. **Assessment:** the mode of assessment (Participation, a short reflective report / a presentation summarizing key takeaways from the lectures / Objective or descriptive type exam, etc.) will be decided by the subject expert.

Learning Resources:

1. Course material and any learning resources suggested by the experts

BT1307 **0-1-2 (2)**

Genetic Engineering and Immunology Lab

Pre-Requisites: BT1211, BT1212

Course Outcomes:

CO-1	Demonstrate basic safe laboratory practices and set up laboratory equipment safely
CO-2	Manipulate nucleic acids employing basic laboratory techniques and use standard procedures to clone them
CO-3	Plan the gene manipulation procedures and interpret the experimental results
CO-4	Analyze antigen-antibody interactions and interpret the results
CO-5	Perform different immunoassays that are used in clinical diagnostics
CO-6	Design assays for immunological research

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3
CO-1	3	1	1	1	–	2	1	1	–	1	–	3	2	–	–
CO-2	2	3	3	3	1	2	1	2	–	3	–	2	3	1	–
CO-3	2	3	3	3	1	2	–	2	2	3	–	2	2	1	1
CO-4	2	3	3	3	1	2	–	–	–	3	–	2	3	1	1
CO-5	2	3	3	3	1	2	1	2	2	3	–	2	3	2	1
CO-6	2	3	3	3	1	2	1	2	1	3	–	2	3	2	1

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Genetic Engineering Lab:

1. Restriction Digestion.
2. Restriction Mapping.
3. Ligation.
4. PCR primer designing and Amplification of DNA fragments using PCR.
5. Restriction Fragment Length Polymorphism (RFLP).

Immunology Lab:

1. ABO Blood Grouping Test.
2. Ouchterlony Double Diffusion (Antigen-antibody pattern).
3. Counter Current Immunoelectrophoresis.
4. Widal Test.
5. DOT ELISA.

Learning Resources:

Text Books:

1. Joseph Sambrook and David Russell, Molecular cloning: A Laboratory Manual, 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. Martin. F. Flajnik, Nevil J. Singh, Steven M. Holland, Paul's Fundamental Immunology, Lippincott Williams & Wilkins, 2023, 8th Edition

BT1309 **0-1-2 (2)**

Bioprocess and Bioreaction Engineering Lab

Pre-Requisites: BT1211, BT1212

Course Outcomes:

CO-1	Estimate specific growth rate using microbial growth curve
CO-2	Estimate Michaelis–Menten constants
CO-3	Find the effect of pH and temperature on enzyme activity
CO-4	Estimate the Monod parameters in batch, fed-batch and continuous cultures

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3
CO-1	2	3	1	–	–	–	–	–	1	–	–	–	3	–	–
CO-2	2	3	–	–	–	–	–	–	2	–	–	–	3	–	–
CO-3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-4	2	3	1	–	–	–	–	–	–	–	–	–	3	1	–

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Growth kinetics of bacteria in Batch and Fed-Batch Bioreactor, Enzyme Immobilization, Microbial death Kinetics, Residence time distribution, fluidized bed bioreactor for cell cultivation, effect of temperature, pH substrate concentration on enzyme activity, inhibition kinetics and estimation of biomass.

Learning Resources:

Text Books:

1. Paulin M. Doran, Bioprocess Engineering Principles, Elsevier Science & Technology Books, 2013, 2nd Edition

Reference Books:

1. Foster C.F., John Ware D.A., Environmental Biotechnology, Ellis Horwood Ltd., 2007

Other Suggested Readings:

1. https://archive.nptel.ac.in/courses/102/105/102105064/
2. https://onlinecourses.nptel.ac.in/noc22_bt19/preview

6th Semester

BT1302 **3-0-2 (4)**

Downstream Processing

Pre-Requisites: **BT1203, BT1207**

Course Outcomes:

CO-1	Understand the principles of downstream processing in biotechnology and pharmaceutical industries
CO-2	Evaluate different techniques used for cell disruption and extraction of intracellular components
CO-3	Develop proficiency in various downstream processing techniques such as chromatography
CO-4	Analyze the importance of downstream processing in the purification of biopharmaceuticals
CO-5	Design downstream processing strategies for specific biopharmaceutical products, considering factors such as yield, purity, and cost-effectiveness

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3
CO-1	3	–	3	–	3	3	–	–	–	3	3	3	2	3	3
CO-2	2	–	3	3	–	3	3	3	3	3	–	–	–	–	–
CO-3	3	–	–	–	–	3	–	–	–	–	2	2	2	3	3
CO-4	3	3	–	2	2	–	–	2	2	2	–	1	1	–	–
CO-5	3	2	–	1	–	–	–	–	–	1	1	–	–	2	1

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction to biomolecules and properties of biological materials: Downstream Processing Principles economics and issues. Importance of downstream in industrial processes – examples.

Size reduction and Cell disruption methods: Recovery of intracellular products, cell disruption equipment.

Isolation of insoluble: Filtration, Sedimentation, Coagulation, and flocculation Centrifugation.

Product recovery: Membrane separation processes: Dialysis, Reverse osmosis, electrodialysis, pervaporation, Extraction methods: Solid-liquid and Liquid -Liquid extraction methods.

Product enrichment: Chromatographic separation and electrophoresis methods: Principles of chromatographic separation methods, different types of chromatographic methods, ion – exchange chromatography, gel chromatography, affinity chromatography. Principles of electrophoresis and electrophoresis mobility, applications. Distillation.

Product polishing and finishing: Crystallization, Drying, Lyophilization and Product stabilization.

List of Experiments: 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:

Textbooks:

1. Mukesh Doble, Principles of Downstream Techniques in Biological and Chemical Processes CRC Press Taylor & Francis Group, 2016
2. Sivasankar, Bio separations: Principles and Techniques, Prentice Hall India Learning Private Limited, 2006

Reference Books:

1. Raja Ghosh, Principles of Bio separations Engineering, World Scientific Publishing Co. Pte. Ltd, 2006
2. Barry A. Perlmutter, Integration and Optimization of Unit Operations, Elsevier Inc, 2022

Other Suggested Readings:

1. https://archive.nptel.ac.in/courses/102/106/102106022
2. https://professional.mit.edu/course-catalog/downstream-processing

BT1304 **3-0-0 (3)**

Bioprocess Instrumentation and Control

Pre-Requisites: MA1161, MA1162, MA1261, BT1202, BT1301

Course Outcomes:

CO-1	Understand the principles of instrumentation and control in Bioprocess Engineering
CO-2	Analyze different components of the control systems
CO-3	Analyze the stability of the feedback control system
CO-4	Analyze biological Regulation and Control System
CO-5	Design Bioprocess Control Systems

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3
CO-1	–	3	–	–	2	1	1	1	–	1	–	–	–	1	–
CO-2	–	3	–	–	2	2	1	1	–	1	–	–	–	1	–
CO-3	–	3	–	3	2	3	2	1	–	3	–	–	–	3	–
CO-4	–	3	3	3	2	3	2	1	1	3	–	–	2	3	–
CO-5	–	3	3	1	2	2	3	1	1	3	–	–	2	1	–

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, 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, Types of controllers: proportional, integral, derivative, PI, PD, PID controllers. Tuning of controllers, Systems 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.

Control and Regulation in Biological Systems: Drug delivery applications, Cardiac Output regulation, Feedback and feedforward control in biological networks, Natural control and regulation in biological systems

Learning Resources:

Text Books:

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

Reference Books:

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

Other Suggested Readings:

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

BT1306 **0-1-4 (3)**

Product Development

Pre-Requisites: **BT1101, BT1161**

Course Outcomes:

CO-1	Express Product Design Ideas using 2D or 3D sketches
CO-2	Model the components with geometric (engineering) specifications and appropriate materials
CO-3	Develop a prototype of the product
CO-4	Evaluate the entire product and the product based on testing with user
CO-5	Explore the scope for protecting novelty of the product through patent

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3
CO-1	–	–	2	3	3	3	2	2	3	3	2	3	3	2	–
CO-2	–	–	2	3	3	3	2	2	3	3	2	3	3	2	–
CO-3	–	–	2	3	3	3	2	2	3	3	2	3	3	2	–
CO-4	–	–	2	3	3	3	2	2	3	3	2	3	3	2	–
CO-5	–	–	2	3	3	3	2	2	3	3	2	3	3	2	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Design Thinking process for Product Development: Review of five step design thinking process of Empathize- Define- Ideate- Prototype- Test.

Project Selection: Identification of the problem through empathy, formulate and ideate to solve the problem.

Introduction: Biotechnology Product and Technology Sectors, Product Development time frame, Biotechnology Product development ideas. Experimental Paths: Basic Research Versus Translational Research. Regulatory Approval and Compliances for Biotechnology Products.

Product Development:

1. Identifying a product of interest and cloning the gene into a suitable vector or Identification of a natural producer of any secondary metabolite.
2. Design and optimization of fermentation process of host cells.
3. Harvesting of fermentation broth/cells through centrifugation and filtration.
4. Isolation of intracellular products by mechanical/enzymatic methods.
5. Precipitation/extraction of the product.
6. Removal of impurities by dialysis or tangential flow filtration.
7. High throughput purification of product by chromatography.
8. Concentration and formulation of the product.
9. Quality Control: testing, monitoring, and regulatory compliance of the product.

Iterative improvement of the product and Report writing: Development of assemblies/mock-up models/ working models/ prototypes/functional models/products, Testing and design review, Report writing.

IPR: Different forms of innovations emanating from the human mind and their protection using different tools of IPR, Basic introduction to Patents, Trademarks, Copyright, Industrial Designs Registrations, Geographical Indications Trade Secrets. Filing of IPR, implications, Ethics and societal implications of Intellectual Property Rights.

Learning Resources:

Textbooks:

1. Craig Shimasaki, Biotechnology Entrepreneurship: Starting, Managing, and Leading Biotech Companies, Academic Press, 2014
2. Sivasankar, Bio separations: Principles and Techniques, Prentice Hall India Learning Private Limited, 2006
3. Class Junghans and Adam Levy, Intellectual Property Management: A guide for Scientists, Engineers, Financers and Managers, Willey, 2006

Reference Books:

1. Raja Ghosh, Principles of Bio separations Engineering, World Scientific Publishing Co. Pte. Ltd, 2006
2. Barry A. Perlmutter, Integration and Optimization of Unit Operations, Elsevier Inc, 2022

BT1382 **1-0-0 (0.5)**

Fractal Course II

Pre-Requisites: **None**

Course Outcomes:

CO-1	Acquire an in-depth understanding of the specific topic covered in the course, which could range from a particular technology, method, or recent advancement in Biotechnology
CO-2	Develop hands-on skills relevant to the course topic, such as using specific tools, software, or techniques
CO-3	Apply learned concepts to solve focused and practical engineering problems related to the course content
CO-4	Understand the interdisciplinary aspects and applications of the course to solve real-world industrial problems

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3
CO-1	3	3	3	–	–	–	–	–	–	–	–	–	1	2	3
CO-2	–	–	–	2	2	3	3	–	–	–	–	–	1	1	1
CO-3	–	–	3	2	2	–	–	–	–	–	–	–	1	1	1
CO-4	–	–	–	–	–	–	–	–	1	3	–	2	2	2	2

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

This one-week course aims to bridge the gap between academic learning and industry application / latest research developments, providing students with a comprehensive understanding of the Biotechnology field and enhancing their readiness for professional careers.

a. **Structure:** Lectures delivered by an expert from the Biotechnology Industry / R&D Organization / Academic Institution (SPARC Collaborators / Foreign Subject Experts in GIAN program / Adjunct Professors from Foreign Universities @ NITW).

b. **Content:** Topics covering current practices, case studies, technological advancements, and future trends.

c. **Interactive Sessions:** Q&A sessions, discussions, and case study analyses to foster interaction between students and the subject expert.

d. **Assessment:** the mode of assessment (Participation, a short reflective report / a presentation summarizing key takeaways from the lectures / Objective or descriptive type exam, etc.) will be decided by the subject expert.

Learning Resources:

1. Course material and any learning resources suggested by the experts

BT1308 **0-1-2 (2)**

Bioprocess Instrumentation and Control Lab

Pre-Requisites: MA1161, MA1162, MA1261, BT1202, BT1301

Course Outcomes:

CO-1	Understand the principles of instrumentation and control in Bioprocess Engineering
CO-2	Gain hands on experience over first order and second order systems and their response
CO-3	Analyze different components of the control systems and their function
CO-4	Develop Models for Bioprocess Control Systems
CO-5	Develop Models for Simulate Analyze natural Biological Networks

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3
CO-1	–	3	–	–	2	1	1	1	–	1	–	–	–	1	–
CO-2	–	3	–	–	2	2	1	1	–	1	–	–	–	1	–
CO-3	–	3	–	3	2	3	2	1	–	3	–	–	–	3	–
CO-4	–	3	3	3	2	3	2	1	1	3	–	–	2	3	–
CO-5	–	3	3	1	2	2	3	1	1	3	–	–	2	1	–

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Experiments: 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 analyser (P, PD, PID controls) levels process analyser, Pressure analyser, temperature process analyser, 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. Coughanowr D R., LeBlanc SE., Process Systems Analysis and Control, McGraw-Hill, 2009, 3rd Edition
2. Michael C K Khoo, Physiological control systems: Analysis, simulation, and estimation, Wiley, 2018, 2nd Edition

Reference Books:

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

Other Suggested Readings:

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

BT1310 **0-1-2 (2)**

Computational Methods in Drug Discovery Lab

Pre-Requisites: **BT1204**

Course Outcomes:

CO-1	Understand the concept of structure-function relationship of lead molecules in drug discovery process
CO-2	Understand the process of target identification in drug discovery
CO-3	Apply proteomics and genomics techniques in drug-discovery and design process
CO-4	Understand the drug delivery systems
CO-5	Design new drugs using computational methods

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3
CO-1	1	2	2	2	2	2	–	–	1	1	–	1	3	3	3
CO-2	–	3	3	3	3	1	–	–	1	–	1	–	3	3	3
CO-3	–	2	2	3	3	2	–	–	1	1	–	–	3	2	3
CO-4	–	1	3	3	3	3	–	–	1	1	1	1	3	2	2
CO-5	–	2	3	3	3	3	2	–	1	1	–	1	3	2	1

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

List of Experiments: Installation of various drug design software, 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, Introduction to molecular dynamics simulation methods, Estimates binding free energy of ligands and receptor, Introduction to molecular dynamics analysis methods.

