NOIDA INSTITUTE OF ENGINEERING AND TECHNOLOGY, GREATER NOIDA, GAUTAM BUDDH NAGAR

(An Autonomous Institute)

Affiliated to

DR. A.P.J. ABDUL KALAM TECHNICAL UNIVERSITY, UTTAR PRADESH LUCKNOW

Evaluation Scheme & Syllabus

For

B. Tech in Biotechnology (BT)

Third Year

(Effective from the Session: 2026-27)

NOIDA INSTITUTE OF ENGINEERING & TECHNOLOGY, GREATER NOIDA

(An Autonomous Institute)

B. TECH (BT)

Evaluation Scheme

SEMESTER V

S. No.	Subject Code	Subject	Types of Subjects	Periods			Evaluation Schemes				End Semester		Total	Credit
				L	T	P	CT	TA	TOTAL	PS	TE	PE		
1	BBT0501	Bioprocess Engineering	Mandatory	3	1	0	30	20	50		100		150	4
2	BBT0504	Plant and Animal Biotechnology	Mandatory	3	1	0	30	20	50		100		150	4
3	BCSCC0501Y	Design Thinking-II	Mandatory	2	0	0	60	40	100				100	2
4		Department Elective II	Departmental Elective	3	0	0	30	20	50		100		150	3
5		Department Elective III	Departmental Elective	3	0	0	30	20	50		100		150	3
6	BBT0551X	Bioprocess Engineering Lab	Mandatory	0	0	4				50		50	100	2
7	BBT0554	Plant and Animal Biotechnology Lab	Mandatory	0	0	2				25		25	50	1
8		Department Elective II Lab	Departmental Elective	0	0	2				25		25	50	1
9	BBT0555	Cheminformatics and Molecular Dynamics	Mandatory	0	0	6				50		100	150	3
10	BCSCC0552	Research Methodology, Ethics and Writing	Mandatory	0	0	2				50			50	1
11	BBT559X	Internship-I	Mandatory	0	0	2				50			50	1
12	BVAC0551	Professional Practice and Employability - I	Compulsory Audit	0	0	6								NA
		MOOCs (For B.Tech. Hons. Degree)	*MOOCs											
		TOTAL		**14**	**2**	**24**	**180**	**120**	**300**	**250**	**400**	**200**	**1150**	**25**

***List of MOOCs (Infosys Springboard) Based Recommended Courses for Third Year (Semester V)**

S. No.	Subject Code	Course Name	University / Industry Partner Name	No of H	Credits
1	BMC0121	Introduction to Data Preprocessing	Infosys Wingspan (Infosys Springboard)	16 h	1
2	BMC0122	Exploratory data analysis using R	Infosys Wingspan (Infosys Springboard)	11h	0.5

PLEASE NOTE: - ***Mini Project or Internship (3-4 weeks) shall be conducted during summer break after IV semester and will be assessed during V semester***

• Compulsory Audit (CA) Courses (Non-Credit - BVAC0551)

➢ All Compulsory Audit Courses (a qualifying exam) do not require any credit.

➢ The Total and obtained marks are not added in the Grand Total.

Abbreviation Used:

L: Lecture, T: Tutorial, P: Practical, CT: Class Test, TA: Teacher Assessment, PS: Practical Sessional, TE: Theory End Semester Exam. CE: Core Elective, OE: Open Elective, DE: Departmental Elective, PE: Practical End Semester Exam, CA: Compulsory Audit, MOOCs: Massive Open Online Courses.

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List of Department Elective (if any): -

S. No.	Subject Code	Subject Name	Types of subjects	Bucket Name	Semester
1	BBT0517	Enzyme Engineering	Department Elective II	Bioprocess	5
2	BBT0515	Biomaterials and Tissue Engineering	Department Elective III	Bioprocess	5
3	BBT0517P	Enzyme Engineering Lab	Department Elective II Lab	Bioprocess	5
4	BBT0514	Data Science	Department Elective II	Computational	5
5	BBT0512	AI in Biotechnology	Department Elective III	Computational	5
6	BBT0514P	Data Science Lab	Department Elective II Lab	Computational	5
7	BBT0518	Industrial waste management	Department Elective II	Environmental	5
8	BBT0516	Bioenergy	Department Elective III	Environmental	5
9	BBT0518P	Industrial waste management Lab	Department Elective II Lab	Environmental	5

NOIDA INSTITUTE OF ENGINEERING & TECHNOLOGY, GREATER NOIDA

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B. TECH (BT)

Evaluation Scheme

SEMESTER VI

S. No.	Subject Code	Subject	Types of Subjects	Periods			Evaluation Schemes				End Semester		Total	Credit
				L	T	P	CT	TA	TOTAL	PS	TE	PE		
1	BBT0601N	Bioseparation Engineering	Mandatory	3	1	0	30	20	50		100		150	4
2	BBT0603Z	Nanobiotechnology	Mandatory	3	1	0	30	20	50		100		150	4
3		Department Elective IV	Departmental Elective	3	0	0	30	20	50		100		150	3
4		Department Elective V	Departmental Elective	3	0	0	30	20	50		100		150	3
5		Open Elective- I	Open Elective	2	0	0	30	20	50		50		100	2
6	BBT0651N	Bioseparation Engineering Lab	Mandatory	0	0	4				50		50	100	2
7	BBT0653Z	Nanobiotechnology Lab	Mandatory	0	0	4				50		50	100	2
8		Department Elective IV Lab	Departmental Elective	0	0	2				25		25	50	1
9	BBT0655	MATLAB for Biotechnology	Mandatory	0	0	6				50		100	150	3
10	BBT0659X	Applied Research with Mini Project	Mandatory	0	0	2				50			50	1
11	BVAC0651	Professional Practice and Employability - II	Compulsory Audit	0	0	6								NA
		MOOCs (For B.Tech. Hons. Degree)	*MOOCs											
		TOTAL		**14**	**2**	**24**	**150**	**100**	**250**	**225**	**450**	**225**	**1150**	**25**

*** List of MOOCs (Infosys Springboard) Based Recommended Courses for Third year (Semester VI)   B. Tech Students**

S. No.	Subject Code	Course Name	University/ Industry Partner Name	N. of Hours	Credits
1.	BMC0136	R Programming for Machine Learning	IIHT	21 h 25 min	1.5
2.	BMC0137	Comprehensive 3D Design Training Course	Infosys Wingspan (Infosys Springboard)	33h 3m	2.5

PLEASE NOTE: - ***Mini Project or Internship (3-4 weeks) shall be conducted during summer break after IV semester and will be assessed during V semester***

- Compulsory Audit (CA) Courses (Non-Credit - BVAC0651)

➢ All Compulsory Audit Courses (a qualifying exam) do not require any credit.

➢ The Total and obtained marks are not added in the Grand Total.

Abbreviation Used:

L: Lecture, T: Tutorial, P: Practical, CT: Class Test, TA: Teacher Assessment, PS: Practical Sessional, TE: Theory End Semester Exam. CE: Core Elective, OE: Open Elective, DE: Departmental Elective, PE: Practical End Semester Exam, CA: Compulsory Audit, MOOCs: Massive Open Online Courses.

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List of Department Elective (if any): -

S. No.	Subject Code	Subject Name	Types of subjects	Bucket Name	Semester
1	BBT0618	Metabolic Engineering	Department Elective IV	Bioprocess	6
2	BBT0611	Bioreactor analysis and Design	Department Elective V	Bioprocess	6
3	BBT0618P	Metabolic Engineering Lab	Department Elective IV Lab	Bioprocess	6
4	BBT0616	Deep learning in Biotechnology	Department Elective IV	Computational	6
5	BBT0614N	Machine learning	Department Elective V	Computational	6
6	BBT0616P	Deep learning in Biotechnology Lab	Department Elective IV Lab	Computational	6
7	BBT0615	Bioremediation Technology	Department Elective IV	Environmental	6
8	BBT0617	Environmental microbiology and Metagenomics	Department Elective V	Environmental	6
9	BBT0615P	Bioremediation Technology Lab	Department Elective IV Lab	Environmental	6

NOIDA INSTITUTE OF ENGINEERING & TECHNOLOGY, GREATER NOIDA
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AICTE Guidelines in Model Curriculum:

A student will be eligible to get Under Graduate degree with Honours only, if he/she completes the additional MOOCs courses such as Infosys Springboard/NASSCOM/CISCO (as applicable) certifications, or any other online courses recommended by the Institute (Equivalent to 20 credits). During Complete B.Tech. Program Guidelines for credit calculations are as follows.

1. For 6 to 12 Hours =0.5 Credit
2. For 13 to18 =1 Credit
3. For 19 to 24 =1.5 Credit
4. For 25 to 30 =2 Credit
5. For 31 to 35 =2.5 Credit
6. For 36 to 41 =3 Credit
7. For 42 to 47 =3.5 Credit
8. For 48 and above =4 Credit

For registration to MOOCs Courses, the students shall follow Infosys Springboard/NASSCOM/CISCO (as applicable) registration details as per the assigned login and password by the Institute these courses may be cleared during the B. Tech degree program (as per the list provided). After successful completion of these MOOCs courses, the students shall provide their successful completion status/certificates to the Controller of Examination (COE) of the Institute through their coordinators/Mentors only.