Learning Resources:

Text Books:

1. Povl Krogsgaard-Larsen, Ulf Madsen, Kristian Stromgaard, Textbook of Drug Design and Discovery, CRC Press, 2017, 5th Edition
2. Gerhard Edwin Seibold, Alexander Hillisch, Rolf Hilgenfeld, Birkhauser, Modern Methods of Drug Discovery, 2003, 1st Edition
3. Schlick, Tamar, Molecular Modelling and Simulation – An interdisciplinary Guide, Springer, 2010, 1st Edition
4. David C Young: Computational Drug Design (A guide for computational and medicinal chemists) Wiley & Sons, Inc., New Jersey, USA, 2009, 1st Edition

Reference Books:

1. Alan Hinchliffe, Molecular Modelling for Beginners, Wiley & Sons Ltd., 2008, 2nd Edition
2. Kourounakis, Advanced Drug Design and Development: A medicinal Chemistry Approach, Taylor and Francis, 1994, 1st Edition
3. Patrick Bultinck, Marcel Dekker, Computational medicinal chemistry for drug discovery, CRC Press, 2004, 1st Edition

7th Semester

BT1401 **3-0-0 (3)**

Modelling Simulation and Optimization of Bioprocesses

Pre-Requisites: **BT1202, BT1301**

Course Outcomes:

CO-1	Understand Modelling Principles
CO-2	Formulate Balance Equations
CO-3	Analyze Batch, Semi continuous or Fed Batch Operation
CO-4	Develop Enzyme and growth kinetic models
CO-5	Comprehend Bioreactor Modelling
CO-6	Develop models for biological systems

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3
CO-1	3	3	2	2	1	2	1	1	1	2	2	2	1	2	–
CO-2	3	3	1	2	2	2	2	1	2	2	1	3	2	1	–
CO-3	3	3	2	3	1	2	2	2	1	3	1	1	1	2	–
CO-4	3	2	3	2	2	1	1	2	2	1	2	1	2	2	–
CO-5	1	2	1	2	1	1	1	2	3	3	2	2	1	1	–
CO-6	3	2	2	3	3	3	1	2	1	1	2	1	2	1	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction to Modelling: Modelling 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 modelling, biomass productivity, modelling 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.

Learning Resources:

Text Books:

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

Reference Books:

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

Other Suggested Readings:

1. http://38.100.110.143/model/index.html
2. https://www.youtube.com/watch?v=gAMhDOFdW3g
3. https://www.youtube.com/watch?v=OhFot__I_x8
4. https://www.youtube.com/watch?v=cSUPrSkemgo

BT1403 **0-0-2 (1)**

Modelling Simulation and Optimization of Bioprocesses Lab

Pre-Requisites: **BT1202, BT1301**

Course Outcomes:

CO-1	Understand Modelling Principles
CO-2	Formulate Balance Equations
CO-3	Analyze Batch, Semi continuous or Fed Batch Operation
CO-4	Develop Enzyme and growth kinetic models
CO-5	Comprehend Bioreactor Modelling
CO-6	Develop models for biological systems

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3
CO-1	3	3	2	2	1	2	1	1	1	2	2	2	1	2	–
CO-2	3	3	1	2	2	2	2	1	2	2	1	3	2	1	–
CO-3	3	3	2	3	1	2	2	2	1	3	1	1	1	2	–
CO-4	3	2	3	2	2	1	1	2	2	1	2	1	2	2	–
CO-5	1	2	1	2	1	1	1	2	3	3	2	2	1	1	–
CO-6	3	2	2	3	3	3	1	2	1	1	2	1	2	1	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

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

Reference Books:

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

Other Suggested Readings:

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=cSUPrSkemgo

BT1405 **0-0-2 (1)**

Instrumentation Methods in Biotechnology Lab

Pre-Requisites: **BT1207**

Course Outcomes:

CO-1	Understand basics of bioanalysis and bioassays
CO-2	Comprehend principles and types of bioanalytical instruments
CO-3	Select appropriate spectroscopic techniques
CO-4	Relate and select appropriate chromatographic techniques
CO-5	Apply bioanalytical techniques learnt in characterization of biomolecules

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3
CO-1	3	–	–	1	3	–	–	2	–	–	–	–	3	3	2
CO-2	3	–	–	1	3	–	–	2	–	–	–	–	3	1	3
CO-3	3	–	–	1	3	–	–	2	–	–	–	–	2	1	3
CO-4	3	–	–	1	3	–	–	2	–	–	–	–	3	1	2
CO-5	3	–	–	2	3	–	–	2	–	–	–	–	3	2	2

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

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

Learning Resources:

Text Books:

1. Wilson K and Walker J, Principles and Techniques of Biochemistry and Molecular Biology, Cambridge University Press, 2005, 6th Edition
2. D. L. Pavia, G. M. Lampman, G. S. Kriz, J. R. Vyvyan, Spectroscopy, Cengage Learning, 2007, 1st Edition
3. Douglas A. Skoog, F. James Holler, Stanley R. Crouch, Principles of Instrumental Analysis, Cengage Learning, 2016, 7th Edition
4. Willard, Merit, Dean and Settle, Instrumental methods of analysis, CBS publishers, 2018, 7th Edition
5. B Notting, Methods in Modern Biophysics, Springer, 2010, 3rd Edition

Reference Books:

1. R.J. Simpson, Proteins and Proteomics: A Laboratory Manual, CSHL press, 2003, 1st Edition
2. J. Sambrook and D. W. Russell, Molecular Cloning: A Laboratory Manual, CSHL (Cold Spring Harbor Laboratory) Press, 2001, 3rd Edition
3. A. J. Ninfa and D. P. Ballou, Fundamental Laboratory Approaches for Biochemistry and Biotechnology, Wiley, 2009, 2nd Edition
4. Joachim W. Engels, Friedrich Lottspeich, Bioanalytics - Analytical Methods and Concepts in Biochemistry and Molecular Biology, Wiley, 2018, 1st Edition

Other Suggested Readings:

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

BT1489 **0-0-0 (2)**

Seminar and Technical Writing

Pre-Requisites: **None**

Course Outcomes:

CO-1	Consolidate ideas based on expert talks attended
CO-2	Prepare a well-organized report employing elements of critical thinking and technical writing
CO-3	Demonstrate the ability to describe, interpret and analyze the subject matter and develop competence in presenting

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3
CO-1	2	–	2	–	–	3	3	–	2	3	–	3	2	2	2
CO-2	2	–	2	–	–	3	3	–	2	3	–	3	–	–	–
CO-3	2	–	2	–	–	3	3	–	2	3	–	3	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Description:

In Seminar and Technical Writing, every student is expected to prepare a well-organized report based on one / all of the following:

- by attending at least 5 expert lectures/ invited talks/ Seminar/ Popular lectures etc. organized by the institute/any of the departments, ideally in a specific domain or with the same theme.
- prepare a business or marketing plan based on patent search

The student is expected to consolidate the ideas from these lectures/patent searches and may even include material from other sources to strengthen the content of the report. The student should prepare a well-organized report based on the above and present it to the panel constituted by the department, for evaluation.

Evaluation Criteria:

The student will be evaluated by the panel based on the below criteria.

Criteria	Description	Weightages
I	Clarity on the topic	15 marks
II	List of lectures attended	15 marks
III	Report	15 marks
IV	Presentation	30 marks
V	Response to questions	25 marks

Evaluation Criteria-CO Mapping

CO / Criteria	CO1	CO2	CO3
I	X		
II	X		
III		X	
IV			X
V			X

BT1491 **0-0-0 (2)**

Short Term Industrial / EPICS / Research Experience

Pre-Requisites: **None**

Course Outcomes:

CO-1	Apply engineering principles to real-world problems, gaining practical experience
CO-2	Plan, manage and execute the work with ethical consideration
CO-3	Review the social and environmental impact of the work
CO-4	Communicate the learnings through report and presentation

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3
CO-1	3	3	3	3	3	–	–	–	–	–	–	3	2	2	2
CO-2	2	2	2	2	2	–	–	3	3	–	3	3	–	–	–
CO-3	–	–	–	–	–	3	3	–	–	–	–	3	–	–	–
CO-4	–	–	–	–	–	–	–	–	–	3	–	3	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Description:

Every student has to undergo either a Summer Internship / EPICS / Research project. The summer internship may be undergone in an Industry/Research organization or any premier academic Institution, including NIT Warangal for 6-8 weeks. The EPICS/research project shall be registered under the guidance of any faculty member in the institute. The student is required to submit a report and present the work before an evaluation committee, nominated by the Head of the Department.

Evaluation Criteria:

The student will be evaluated by the panel based on the below criteria. Weightage for each criterion will be determined by the panel and will be informed to the students.

Criteria	Description	Weightages
I	Relevance of the area of work	25 marks
II	Performance of the Task	20 marks
III	Crucial learnings from the work	20 marks
IV	Report Preparation	15 marks
V	Presentation and Response to questions	20 marks

Evaluation Criteria-CO Mapping

CO / Criteria	CO1	CO2	CO3	CO4
I	X			
II		X		
III			X	
IV				X
V				X

BT1495 **0-0-0 (2)**

Minor Project

Pre-Requisites: **None**

Course Outcomes:

CO-1	Apply engineering principles to real-world projects
CO-2	Plan and monitor project tasks individually or as a team
CO-3	Demonstrate practical experience in project execution
CO-4	Communicate project findings clearly through reports and presentations

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3
CO-1	3	3	3	3	3	–	–	–	2	1	–	3	2	2	2
CO-2	2	2	2	2	2	–	–	–	3	2	3	3	–	–	–
CO-3	2	2	2	2	2	–	–	–	3	2	3	3	1	1	–
CO-4	1	1	1	1	1	–	–	–	3	3	–	–	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Description:

Students are expected to choose real world or relevant problems and apply the engineering principles learned, to solve the problem through building prototypes or simulations or writing codes or establishing processes/synthesis/correlations etc. The department constituted panel can decide the suitability and worthiness of the project

Evaluation Criteria:

The student will be evaluated by the panel based on the below criteria. Weightage for each criterion will be determined by the panel and will be informed to the students.

Criteria	Description	Weightages
I	Identification of Problem Domain	20 marks
II	Study of Existing Systems and establishing clear objectives	20 marks
III	Planning of project and work distribution within the team	10 marks
IV	Proper Documentation and Technical Writing	20 marks
V	Presentation and Response to questions	30 marks

Evaluation Criteria-CO Mapping

CO / Criteria	CO1	CO2	CO3	CO4
I	X			
II	X			
III		X	X	
IV				X
V				X

8th Semester

BT1498 **0-0-0 (6)**

Major Project

Pre-Requisites: **None**

Course Outcomes:

CO-1	Identify a domain specific and contemporary topic
CO-2	Review literature to identify gaps and define objectives & scope of the work
CO-3	Develop a prototype/model, experimental set-up or software systems to meet the objectives
CO-4	Analyze the results to draw valid conclusions

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3
CO-1	3	2	–	–	2	1	–	1	3	1	1	2	2	2	2
CO-2	2	2	–	–	1	2	1	1	2	2	–	3	1	–	1
CO-3	2	2	3	3	3	2	2	2	2	1	3	2	2	2	2
CO-4	2	2	–	3	3	–	–	–	2	2	–	3	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Description:

Students are expected to choose real-world contemporary problem and apply the engineering principles learned, to solve the problem through building prototypes or simulations or writing codes or establishing processes/synthesis/correlations etc. The department constituted panel will decide the suitability and worthiness of the project

The B.Tech. Project work will be evaluated for 100 marks, with the following weightages:

Component	**Weightage**
Periodic evaluation by Guide	40 marks
Mid-term review	20 marks
End Semester viva-voce examination	40 marks
Total	100 marks

Evaluation Criteria:

The student will be evaluated by the panel based on the below criteria. Weightage for each criterion will be determined by the panel and will be informed to the students.

Criteria	**Description**	**Weightages (%)**
I	Selection of Topic	05
II	Literature Survey	10
III	Objectives and Solution Methodology	15
IV	Performance of the Task and clarity on the work	20
V	Report Preparation	20
VI	Presentation and Response to questions	30

Evaluation Criteria-CO Mapping

CO / Criteria	CO1	CO2	CO3	CO4
I	X			
II		X		
III		X		
IV			X	
V				X
VI				X

Refer to the B.Tech. – Regulations for any further information regarding mid-term review, end semester evaluation, template for report preparation and plagiarism guidelines, etc.

Professional Elective - I

BT1321 **3-0-0 (3)**

Industrial Biotechnology

Pre-Requisites: **None**

Course Outcomes:

CO1	Understand the steps involved in the production of bioproducts and methods to improve productivity
CO2	Apply basic biotechnological principles, methods and models to understand the primary and secondary metabolites
CO3	Understand the methodologies and production methods for the production of r-DNA products

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3
CO-1	2	1	–	–	–	–	–	–	–	–	–	2	2	–	–
CO-2	3	3	3	3	–	–	–	–	–	–	–	2	2	2	1
CO-3	2	3	2	2	–	–	–	–	–	–	–	2	2	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction to Industrial Bioprocess: Biotechnology: Scope and importance, Commercial potential of Biotechnology in India. Historical overview of industrial fermentation process -traditional and modern Biotechnology. Industrial Fermentation- microorganisms, mode of operation, fermentation processes- pictorial representation.

Production of Primary Metabolites: A brief outline of processes for the production of some commercially important organic acids (citric acid, lactic acid & acetic acid); amino acids (glutamic acid & tryptophan) and alcohols (ethanol & butanol)

Production of Secondary Metabolites: Production processes for various classes of secondary metabolites: antibiotics: (penicillin streptomycin & erythromycin), vitamins (Vit B12 and Vit B2) and steroid biotransformation.

Production of Enzymes and Other Bioproducts: Production of industrial enzymes (proteases & amylases), Production of biopesticide, Biofertilizers, bio-preservative (Nisin), biopolymers (xanthan gum & PHB), cheese, SCP.

Production of Modern Biotechnology Products: Production of recombinant proteins having therapeutic and diagnostic applications (insulin, human growth hormone), Production of recombinant vaccines (Hepatitis B vaccine, cholera vaccine), production of monoclonal antibodies.

Learning Resources:

Text Books:

1. Lee, S.Y., Nielsen, J. and Stephanopoulos, G., Industrial Biotechnology: Products and Processes, John Wiley & Sons, 2016
2. Waites, M.J., Morgan,N.L., Rockey,J.S., Higton, G., Industrial Microbiology: An Introduction Blackwell, 2001
3. Cruger, W., Cruger, A., A Textbook of Industrial Microbiology, Panima Publishing Corporation, 2nd Edition, 2005

4. Stanbury, P.F., A. Whitaker and S.J. Hall, Principles of Fermentation Technology, Butterworth – Heinemann (an imprint of Elsevier), 1995, 2nd Edition
5. James D. Watson, Richard M. Myers, Amy A. Caudy, and Jan A. Witkowski, Recombinant DNA: Genes and Genomes: A Short Course - W. H. Freeman, 2007

Reference Books:

1. Prescott, S.C. and Cecil G. Dunn, Industrial Microbiology, Agrobios (India), 2005
2. Moo-Young, Murrey, Comprehensive Biotechnology, 4 Vols. Pergamon Press, (An Imprint of Elsevier), 2004
3. C. F. A Bryce and EL. Mansi, Fermentation microbiology & Biotechnology, 1999
4. K. G. Ramawat and Shaily Goyal, Comprehensive Biotechnology, 2009

BT1323 **3-0-0 (3)**

Biodiversity and Conservation

Pre-Requisites: **None**

Course Outcomes:

CO-1	Understand the concepts of diversity in microbes, plant and animal
CO-2	Comprehend to know the hotspots and genetic resources
CO-3	To learn the endemic and threatened species for conservation
CO-4	To study the conservation organization and their activities

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3
CO-1	1	2	–	–	–	–	3	2	–	3	–	2	–	–	–
CO-2	–	–	–	–	–	2	1	2	–	–	–	–	–	3	–
CO-3	–	3	–	–	–	1	–	–	–	–	–	–	–	–	–
CO-4	–	–	–	–	–	–	–	–	3	–	–	3	3	–	–

Syllabus:

Introduction: Biodiversity: Definition, levels, organization, uses, and valuing biodiversity; Genetic Diversity: Nature and origin of genetic variation, measuring genetic diversity; Species Diversity: Concept of species, measurement of species diversity, global distribution of species riches. Ecosystem diversity: Terrestrial and aquatic ecosystems. Center of mega diversity and biodiversity hotspots; Biodiversity vs. Biotechnology.

Genetic resources and importance of Biodiversity: Plant Genetic Resources, Agrobiodiversity, Centre of Origin of Agrobiodiversity; Animal Genetic Resources, Germplasm Characterization and Evaluation; Convention of Biological Diversity.

Biodiversity loss & conservation: Direct drivers of biodiversity loss, Consequences of Biodiversity Loss, Extinction of Species; Biodiversity Conservation: *Ex-situ* and *In-situ* conservation of biodiversity, Role of Traditional Knowledge in Biodiversity Conservation, Threats to biodiversity: Habitat loss, poaching of wildlife, man-life conflicts.

Conservation Organizations and their activities: Brief account of the Conservation Organizations and their activities-CI, WWF, UNEP, FAO, IUCN. International Agreements on Biodiversity Conservation-CBD, CITES, IPCC, UNFCC, RAMSAR; National Instruments to Conserve Biological Diversity, National Biodiversity Act 2002, National Green Tribunal Act (2010); Biodiversity and Interface with IPR, Principles of Biodiversity Governance, Biodiversity and Human Happiness.

Learning Resources:

Text Books:

1. K.V. Krishnamurthy, An advanced text book on Biodiversity, 2003
2. Wilson, E.O and F.M Peters, Biodiversity, National Academy Press Washington
3. Pushpangadan, P. K. Ravi and V. Santhosh, Conservation and Economic evaluation of Biodiversity, Oxford & IBH Publishers, New Delhi
4. Ray S. and Ray A.K, Biodiversity and biotechnology, New central book Agency (P) Ltd., Kolkata, 2010

Reference Books:

1. Agarwal, S.K, Biodiversity conservation, Rohini Publishers, Jaipur, 2002
2. Primack, R.B., Essentials of Conservation Biology, Sinauer Associates, Sunderland, Ma. USA, 2002, 3rd Edition
3. Gaston, K.J and Spicer, J.I, Biodiversity: An Introduction, Blackwell Publishing Company, USA, 2004

Other Suggested Readings:

1. https://onlinecourses.swayam2.ac.in/nou22_bt04/preview
2. https://onlinecourses.nptel.ac.in/noc23_lw06/preview
3. https://onlinecourses.swayam2.ac.in/cec21_ge31/preview

BT1325 **3-0-0 (3)**

Biological Programming

Pre-Requisites: **None**

Course Outcomes:

CO-1	Understand the scripting language and its procedures
CO-2	Apply the programming in strings, file handling and file management to develop programs
CO-3	Develop basic programs in Python
CO-4	Write a R-programs, matrixes, strings, file handling and file management to develop programs
CO-5	Apply the programming knowledge for any given biological problem
CO-6	Apply and analyze the data using visualization and analysis tools

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3
CO-1	3	3	3	2	3	2	–	1	2	1	3	3	3	3	3
CO-2	2	2	2	3	3	2	–	1	2	3	3	3	3	3	3
CO-3	3	3	3	3	3	3	–	2	3	3	3	3	3	3	3
CO-4	3	3	3	3	3	3	–	2	3	3	3	3	3	3	3
CO-5	3	3	3	3	3	3	–	2	3	3	3	3	3	3	3
CO-6	3	3	3	3	3	3	–	2	3	3	3	3	3	3	3

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction to python, python features, writing python program, values and variables. Files Handling: Exception handling, try, except statement, functions; built-in functions, commonly used modules. Strings; creating and storing strings, the string 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.

Matrices; Creating a matrix, Naming rows and columns, Subset a matrix, unit matrix, cross matrix, Computing covariance and correlation matrix, Data frames, Creating a data frame, filtering data, Setting values, Setting values as a list, Setting values as a matrix factors, useful functions for data frames. Arrays, array indexing, subsections of an array, the array function, mixed vector and array arithmetic generalized transpose of an array, matrix facilities, matrix multiplication, linear equations and inversion.

File handling, Reading and writing text-format data in a file, importing data, importing data using built-in functions, importing data using the readr package, Reading and writing Excel/CSV worksheets, Reading and writing native data files, Reading and writing a single object in native format, Saving and restoring the working environment Loading built-in datasets.

Visualizing data; Creating scatter plots, Customizing chart elements, Plotting lines in multiple periods, Plotting lines with points, Plotting a multi-series, Creating bar charts, pie charts, histogram and density plots, box plots. Pandas, Numpy, Dask, Matplotlib, Pandas-profiling, Scikit-learn, PyTorch, OpenCV, SQLAlchemy, Dask

Learning Resources:

Text Books:

1. Kun Ren, Learning R Programming, Packt Publishing Ltd., 2012
2. Larry Pace, Beginning R, an introduction to statistical programming, Apress, 2018
3. Gowrishankar S, Veena A, Introduction to python programming, CRC Press, 2019, 1st Edition
4. Magnus Lie Hetland, Beginning Python, Apress, 2008, 1st Edition

Reference Books:

1. Garrett Grolemund, O'Reilly Hands-On Programming with R: Write Your Own Functions and Simulations, 2014
2. R Programming for Bioinformatics, Robert Gentleman, CRC press, 2007

Other Suggested Readings:

1. https://onlinecourses.nptel.ac.in/noc22_cs32/previewNPTEL Courses

Professional Elective – II, III

BT1322 **3-0-0 (3)**

Biophysics

Pre-Requisites: **BT1207**

Course Outcomes:

CO-1	Define ergocity in a system and concept of ensembles
CO-2	Understand forces involved in biological systems
CO-3	Illustrate difference between quantum and molecular mechanics
CO-4	Identify Stochastic and deterministic simulation techniques
CO-5	Apply Molecular Dynamics Simulations for biological systems

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3
CO-1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-2	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-3	2	–	–	–	–	–	–	–	–	–	–	–	–	1	–
CO-4	2	1	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-5	–	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.

Basic concepts 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 & Types Model Building- Velocity Verlet and Leap-frog algorithms, Periodic Boundary conditions, generating *ab initio* and template-based models Applications of Molecular Dynamics Simulations.

Learning Resources:

Text Books:

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

Reference Books:

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

Other Suggested Readings:

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

BT1324 **3-0-0 (3)**

Enzyme Technology

Pre-Requisites: **BT1207**

Course Outcomes:

CO-1	Understand the basic principles of the Enzyme mechanism
CO-2	Explain enzyme kinetics with and without inhibitors
CO-3	Demonstrate the immobilization techniques and their potential applications
CO-4	Identify techniques for isolation and purification of industrially important enzymes
CO-5	Apply principles of enzyme technology to develop an efficient enzymatic process

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3
CO-1	2	2	–	–	–	–	–	–	–	2	–	3	3	–	–
CO-2	3	3	2	3	1	–	–	–	–	–	–	2	2	–	–
CO-3	3	2	3	3	–	–	–	–	–	–	–	2	2	–	–
CO-4	2	1	3	3	–	–	2	–	–	–	–	2	2	1	2
CO-5	3	2	3	3	–	–	2	–	–	2	–	2	2	1	2

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

General introduction: Nomenclature and Classification of enzymes, Types of specificity, Active sites. Enzyme activity—chemical nature of enzymes. Protein nature of enzymes and nonprotein enzymes—ribozymes and DNAzymes. Coenzymes and Cofactors—prosthetic group, coenzymes involved in different metabolic pathways.

Enzyme-substrate interaction: Lock and Key mechanism, Induced Fit mechanism, transition state Hypotheses, Enzyme function, and general mechanism. Mechanism of enzyme catalysis: Acid-base catalysis, covalent catalysis, Metal ion catalysis, Proximity and orientation effects, etc. Mechanism of Serine proteases: Chymotryspin, Lysozyme, Carboxypeptidase A and Ribonuclease, and Proenzymes (Zymogens).

Kinetics of free enzymes: Basic concepts of bioenergetics, Factors affecting the rates of chemical reactions, Enzyme Kinetics: Michaelis-Menten Equation, Measurement of Km and Vmax, Enzyme inhibition: Reversible (competitive, uncompetitive and mixed) and irreversible, Kinetics of multi-substrate reaction: Sequential reactions and ping-pong reactions. Multienzyme complex and multifunctional enzymes, Kinetics of allosteric enzymes and enzyme regulation.

Immobilized enzymes: 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 and recombinant), Strategies of isolation and purification of new enzymes from different sources, downstream processing, Applications of enzymes in the food industry, detergents, energy, waste treatment, pharmaceutical, medical, and analytical purposes.