The students shall be awarded Honours Degree as per following criterion.

i. If he / she secures 7.50 as above CGPA.
ii. Passed each subject of that degree program in the single attempt without any grace.
iii. Successful completion of MOOCs based 20 credits

Course Code: BBT0501	**Course Name: Bioprocess Engineering**	**L**	**T**	**P**	**C**
Course Offered in: Department of Biotechnology		**3**	**1**	**0**	**4**
Prerequisite: Students should know about the basics of microbiology.					
Course Objective: To develop an understanding of bioprocess principles, including upstream and midstream processing, for the design, operation, and optimization of biotechnological production systems.					
Course Outcome: After completion of the course, the student will be able to		**Bloom's Level**			
CO1	Demonstrate the equation for microbial cell growth.	K3			
CO2	Understand the importance of enzymes and its immobilization.	K2			
CO3	Illustrate the scale up concepts for bioprocesses.	K3			
CO4	Apply manufacturing processes for the production of antibiotics and proteins.	K3			
CO5	Determine sensors and instruments needed for measurement and control.	K3			

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

Course Contents / Syllabus		
Unit 1	**Microbial Growth and Stoichiometry**	**12 Hrs**
Microbial growth kinetics, Parameters affecting microbial growth, substrate utilization and product formation kinetics, stoichiometry of growth and product formation, Yield coefficients of biomass and product formation, Quantitative analysis of microbial growth by direct and indirect methods.		
Unit 2	**Enzymes and Ideal Reactor Operation**	**11 Hrs**
Principles of enzyme catalysis, enzyme kinetics study, immobilized enzymes and their types, bioreactors-batch, fed-batch or continuous bioreactors, Immobilized cell systems.		
Unit 3	**Bioreactor control mechanism**	**13 Hrs**

Principles of enzyme catalysis, enzyme kinetics study, immobilized enzymes and their types, bioreactors-batch, fed-batch or continuous bioreactors, Immobilized cell systems. Solid-state fermentations, energy balance and mass transfer, operation and control of bioreactors (aeration, agitation, heat transfer, mass transfer scale-up and scale-down of bioreactors).

Unit 4	**Application of Bioprocess Engineering**	**12 Hrs**

Bioprocessing significance, Bioprocesses for the production of antibiotics, proteins, polysaccharides, aroma etc. Case studies on production of antibiotics, enzymes, insulin, bio-ethanol.

Unit 5	**Modelling and Optimization in bioprocess Engineering**	**12 Hrs**

Instrumentation and monitoring, Concept of sterilization, Types of sterilization, Batch and continuous sterilization, Optimization and process/mathematical modelling for enhanced product formation, Types of mathematical models in bioprocess engineering, examples of industrial bioprocesses.

Total	**60 Hrs**

Textbook:

S.No	**Book Title with publication agency & year**	**Author**
1	*Bioprocess Engineering: Basic Concepts* (3rd ed., Prentice Hall/Pearson, 2017)	Michael Shuler; Fikret Kargi; Matthew DeLisa
2	*Bioprocess Engineering Principles* (2nd ed., Academic Press, 2012)	Pauline M. Doran
3	*Basic Biotechnology* (2nd ed., Cambridge University Press, 2001)	Colin Ratledge; Bjorn Kristiansen

Reference Books:

S.No	**Book Title with publication agency & year**	**Author**
1	*Bioseparations Science and Engineering* (Oxford University Press, 2003)	Roger G. Harrison; Paul W. Todd; Scott R. Rudge; Demetri P. Petrides
2	*Bioreaction Engineering: Bioprocess Monitoring* (Vol. 3 in the Bioreaction Engineering series, Wiley, circa 1997)	Karl Schügerl (with D. A. John Wase)
3	*Introduction to Biochemical Engineering* (Tata McGraw-Hill Education, New Delhi, 2005)	D. G. Rao (amazon.in, Google Books, libcat.iitd.ac.in)

Self-Study Content Links:		Duration (in Hrs)
MOOCs	https://nptel.ac.in/courses/102103672	36-48 Hrs
Video Lectures		
Web References		

Course Code: BBT0504	Course Name: Plant and Animal Biotechnology	L	T	P	C
Course Offered in: BT		3	1	0	4

Prerequisite: Basic knowledge of Plant physiology, growth development, cell biology, and Science

Course Objective:

To provide students with theoretical knowledge and practical skills in plant and animal biotechnology, including tissue culture, genetic transformation, genome editing, biopharmaceutical production, and ethical/regulatory aspects for industrial, agricultural, and medical applications.

Course Outcome: After completion of this course students will be able to:		Bloom's Level
CO 1	Apply plant tissue culture principles in lab and industry.	K3
CO2	Analyze applications of plant tissue culture techniques.	K4
CO3	Apply animal cell culture for biomanufacturing.	K3
CO4	Evaluate gene transfer methods and transgenics.	K5
CO5	Assess genome editing tools and applications.	K5

CO-PO Mapping (Scale 1: Low, 2: Medium, 3: High)

CO/ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	2	2	3	3	1	1	1	–	2	3	2
CO2	3	3	2	2	3	3	2	1	2	2	–	2	3	3
CO3	3	3	3	3	3	2	2	1	2	2	1	3	3	3
CO4	3	3	3	3	3	2	1	2	2	2	2	3	3	3
CO5	3	3	3	2	2	3	3	3	3	3	2	3	3	3

Course Contents / Syllabus

Unit 1	Principles and Industrial Setup of Plant Tissue Culture	16 Hrs

History and commercial evolution of plant tissue culture, GLP-compliant tissue culture laboratory setup, industrial sterilization techniques and biosafety protocols, automated media preparation and bioreactor-grade media formulation, in vitro regeneration pathways including organogenesis and somatic embryogenesis, protoplast isolation, viability testing, and fusion for industrial applications.

Unit 2	**Industrial Applications of Plant Tissue Culture**	**12 Hrs**
Commercial micropropagation and nursery plant production, virus-free plant generation through meristem culture, anther, ovary, and pollen culture for haploid and doubled haploid production, embryo rescue in plant breeding, somatic hybridization for trait improvement, secondary metabolite production in suspension cultures and bioreactors, synthetic seed technology and encapsulation, cryopreservation of elite germplasm.		
Unit 3	**Animal Cell Culture and Biomanufacturing**	**12 Hrs**
History and industrial development of animal cell culture, preparation of defined and serum-free media, scale-up from flasks to industrial bioreactors, establishment of primary and continuous cell lines, hybridoma technology and monoclonal antibody production, applications in vaccine development and therapeutic protein production, quality control and biosafety, GLP and GMP in animal cell culture labs.		
Unit 4	**Gene Transfer Methods and Transgenics**	**10 Hrs**
Genetic transformation methods in plants and animals, Agrobacterium-mediated transformation, direct gene transfer techniques including electroporation and biolistics, screening and molecular characterization of transgenics, applications in pest resistance and nutritional enhancement, use of male sterility in hybrid seed production, production of transgenic animals for disease models and therapeutic proteins, regulatory frameworks and biosafety guidelines for GMOs.		
Unit 5	**Genome Editing and Future Trends**	**10 Hrs**
CRISPR-Cas systems and other genome editing tools, delivery methods including viral vectors and nanocarriers, applications of genome editing in crop and animal improvement, innovations such as base and prime editing, case studies of genome editing in agriculture and medicine, IPR and patenting of edited organisms, ethical, legal and societal implications of genome editing, emerging trends and industry opportunities.		
Total		**60 Hrs**
Textbook: 1. George E. F., Hall A H, and De Klerk G J (2008) Plant propagation by tissue culture. Springer. 2. Bhojwani SS and Razdan M K (1996) Plant Tissue Culture : Theory and Practice. Elsevier. 3. Herman, Edwin B., (Ed.) (2009) Genetic modification of plants: methods and applications 2005- 2009, USA: Agritech Consultants. 4. Pörtner, R. (2007) Animal Cell Biotechnology: Methods and Protocols. Totowa, NJ: Humana Press. 5. Freshney R.I. (2010) Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications. Wiley, John and Sons, Inc; New Jersey		
Reference Books: 1. Herman, Edwin B., (Ed.) (2007) Microbial contaminants in plant tissue culture, Vol. III : 2003 – 2007. Agritech Consultants, Inc. Shrub Oak. 2. Neumann, K H, Kumar, A, Imani, J (2009) Plant Cell and Tissue Culture – A tool in biotechnology : Basics and applications. 3. Halford,Nigel G. (Ed.) (2006) Plant Biotechnology: Current and Future Applications of genetically modified crops. John Wiley and Sons Ltd. 4. Chrispeels MJ; Sadava DE (2003) Plant, Genes and Crop Biotechnology. Jones and Bartlett Publishers, Inc.		

Self-Study Content Links:		**Duration (in Hrs)**
MOOCs	https://nptel.ac.in/courses/102106080 https://nptel.ac.in/courses/102106821	36-48 Hrs 36-48 Hrs
Video Lectures		
Web References		
NPTEL/ Youtube/ Faculty Video Link:		

Unit 1	https://app.jove.com/science-education/v/11112/in-vitro-plant-tissue-culture-and-genetic-modifications
Unit 2	https://www.learninsta.com/applications-of-plant-tissue-culture/
Unit 3	https://www.youtube.com/watch?v=8zZsJxjKjwQ
Unit 4	https://www.researchgate.net/publication/387476821_The_Application_of_Transgenic_Technology/fulltext/676f9a56894c55208530acbe/The-Application-of-Transgenic-Technology.pdf
Unit 5	https://www.youtube.com/watch?v=2PP4lVH8N2Q

Course Code: BBT0517	Course Name: Enzyme Engineering	L	T	P	C
Course Offered in: Biotechnology		3	0	0	3

Prerequisite: Students should know about the basics of biochemistry.

Course Objective:

To equip students with the knowledge and skills to discover, modify, and optimize enzymes for enhanced performance and stability in various industrial and biomedical applications.

Course Outcome: After completion of this course students will be able to:		**Bloom's Level**
CO 1	Understand the classification, nomenclature, structure, and fundamental properties of enzyme-substrate interactions.	K2
CO2	Explain enzyme kinetics, catalytic mechanisms, and the factors influencing enzyme-catalyzed reactions.	K2
CO3	Apply kinetic models and inhibition principles	K3
CO4	Demonstrate suitable enzyme immobilization techniques and evaluate mass transfer effects in immobilized enzyme systems.	K5
CO5	Analyze the industrial and analytical applications of enzymes	K4

CO-PO Mapping (Scale 1: Low, 2: Medium, 3: High)

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

Course Contents / Syllabus

Unit 1	**Basic concepts of enzyme**	**10 Hrs**

Introduction to enzymes, IUB system of classification and nomenclature of enzymes. Holoenzyme, apoenzyme, prosthetic group. Features of active site, activation energy, enzyme specificity and types. Interaction between enzyme and substrate- lock and key model, induced fit model.