Learning Resources:

Text Books:

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

Reference Books:

1. Klaus Buchholz, Volker Kasche, Uwe Theo Bornscheuer, Biocatalysts and Enzyme Technology, Wiley Publishing, 2012, 2nd Edition
2. H. W. Blanch and D. S. Clark, Biochemical Engineering, Marcel, Dekker Inc., 1996, 2nd Edition

Other Suggested Readings:

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

BT1326 **3-0-0 (3)**

Biomaterials Engineering

Pre-Requisites: **None**

Course Outcomes:

CO-1	Understand common use and categorization of biomaterials as metals, ceramics and polymers and its chemical structure, properties and morphology
CO-2	Assess biocompatibility of materials
CO-3	Identify various applications of biomaterials
CO-4	Develop biomaterials and tissue culture scaffolds for specific applications
CO-5	Design bioreactors for specific biomaterials and applications

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3
CO-1	3	–	–	1	3	–	–	2	–	–	–	–	3	3	2
CO-2	3	–	–	1	3	–	–	2	–	–	–	–	3	1	3
CO-3	3	–	–	1	3	–	–	2	–	–	–	–	2	1	3
CO-4	3	–	–	1	3	–	–	2	–	–	–	–	3	1	2
CO-5	3	–	–	2	3	–	–	2	–	–	–	–	3	2	2

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction to Biomaterials, Classification, Biomaterial Synthesis: Introduction, Property requirements of materials; Classification of Biomaterials: Metals and Metal alloys, Ceramics, Glass, Carbon, Polymers, composites, Natural Vs Genetically engineered materials, Biomaterials Vs Biological Materials, Nano Materials; Synthesis, characterization, and fabrication methods.

Biocompatibility of Biomaterials: Protein structure, interaction of proteins with synthetic materials. Surface engineering for biocompatibility; Characterization of cell material interactions; inflammatory responses; acute inflammation, chronic inflammation, foreign body response, assessment of material performance.

Biomaterial Applications: Orthopaedic, Orthodontic, Ophthalmic applications. Cardiovascular implants. Artificial vascular grafts. Skin repair/replacement materials. Scaffolds for tissue engineering and regenerative medicine applications, Biomaterials for drug delivery: Controlled Release applications.

Bioreactors Design, Entrepreneurship and Ethical Issues: Bioreactors for tissue engineering and bone engineering applications, Spinner flask bioreactor, rotating wall bioreactor, direct perfusion bioreactor and hollow fiber bioreactor; Ethical and legal Issues in Biomaterials and Medical Devices.

Learning Resources:

Text Books:

1. Buddy D. Ratner, Allan S Hoffman, Frederick J Schoen, Jack E Lemons, Biomaterials Science: An Introduction to Materials in Medicine, Academic Press, 2014, 3rd Edition
2. Carlos P. Bergmann, Santos dos V, Brandalise RN, Savaris M, Engineering of Biomaterials: Topics in Mining, Metallurgy and Materials Engineering Series, Springer, 2017, 1st Edition

Reference Books:

1. Sujatha V. Bhat, Biomaterials, Narosa Publishing house, 2010, 2nd Edition
2. Park J and Lakes R S, Biomaterials: An Introduction, Springer USA, 2007, 3rd Edition

Other Suggested Readings:

1. https://www.ibiology.org/speakers/robert-langer/

BT1326 **3-0-0 (3)**

Plant Biotechnology

Pre-Requisites: **BT1208**

Course Outcomes:

CO-1	Comprehend the concepts of Plant tissue culture techniques
CO-2	Understand the Technology of plant propagation and germplasm preservation
CO-3	Study of conventional and molecular marker breeding and hardening techniques
CO-4	Understand the basic techniques in culture of animal cells
CO-5	Understand and apply the concept of transgenic animals for recombinant product production

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3
CO-1	3	1	–	–	3	2	3	–	–	–	1	2	3	–	2
CO-2	–	3	–	–	–	–	3	–	–	–	1	2	–	–	2
CO-3	–	–	3	–	3	–	3	–	–	–	1	–	–	–	–
CO-4	–	–	2	–	1	–	–	2	–	–	–	–	3	2	–
CO-5	–	1	1	2	–	2	–	3	–	–	–	–	1	1	–

1 - Slightly; **2 - Moderately;** **3 – Substantially**

Syllabus:

Introduction to Plant Tissue culture: Historical developments and landmarks in plant tissue culture, Basic techniques in plant tissue culture. Formulation of media for plant tissue culture. Plant growth regulators – Involvement in plant differentiation and morphogenesis. Micropropagation and its uses, commercial exploitation of micropropagation, Centers of germplasm preservation in India.

Culture techniques: Initiation and maintenance of callus cultures, cell suspensions – Continuous and Batch cultures, Mass cultivation of plant cells using bioreactors. Concept of totipotency. Induction of morphogenesis in vitro. Somatic embryogenesis and Organogenesis. Factors affecting somatic embryogenesis and organogenesis, Somatic hybrids and cybrids, Embryo Rescue, Embryo Culture Isolation, purification and culture of protoplasts.

Hardening & Applications: Hardening- Hardening stages, Role of Poly house, Net House, Compost, Chemical fertilizer, Cocopit and Soil in hardening. Androgenic Haploids and its Applications in crop improvement, Meristem culture, Zygotic Embryo culture, Endosperm culture - Importance and applications.

Transgene technology: Genetic Transformation methods for production of transgenic plants (Direct, Indirect), Production of secondary metabolites from cell cultures and hairy root cultures, strategies used for enhanced production of secondary metabolites, Biotransformation using plant cell cultures. Plastid transformation.

Learning Resources:

Text Books:

1. Bhojwani. S.S. & Razdan. M.K, Plant Tissue Culture: Theory and Practice, Elsevier Science Publishers, New York, 1998, Revised Edition
2. Chawla. H.S, Introduction to Plant Biotechnology, Oxford & IBH

3. Ramawat. K. G & Merillon, Biotechnology: Secondary Metabolites, J. M. Science Pub., Netherlands, 2007, 2nd Edition
4. R. Endress, Plant Cell Biotechnology, Springer-Verlag

Reference Books:

1. Razdan. M.K., An Introduction to Plant Tissue Culture, Oxford & IBH Publishing, 2019, 3rd Edition

Other Suggested Readings:

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

BT1330 **3-0-0 (3)**

Unit Operations in Biotechnology

Pre-Requisites: **None**

Course Outcomes:

CO-1	Understand various unit operations involved in bioprocess industry
CO-2	Describe fluid flow operation and its measurement
CO-3	Identify heat transfer equipment for bioprocessing
CO-4	Comprehend the unit operation equipment involved in bioseparations
CO-5	Relate appropriate unit operation techniques in bioprocessing

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3
CO-1	2	1	–	–	–	–	1	–	–	–	–	1	2	–	–
CO-2	2	1	–	–	–	–	1	–	–	–	–	1	2	–	–
CO-3	2	1	–	–	–	–	1	–	–	–	–	1	2	–	–
CO-4	2	1	–	–	–	–	1	–	–	–	–	1	2	–	–
CO-5	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 Operations: Size reduction: crushing, grinding, pulverizing; mechanical separation, filtration, settling, sedimentation, screening, flotation.

Separation Operations: Absorption and Stripping, Adsorption and Desorption; 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. Distillation.

Learning Resources:

Text Books:

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

Reference Books:

1. Christie J Geankoplis, Transport Processes and Separation Processes Principles Prentice Hall, 2003, 4th Edition
2. R. B. Bird, W. E. Stewart and E. N. Lightfoot, Transport Phenomena, John Wiley, 2006, 2nd Edition
3. Coulson, J.M. and J.F. Richardson, Chemical Engineering, Butterworth - Heinemann, 1991, 4th Edition

Other Suggested Readings:

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

BT1332 **3-0-0 (3)**

Advanced Bioinformatics

Prerequisites: BT1204

Course Outcomes:

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:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3
CO-1	1	2	–	2	3	–	–	–	–	–	–	1	1	2	3
CO-2	1	2	–	2	3	–	–	–	–	–	–	1	1	2	3
CO-3	1	2	–	2	3	–	–	–	–	–	–	1	1	2	3
CO-4	1	2	–	2	3	–	–	–	–	–	–	1	1	2	3

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Analysis of chromosomes using genome browsers, BioMart, biomaRt, and ENCODE project, finding genes in eukaryotic genomes, resources for studying protein-coding genes: RefSeq, UCSC Genes, GENCODE, protein-coding genes in eukaryotes: new paradox.

Analysis of next-generation genome sequence data, from generating sequence data to FASTQ, genome assembly, SAM/BAM format and SAMtools, variant calling, summarizing variation, visualizing and tabulating next-generation sequence data.

Low and high-throughput technologies to study mRNAs, genome-wide measurement of gene expression, interpretation of RNA analyses, RNA-seq. data analysis, setting up TopHat and CuffLinks, TopHat to Map Reads to a Reference Genome, Cufflinks to assemble Transcripts, Cuffdiff to determine differential expression, CummeRbund to visualize RNA-seq. results.

Learning Resources:

Text Books:

1. Andreas D. Baxevanis, Gary D. Bader, David S. Wishart, Bioinformatics, Wiley, 2019, 4th Edition
2. Arthur M. Lesk, Introduction to Bioinformatics, Oxford University Press, 2019, 5th Edition
3. Jonathan Pevsner, Bioinformatics and Functional Genomics, Wiley-Blackwell, 2015, 3rd Edition

Reference Books:

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

Other Suggested Readings:

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

Professional Elective – IV, V

BT1421 **3-0-0 (3)**

Genomic Data Analysis

Prerequisites: BT1206, BT1208, BT1209

Course Outcomes:

CO-1	Identify the genomics technologies to generate different genomics data
CO-2	Understand the use of different types of genomics data for biomedical applications
CO-3	Apply the mathematical and statistical tools for analyzing the genomics data
CO-4	Categorize human disease through genomics

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3
CO-1	3	2	–	3	1	–	–	–	–	–	–	–	3	–	2
CO-2	3	2	–	3	1	–	–	–	–	–	–	–	3	–	–
CO-3	3	2	–	3	2	–	–	–	–	–	–	–	3	–	2
CO-4	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, RNAseq, 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: omnigenic 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. Sorin Draghici, Statistics and Data Analysis for Microarrays Using R and Bioconductor, (Chapman & Hall/CRC Computational Biology Series Book 4), 2nd Edition
2. Motulsky H, Intuitive Biostatistics, Oxford University Press, 2009, 2nd Edition

Reference Books:

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

Other Suggested Readings:

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)

BT1423 **3-0-0 (3)**

Structural Biology

Prerequisites: **BT1207, BT1208**

Course Outcomes:

CO-1	Determine the hierarchy in protein structures and structure-function relationship
CO-2	Understand techniques involved in determining the structure of a biomolecule
CO-3	Illustrate the role of computers to visualize the crystal structures
CO-4	Identify the need of computer-based simulations
CO-5	Apply Molecular Dynamics Simulations to study molecular systems

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3
CO-1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-2	2	–	–	–	3	–	–	–	–	–	–	–	–	–	–
CO-3	2	–	–	–	3	–	–	–	2	–	–	–	–	–	–
CO-4	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-5	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: introduction to 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. Branden C. I., and Tooze J., Introduction to Protein Structure, Taylor and Francis, 2001, 2nd Edition
2. Lesk A. M., Introduction to Protein Architecture: The Structural Biology of Proteins, Oxford University Press, 2014, 4th Edition-revised

Reference Books:

1. Voet, D, Voet, J. G., and Pratt C. W., Biochemistry, John Wiley and Sons, 2016, 5th Edition
2. Berg J, M., Stryer L., Tymoczko J, Biochemistry, Gatto G, W.H. Freeman & Co, 2019, 9th Edition

3. Creighton. T.E., Proteins, Structure and Molecular Properties, W.H. Freeman & Co, 1993, 2nd Edition
4. McPherson, A., Introduction to Macromolecular Crystallography, Wiley Blackwell, 2009, 2nd Edition
5. Drenth, J., Principles of Protein X-Ray Crystallography, Springer, 2007, 3rd Edition
6. Rhodes, G., Crystallography Made Crystal Clear, Academic Press, 3rd Edition

Other Suggested Readings:

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

BT1425 **3-0-0 (3)**

Cancer Biology

Pre-Requisites: **BT1206, BT1208**

Course Outcomes:

CO-1	Identify the factors that contribute to cancer development
CO-2	Understand the cellular and molecular mechanisms of cancer
CO-3	Get insights into how cancer rewires the key defense mechanisms of the body to spread
CO-4	Explain existing and emerging anti-cancer therapies

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3
CO-1	–	2	–	1	1	–	–	1	–	–	–	1	2	–	–
CO-2	–	1	1	2	–	–	–	–	–	–	–	2	–	1	–
CO-3	–	1	–	3	–	–	–	–	–	–	–	2	–	2	–
CO-4	1	–	3	1	1	–	1	2	–	–	–	1	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: 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, Warburg effect, role of immune system in cancer: inflammation, tumor associated macrophages, role of angiogenesis in cancer, stem cells and cancer: Wnt signaling, Hh signaling, drug resistance, cancer stem cells.

Cancer Therapy: Diagnosis of cancer, conventional therapies: surgery, radiotherapy and chemotherapy, emerging therapies: immunotherapy, gene therapy, personalized and targeted therapies, palliative care.