Unit 2	Enzyme Kinetics	10 Hrs
Mechanistic Models for Simple Enzyme Kinetics: Michaelis-Menten approach, Briggs and Haldane approach, determination of Km and Vmax, turnover number, Experimentally Determining Rate Parameters for Michaelis–Menten Type Kinetics, Factors affecting the velocity of enzyme catalyzed reaction- enzyme concentration, temperature, pH, substrate concentration, inhibitors and activators.		
Unit 3	**Enzyme Inhibition**	**08 Hrs**
Enzyme inhibition: irreversible; reversible (competitive, uncompetitive and non-competitive inhibition); Substrate and Product inhibition, Allosteric regulation of enzymes, concerted and sequential model; Deactivation Kinetics.		
Unit 4	**Enzyme Immobilization**	**08 Hrs**
Immobilized Enzyme, Types of carrier matrix, Different methods of immobilization: Adsorption, Matrix entrapment, Encapsulation, Cross linking and Covalent binding, Effect of Mass-Transfer Resistance: External and internal mass transfer resistance, Effective Diffusivities in Biological Gels		
Unit 5	**Industrial Applications of Enzymes**	**09 Hrs**
Commercial application of enzymes in Food, Pharmaceutical and other industries, Enzymes for analytical and diagnostic application, Case study for Industrial production of High Fructose Corn Syrup (HFCS)		
Total		**45 Hrs**

Textbook:

1. M L, Kargi F, " Bioprocess Engineering- Basic Concepts" , 2nd ed, Prentice Hall of India Ltd. (2002)
2. Peters, M S and Timmerhaus K D,"Plant Design and Economics for Chemical Engineers", McGraw Hill, New York , 4th Edition (2003)
3. Ulrich , G D,"A Guide to Chemical Engineering Process Design and Economics", John Wiley (1984)

Reference Books:

1. Bailey J E and Ollis D F, "Biochemical Engineering Fundamentals" , McGraw Hill (1986)
2. Peters, M S and Timmerhaus K D,"Plant Design and Economics for Chemical Engineers", McGraw Hill, New York , 4th Edition (2003)
3. Ulrich , G D,"A Guide to Chemical Engineering Process Design and Economics", John Wiley (1984)

Self-Study Content Links:		**Duration (in Hrs)**
MOOCs	https://nptel.ac.in/courses/102102033	36-48 Hrs
Video Lectures		
Web References		

NPTEL/ Youtube/ Faculty Video Link:

Unit 1	https://youtu.be/R23ZXqysTZc?si=BPlwg_A-dkXP5te4
Unit 2	https://youtu.be/CotD9m8Wm78?si=AQYK6urvksE02uD9

Unit 3	https://youtu.be/6EDBlowVST0?si=M2M_5qeBy_59bBGM
Unit 4	https://youtu.be/s7yZCEX8VZI?si=CElhhPwBMUSDeiKo
Unit 5	https://youtu.be/LUKbmjysmsg?si=JCBcSU8JCAjqdE66

Course Code: BBT0514	**Course Name: Data Science**	**L**	**T**	**P**	**C**
Course Offered in:		3	0	0	3

Prerequisite: Basic knowledge of data analysis and visualization

Course Objective: Understand core data science concepts applicable across domains, perform data preprocessing and statistical analysis on structured datasets, build regression and classification models, Apply data science techniques to biotechnology and other real-world domains

Course Outcome: After completion of the course, the student will be able to		**Bloom's Level**
CO1	Explain the fundamentals, lifecycle, tools, and applications of Data Science and Analytics in various domains.	K2
CO2	Apply data preprocessing and exploratory data analysis techniques for handling and visualizing datasets.	K3
CO3	Explain statistical methods, probability distributions, and hypothesis testing techniques used in Data Science.	K2
CO4	Apply regression techniques for prediction and evaluation of data-driven models.	K3
CO5	Explain classification techniques, model evaluation metrics, and data visualization methods used in Data Science applications.	K2

CO-PO Mapping (Scale 1: Low, 2: Medium, 3: High)

CO/ PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	1	1	2	2	2	1	1	1	1	2	2	2
CO2	3	3	2	2	3	1	1	1	1	2	1	2	2	3
CO3	3	3	2	3	2	1	1	1	1	2	1	2	2	3
CO4	3	3	3	3	2	1	1	1	1	2	1	2	3	2
CO5	3	3	2	3	2	2	1	1	2	2	1	2	2	3

Course Contents / Syllabus

Unit 1	**Introduction to Data Science**	**10 Hrs**

What is Data Science and Analytics, Evolution of Data Science, Data Science Lifecycle, Types of Data (structured, unstructured, time- series), Data Science vs Data Analytics vs AI, Tools & Technologies (Python, R, SQL – overview), Applications across domains: Biotechnology, Healthcare, Finance, Business, Social Media.

Unit 2	**Data Preprocessing & Exploration**	**10 Hrs**

Types of variables and data formats, Data cleaning: Missing values, noise, inconsistencies, Outlier detection and treatment, Feature selection and transformation, Data normalization and scaling, Exploratory Data Analysis (EDA): Visualization (histogram, boxplot, scatterplot)		
Unit 3	**Statistical Methods for Data Science**	**9 Hrs**
Population and Sample, Measurement Levels, Representation of categorical variables, Descriptive statistics: Mean, median, mode, skewness, variance, Standard Deviation, Correlation and covariance, Probability distributions: Normal, Binomial, Poisson, Hypothesis testing: t-test, chi-square, ANOVA.		
Unit 4	**Regression Techniques**	**8 Hrs**
Introduction to Regression, Simple Linear Regression, Multiple Linear Regression, Model evaluation: R^2, Adjusted R^2, p-value interpretation, Assumptions of regression, Applications: Predicting growth trends (biotech), Sales forecasting (business), Risk prediction (finance)		
Unit 5	**Classification & Data Visualization**	**8 Hrs**
Logistic Regression, Concept of classification, Model evaluation: Confusion matrix, Accuracy, Precision, Recall, F1-score, Introduction to data visualization: Graphical representation techniques, Case studies across domains: Disease prediction, Customer segmentation, Fraud detection.		
Total		**45 Hrs**

Textbook:

S.No	Book Title with publication agency & year	Author
1	An Introduction to Statistical Learning with Applications in R, Springer, 2021 (2nd Edition)	Gareth James, Daniela Witten, Trevor Hastie, Robert Tibshirani
2	Practical Statistics for Data Scientists, O'Reilly Media, 2020 (2nd Edition)	Peter Bruce, Andrew Bruce, Peter Gedeck
Self-Study Content Links:		**Duration (in Hrs)**
MOOCs	Data Science : Complete Data Science & Machine Learning - Viewer | Infosys Springboard	25 Hrs
Video Lectures		
Web References	Python for Data Science, IIT Madras Prof. Ragunathan Rengasamy https://nptel.ac.in/courses/106106212	20 Hrs

Course Code: BBT0518	Course Name: Industrial Waste Management	L	T	P	C
Course Offered in: BT		3	0	0	3

Prerequisite: Basic knowledge of Plant physiology, growth development, cell biology, and Science

Course Objective:

To introduces industrial waste types, their environmental impact, and sustainable treatment methods, with a focus on biotechnological approaches, regulatory standards, and innovative solutions for effective waste management.

Course Outcome: After completion of this course students will be able to:		**Bloom's Level**
CO 1	Formulate an insight into the pollution from major industries including the sources and characteristics of pollutants	K3
CO2	Analyze the mode of treatment based on waste characteristics	K3
CO3	Design of wastewater treatment plants to attain standard limits	K4
CO4	Assess the impact of industrial wastes on the environmental compartments (land, water and air)	K4
CO5	Analyze and choose appropriate strategy to convert waste to economic goods	K4

CO-PO Mapping (Scale 1: Low, 2: Medium, 3: High)

CO/ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	2	2	3	3	1	1	1	–	2	3	2
CO2	3	3	2	2	3	3	2	1	2	2	–	2	3	3
CO3	3	3	3	3	3	2	2	1	2	2	1	3	3	3
CO4	3	3	3	3	3	2	1	2	2	2	2	3	3	3
CO5	3	3	3	2	2	3	3	3	3	3	2	3	3	3

Course Contents / Syllabus

Unit 1	Introduction to Industrial Wastes and Environmental Impacts	09 Hrs

Introduction to industrial wastes and their effects on the environment, Sources and classification of industrial wastes, Industrial waste generation in India and globally, Environmental impacts and threats to biodiversity,

Toxic effects of industrial effluents, Case studies – Bhopal gas tragedy, Chernobyl disaster, Role of regulatory authorities – State and Central Pollution Control Boards, Choosing suitable treatment technologies based on waste type, Benefits of biological treatment over traditional methods, Basics of solid waste landfill and leachate management, Composting and vermicomposting of industrial wastes, Waste management strategies and the waste management pyramid.		
Unit 2	**Industrial Waste Standards, Treatment Techniques, and Case Studies**	**10 Hrs**
Waste disposal standards and methods to reduce waste, Disposal norms for treated water, solid waste, and air emissions, Key parameters of industrial wastewater – COD, BOD, TOC, TDS, TSS, VSS, TKN, Ammonia, Chloride, Sulfide, Sulfate, Metal detection using AAS and ICP-MS, Heavy metal removal – physical and biological methods, Role of Effluent Treatment Plants (ETPs and CETPs), Case studies on industrial waste treatment, Techniques to reduce volume and strength of waste, Modifications in materials and processes, 4R principles – Reduce, Reuse, Recycle, Recovery, Flow diagrams of waste treatment processes in industries – Textile, Tannery, Pharmaceutical, Electroplating, Dairy, Sugar, Paper, Distillery, Steel, Refinery, Fertilizer, Thermal Power, Basics of hazardous waste handling – treatment and secure landfilling.		
Unit 3	**Wastewater Treatment Processes and Advanced Remediation Methods**	**09 Hrs**
Steps in treating industrial wastewater – Primary, Secondary, and Tertiary, Physical-chemical treatment – Coagulation, Flocculation, and Precipitation (with pros and cons), Biological treatment – Aerobic (Activated Sludge, SBR, Fluidized Bed Reactors), Anaerobic (UASB, MBR), Advanced reactors for efficient treatment, Reusing bio-sludge and energy generation, Methods for removing resistant organic compounds, Advanced Oxidation Processes (AOPs), Removal of volatile organic compounds (VOCs), Adsorption using activated carbon, Color and dye removal from textile wastewater using microbes and enzymes.		
Unit 4	**Biotechnological Innovations in Waste Management**	**09 Hrs**
Biodegradation and recycling of industrial waste, Use of immobilized cells and enzymes in treatment, Energy production from hybrid treatment methods, Sustainable waste technologies – case studies from the EU, Algae-based systems for nutrient and pollutant removal, Algal bioreactor designs, Microbial Fuel Cells (MFC) for electricity generation, Water splitting and hydrogen production, Making bioplastics and polymers from wastewater, Plastic-degrading bacteria, Heavy metal cleanup through phytoremediation, Superbugs for oil spill and refinery waste treatment, Role of biosurfactants in pollution control, Nanotechnology in waste treatment, Use of nano-enzymes for pollution removal.		
Unit 5	**Environmental Regulations, Impact Assessment, and Sustainability Practices**	**8 Hrs**
Environmental concerns and related laws, Environmental Assessment and Management Systems, Laws governing solid and liquid waste management, Understanding Environmental Impact Assessment (EIA), Toxicology and chemical safety standards, Nuclear waste handling, Air and water pollution control in urban areas, Case studies of river pollution cleanup, Environmental audits and ISO 14001 standards, Measuring and managing carbon footprint and carbon credits, Occupational health and safety in industries, Identifying waste hazards, Life Cycle Assessment (LCA) of waste, Role of biological agents in cleaning pollutants..		
Total		**45 Hrs**
Textbook:		

1. Eckenfelder, W.W. (1999) "Industrial Water Pollution Control", McGraw Hill
2. Clair N. Sawyer, Perry L. McCarty, "Chemistry for Environmental Engineering and Science", McGraw Hill, 1978
3. Metcalf and Eddy Inc., Wastewater Engineering: Treatment and Reuse, 2016

Reference Books:

1. Eckenfelder, W.W. (1999) "Industrial Water Pollution Control", McGraw Hill
2. Clair N. Sawyer, Perry L. McCarty, "Chemistry for Environmental Engineering and Science", McGraw Hill, 1978
3. Metcalf and Eddy Inc., Wastewater Engineering: Treatment and Reuse, 2016

NPTEL/ Youtube/ Faculty Video Link:

Unit 1	https://app.jove.com/science-education/v/11112/in-vitro-plant-tissue-culture-and-genetic-modifications
Unit 2	https://www.learninsta.com/applications-of-plant-tissue-culture/
Unit 3	https://www.youtube.com/watch?v=8zZsJxjKjwQ
Unit 4	https://www.researchgate.net/publication/387476821_The_Application_of_Transgenic_Technology/fulltext/676f9a56894c55208530acbe/The-Application-of-Transgenic-Technology.pdf
Unit 5	https://www.youtube.com/watch?v=2PP4lVH8N2Q

Self-Study Content Links:		**Duration (in Hrs)**
MOOCs	https://nptel.ac.in/courses/105105350	36-48 Hrs
Video Lectures		
Web References		

Course Code: BBT0515	Course Name: Biomaterials and Tissue Engineering	L	T	P	C
Course Offered in: BT		3	0	0	3

Prerequisite: Knowledge of cell biology, molecular biology, and physiology

Course Objective:

Overview and classification of biomaterials Biocompatibility and biodegradability Scaffold design and fabrication Tissue regeneration strategies Recent advances and clinical applications

Course Outcome: After completion of this course students will be able to:		**Bloom's Level**
CO 1	Understand and classify different types of biomaterials and their essential properties.	K2
CO2	Illustrate the interactions between biomaterials and biological systems at the cellular and molecular level.	K3
CO3	Comprehend knowledge of cell types, scaffolds, and signaling molecules in basic tissue engineering strategies.	K3
CO4	Illustrate scaffold design parameters and fabrication techniques for specific tissue engineering applications.	K3
CO5	Analyze informed perspectives on clinical applications, ethical considerations, and emerging trends in biomaterials and tissue engineering.	K4

CO-PO Mapping (Scale 1: Low, 2: Medium, 3: High)

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

Course Contents / Syllabus

Unit 1	Introduction to Biomaterials	09 Hrs

Definition and Scope of Biomaterials: Historical perspective and evolution, Applications in healthcare and biotechnology, Classification of Biomaterials: Metallic, polymeric, ceramic, and composite materials, Natural

vs synthetic biomaterials, Essential Properties of Biomaterials: Biocompatibility, biodegradability, mechanical strength, Surface energy, corrosion resistance, Host Response to Biomaterials: Inflammation, foreign body reaction, Immunological considerations, Regulatory and Ethical Aspects: ISO standards, FDA classification, Ethics in biomaterials use		
Unit 2	**Biomaterial–Tissue Interactions**	**09 Hrs**
Protein Adsorption on Biomaterial Surfaces: Vroman effect, Surface chemistry and topography influence, Cellular Response to Biomaterials: Cell adhesion, proliferation, and migration, Role of integrins and focal adhesion, Hemocompatibility and Immune Response: Blood-material interaction, Coagulation cascade and thrombosis, In vitro and In vivo Testing of Biomaterials: Cytotoxicity, genotoxicity, Animal models and implantation studies		
Unit 3	**Tissue Engineering Basics**	**09 Hrs**
Introduction to Tissue Engineering: Definition, goals, and scope, Triad: Cells, scaffolds, signaling molecules, Cell Sources for Tissue Engineering: Autologous, allogeneic, and xenogeneic cells, Stem cells: embryonic, adult, and iPSCs, Biomaterials as Scaffolds: Natural polymers: collagen, alginate, chitosan, Synthetic polymers: PLGA, PEG, PCL, Growth Factors and Bioreactors: Controlled delivery of biomolecules, Types of bioreactors and dynamic culture conditions		
Unit 4	**Scaffold Design and Fabrication Techniques**	**10 Hrs**
Scaffold Design Parameters: Porosity, pore size, interconnectivity, Mechanical properties, Fabrication Techniques: Electrospinning, freeze-drying, 3D printing, Solvent casting and particulate leaching, Surface Modification and Functionalization: Plasma treatment, coating with bioactive molecules, Smart and stimuli-responsive scaffolds, Characterization of Scaffolds: Mechanical testing (tensile, compressive strength), Morphological and topographical analysis (SEM, AFM), Biodegradation and swelling studies		
Unit 5	**Clinical Applications and Future Trends**	**08 Hrs**
Clinical Applications of Tissue Engineering: Skin substitutes, bone grafts, cartilage repair, Cardiovascular, neural, and ocular implants, Organ-on-Chip and Biofabrication: Microfluidics in tissue engineering, Organoids and lab-grown tissues, Immunomodulatory Biomaterials: Role in regenerative immunology, Materials to regulate immune response, Translational Research and Commercialization: Clinical trials, regulatory pathways, Challenges in product development and scale-up, Emerging Trends: AI in biomaterials design, 4D biomaterials and stimuli-responsive systems		
	Total	**45 Hrs**

Textbook:

1. Ratner B.D. et al. (2012). Biomaterials Science: An Introduction to Materials in Medicine, Elsevier.
2. Lanza R., Langer R., Vacanti J. (2014). Principles of Tissue Engineering, Academic Press.

Reference Books:

1. Temenoff, J. S., and Mikos, A. G. (2008). Biomaterials: The Intersection of Biology and Materials Science, Pearson.
2. Palsson, B., and Bhatia, S. (2003). Tissue Engineering, Prentice Hall.
3. D. Eberli (Ed.) (2017). Tissue Engineering and Regenerative Medicine, InTechOpen.

Self-Study Content Links:	**Duration (in Hrs)**

MOOCs	https://nptel.ac.in/courses/102106057 https://nptel.ac.in/courses/102106081	36-48 Hrs 36-48 Hrs
Video Lectures		
Web References		
NPTEL/ Youtube/ Faculty Video Link:		

Course Code: BBT0512	Course Name: Artificial Intelligence in Biotechnology	L	T	P	C
Course Offered in:		3	0	0	3

Prerequisite: Basic knowledge of data and AI with python programming

Course Objectives

To introduce AI concepts and tools for analyzing biological data, modeling bioprocesses, and enhancing decision-making in biotechnology applications.:

Course Outcome: After completion of the course, the student will be able to		**Bloom's Level**
CO1	Explain the fundamental concepts, history, and scope of AI, including problem formulation.	K2
CO2	Apply search algorithms and heuristic techniques for solving AI-based problems.	K3
CO3	Explain the stages involved in the AI project life cycle including problem scoping, data acquisition, exploration, and modeling.	K2
CO4	Apply Python-based tools and libraries for data analysis, visualization, and statistical analysis of biological datasets.	K3
CO5	Explain the applications of Artificial Intelligence in various fields of Biotechnology and Bioengineering.	K2

CO-PO Mapping (Scale 1: Low, 2: Medium, 3: High)

CO/ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PSO 1	PSO 2	PSO 3
CO1	3	2	1	1	2	1	1	1	1	1	2	2	1	2
CO2	3	3	2	2	3	1	1	1	1	1	2	3	2	2
CO3	2	2	2	1	2	1	1	2	2	1	2	2	2	2
CO4	2	2	3	2	3	1	1	1	1	1	2	3	3	3
CO5	3	3	2	2	3	2	2	1	2	1	3	3	3	3

Course Contents / Syllabus

Unit 1	**Introduction to AI**	**9 Hrs**
Concept of AI, history, scope, agents, environments, Problem Formulations, Review of tree and graph structures, State space representation, Search graph and Search tree		
Unit 2	**Search Algorithms**	**9 Hrs**

Uniformed Search - Depth and Breadth first search, Informed Search - Best first search, A*algorithm, Graph Search and Tree, Search, Random search, Search with closed and open list, Heuristic search.		
Unit 3	**AI Project Life Cycle**	**8 Hrs**
AI Project Cycle, Problem scoping, Data acquisition, Data Exploration, Modeling.		
Unit 4	**Data Analysis using Python**	**9 Hrs**
Data analysis using Python: arrays and data frames using NumPy and Pandas; data visualization using Matplotlib/Seaborn; statistical analysis (mean, variance, correlation, regression); handling biological datasets (gene expression, protein data).		
Unit 5	**Application of AI in Biotechnology**	**10 Hrs**
Application of AI in Biochemical Engineering, AI in Bioreactor Engineering, AI for Bioresource and Bioenergy, AI for Environmental Bioengineering, AI for Metabolic and Protein Engineering, AI for Biomaterial Engineering		
	Total	**45 h**