Learning Resources:

Text Books:

1. Robert A Weinberg, The Biology of Cancer, Garland Science, 2013, 2nd Edition
2. Robin Hesketh, Introduction to Cancer Biology, Cambridge University Press, 2012, 1st Edition

Reference Books:

1. Lewis J. Kleinsmith, Principles of Cancer Biology, Pearson Education India, 2016, 1st Edition

Other Suggested Readings:

1. https://onlinecourses.swayam2.ac.in/aic20_ge02/preview

BT1427 **3-0-0 (3)**

Transport Phenomena in Bioprocess Systems

Pre-Requisites: **PH1161, BT1161, BT1203**

Course Outcomes:

CO-1	Understand various laws in momentum transfer, types of fluids, viscosity and measurement
CO-2	Summarize the isothermal system, mixing mechanisms and power requirement for Newtonian and Non-Newtonian fluids
CO-3	Relate the mechanisms of heat transfer in a bioprocess operation
CO-4	Understand diffusion properties, film theory concepts and mass transfer between various states
CO-5	Illustrate the role of oxygen transfer in growth and metabolism of the cells

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3
CO-1	2	1	1	1	1	1	1	–	–	–	–	–	3	–	–
CO-2	2	1	2	1	1	1	1	–	–	–	–	–	3	–	–
CO-3	2	1	1	1	–	1	2	–	–	–	–	–	3	–	–
CO-4	2	–	–	1	–	1	2	–	–	–	–	–	3	–	–
CO-5	2	–	–	1	–	1	2	–	–	–	–	–	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.

Learning Resources:

Text Books:

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

Reference Books:

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

Other Suggested Readings:

1. https://archive.nptel.ac.in/courses/102/106/102106086/
2. https://archive.nptel.ac.in/courses/102/106/102106083/

BT1429 **3-0-0 (3)**

Molecular Pathogenesis

Pre-Requisites: **BT1205**

Course Outcomes:

CO-1	Analyze human-pathogen interactions using modern understanding of Koch's postulates
CO-2	Understand the molecular basis of evolution of pathogens
CO-3	Select appropriate model to analyze specific interaction of host-pathogen
CO-4	Use suitable molecular technique to assess pathogenicity
CO-5	Relate the roles and regulations of virulence factors in pathogenicity

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3
CO-1	2	1	1	1	1	1	1	–	–	–	–	3	–	–	–
CO-2	2	1	2	2	1	1	1	–	–	–	–	3	2	2	–
CO-3	2	1	1	1	–	1	2	–	–	–	–	–	–	–	–
CO-4	2	–	1	2	–	1	2	–	–	–	–	3	2	2	–
CO-5	2	–	1	2	–	1	2	–	–	–	–	–	–	–	–

1- Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Human microbiota and disease: Normal microbiota of human body and their interaction with host system. Characterization of human microbiota. Establishing connection between microbes and diseases—Koch's Postulates and its limitations. Modern alternatives to Koch's postulates, Concept of disease and virulence.

Molecular evolution of pathogens: Mechanisms of genetic variations, Different forms of mutations, chromosomal rearrangements, Horizontal gene transfer methods, Pathogenicity islands and pathogen evolution.

Molecular techniques and use of different models: Different animal and tissue culture models to measure pathogenicity—Experimental methods—LD_{50} and ID_{50} values estimation, competition assay, gentamicin protection and plaque assay, Different molecular approaches to identify pathogenic and host factors for establishing diseases.

Molecular mechanisms of pathogenicity: Strategies to evade host defense mechanisms—preinfection, colonization and evading host immunity. Production, secretion and delivery of different toxins and virulence factors. Different regulatory mechanisms for virulence genes, Quorum sensing.

Learning Resources:

Text Books:

1. Wilson, B. A., Salyers, A. A., Whitt, D. D. and Winkler, M. E, Bacterial Pathogenesis: A Molecular Approach, ASM Press, 2011, 3rd Edition

Reference Books:

1. Wiliam coleman & Gregory Tsongalis, Molecular Pathology: The molecular basis of human disease, Academic Press, 2017, 2nd Edition
2. Williams, P. Ketky, J and Salmond G, Methods in Microbiology: Bacterial Pathogenesis, Vol. 27, Academic Press, 1998

BT1431 **3-0-0 (3)**

Systems Biology

Pre-Requisites: **BT1202, BT1206, BT1208, MA1261**

Course Outcomes:

CO-1	Understand basic, advanced principles of systems biology and biological networks
CO-2	Understand networks behavior and emergent properties of biological networks
CO-3	Apply kinetics principles to develop systems-level mathematical models in biology
CO-4	Create and Analyze predictive mathematical models of biological interaction networks
CO-5	Design Systems biology-based research studies

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3
CO-1	–	3	–	–	2	1	1	1	–	1	–	–	–	1	–
CO-2	–	3	–	–	2	2	1	1	–	1	–	–	–	1	–
CO-3	–	3	–	3	2	3	2	1	–	3	–	–	–	3	–
CO-4	–	3	3	3	2	3	2	1	1	3	–	–	2	3	–
CO-5	–	3	3	1	2	2	3	1	1	3	–	–	2	1	–

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, ultrasensitivity, 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, autoregulation, 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.

Learning Resources:

Text Books:

1. Uri Alon, Introduction to Systems Biology, Chapman & Hall/CRC Mathematical and Computational Biology, 2019, 2nd Edition
2. Eberhard O. Voit, A First course on Systems Biology, Garland Science, 2017, 2nd Edition

Reference Books:

1. Zoltan Szallasi, Jörg Stelling, Vipul Periwal, Systems Modeling in Cellular Biology: From Concepts to Nuts and Bolts, Princeton Hall of India, ISBN: 978-81-203-3172-3, 2007, 1st Edition
2. Karthick Raman, An Introduction to computational Systems Biology: System-level modelling of cellular networks, CRC press, Taylor and Francis Group, 2021, 1st Edition
3. James Ferrel, Systems Biology of cell signaling: Recurring themes and quantitative models, CRC Press Inc, 2021, 1st Edition

Other Suggested Readings:

1. https://nptel.ac.in/courses/102/106/102106068/
2. https://www.ibiology.org/playlists/synthetic-biology/
3. Relevant research articles

Professional Elective – VI, VII, VIII

BT1422 **3-0-0 (3)**

Environmental Biotechnology

Pre-Requisites: **BT1102**

Course Outcomes:

CO-1	Understand the biological treatment techniques for wastewater
CO-2	Understand the principle of industrial waste management
CO-3	Describe the use of biotechnological processes to protect the environment
CO-4	Contrast approaches to anaerobic digestion of wastes and solve related problems
CO-5	Understand the hazardous waste management

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3
CO-1	–	–	–	1	2	–	–	–	1	–	–	–	2	–	–
CO-2	–	–	–	1	3	–	–	–	2	–	–	–	2	1	1
CO-3	–	–	–	1	3	–	–	–	–	–	–	–	2	–	2
CO-4	–	–	–	2	2	–	–	–	2	–	–	–	2	2	2
CO-5	–	–	–	2	3	–	–	–	1	–	–	–	2	2	2

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction: Biological Treatment of Wastewater – Aerobic System Biological processes for domestic and industrial wastewater treatments; Aerobic systems - activated sludge process, trickling filters, biological filters, rotating biological contractors (RBC), Fluidized bed reactor (FBR), expanded bed reactor, inverse fluidized bed biofilm reactor (IFBBR) packed bed reactors air- sparged reactors. Anaerobic System Anaerobic biological treatment – contact digesters, packed column reactors, UASB

Bioremediation: Introduction, constraints and priorities of Bioremediation, Biostimulation of naturally occurring microbial activities, Bioaugmentation, *in situ*, *ex-situ*, intrinsic & engineered bioremediation. Solid phase bioremediation - land farming, prepared beds, soil piles, Phytoremediation. Composting, Bioventing & Biosparging; Liquid phase bioremediation - suspended bioreactors, fixed biofilm reactors.

Metal Biotechnology Mining and Metal biotechnology: Introduction, with special reference to Copper & Iron. Microbial transformation, accumulation and concentration of metals, metal leaching, extraction and future prospects.

Hazardous Waste Management: Introduction - Xenobiotic compounds, recalcitrance. Hazardous wastes - biodegradation of Xenobiotics and Plastics. Biological detoxification - market for hazardous waste management, biotechnology application to hazardous waste management - examples of biotechnological applications to hazardous waste management – cyanide detoxification - detoxification of oxalate, urea etc. - toxic organics – phenols, STP, antibiotic treatment.

Learning Resources:

Text Books:

1. Surajbhan Sevda, Solid Waste Management: Biological Approaches, Taylor & Francis Group, 2024, 1st Edition

2. Paulin M. Doran, Bioprocess Engineering Principles, Elsevier Science & Technology Books, 2013, 2nd Edition

Reference Books:

1. Foster C.F., John Ware D.A, Environmental Biotechnology, Ellis Horwood Ltd., 2007
2. Karrely D., Chakrabarty K., Omen G.S., Biotechnology and Biodegradation, Advances in Applied Biotechnology Series, Vol.4, Gulf Publications Co. London, 2009

Other Suggested Readings:

1. https://archive.nptel.ac.in/courses/102/105/102105088/
2. https://nptel.ac.in/courses/103107084

BT1424 **3-0-0 (3)**

Protein Engineering

Pre-Requisites: **BT1206, BT1208**

Course Outcomes:

CO-1	Relate Protein structure to protein function
CO-2	Comprehend protein folding pathways
CO-3	Select appropriate techniques for protein engineering
CO-4	Understand the protein characterization techniques

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3
CO-1	2	1	–	2	–	2	–	–	–	–	–	3	3	1	–
CO-2	1	2	–	2	2	1	–	–	–	–	–	–	3	–	–
CO-3	1	2	–	2	2	1	–	–	–	–	–	1	2	1	–
CO-4	2	1	1	2	2	–	–	–	1	–	–	–	3	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

The Relationship between Protein Structure and Function: Protein synthesis, Protein structure, families of protein structures: alpha, alpha/beta, beta, etc., protein function and structure-function relationships. Ramachandran plot, Motifs of protein structures and their packing, Protein folding pathways in prokaryotes and eukaryotes, Structure of chaperones and role of chaperones in protein folding, Folding of single domain and multi-domain proteins, Inclusion bodies and recovery of active proteins.

Methods in Protein Engineering: Strategies for protein engineering; Protein Engineering with Random and Site-specific mutation, PCR based methods for engineering proteins, Role of low-fidelity enzymes in protein engineering, Gene shuffling and Directed evolution of proteins, Antibody engineering.

Structural Analysis of Proteins: Similar structure and function of homologous proteins, Role of multiple alignment, Homology and ab- initio method for protein structure prediction, Phage display systems; Rational protein design, Different databases and their uses.

Proteome analysis: Introduction to the concept of proteome, components of proteomics, proteomic analysis, importance of proteomics in biological functions, protein identification, protein arrays, protein chips and applications, cross linking methods, affinity methods, yeast hybrid systems, isotope labeling, Protein identification with two-dimensional gel electrophoresis data and mass spectrometry data, Functional proteomics tools.

Learning Resources:

Text Books:

1. Anton Torres, Protein Engineering and Design, Syrawood Publishing House, 2017

2. Mallorie N Sheehan, Protein Engineering: Design, Selection & Applications (Protein Biochemistry, Synthesis, Structure and Cellular Functions), Nova Science Publishers Inc; UK, 2011

Reference Books:

1. Ed. Lilia Alberghina, Protein engineering in Industrial biotechnology, Harwood Academic Publishers, 2002
2. Pennington, S.R and M.J. Dunn, Proteomics: Protein Sequence to Function, Viva Books, 2002

Other Suggested Readings:

1. https://www.springer.com/gp/book/9783030568979
2. https://www.science.gov/topicpages/p/protein+engineering+study.html

BT1426 **3-0-0 (3)**

Metabolic Engineering

Pre-Requisites: **BT1207, BT1303**

Course Outcomes:

CO-1	Explain the concepts of cellular reactions and regulations
CO-2	Identify the appropriate metabolic pathways to produce a desired product
CO-3	Illustrate potential metabolic engineering strategies using quantitative metabolic models
CO-4	Develop metabolic flux models using available tools and software
CO-5	Design effective strategies to implement genetic manipulations

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3
CO-1	2	1	1	1	1	–	–	–	–	–	–	2	1	1	1
CO-2	3	3	3	3	3	–	–	–	–	–	–	2	3	3	3
CO-3	2	3	3	3	3	–	–	–	–	–	–	1	3	3	3
CO-4	2	2	2	2	3	–	–	–	–	–	–	1	2	3	3
CO-5	3	2	2	2	2	–	–	–	–	–	–	2	2	2	2

1 - Slightly; **2 - Moderately;** **3 – Substantially**

Syllabus:

Basic Concepts of Metabolic Engineering: Review of Cellular Metabolism: Transport Processes, Fueling Reactions, Biosynthetic Reactions, Polymerization, Growth Energetics, Comprehensive Models for Cellular Reactions. Comprehensive Models for Cellular Reactions: Stoichiometry of Cellular Reactions, Reaction Rates, Dynamic Mass Balances, Yield Coefficients, and Linear Rate Equations. Material Balances and Data Consistency: The Black Box Model, Elemental Balances, Heat Balance, Analysis of Overdetermined Systems, and Identification of Gross Measurement Errors.

Metabolic regulation and application: Metabolic regulation network at enzyme level and whole cell level, Basic concept and successful application of metabolic engineering with examples such as strain improvement, product overproduction, byproduct minimization, extension of substrate utilization range and product spectrum, xenobiotic degradation.

Systems metabolic modelling: metabolic pathway synthesis algorithm, Metabolic flux analysis and its application, Concepts of Flux balance analysis (FBA), Regulatory on-off Minimization (ROOM) and Minimization of metabolic adjustments (MOMA), Elementary mode, analysis, Extreme pathways, Determination of metabolic fluxes by isotope labelling, and Metabolic control analysis (MCA).