Textbook:

S.No	Book Title with publication agency & year	Author
1	Artificial Intelligence Basics: A Non-Technical Introduction, Apress, 2019 (latest edition)	Tom Taulli
2	Artificial Intelligence: The Basics, Routledge, 2011 (latest edition)	Kevin Warwick
3	Artificial Intelligence in Biotechnology, Arcler Education Incorporated, 2020 (latest edition)	Preethi Kartan

Reference Books:

S.No	Book Title with publication agency & year	Author
1	Artificial Intelligence – A Modern Approach, Pearson, 2021 (4th Edition, latest)	Stuart Russell; Peter Norvig
2	Artificial Intelligence By Example, Packt Publishing, 2020 (2nd Edition, latest)	Denis Rothman

Self-Study Content Links:		**Duration (in Hrs)**
MOOCs	Artificial Intelligence and Machine Learning: Complete Guide - TOC | Infosys Springboard	22 Hrs
Video Lectures		

Web References	Artificial Intelligence, IIT Kharagpur Prof. Anupam Basu, Prof. S. Sarkar https://nptel.ac.in/courses/106105077	36 Hrs

Course Code: BBT0516	Course Name: Bioenergy	L	T	P	C
Course Offered in: Biotechnology		3	0	0	3

Prerequisite: Basic understanding of biology, chemistry, and environmental science, along with fundamental knowledge of energy systems and biotechnology principles.

Course Objective:

To provides an overview of bioenergy sources, generation technologies, and their environmental impact, covering feedstocks, biofuel types, waste-to-energy methods, and sustainable practices, along with relevant policies and future R and D directions.

Course Outcome: After completion of this course students will be able to:		**Bloom's Level**
CO1	Formulate the appropriate biofuel production based on available feedstocks	K2
CO2	Analyze cell wall components of biomass	K4
CO3	Apply thermo-chemical conversion process for biomass conversion to produce biofuel	K3
CO4	Apply enzymatic process to convert biomass to fuel and value added chemicals	K3
CO5	Employ synthetic routes for ease and fast biofuel production	K3

CO-PO Mapping (Scale 1: Low, 2: Medium, 3: High)

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

Course Contents / Syllabus

Unit 1	Introduction to Sources of energy	09 Hrs

Non-renewable vs renewable resources – fossil fuels, solar, wind, and biomass, Classification of bioenergy – liquid and gaseous biofuels, Global and Indian bioenergy status overview, Role of biomass in a sustainable environment, Technologies for converting biomass to energy, Circular and bio-based economy concepts, Environmental impacts of biofuels, Feedstocks – food vs feed vs fuel, Characteristics of ideal bioenergy feedstock, Waste resources – industrial waste, MSW, crop residues, and by-products, Energy crops – terrestrial

and aquatic, Benefits of switching from fossil fuels to biofuels, Basics of biomass and biogas, Cradle-to-grave waste-to-energy approach, Political drivers and policies for bioenergy, Impact of fossil fuels, Role of bioenergy in global warming mitigation, Carbon dioxide (CO_2) sequestration approaches		
Unit 2	**First Generation Bioenergy**	**09 Hrs**
Biofuels from food crops – corn, sugarcane, sugar beet, soybean, canola, coconut oil, fryer grease, Food vs fuel debate – challenges and consequences, Role of plant cell wall components – lignin, cellulose, hemicellulose, Biomass conversion challenges and lignin recalcitrance, Importance of cellulose and hemicellulose in ethanol production, Physico-chemical and biological biomass conversion methods, Enzyme-based conversion – MnP, LiP, laccase, Lignin breakdown mechanisms via enzymes and microbes, Conversion of hexose and pentose sugars to ethanol, By-products and inhibitors in ethanol production, Waste reuse from bioethanol plants, Biodiesel production from vegetable oils, Transesterification process explained		
Unit 3	**Second and Third Generation Bioenergy**	**10 Hrs**
Second-generation biofuels – non-edible biomass and wood, Biomass pretreatment – physical, chemical, and biological strategies, Green chemicals for eco-friendly pretreatment, Bioethanol plant components and biorefinery concepts, Solid and liquid waste management using bioenergy, Biomethanation and microbiology of anaerobic digestion, Biological hydrogen production – dark fermentation, algae-based systems, Third-generation biofuels – need and importance, Role of GM organisms and microbes in enhancing yield, GM crops for biofuel – high biomass, oil crops, Hybrid biomass-based energy systems, Algae for biofuel and value-added product synthesis		
Unit 4	**Fourth generation bioenergy and next generation biomolecules**	**09 Hrs**
CO_2 biosequestration using plants and algae, Synthetic biofuels – types and sustainability benefits, Pyrolysis bio-oil and bio-char, Hydrogenated biodiesel, pyrolysis diesel, Fuel comparisons – diesel (ASTM), DME, SNG, CNG, biogas, Bio-butanol production, ABE fermentation (acetone, butanol, ethanol), Challenges and metabolic engineering in ABE process, Use of GM microbes for enhanced ABE yields, Conversion of waste biomass to alkanes and alkenes, Economic potential of biomass-based chemical production, Current and emerging global and Indian trends in new bioenergy research		
Unit 5	**Policies and Future Trends of Biofuels and Bioenergy**	**08 Hrs**
Overview of India's national biofuel policy, Current and future trends directions, Global collaborations – Mission Innovation India, Horizon 2020, Legal support for biofuel development, International cooperation for India's biofuel sector, Government initiatives and industry policies, Investment and industrial opportunities in biofuels, Socio-economic and ecological impacts of bioenergy, Comparison of bioenergy with solar and wind energy, Role of comm**Unit**y in renewable energy programs, Techno-economic evaluation of biofuel projects, Energy recovery from industrial waste, Zero-discharge wastewater and energy systems, Urban-rural integration for sustainable energy, Life-cycle assessment (LCA) of biofuels		
	Total	**45 Hrs**
Textbook: 1. David M. Mousdale, "Biofuels: Biotechnology, Chemistry, and Sustainable Development", CRC Press, 2008. 2. Roland A. Jansen, "Second Generation Biofuels and Biomass", Wiley – VCH Verlag GmbH Co., 2013. 3. A.H. Scragg, "Biofuels, Production, Application and Development", CAB International, 2009.		

4. Robert C. Brown and Tristan R. Brown, “Biorenewable Resources: Engineering New Products from Agriculture”, Wiley-Blackwell Publishing, 2nd Edition, 2014.

Reference Books:

1. David M. Mousdale, “Biofuels: Biotechnology, Chemistry, and Sustainable Development”, CRC Press, 2008.
2. Roland A. Jansen, “Second Generation Biofuels and Biomass”, Wiley – VCH Verlag GmbH Co., 2013.
3. A.H. Scragg, “Biofuels, Production, Application and Development”, CAB International, 2009.
4. Robert C. Brown and Tristan R. Brown, “Biorenewable Resources: Engineering New Products from Agriculture”, Wiley-Blackwell Publishing, 2nd Edition, 2014.

Self-Study Content Links:		**Duration (in Hrs)**
MOOCs	https://nptel.ac.in/courses/103103207 https://nptel.ac.in/courses/102104057	40 Hrs 40 Hrs
Video Lectures		
Web References		

Lab Course Code: BBT0551X	Lab Course Name: Bioprocess Engineering Lab	L	T	P	C
Course Offered in: Biotechnology		0	0	4	2
Prerequisite: Basics of microbiology					
Course Objective:					
Students gain hands-on experience in media formulation, sterilization, and control of critical parameters such as pH, temperature, and dissolved oxygen, essential for efficient bio manufacturing processes.					

Course Outcome: After completion of this course students will be able to:		**Bloom's Level**
CO1	Apply bioprocess and fermentation techniques for microbial cultivation, product formation, and biochemical estimations.	K3
CO2	Analyze microbial growth behavior, process kinetics, and environmental factors influencing bioprocess performance.	K4
CO3	Evaluate fermentation parameters, media optimization methods, and downstream processing techniques	K5
CO4	Design suitable bioprocess strategies for the production and optimization of industrially important microbial products.	K6

CO-PO Mapping (Scale 1: Low, 2: Medium, 3: High)

CO/PO	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO10**	**PO11**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	3	2	2	2	3	1	3	2	2	1	1	3	2	2
CO2	3	3	2	3	2	1	3	2	2	1	2	2	3	3
CO3	3	3	3	3	2	2	2	2	2	2	2	2	3	3
CO4	3	3	3	2	3	2	2	2	2	3	2	3	3	2

List of Practical's (Indicative and Not Limited To)		
1.	To understand the key parts, control systems and functioning of a fermenter.	CO1
2.	To determine batch growth kinetics of bacteria.	CO2
3.	To perform media optimization using Plackett-Burmann method.	CO3
4.	To produce ethanol from grape juice using yeast fermentation process.	CO1

5.	Production of wine via Fermentation.	CO4
6.	Production of amylase from micro-organism using solid-state fermentation.	CO4
7.	To estimate the protein using Bradford method.	CO1
8.	Immobilization of enzymes by sodium alginate method.	CO1
9.	Upstream and downstream of bioprocess to produce citric acid by *Aspergillus niger.*	CO3
10.	Estimation of volumetric oxygen transfer coefficient by sodium-sulphate method.	CO2
11.	Microbial production of Biosurfactant using suitable strain.	CO4
12.	Determine the effect of peptone concentration on E *.coli* growth	CO2
13.	Determination of specific thermal death rate constant (kd) for *E.Coli*	CO2
14.	Determine the effects of temperature & pH on suitable microbial strain	CO2
		Total H: 60 Hrs

Lab Course Code: BBT0554	Lab Course Name: Plant and Animal Biotechnology Lab	L	T	P	C
Course Offered in: Biotechnology		**0**	**0**	**2**	**1**

Prerequisite: Basics of Plant and Animal Biology

Course Objective:

To equip students with the ability to design, perform, and evaluate plant and animal biotechnology experiments using appropriate tools, aseptic techniques, and analytical approaches for applications in agriculture and healthcare.