Learning Resources:

Text Books:

1. G. Stephanopoulos, A. Aristidou, and J. Nielsen, Metabolic Engineering Principles and Methodologies, Academic Press, 1998, 1st Edition
2. C.S. Smolke, Metabolic pathway engineering handbook: Fundamentals, CRC press, 2010, 1st Edition

Reference Books:

1. Miguel Antonio Aon, Sonia Cortassa, Alberto Alvaro Iglesias, David Lloyd, An Introduction to Metabolic and Cellular Engineering, World scientific publishing company, 2002, 1st Edition

2. Y. Lee and E. T. Papoutsakis, Metabolic Engineering, Marcel Dekker, 1999, 1st Edition

Other Suggested Readings:

1. https://nptel.ac.in/courses/102/105/102105086/

BT1428 **3-0-0 (3)**

Biosensors

Pre-Requisites: **CY1161, BT1207, BT1208**

Course Outcomes:

CO-1	Understand the basic components of biosensors and biorecognition molecules
CO-2	Demonstrate the transduction techniques used in biosensor development
CO-3	Apply the principles of engineering to design and fabricate biosensors
CO-4	Illustrate the application of biosensors in health and environment

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3
CO-1	2	1	–	–	–	–	–	–	–	–	–	2	2	–	–
CO-2	3	3	3	3	–	–	–	–	–	–	–	2	2	2	1
CO-3	2	3	2	2	–	–	–	–	–	–	–	2	2	–	–
CO-4	3	3	3	3	–	–	–	–	–	–	–	2	2	3	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

General overview of biosensors: Introduction to biosensors, main elements in biosensor, biosensor classification, biorecognition molecules in biosensors such as enzymes, oligonucleotides and nucleic acids, membrane receptors, cell-based systems, biomimetic systems, aptamers, immobilization techniques for biomolecules.

Transducer systems in biosensors: Physico-chemical transducers: electrochemical transducers (amperometric, potentiometric, impedimetric); optical transducers (absorption, fluorescence, SPR); thermal transducers; piezoelectric transducers.

Design and fabrication of biosensors: Design Considerations: calibration, dynamic range, linear range, signal to noise, sensitivity, selectivity, Interference, reproducibility, detection limit, stability. Fabrication techniques: self-assembled monolayers, screen printing, photolithography, micro-contact printing, MEMS, Miniaturization, nanomaterial-based biosensors.

Application of Biosensors in health and environment: Application of biosensors in healthcare: biosensors in glucose monitoring, microfabricated biosensors and point-of-care diagnostics systems, biosensors in cancer diagnosis, forensic science benefits, Biosensors in environmental monitoring, current challenges.

Learning Resources:

Text Books:

1. Brian R. Eggins, Chemical Sensors and Biosensors, John Wiley& Sons, 2003, 1st Edition
2. Donald G. Buerk, Biosensors: Theory and Applications, CRC Press, 2009, 1st Edition
3. Chandra Mouli Pandey and Bansi Dhar Malhotra, Biosensors: Fundamentals and Applications, De Gruyter 2019, 1st Edition

Reference Books:

1. Florinel-Gabriel Banica, Chemical Sensors and Biosensors: Fundamentals and Applications, Wiley, 2012, 1st Edition

2. Alice Cunningham, Introduction to Bioanalytical Sensors, John Wiley& Sons, 1st Edition

Other Suggested Readings:

1. https://www.edx.org/course/principles-of-electronic-biosensors

BT1430 **3-0-0 (3)**

Nanobiotechnology

Pre-Requisites: **None**

Course Outcomes:

CO-1	Understand the basic principles of nanotechnology
CO-2	Learn the different methods of synthesis of nanomaterials
CO-3	Study the various techniques of characterization of nanomaterials
CO-4	Comprehend the various applications of nanobiotechnology

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3
CO-1	2	1	–	2	–	2	–	–	–	–	–	–	3	1	–
CO-2	1	2	–	2	2	1	–	–	–	–	–	–	3	–	–
CO-3	1	2	–	2	2	1	–	–	–	–	–	–	2	1	–
CO-4	2	1	1	2	2	–	–	–	1	–	–	–	3	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction to Nanotechnology and Nano-biotechnology: Types of nanomaterials: Nanoparticles, Nanowires, Nanotubes, Thin films and Multilayers. Properties of Nanomaterials, Biomolecules as nanostructures.

Synthesis of nanomaterials and Basic characterization techniques: Electron microscopy, Atomic force microscopy, Photon correlation spectroscopy. Functionalization of nanomaterials for biological applications.

Applications of nanomaterials and future prospects: Nanomaterials in optical biosensors and imaging, Nanomaterials in electrochemical biosensors and bioseparation processes. Nanostructures for drug delivery. Targeting and Routes of delivery, Photodynamic therapy. Nanotoxicology. Recent trends in nanobiotechnology.

Learning Resources:

Text Books:

1. M. Ratner and D. Ratner, Nanotechnology –a gentle introduction to the next big idea, Pearson education, 2007, Latest Edition
2. Christof M. Niemeyer, Chad A. Mirkin. Nanobiotechnology: Concepts, Applications and Perspectives, Wiley, John & Sons, 2004, 1st Edition

Reference Books:

1. L. E. Foster, Nanotechnology-Science, Innovation and opportunity, Person education inc, 2007, Latest Edition

Other Suggested Readings:

1. https://nptel.ac.in/courses/118102003

BT1432 **3-0-0 (3)**

Animal Biotechnology

Pre-Requisites: **BT1206, BT1208, BT1303**

Course Outcomes:

CO-1	Understand the importance of animals in human welfare
CO-2	Explain the methods to create transgenic animals and their importance
CO-3	Demonstrate the importance of genetically engineered animal models for applications in drug development and disease research
CO-4	Explain the techniques to improve livestock breeding and animal welfare

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3
CO-1	3	2	–	2	–	1	2	–	–	–	–	1	–	1	–
CO-2	3	2	2	2	–	1	1	2	–	–	–	2	2	–	–
CO-3	1	3	2	3	–	2	1	2	–	–	–	2	3	–	–
CO-4	1	–	3	1	–	3	2	2	–	–	–	1	–	–	1

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction: Basics and scope of animal biotechnology, historical background of animals in human welfare, culture of animal cells, natural and synthetic media, growth conditions, kinetics of cell growth, Micro & macro-carrier culture; spheroid cultures.

Transgenic animals: Definition, generation of transgenic animals -microinjection, somatic cell nuclear transfer, gene transfer into gametes, vector mediated gene transfer, applications of transgenic animals- in agriculture, production of pharmaceuticals, recombinant products, donor organs, knock out animals, knock-in animals.

Animal models in disease research: animal models in modern biomedical research, criteria for choosing an animal model, animal models for tuberculosis, neurodegenerative disorders, rheumatoid arthritis, cancer research, animal models for enteric diseases, translational significance of animal models, epigenetics and animal models, advantages, and concerns.

Applications of animal biotechnology: Hybridoma technology, stem cell technology, livestock improvement, assisted reproductive technologies, recombinant vaccines, recent advances, ethical issues, and concerns.

Learning Resources:

Text Books:

1. Ashish Verma, Anchal Singh, Animal Biotechnology: Models in Discovery and Translation, Academic Press, 2019, 2nd Edition
2. M. Butler, Animal Cell Culture and Technology, Taylor & Francis, 2003, 2nd Edition

Reference Books:

1. R. Ian Freshney, Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications, Wiley-Blackwell, 2021, 8th Edition

Other Suggested Readings:

1. https://onlinecourses.nptel.ac.in/noc20_me04/preview

BT1434 **3-0-0 (3)**

Pharmaceutical Biotechnology

Pre-Requisites: **None**

Course Outcomes:

CO-1	Explain the strategies in new drug discovery process
CO-2	Extend the knowledge of pharmaceutical manufacturing
CO-3	Outline the concept of pharmacodynamics and pharmacokinetics
CO-4	Analyze the quality control procedures in the production of various biopharmaceuticals

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3
CO-1	1	3	–	2	–	2	–	3	–	–	–	–	3	–	–
CO-2	–	–	–	–	–	–	3	–	1	2	–	2	–	–	–
CO-3	2	–	3	–	–	–	2	–	3	2	–	3	–	–	2
CO-4	–	–	–	–	–	3	–	–	–	–	2	3	–	3	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction to Pharmaceutical Biotechnology: An overview and history of biopharmaceutical industry, The business and the future of Biopharmaceuticals, Drug regulation and control, Scope and applications of biotechnology in pharmacy.

Drug discovery and Drug administration: Strategies for new drug discovery, finding a lead compound, combinatorial approaches to new drug discovery, pre-clinical and clinical trials. Routes of drug administration, membrane transport of drugs, absorption, distribution, metabolism and excretion of drugs. Factors modifying drug action, mechanism of drug action on human beings, receptor theory of drug action, pharmacogenomics, adverse effects of drugs and toxicology, Drug interactions.

Bioreactor selection and Operation: Production of pharmaceuticals by genetically engineered cells-hormones and vaccines. Regulatory issues in pharmaceutical products. Fermentation products in Pharmaceutical industry: Antibodies, Therapeutic proteins, Vitamins, Amino acids, Monoclonal Antibodies.

Quality control and Instrumentation: Quality control of antibiotic and non-antibiotic formulations using titrimetric, spectrophotometric, chromatographic methods as per IP/US Pharmacopoeia. Microbiological assays of vitamins and antibiotics. Sterility testing and stability testing of parenteral formulations.

Learning Resources:

Text Books:

1. Tripathi, K.D., Essentials of Medical Pharmacology, Jaypee Brothers Medical Publishers, 2008, 1st Edition
2. Dr. Oliver Kayser and Prof. Dr. Rainer H., Müller, Pharmaceutical Biotechnology, Wiley, 2004, 1st Edition

Reference Books:

1. Walsh G., Biopharmaceuticals: Biochemistry and Biotechnology, Wiley, 2013, 2nd Edition
2. Crommelin J.A. and Sindelar R.D., Routledge Pharmaceutical Biotechnology, Taylor & Francis, 2003, 1st Edition

Other Suggested Readings:

1. https://nptel.ac.in/courses/102/108/102108077/
2. https://nptel.ac.in/courses/104/106/104106106/

BT1436 **3-0-0 (3)**

Analytical Biotechnology

Pre-Requisites: **None**

Course Outcomes:

CO-1	To understand the fundamental principles and applications of analytical techniques in biotechnology
CO-2	To explore the methodologies for analyzing biological molecules and systems
CO-3	To learn about the instrumentation and techniques used in analytical biotechnology
CO-4	Select appropriate chromatographic techniques
CO-5	Apply bioanalytical techniques learnt in characterization of biomolecules

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3
CO-1	3	–	–	1	3	–	–	2	–	–	–	–	3	3	2
CO-2	3	–	–	1	3	–	–	2	–	–	–	–	3	1	3
CO-3	3	–	–	1	3	–	–	2	–	–	–	–	2	1	3
CO-4	3	–	–	1	3	–	–	2	–	–	–	–	3	1	2
CO-5	3	–	–	2	3	–	–	2	–	–	–	–	3	2	2

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Importance of Analytical Techniques in Biotechnology: Protein extraction and quantitation, modern approaches in bioanalysis and bioassays, radioisotope techniques, concepts, autoradiography, RIA, applications in biological sciences.

Principles 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.

Spectrometry: UV-Visible spectrometry, fluorescence spectrometry, IR spectrometry, CD spectrometry, Fourier transform infrared spectrometry (FTIR), principles and applications of different chromatographic techniques, mass spectrometry (LCMS), gas chromatography–mass spectrometry (GCMS), atomic absorption spectrometry (AAS), two-dimensional gel electrophoresis.

Next generation sequencing (NGS), matrix-assisted laser desorption ionization time-of-flight (MALDI-TOF), flow cytometry - fluorescence-activated cell sorting (FACS), differential scanning calorimetry (DSC)

Learning Resources:

Text Books:

1. Kane Lloyd, Analytical Biotechnology, Callisto Reference, 2019
2. Keith Wilson, Principles and Techniques of Biochemistry and Molecular Biology, Cambridge, 2010

Reference Books:

1. Piotr Vasilevich,Koros, Handbook Of Analytical Biotechnology : Analysis And Applications, 2015

2. D. L. Pavia, G. M. Lampman, G. S. Kriz, J. R. Vyvyan, Spectroscopy, Cengage Learning, 2007
3. Douglas A. Skoog, F. James Holler, Stanley R. Crouch, Principles of Instrumental Analysis, Cengage Learning, 2016

Other Suggested Readings:

1. https://onlinecourses.nptel.ac.in/noc22_bt60/preview

BT1436 **3-0-0 (3)**

Biosafety, Bioethics & IPR

Pre-Requisites: **None**

Course Outcomes:

CO-1	Understand basic principles of biosafety and follow good laboratory practices
CO-2	Identify design requirements of confinement facilities at different Biosafety levels
CO-3	Understand the societal and bioethical issues related to modern biotechnology
CO-4	List out the different forms of Intellectual property rights
CO-5	Comprehend international agreements and protocols for Biosafety, Bioethics & IPR

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3
CO-1	3	2	–	3	3	–	–	–	–	–	–	–	3	–	2
CO-2	3	2	–	3	3	–	–	–	–	–	–	–	3	–	–
CO-3	3	2	–	3	3	–	–	–	–	–	–	–	3	–	2
CO-4	3	2	–	3	3	–	–	–	–	–	–	–	3	–	2
CO-5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

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, RCGM, GEAC etc. 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 & 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 & complete; precautions while patenting – disclosure / non-disclosure, patent licensing, Patent infringement, patent evergreening, 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 & 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, Essence of Belmont Report.