Course Outcome: After completion of this course students will be able to:		**Bloom's Level**
CO1	Perform plant tissue culture techniques for in vitro growth and regeneration.	K3
CO2	Perform and maintain animal cell culture and cytological procedures.	K3
CO3	Analyze molecular and cellular assays for cell viability, genetics, and physiological responses.	K4

CO-PO Mapping (Scale 1: Low, 2: Medium, 3: High)

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	2	2	1	2	–	1	1	–	2	3	2
CO2	3	3	2	2	3	2	1	–	2	2	–	2	3	2
CO3	3	3	2	2	3	1	–	–	2	1	–	2	3	2

List of Practical's (Indicative and Not Limited To)	CO Mapping
1. Preparation of stock solution for plant tissue culture media; and sterilization of standard tissue culture media.	CO1
2. Sterilization of explants and generation of undifferentiated mass of cells	CO1
3. Micropropagation via Nodal Culture	CO1
4. Protoplast Isolation Using Enzymatic Method	CO1
5. To prepare hydrated synthetic seeds in vitro	CO1
6. Effect of Growth Regulators on Callus Morphology	CO1

7.	Preparation and Staining of Blood Smear	CO2
8.	Primary Culture of Chick Embryo Fibroblasts	CO2
9.	Cryopreservation and Thawing of Animal Cells	CO2
10.	Observation of Mitosis in Onion Root Tip and Correlation with Animal Cells	CO2
11.	Lymphocyte Culture and Chromosome Preparation (Karyotyping)	CO2, CO3
12.	DNA Extraction from Plant /Animal Tissues	CO3
13.	Trypan Blue Exclusion Assay	CO3
14.	Hemolysis Assay Using Red Blood Cells (RBCs)	CO3
15.	Observation of Apoptosis in Cultured Cells	CO3
		Total H: 30 Hrs

Lab Course Code: BBT0517P	Lab Course Name: Enzyme Engineering Lab	L	T	P	C
Course Offered in: Biotechnology		0	0	2	1

Prerequisite: Basics of Microbiology and Biochemistry

Course Objective:

To equip students with practical skills for analyzing, modifying, and applying enzymes in industrial and biotechnological contexts.

Course Outcome: After completion of the course, the student will be able to

Course Outcome: After completion of this course students will be able to:		**Bloom's Level**
CO1	Identify and extract enzymes from various biological sources and assess their potential for commercial applications.	K3
CO2	Apply experimental techniques to determine enzyme activity, specific activity, and kinetic parameters of enzymes	K3
CO3 CO 1	Analyze the effects of environmental and chemical factors and interpret enzyme behavior using kinetic models.	K4

CO-PO Mapping (Scale 1: Low, 2: Medium, 3: High)

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

List of Practical's (Indicative and Not Limited To)	**CO Mapping**
1. Identification of enzymes in different sources	CO1
2. Production of commercially important enzymes from microbial sources	CO1
3. Isolation of alpha amylase from plant source	CO1
4. Determination of Enzyme Activity of α-Amylase using DNS Method	CO2
5. Determination of specific enzyme activity	CO2
6. Effect of pH on enzyme activity	CO3
7. Effect of temperature on enzyme activity	CO3

8.	Determination of Km and Vmax of Amylase	CO2, CO3
9.	Study of enzyme Inhibition	CO3
10.	To observe action of lipase on milk	CO2
		Total H: 30 Hrs.

Subject Code: BBT0514P	Subject Name: Data Science Lab	L	T	P	C
Applicable in Department: Biotechnology		0	0	2	1

Course Objective: Data Science course aims to provide students with hands-on experience in data analysis using Python or R. It focuses on data cleaning, manipulation, and applying statistical techniques such as measures of central tendency, regression, and hypothesis testing. The course builds essential programming and analytical skills needed for real-world data science applications.

Course Outcomes (CO)-

Course Outcome: After completion of this course students will be able to:		**Bloom's Level**
CO1	Students will be able to understand various data formats and basic programming in Python/R.	K2
CO2	Handle missing data and manage data wrangling and manipulation	K3
CO3	Students will gain proficiency in programming languages such as R or Python to implement statistical analyses.	K3

CO-PO Mapping

CO/PO	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO10**	**PO11**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	3	2	-	2	3	1	1	2	1	2	3	2	2	3
CO2	2	3	2	3	2	2	-	-	2	1	2	2	1	3
CO3	3	2	1	3	3	2	1	2	-	1	3	2	1	3

List of Practical's (Indicative and Not Limited To)

Sr. No	Practical Title	CO Mapping
1.	Write a Programs to read, clean, and manipulate datasets. Handle missing data, Sort data, Row filtration and Data formats.	CO1
2.	Program to remove redundant Variables, identifying and removing outliers	CO2
3.	Classification and visualization of datasets from genomics, finance, and social media domains.	CO2, CO3
4.	Compute mean, median, mode, variance, standard deviation, skewness, and correlation using Python.	CO4

5	Build regression models for predicting microbial growth, sales trends, or financial risk.	CO3, CO4
6	Perform Normal distribution analysis, t-test, chi-square test, and ANOVA on sample datasets.	CO4
7	Develop a logistic regression model for disease classification or customer segmentation.	CO4
8	Generate histograms, scatterplots, boxplots, and correlation heatmaps for healthcare or biotech datasets.	CO3, CO4
9	Apply Hierarchical and k-means clustering and clusters visualization using PCA test	CO3
10	Calculate confusion matrix, accuracy, precision, recall, F1-score, and create interactive visualizations for prediction analysis.	CO4
		Total = 30 Hrs

Lab Course Code: BBT0518P	Lab Course Name: Industrial waste management Lab	L	T	P	C
Course Offered in: Biotechnology		0	0	2	1

Prerequisite: Basics of analytical tools and microbiology

Course Objective:

It emphasizes reducing industrial solid and hazardous waste, applying energy conversion technologies, and understanding technological, organizational, and legislative advancements. Additionally, it highlights waste characterization, mass balance analysis, carbon footprint evaluation, and integrating environmental regulations into new treatment technologies for improved sustainability.

Course Outcome: After completion of the course, the student will be able to

Course Outcome: After completion of this course students will be able to:		**Bloom's Level**
CO1	Gain insights into industrial pollution, identifying sources and pollutant characteristics	K2
CO2	Apply treatment methods based on waste properties for effective management.	K3
CO3	Analyze wastewater treatment systems to meet regulatory standards	K4

CO-PO Mapping (Scale 1: Low, 2: Medium, 3: High)

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	3	1	2	1	3	2	1	1	1	1	3	2	2
CO2	2	3	1	2	2	1	1	1	2	1	2	3	2	2
CO3	2	3	2	2	2	1	2	1	1	1	1	3	3	2

List of Practical's (Indicative and Not Limited To)	**CO Mapping**
1. Classification of Industrial Wastes	CO1
2. Analysis of BOD and COD in Effluents	CO1, CO2
3. TSS, TDS and pH Measurement of Industrial Wastewater	CO1, CO2
4. Coagulation and Flocculation Test (Jar Test)	CO2
5. Heavy Metal Detection using AAS or Colorimetric Methods	CO1, CO2
6. Simulation of Primary, Secondary, and Tertiary Treatment	CO2, CO3

7. Composting and Vermicomposting of Organic Waste	CO2
8. Color and Dye Removal using Microbial Treatment	CO2, CO3
9. To assess air pollutants like SO_2, NOx, and particulate matter using simple air samplers or filter paper methods.	CO1
10. Algal Bioreactor for Nutrient Removal	CO2, CO3
	Total H: 30 Hrs.

Course Code: BBT0555	Course Name: Cheminformatics and Molecular Dynamics	L	T	P	C
Course Offered in: Biotechnology		0	0	6	3

Prerequisite: A basic understanding of chemistry, molecular biology, and computational techniques is recommended for this workshop.

Course Objective:

This course covers the fundamentals of cheminformatics in drug discovery, focusing on molecular structure representation, data mining, and selection of suitable data formats. It also highlights the integration of AI/ML techniques in cheminformatics for efficient drug development.

Course Outcome: After completion of this course students will be able to:		**Bloom's Level**
CO 1	Understand the fundamental principles of cheminformatics and apply them to drug discovery. Use the concepts of looping, branching, and decision-making statements for a given problem.	K3
CO2	Use molecular descriptors and tools for structure representation, similarity searching, and molecular property predictions	K2
CO3	Design computational models for drug discovery using QSAR, docking, and other methods.	K5
CO4	Apply data mining, machine learning, and deep learning techniques in the drug design process.	K3
CO5	Integrate various cheminformatics tools in a workflow for modern drug discovery.	K4

CO-PO Mapping (Scale 1: Low, 2: Medium, 3: High)

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

Course Contents / Syllabus

Unit 1	Basics of Cheminformatics	16 Hrs
Exercise 1: Define Cheminformatics and trace its historical development. Exercise 2: Identify key applications of cheminformatics in drug discovery. Exercise 3: List and explain key domains in cheminformatics. Exercise 4: Describe the role of cheminformatics in drug discovery workflow. Exercise 5: Convert chemical structures into SMILES, InChI, and SDF formats. Exercise 6: Calculate and interpret 1D, 2D, and 3D molecular descriptors.		
Unit 2	**Chemical Information Sources**	**16 Hrs**
Exercise 7: Retrieve chemical information from PubMed, Scopus, and SciFinder. Exercise 8: Perform chemical patent search using USPTO or WIPO. Exercise 9: Apply text mining tools to extract chemical data from literature. Exercise 10: Explore and interpret DrugBank, ZINC, and BindingDB datasets. Exercise 11: Identify and analyze compound supplier databases. Exercise 12: Use spectral databases (NMR, MS, IR) for compound analysis.		
Unit 3	**Medicinal Chemistry**	**16 Hrs**
Exercise 13: Outline the early steps in the drug discovery pipeline. Exercise 14: Describe ligand-protein interactions and receptor models. Exercise 15: Construct a pharmacophore model for a known ligand. Exercise 16: Perform virtual screening for lead identification. Exercise 17: Develop a linear QSAR model using given descriptors. Exercise 18: Predict ADME/T properties of a compound dataset.		
Unit 4	**Chemical Database Design and Management**	**16 Hrs**
Exercise 19: Compare relational and object-oriented database models. Exercise 20: Design a schema for storing chemical and biological data. Exercise 21: Write SQL queries for structure-based search in a database. Exercise 22: Conduct substructure and similarity searches on ChEMBL. Exercise 23: Access and extract data from cheminformatics portals like PubChem. Exercise 24: Use MySQL and KNIME for database creation and querying.		
Unit 5	**Drug Design and Discovery**	**16 Hrs**
Exercise 25: Outline the complete drug design and discovery workflow. Exercise 26: Implement structure-based virtual screening using AutoDock. Exercise 27: Perform ligand-based drug design using similarity search. Exercise 28: Apply de novo drug design techniques for novel compounds.		

Exercise 29: Conduct fragment-based drug discovery and hit optimization. Exercise 30: Analyze a COVID-19 drug discovery pipeline using AI tools.	
Total	**80 Hrs**

Textbook:

1."Cheminformatics: A Textbook" by Jürgen Gasteiger and Thomas Engel (2nd Edition, 2013, Springer, ISBN-13: 978-3642221124)

2."Introduction to Chemoinformatics" by Andrew R. Leach and Valerie J. Gillet (2nd Edition, 2007, Pearson Education, ISBN-13: 978-0130422085)

3. "Medicinal Chemistry: An Introduction" by Gareth Thomas (3rd Edition, 2016, Wiley-Blackwell, ISBN-13: 978-1118953435)

Reference Books:

"Molecular Modeling Basics" by Jan M. Haerter (1st Edition, 2011, Wiley-VCH, ISBN-13: 978-3527331529)

"Computational Chemistry: A Practical Guide for Applying Techniques to Real-World Problems" by David C. Young (1st Edition, 2001, Wiley-Interscience, ISBN-13: 978-0471300802)

Self-Study Content Links:		**Duration (in Hrs)**
MOOCs		
Video Lectures		
Web References		

Course Code: BCSCC0501Y	**Course Name: Design Thinking II**	**L**	**T**	**P**	**C**
Course Offered in: Biotechnology		2	1	0	3

Prerequisite: Student must complete Design Thinking-I course

Course Objective: The objective of this course is to upgrade Design Thinking skills by learning & applying advanced and contextual Design Thinking Tools. It aims to solve a Real-Life Problem by applying Design Thinking to create an impact for all the stakeholders

Course Outcome: After completion of the course, the student will be able to		**Bloom's Level**
CO1	Learn sophisticated design tools to sharpen their problem-solving skills.	K2
CO2	Generate innovative ideas using design thinking tools and converge to feasible idea for breakthrough solution.	K4
CO3	Implement storytelling for persuasive articulation.	K3
CO4	Understanding the nature of leadership empowerment.	K2
CO5	Understand the role of a human being in ensuring harmony in society and nature.	K2

CO-PO Mapping (Scale 1: Low, 2: Medium, 3: High)

CO\PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	2	2	1	1	3	1	1	2	2	1	3	2	2	1
CO2	3	3	3	2	3	1	1	2	2	2	3	2	3	2
CO3	1	1	2	1	2	1	1	2	3	2	2	1	1	2
CO4	1	1	1	1	1	1	1	3	3	2	2	1	1	1
CO5	1	1	1	1	1	3	3	2	2	1	2	1	1	1

Course Contents / Syllabus

Unit 1	**Introduction**	**10 Hrs**

Design thinking & Innovation, Design Thinking Mindset and Principles, recap of 5-Step Process of Design Thinking, Design Approaches, additional in-depth examples of each design approaches. Simon Sinek's – Start with Why, The Golden Circle, Asking the "Why" behind each example (an in-class activity of asking 5-WHYS) , The Higher Purpose, in-class activity for LDO & sharing insights Visualization and it's importance in design thinking, reflections on wheel of life (in-class activity for visualization & Wheel of Life), Linking it with Balancing Priorities (in class activity), DBS Singapore and Bank of Americas' Keep the Change Campaign. Litter of Light & Arvind Eye Care Examples, understanding practical application of design thinking tools and concepts, case study on McDonald's Milkshake / Amazon India's Rural Ecommerce & Gillette Working on 1-

hour Design problem, Applying RCA, and Brainstorm on innovative solutions. Main project allocation and expectations from the project		
Unit 2	**Refinement and Prototyping**	**08 Hrs**
Refine and narrow down to the best idea, 10-100-1000gm, QBL, Design Tools for Convergence – SWOT Analysis for 1000gm discussion. In-class activity for 10-100-1000gm & QBL Prototyping (Convergence): Prototyping mindset, tools for prototyping – Sketching, paper models, pseudo- codes, physical mockups, Interaction flows, storyboards, acting/role-playing etc, importance of garnering user feedback for revisiting Brainstormed ideas, Napkin Pitch, Usability, Minimum Viable Prototype, Connecting Prototype with 3 Laws, A/B Testing, Learning Launch. Decision Making Tools and Approaches – Vroom Yetton Matrix, Shift-Left,Up,Right, Value Proposition, Case study: Careerbuddy,You-Me-Health Story & IBM Learning Launch. In-class activities on prototyping- paper-pen / physical prototype/ digital prototype of project's 1000gm idea		
Unit 3	**Storytelling, Testing and Assessment**	**08 Hrs**
Storytelling: Elements of storytelling, Mapping personas with storytelling, Art of influencing, Elevator Pitch, Successful Campaigns of well-known examples, in-class activity on storytelling. Testing of design with people, conducting usability test, testing as hypothesis, testing as empathy, observation and shadowing methods, Guerrilla Interviews, validation workshops, user feedback, record results, enhance, retest, and refine design, Software validation tools, design parameters, alpha &beta testing, Taguchi, defect classification, random sampling Final Project Presentation and assessing the impact of using design thinking		
Unit 4	**Innovation, Quality and Leadership**	**06 Hrs**
Innovation: Need & Importance, Principles of innovations, Asking the Right Questions for innovation, Rationale for innovation, Quality: Principles & Philosophies, Customer perception on quality, Kaizen, 6 Sigma. FinTech case study of Design Thinking application – CANVAS Leadership, types, qualities and traits of leaders and leadership styles, Leaders vs Manager, Personas of Leaders & Managers, Connecting Leaders-Managers with 13 Musical Notes, Trait theory, LSM (Leadership Situational Model), Team Building Models: Tuckman's and Belbin's. Importance of Spatial elements for innovation		
Unit 5	**Understanding Human Desirability**	**08 Hrs**
Program needed to achieve the comprehensive human goal: the five dimensions of human endeavor(ManaviyaVyavstha) are: Education- Right living (Sikhsa- Sanskar), Health – Self-regulation (SwasthyaSanyam), Justice – Preservation (Nyaya- Suraksha), Production – Work (Utpadan – Karya), Exchange – Storage (Vinimya – Kosh), Darshan-Gyan-Charitra (Shifting the Thinking) Interconnectedness and mutual fulfilment among the four orders of nature recyclability and self-regulationin nature, thinking expansion for harmony: Self-exploration (Johari's window), group behaviour, interpersonal behaviour and skills, Myers-Briggs personality types (MBTI), FIRO-B test to repair relationships.		
Total Lecture Hours		**48 Hrs**

Textbook:

S.No	**Book Title with publication agency & year**	**Author**
1	UnMukt: Science and Art of Design Thinking (Polaris / School of Design Thinking, 2020)	Arun Jain

2	Basics Design 08: Design Thinking (AVA Publishing, 2010)	Gavin Ambrose; Paul Harris
3	A Foundation Course in Human Values and Professional Ethics (Excel Books, New Delhi, 2010)	R. R. Gaur; R. Sangal; G. P. Bagaria
1	Solving Problems with Design Thinking: Ten Stories of What Works (Columbia Business School Publishing, 2013)	Jeanne Liedtka; Andrew King; Kevin Bennett
2	Universal Human Values and Professional Ethics (S. K. Kataria & Sons, New Delhi, 2022)	Dr. Ritu Soryan
3	101 Design Methods: A Structured Approach for Driving Innovation in Your Organization (John Wiley & Sons, 2013 per your data though first edition released Oct 2012)	Vijay Kumar
4	The Design of Business: Why Design Thinking Is the Next Competitive Advantage (Harvard Business Press, November 2009, Boston MA)	Roger L. Martin
5	Change by Design: How Design Thinking Transforms Organizations and Inspires Innovation (Harper Business / HarperCollins, 2009)	Tim Brown
Self-Study Content Links:		**Duration (in Hrs)**
MOOCs	https://nptel.ac.in/courses/109104109 https://www.nptel.ac.in/courses/110106124	**40 Hrs** **40 Hrs**
Video Lectures		
Web References		
NPTEL/ Youtube/ Faculty Video Link:		
Unit 1	https://www.youtube.com/watch?v=6_mHCOAAEI8 https://nptel.ac.in/courses/110106124 https://designthinking.ideo.com/ https://blog.experiencepoint.com/how-mcdonalds-evolved-with-design-thinking	

Unit2	https://www.coursera.org/lecture/uva-darden-design-thinking-innovation/the-ibm-story-iq0kE https://www.coursera.org/lecture/uva-darden-design-thinking-innovation/the-meyouhealth-story-part-i-what- isW6tTs https://onlinecourses.nptel.ac.in/noc19_mg60/preview
Unit 3	https://nptel.ac.in/courses/109/104/109104109/ https://www.d-thinking.com/2021/07/01/how-to-use-storytelling-in-design-thinking/
Unit 4	https://www.worldofinsights.co/2020/10/infographic-8-design-thinking-skills-for-leadership- development/
Unit 5	https://www.youtube.com/watch?v=hFGVcx1Us5Y

Course Code: BCSCC0552	Course Name: Research Methodology, Ethics and Writing	L	T	P	C
Course Offered in: All Engineering Programs		**0**	**0**	**2**	**1**

Prerequisite: Basic communication skills, engineering fundamentals

Course Objective:

This course equips students with fundamental research skills, including problem identification, literature review, data analysis, technical documentation, and ethical publication practices, while enhancing technical writing and scientific communication for academic and professional applications.