Learning Resources:

Text Books:

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

Reference Books:

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

Other Suggested Readings:

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

Open Elective - I

BT1475 **2-0-0 (2)**

Green Technology

Pre-Requisites: **None**

Course Outcomes:

CO-1	Understand historical, global, environmental and economic impacts of biomass technology systems
CO-2	Address biomass energy and non-renewable energy challenges
CO-3	Understand green buildings concept
CO-4	Understand economics of green energy

Syllabus:

Biomass Energy: Basic concepts, sources of biomass energy, uses of biomass energy, science and engineering aspects of biomass energy, estimation of air required for complete combustion, estimation of minimum amount of air required for a fuel of known composition, calculation of the composition of fuel & excess air supplied, from exhaust gas analysis, dew point of products, flue gas analysis (O_2, CO_2, CO, NOx, SOx).

Energy Transformation: Energy transformation from source to services, energy sources, Sun as the source of energy; biological processes; photosynthesis; fossil fuel reserves - estimates, duration; theory of renewability, renewable resources; overview of global/ India's energy scenario.

Environmental Effects: Environmental effects of energy extraction, conversion and use; sources of pollution from energy technologies, criteria for choosing appropriate green energy technologies.

New Green Energy Concepts: Green buildings, green roof design characteristics, conceptual water and energy balance in a green roof, evapotranspiration.

Economics of Energy: Market barriers of biomass fuels, biomass fuel standardization, sustainability of biomass fuels, economics of biomass fuels, fuel stoichiometry and analysis: fuel stoichiometry relations, fuel-wood use in rural households, future energy scenario in rural areas, utilization of biomass in industrial and semi-industrial settings, future utilization of biomass in India.

Learning Resources:

Text Books:

1. Surajbhan Sevda, Solid Waste Management: Biological Approaches, 2024, Taylor & Francis Group, 1st Edition
2. Foster C.F, John Ware D.A., Environmental Biotechnology, Ellis Horwood Ltd., 2007

Reference Books:

1. Surajbhan Sevda, The Principles of Green Energy & Technology: Basic Concepts to Applications – Volume I, 2024, Taylor & Francis Group, 1st Edition
2. Dustin R. Mulvaney, Green Technology: An A to Z guide, SAGE publications, 2011, 1st Edition

Other Suggested Readings:

1. https://nptel.ac.in/courses/103/107/103107157/

BT1477 **2-0-0 (2)**

Biofuel Engineering

Pre-Requisites: **None**

Course Outcomes:

CO-1	Identify and selecting the appropriate potential biomass sources for Biofuels production
CO-2	Understand and differentiate the energy harvesting biochemical pathways
CO-3	Understand the production process of liquid, gaseous biofuels and bioelectricity
CO-4	Apply the bioreactor design strategies and microbial models for efficient biofuel production process
CO-5	Forecast the entrepreneurial opportunities in Bioenergy

Syllabus:

Introduction to Biofuels: Overview of Biofuels, Introduction to Biorefinery, Harvesting energy from biochemical reactions, National Biofuel Policy and law.

Liquid fuels and Gaseous fuels: Biofuel Feedstocks, Biomass conversion technologies, Ethanol production from different feed stocks, Biodiesel Production Chemistry and Thermodynamic Aspects, Microbial engineering for biofuels production. Biological production of Hydrogen and Methane, Biomass gasification: Pyrolysis and Combustion.

Bioelectricity: Microbial Fuel Cells (MFC), Fuel cell design and MFC performance, Biopower production process, Entrepreneurial opportunities in Bioenergy

Learning Resources:

Text Books:

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

Reference Books:

1. Vijai K. Gupta, Bioenergy Research: Advances and Applications, Elsevier B.V. Netherlands, 2014, 1st Edition
2. Vaughn C. Nelson, Kenneth L. Starcher, Introduction to Bioenergy (Energy and the Environment), CRC Press, 2011, 1st Edition
3. Vijai K. Gupta, Biofuel Technologies-Recent Developments, Springer-Verlag Berlin Heidelberg, 2013, 1st Edition
4. Kazuyuki Shimizu, Metabolic Regulation and Metabolic Engineering for Biofuel and Biochemical Production, CRC Press, 2017,1st Edition
5. David M. Mousdale, Biofuel-Biotechnology, Chemistry, and sustainable Development, CRC Press Taylor & Francis Group, 2008, 1st Edition
6. Ayhan Demirbas, Green Energy and Technology, Biofuels, Securing the Planet's Future Energy Needs, Springer, 2009, 1st Edition

Other Suggested Readings:

1. https://nptel.ac.in/courses/102/104/102104057/Website reference links

Open Elective - II

BT1476 **2-0-0 (2)**

Computer Aided Drug Design

Pre-Requisites: **BT1161**

Course Outcomes:

CO-1	Understand the structure-function relationship of lead molecules in drug discovery process
CO-2	Understand the process of target identification in drug discovery
CO-3	Apply proteomics and genomics techniques in drug-discovery and design process
CO-4	Understand the drug delivery systems
CO-5	Design new drugs using computational methods

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.

Protein structure determination in drug discovery: Crystallography, 2D NMR, Cryo-EM, de novo design and basics of instrumentation methods used in the drug discovery process.

Computational Approaches: Concept of homology and docking, steps involved in homology model building, AI tools in drug discovery, Compound library design, QSAR, ADMET predictions, Pharmacophore modelling, Introduction to molecular dynamics simulation methods, force fields, search algorithms, preparation of target, design of ligands and analysis of results.

Learning Resources:

Text Books:

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

Reference Books:

1. Alan Hinchliffe, Molecular Modelling for Beginners, Wiley & Sons Ltd. 2008, 2nd Edition
2. Kourounakis, Advanced Drug Design and Development: A medicinal Chemistry Approach, Taylor and Francis, 1994, 1st Edition
3. Patrick Bultinck, Marcel Dekker,Computational medicinal chemistry for drug discovery, CRC Press, 2004, 1st Edition
4. JorgKnablein, Modern Biopharmaceuticals: Design, Development and Optimization, Wiley – VCH, 2005, 1st Edition
5. Andrew R. Leach, Molecular Modelling, Principles & Applications, Addison WesleyLongman, Singapore, 1996, 1st Edition
6. Schlick, Tamar, Molecular Modelling and Simulation – An interdisciplinary Guide, 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

SYLLABI

Minor: Biotechnology

BT1M01 **2-0-2 (3)**

Essential Biochemistry

Pre-Requisites: **None**

Course Outcomes:

CO-1	Identify the structure and functions of biomolecules
CO-2	Understand complex biochemical pathways and metabolism
CO-3	Determine the kinetic parameters of enzymatic reactions
CO-4	Estimate and separate biomolecules using Chromatography and Electrophoresis
CO-5	Demonstrate biochemical reactions of proteins, carbohydrates and nucleic acids with organic and inorganic solvents

Syllabus:

Introduction: The Facts of Life, Water: The Medium of Life, pH, acids, bases, buffers, weak bonds and covalent bonds. Thermodynamics of Biological Systems.

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: 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: 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

Laboratory: Any five experiments.

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 (λmax).
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 Vmax & Km.
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. David L. Nelson, Michael M. Cox, Lehninger Principles of Biochemistry, W. H. Freeman and Company, 2017, 7th Edition
2. Reginald H. Garrett, Charles M. Grisham, Biochemistry, Cengage Learning, 2017, 6th Edition
3. Keith Wilson and John Walker, Practical Biochemistry: Principles and Techniques, Cambridge University Press,2000, 5th Edition

Reference Books:

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

Other Suggested Readings:

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

BT1M02 **2-0-2 (3)**

Foundations in Cell Biology

Pre-Requisites: **BT1M01**

Course Outcomes:

CO-1	Understand cell theory and cellular compartmentalization
CO-2	Describe structure and function of the plasma membrane and cell organelles
CO-3	Comprehend the molecular mechanisms of cell cycle
CO-4	Relate the importance of cell cycle on cancer development
CO-5	Explain the role of apoptotic cell death in cellular development
CO-6	Perform cell manipulation techniques used in basic cell biology research

Syllabus:

Introduction to Cell, Structure and Function: Discovery of cells & Basic properties of cell, Cell theory; Cell complexity, Different classes of cells; Prokaryotic & Eukaryotic cell. Structural organization and function of intracellular organelles, Cell membrane components, Basics of membrane transport systems.

Cell Division and Cell Cycle: Mitosis, meiosis, cell cycle checkpoint, molecular mechanics of cell cycle, role of cyclin dependent kinases in controlling the cell cycle, cell death and cell renewal.

Cell Signaling: Introduction to cell signaling, Intracellular signaling and types of signal receptors, Signal Transduction by hormones - Steroid / Peptide hormones, Concept of Secondary messengers.

Stem Cells and Cancer: Embryonic and adult stem cells, Cell differentiation, Cancer biology basics, Characteristics of Cancer Cells, Types of Tumors, Molecular Basis of Cancer – Proto oncogene, Tumor Suppressor gene.

Laboratory: Any five experiments.

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 labeling and microscopic detection of cellular components (direct and indirect labeling).

Learning Resources:

Text Books:

1. Geoffrey M. Cooper, Robert E Hausman, The Cell: A Molecular Approach, Oxford University press, 2015, 7th Edition
2. Karp, G., Iwasa, J., Marshall, W, Karp's Cell and Molecular Biology, Wiley, 2019, 9th Edition

Reference Books:

1. Bruce Alberts, Alexander D. Johnson, Julian Lewis, David Morgan, Martin Raff, Keith Roberts, Molecular Biology of the Cell, Garland Science, 2015, 6th Edition
2. Allyn A. Bregman, Laboratory Investigations in Cell and Molecular Biology, Wiley, 2001, 4th Edition

Other Suggested Readings:

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

BT1M03 **2-0-2 (3)**

Principles of Bioprocess Engineering

Pre-Requisites: **None**

Course Outcomes:

CO-1	Understand the roles and responsibilities of a bioprocess engineer
CO-2	Understand sterilization techniques and estimate the sterilization time
CO-3	Comprehend rheology of fermentation fluids& determine power requirement in bioreactors
CO-4	Develop design equations for bioreactors & calculate oxygen demand for cell growth
CO-5	Understand the scale up concepts for bioprocesses
CO-6	Identify sensors and instruments needed for measurement and control

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 KLa, 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: Any five experiments.

Growth kinetics of bacteria in a fed-batch reactor, enzyme immobilization, microbial death kinetics, residence time distribution, fluidized bed bioreactor for cell cultivation, determination of mixing time and power number in chemostat, effect of temperature, pH substrate concentration on enzyme activity, inhibition kinetics and estimation of biomass.

Learning Resources:

Text Books:

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

Reference Books:

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

Other Suggested Readings:

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

BT1M04 **2-0-2 (3)**

Elements of Bioseparations Technology

Pre-Requisites: **BT1M03**

Course Outcomes:

CO-1	Understand separation techniques used in downstream process
CO-2	Design and optimize downstream processes
CO-3	Understand the requirements for successful operation of downstream processes
CO-4	Understand the principles of major unit operations used in downstream processing of biopharmaceuticals

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.

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, Protein Precipitation, Dialysis; Extraction and Freeze Drying.

Laboratory: Any five experiments.

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. Paul A. Belter, Bioseparations: Downstream Processing for Biotechnology, Wiley-Blackwell, 2008, 1st Edition
2. Sivasankar, Bioseparations: Principles and Techniques, Prentice Hall India, 2010, 1st Edition
3. Prasad, Downstream Process Technology, Prentice Hall India, 2010,1st Edition

Reference Books:

1. Butterworth –Heinemann, Product Recovery in Bioprocess technology, BIOTOL series, 2010, 1st Edition
2. Ronald & J. Lee, Principles of Downstream processing, Wiley Publications, 2007, 1st Edition
3. Ahuja S, Handbook of Bioseparations, Academic Press, 2000, 1st Edition
4. Harrison RG, Bioseparations: Science and Engineering, Oxford University Press, 2003, 1st Edition

5. Robert K, Protein Purification: Principles and Practice: Scopes, Springer, 2014, 3rd Edition
6. Mohamed A. Desai, Downstream Processing of Proteins: Methods and Protocols, Humana Press, 2012, 1st Edition

Other Suggested Readings:

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

BT1M06 **2-0-2 (3)**

Systems Biology for Engineers

Pre-Requisites: BT1M01, BT1M03

Course Outcomes:

CO-1	Understand basic, advanced principles of systems biology and biological networks Applications
CO-2	Understand networks behavior and emergent properties of biological networks/Systems
CO-3	Apply kinetics principles to develop systems level mathematical models in biology
CO-4	Create predictive mathematical models of biological interaction networks to explore their emergent behavior
CO-5	Draw insights form systems level models/ studies for biotechnological and biomedical applications

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, autoregulation, 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.

Laboratory: Any five experiments.

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

Reference Books:

1. Eberhard O. Voit, Computational Analysis of Biochemical Systems, 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

Other Suggested Readings:

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

BT1M05 **2-0-2 (3)**

In Silico Drug Discovery

Pre-Requisites: **None**

Course Outcomes:

CO-1	Understand the concept of structure-function relationship of lead molecules in drug discovery
CO-2	Understand the process of target identification in drug discovery
CO-3	Apply proteomics and genomics techniques in drug-discovery and design process
CO-4	Understand the drug delivery systems
CO-5	Design new drugs using computational methods

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 & 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. History of QSAR, 2D-QSAR; 3D-QSAR, descriptors of QSAR, Tools and techniques of QSAR, Parameters Used in QSAR, Applications of QSAR, 3D pharmacophore hypothesis

Introduction to Docking: Scoring functions, Docking Process – Protein Preparation, Building the ligand, setting the bounding box, running the docking calculations. Molecular docking software and their utilities in drug design. High-throughput screening.

Laboratory: Any five experiments.

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. PovlKrogsgaard-Larsen, Ulf Madsen, Kristian Stromgaard, Textbook of Drug Design and Discovery, CRC Press, 2017, 5th Edition
2. Gerhard Edwin Seibold, Alexander Hillisch, Rolf Hilgenfeld, Birkhauser, Modern Methods of Drug Discovery, 2003, 1st Edition
3. JorgKnablein, Modern Biopharmaceuticals: Design, Development and Optimization, Wiley–VCH, 2005, 1st Edition
4. Schlick, Tamar, Molecular Modelling and Simulation – An interdisciplinary Guide, Springer, 2010, 1st Edition
5. David C Young, Computational Drug Design (A guide for computational and medicinal chemists), Wiley & Sons, Inc., New Jersey, USA, 2009, 1st Edition

Reference Books:

1. Alan Hinchliffe, Molecular Modelling for Beginners, Wiley & Sons Ltd., 2008, 2nd Edition
2. Kourounakis, Advanced Drug Design and Development: A medicinal Chemistry Approach, Taylor and Francis, 1994, 1st Edition
3. Patrick Bultinck, Marcel Dekker, Computational medicinal chemistry for drug discovery, CRC Press, 2004, 1st Edition

BT1M07 **2-0-2 (3)**

Introductory Modelling Simulation and Optimization of Bioprocesses

Pre-Requisites: **BT1M03**

Course Outcomes:

CO-1	Understand modeling principles
CO-2	Formulate balance equations
CO-3	Analyze batch, semi continuous / fed batch operation
CO-4	Develop enzyme and growth kinetic models
CO-5	Comprehend bioreactor modeling
CO-6	Develop models for biological systems

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 un segregated 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.

Laboratory: Any five experiments.

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

Reference Books:

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

Other Suggested Readings:

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=cSUPrSkemgo

SYLLABI

Honors: Biotechnology

BT1H01 **3-0-0 (3)**

Nutrigenomics

Pre-Requisites: **BT1204**

Course Outcomes:

CO-1	Demonstrate the concepts of Nutrition and Genomics
CO-2	Explain the role of differential gene expressions in diseases
CO-3	Analyze nutritional genomics in association with human metabolism and diseases
CO-4	Evaluate the nutritional data using computational tools

Syllabus:

Introduction to Nutrigenomics: Genome, genomics, nutrigenetics, nutrigenomics: A brief introduction, primer on genomics and beyond, Genome-wide association studies. Nutrigenomics: measuring nutrition-responsive genome activity, Transcriptomics, Proteomics, and Metabolomics. Nutrigenetics: measuring interindividual response to nutrients, Genetic responses to individual nutrients.

Expression of Nutrigenomics: Nutrient–Gene Interactions: Lunasin Structure and Function, Lunasin Treatment of Prostate Cancer and Gene Expression Profiling, Lunasin-Induced Gene Expression Profiles, Genes Involved in Suppression of Cell Proliferation, Genes Involved in Protein Degradation, Modulation of Gene Expression by Dietary Iron, Zinc, Selenium.

Nutritional Metabolic Responses: Nutrigenomic approaches to understand the transcriptional and metabolic responses, obesity, anti-obesity action of Luteolin, Inflammation, and Cardiometabolic syndrome. Applications of genomics and bioinformatics in nutrition. Nutritional genomics: cellular signaling and molecular targets, Vitamin-D on cardiovascular disease.

Advances in Nutrigenomics: Personalization the norm of Nutrigenomics, Public Health and Nutrigenomics, Public Health Applications of Nutrigenomics, Implementation and Evaluation. Bio-computation and analysis of complex datasets in Nutritional Genomics: Nutritional Genomics: Part of High-Throughput Biology, Proteomics and Metabolomics Data, Sources of Complexity in Nutritional Genomics, Data Sets in Nutritional Genomics, Level of Complexity in Gene Expression Experiments.

Learning Resources:

Text Books:

1. Jim Kaput Raymond L. Rodriguez, Nutritional Genomics, John Wiley & Sons, Inc, 2019
2. Wiyane R Bildak, Raymond L Rodriguez, Nutritional genomics, CRC Press, Taylor & Francis Group, 2012

Reference Books:

1. David Castle, Nola M, Nutrition and Genomics Issues of Ethics, Law, Regulation and Communication, Academic Press, Elsevier, 2014
2. Gerald Rimbach, Jurgen Fuchs, Lester Packer, Nutrigenomics, CRC Press, Taylor & Francis Group, 2018

BT16004 **3-0-0 (3)**

Biomaterials and Tissue Engineering

Pre-Requisites: BT1206, BT1208

Course Outcomes:

CO-1	Classify different stem cells
CO-2	Explain the construction of connective tissues
CO-3	Select the procedure for isolation and identification of stem cells
CO-4	Construct scaffolds for tissue engineering
CO-5	Identify regulatory considerations for biomaterials used in tissue engineering

Syllabus:

Cell Culture Medium: Introduction to the balanced salt solutions and growth medium, Chemical, physical and metabolic functions of different constituents of culture medium, role of carbon-di- oxide and role of serum and its supplements in maintaining cells in culture medium, serum and protein free defined media and their application.

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

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

Tissue Engineering: Elements of biomaterials, Mechanical concepts in biomaterials, Characterization of biomaterials, Methods for the determination of biocompatibility, Basic techniques to manufacture scaffolds, Bioreactor for tissue engineering –Design and scale up, Hollow fiber systems, Micro carrier-based systems.

Learning Resources:

Text Books:

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

Reference Books:

1. Clemens van Blitterswijk, Tissue Engineering, Academic Press, 2008
2. Robert Lanza, Principles of Tissue Engineering, Academic Press Inc, 2020, 5th Edition

Other Suggested Readings:

1. https://www.sciencedirect.com/science/article/pii/S1672022915000029
2. https://www.nibib.nih.gov/science-education/science-topics/tissue-engineering-and-regenerative-medicine

BT1H02 **3-0-0 (3)**

Agricultural Biotechnology

Pre-Requisites: **None**

Course Outcomes:

CO-1	Apply plant tissue culture techniques in agriculture and horticulture
CO-2	Understand the utility of mycorrhiza as biofertilizers in agriculture
CO-3	Apply biotechnology techniques in the field of agriculture
CO-4	Comprehend biosafety regulations for genetically modified crops
CO-5	Understand quality improvement techniques used for commercial crop varieties

Syllabus:

Introduction to Agriculture: An introduction, Impact of Biotechnology on Agrobiodiversity; Biotechnology for Agriculture; Micropropagation Technology and its use in Agriculture, Role of biofertilizers and bio-pesticides in sustainable agriculture, Mass cultivation of microbial inoculants, plant growth promoting rhizobacteria diazotrophic microorganism, Free living and symbiotic nitrogen fixing microbes, Molecular basis of legume rhizobium symbiosis.

Biofertilizer in Agriculture: Mechanism of biological nitrogen fixation process, Study of nitrogen fixation, rhizobial nodulation gene and hydrogen uptake genes in nitrogen fixation process. Production of biofertilizers and applications of rhizobium, azotobacter, azolla and, mycorrhiza: Applications in agriculture and forestry, Plant growth regulators in agriculture and horticulture.

Molecular Application in Agriculture: Molecular aspects of biotic and abiotic stress responses and genetic engineering for drought, salinity and Temperature. Insect resistance – BT gene applications. Virus resistance – coat protein mediated, nucleocapsid gene and RNAi approach. Fungal resistance – PR proteins chitinase, beta glucanases. Nematode resistance – Nematode infestation and engineering for nematode resistance. Long shelf-life of fruits and flowers: use of ACC synthase, polygalacturanase, ACC oxidase. Male sterile lines: barstar and barnase systems. Genetic improvement of nutritional quality of oils.

Quality Improvement using Agricultural Biotechnology: Improvement of qualitative characters – Nutritional value of storage products – elite strains rich in iron, protein and amino acids, golden rice and its color – anthocyanines, betalaines, crocin and crocetins. Flavors – capsaicin, vanillin, stevioside thaumatin, The recent trends in agriculture.

Learning Resources:

Text Books:

1. Arie Altman, Agricultural Biotechnology, Marcel Dekker, Inc. 2012
2. Bajaj YPS, Biotechnology in Agriculture and Forestry, Vol.22. Springer-Verlag, 2010

Reference Books:

1. Dr. K.H. Singh Dr. Ajay Kumar Thakur, Dr. Nehanjali, Agricultural Biotechnology at a Glance, Parmar science technology publisher; 2019,1st Edition
2. H.D Kumar, Agricultural Biotechnology, Daya Publishing House, 2005

BT16021 **3-0-0 (3)**

Recombinant DNA Technology

Pre-Requisites: **BT1303**

Course Outcomes:

CO-1	Design suitable cloning strategies for bacteria, plant and animal cells
CO-2	Apply appropriate mutagenesis approach to generate desired genetic combination
CO-3	Design cloning strategies for heterologous gene expression in bacteria and yeast
CO-4	Apply appropriate gene transfer techniques for animals and plants
CO-5	Develop transgenic organisms for the benefit of society

Syllabus:

Molecular Cloning and Advanced Vectors: Plasmids and Phage Vectors, Cosmids, phagemid and other advanced vectors: phage-derived PACs, BACs, YACs and gateway cloning vectors—cloning strategies.

Mutagenesis Strategies: Changing genes – site directed mutagenesis, reverse mutagenesis, cassette mutagenesis. Gene knockout, RNA interference, CRISPR-Cas9, transposon mutagenesis.

Cloning Strategies in Bacteria other than *E. coli* and Yeasts: Cloning in gram negative and gram-positive bacteria—Different vectors and suitable cloning strategies. Integrative vectors for fungi, Yeast promoter systems for over expression of genes, multipurpose vectors.

Gene Transfer Strategies: Gene transfer strategies and generation of transgenic plants and animals—Transfection techniques and use of suitable selectable markers, over expression of transgenes, Agrobacterium mediated transformation, Direct DNA transfer method and use of viral vectors for plants and animals, Advance transgenic technologies.

Learning Resources:

Text Books:

1. Old RW and Primrose SB, Principles of gene manipulation and Genomics, Blackwell Scientific Publications, 2006, 7th Edition
2. Kelly T. Hughes and Stanley R. Maloy, Advanced Bacterial Genetics: Use of Transposons and Phage for Genomic Engineering, Methods in Enzymology, Vol. 421, Academic Press, 2007

Reference Books:

1. Brown TA, Gene Cloning and DNA Analysis: An Introduction, Blackwell Publishing, 2016, 7th Edition
2. Green, M. R. and Sambrook, J, Molecular Cloning: A Laboratory Manual. (3 volume set), Cold Spring Harbor Lab Press, 2012, 4th Edition

Other Suggested Readings:

1. https://nptel.ac.in/courses/102/103/102103013/

BT16025 **3-0-0 (3)**

Bioeconomy and Biorefineries

Pre-Requisites: BT1207, BT1301

Course Outcomes:

CO-1	Understand biofuel policies, law, demand and supply barriers
CO-2	Analyze biomass composition and structure
CO-3	Apply concept of biorefinery to substitute oil dependent economy
CO-4	Utilize synthetic biology and metabolic engineering principles for biofuels production
CO-5	Evaluate the standards and life cycle assessment of biofuels

Syllabus:

Introduction to Biofuels: Oil economy Vs Bio economy, working principle of IC engines, Biofuels in the global energy scene, National biofuel policy and law. Biofuel Feedstocks.

Biomass Conversion and Bioprocess Technologies: Classification of biofuels, Biomass composition and analysis. Biomass conversion technologies. First, second, third and advanced biofuels production technologies/process and challenges. Consolidated bioprocess engineering (CBP) for biofuels. Concept of Bio refinery: Biomass to value added compounds, Bioelectricity.

Synthetic Biology and Metabolic Engineering for Biofuels: Biomass converting enzymes and manipulations, Synthetic biology and metabolic engineering approaches (case studies) for biofuels production.

Analysis and Assessment of Biofuels: Life Cycle assessment of biomass and biofuels, Standards of biofuels, Exergy analysis of biofuels.

Learning Resources:

Text Books:

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

Reference Books:

1. Vijai K. Gupta, Bioenergy Research: Advances and Applications, Elsevier B.V. Netherlands, 2014, 1st Edition
2. Krzysztof J Ptasinski, Efficiency of Biomass Energy: An Exergy Approach to Biofuels, Power, and Biorefineries, John Wiley & Sons, 2015, 1st Edition

Other Suggested Readings:

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