Course Outcome: After completion of the course, the student will be able to

		Bloom's Level
CO1	Identify and formulate a domain-specific real-world problem through literature review, objective setting, and structured project planning for research-based implementation.	K4
CO2	Design, develop, and validate a functional prototype/model/system using appropriate tools, technologies, and methodologies while integrating ethical, safety, reliability, and performance considerations.	K4
CO3	Analyze project outcomes, prepare technical documentation, and draft a structured research paper/report in IEEE/Scopus/UGC-approved format for effective scientific communication and publication readiness.	K4

CO-PO Mapping (Scale: 1: Low, 2: Medium, 3: High)

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	2	–	2	1	–	–	2	–	1	–
CO2	2	3	1	3	2	–	–	2	1	2	–
CO3	2	3	2	3	2	–	–	3	2	3	1

Course Contents / Syllabus

Unit 1	Fundamentals of Research Methodology and Literature Review	7 Hrs

Definition of research, objectives of research, motivation and significance of research, types of research including fundamental, applied, qualitative, quantitative, and experimental research, stages of research process, research problem identification, formulation of research questions, identification of technical gaps, literature review methodologies, use of scientific databases such as Google Scholar, Scopus, Web of Science, IEEE Xplore, and ScienceDirect, keyword selection strategies, source reliability and credibility evaluation, annotated bibliography preparation, critical analysis of published research papers, and review writing techniques.

Unit 2	Data Collection, Analysis, and Technical Documentation	7 Hrs

Primary and secondary data sources, data gathering methods, survey techniques, questionnaire design, experimental observations, data organization, structured sampling methods including random sampling, stratified sampling, and systematic sampling, basic statistical concepts including mean, median, standard deviation, graphical data representation, data analysis techniques, spreadsheet-based analysis, technical report preparation, scientific report structure including abstract, introduction, methodology, results, discussion, and conclusion, mini-project execution, research documentation, and technical documentation practices.		
Unit 3	**Citation Management, Publication Ethics, and Research Integrity**	**7 Hrs**
Ethical research practices, scholarly publishing standards, academic reference management, citation systems including IEEE, APA, and MLA, reference management software such as Mendeley and Zotero, plagiarism awareness, similarity detection tools, responsible citation practices, authorship ethics, predatory journals, peer review systems, journal indexing, impact factors, research integrity principles, publication misconduct, ethical compliance, professional publishing standards, citation formatting exercises, plagiarism analysis, journal quality evaluation, and ethical case studies.		
Unit 4	**Technical Writing and Research Documentation**	**9 Hrs**
Scientific and technical writing skills, engineering research documentation, professional documentation practices, technical report writing, project report preparation, review paper writing, conference paper drafting, research manuscript development, scientific writing styles, report organization, abstract preparation, introduction framing, methodology documentation, results presentation, discussion development, conclusion writing, proofreading, technical editing, document formatting, visual representation of technical data using tables, charts, and figures, documentation standards, formal technical presentations, dissemination of research findings, manuscript section drafting, technical document editing, and professional written communication.		
	Total	**30 Hrs**

Textbook:

1. C.R. Kothari & Gaurav Garg – Research Methodology: Methods and Techniques
2. Ranjit Kumar – Research Methodology: A Step-by-Step Guide for Beginners
3. Michael Alley – The Craft of Scientific Writing
4. Day & Gastel – How to Write and Publish a Scientific Paper
5. George Thomas – Research Methodology and Scientific Writing

Reference Materials

1. IEEE Author Guidelines
2. Elsevier Researcher Academy Resources
3. Springer Author Academy
4. WIPO Resources for Research Documentation
5. University digital library resources

Self-Study Content Links:		**Duration (in Hrs)**
MOOCs	https://www.nptel.ac.in/courses/121106007	**40 Hrs**
Video Lectures		

Web References		
NPTEL/ YouTube/ Faculty Video Link:		
Unit 1	https://www.youtube.com/watch?v=rz30rRfManE&list=PLdj5pVg1kHiOypKNUmO0NKOfvoIThAv4N	
Unit 2	https://www.youtube.com/watch?v=HYj4Ght1_qs	
Unit 3	https://www.youtube.com/watch?v=N9tJCs-czOU&list=PLnIj1GYixjfrOhcWQq_ANzLFDniGYZ_-Q	
Unit 4	https://www.youtube.com/watch?v=NM53k7x_jjk	

Course Code: BBT0601N	Course Name: Bioseparation Engineering	L	T	P	C
Course Offered in: All Engineering Programs		3	1	0	4

Prerequisite: Basic knowledge of Analytical techniques

Course Objective:

To provide students with a comprehensive understanding of separation techniques in downstream processing, including chromatography and membrane-based methods, and their optimization for efficient biomolecule recovery, purification, and bioprocessing applications.

Course Outcome: After completion of this course students will be able to:		**Bloom's Level**
CO1	Apply principles of bioseparation techniques to solve basic biomolecule separation problems	K3
CO2	Apply extraction, adsorption, membrane separation, and DNA/RNA recovery techniques for efficient product recovery	K3
CO3	Apply different bioseparation techniques for efficient product isolation at lab and pilot scales	K3
CO4	Understand and analyze chromatographic techniques to separate and purify biomolecules	K4
CO5	Apply and Analyze product polishing operations in downstream processing considering process economics and environmental sustainability.	K4

CO-PO Mapping (Scale: 1: Low, 2: Medium, 3: High)

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

Course Contents / Syllabus

Unit 1	Introduction to Bioseparation	12 Hrs

Introduction to separation of biomolecules and its importance in Biotechnology, working principle, methodology, industrial applications of centrifugation (types: analytical, preparative, density gradient, ultracentrifugation), filtration, cell disruption (physical and chemical methods), flocculation.		
Unit 2	**Product Recovery**	**12 Hrs**
Working Principle, Methodology, and applications of Extraction (Infusion, Decoction, Digestion, Maceration, Percolation, Soxhalation, Supercritical fluid extraction, Counter current extraction, MAE, UAE), adsorption (types and isotherms), membrane-based separation, Precipitation. Separation of different types of DNA and RNA from cells.		
Unit 3	**Product Isolation**	**12 Hrs**
Working principle, methodology, and industrial applications of Ultrafiltration (models-capillary flow model, solution diffusion model), Polymer beads for immobilization of biomolecules (types- cross linking, Adsorption, covalent binding, entrapment, microencapsulation), Magnetic Beads for Bio-separation, Cell Sorting (FACS, MACS), Microfluidics based separation		
Unit 4	**Product Purification**	**12 Hrs**
Working principle, methodology, and Industrial application of Basics of chromatography and its use in separation of biomolecules (types: Paper chromatography, TLC, GC, HPLC, Ion exchange chromatography, Gel filtration chromatography, affinity chromatography), Methods for separation of the proteins based on size, charge and chemical nature of the proteins via Electrophoresis (zone electrophoresis, moving boundary electrophoresis)		
Unit 5	**Product Polishing**	**12 Hrs**
Product polishing: Working principle, methodology, industrial application of crystallization, drying (drum dryer, Spray Dryer, Freeze Dryer, Tray Dryer, Fluidized Bed Dryer, Vacuum Dryer). Case studies: illustrative examples pertaining to downstream processing of bioproducts (Ethanol, citric acid, biopharmaceuticals, antibiotics, and recombinant products).		
	Total	**60 Hrs**

Textbook:

1. Bioseparations: Principles and Techniques" by Sivasankar
2. "Bioseparation: Volume 47 (Advances in Biochemical Engineering/Biotechnology)" by C A Heath and A L Nguyen
3. "Bioseparation Engineering: A Comprehensive DSP Volumen" by Abhishek Awasthi and Ajay Kumar
4. "Bioseparations Downstream Processing for Biotechnology" by Paul A Belter and E L Cussler
5. "Bioseparations Engineering: Principles, Practice, and Economics" by Michael R Ladisch
6. "Bioseparations Science and Engineering" by Roger G Harrison

Reference Materials

1. IEEE Author Guidelines

2. Elsevier Researcher Academy Resources 3. Springer Author Academy 4. WIPO Resources for Research Documentation 5. University digital library resources		
Self-Study Content Links:		**Duration (in Hrs)**
MOOCs	https://onlinecourses.nptel.ac.in/e-learning/preview/noc23_bt44 https://onlinecourses.nptel.ac.in/e-learning/preview/noc24_ch18	**36 Hrs** **36 Hrs**
Video Lectures		
Web References		

Course Code: BBT0603Z	Course Name: Nanobiotechnology	L	T	P	C
Course Offered in: Biotechnology		3	1	0	4

Prerequisite: Students should know about the basic molecular and cell biology.

Course Objective:

To introduce the fundamentals of nanobiotechnology, nanomaterial synthesis, characterization techniques, and nanofabrication, with applications in biomedical polymers, disease diagnosis, imaging, and treatment.

Course Outcome: After completion of this course students will be able to:		**Bloom's Level**
CO 1	Understand the basics of nanoscience, nanobiotechnology, nanotechnology and its techniques.	K2
CO2	Explain the effective strategies of nanomaterials synthesis through physical, chemical, and biological processes.	K2
CO3	Compare potential tools and techniques used for characterization of nanomaterials and their applications.	K3
CO4	Classify and differentiate the synthesis and application of different classes of biomedical polymers and their uses.	K3
CO5	Understand and conclude the concept of diagnosis, imaging, and treatment of disease through nanotechnology tools and techniques.	K4

CO-PO Mapping (Scale 1: Low, 2: Medium, 3: High)

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

Course Contents / Syllabus

Unit 1	**Introduction to Nanobiotechnology**	**13 Hrs**
Nanobiotechnology, History, Origin, Fundamental Concepts, Approaches, Current research trends, Moore's Law and relevance to Nanobiotechnology, Discussion on Micro and Nanofabrication process (photolithography, soft lithography, Etching techniques).		
Unit 2	**Nanomaterials synthesis and applications:**	**12 Hrs**
Carbon based nanomaterials types (Carbon nanotubes (SWCNTs, MWCNTs), Graphene, Carbon dots, Fullerenes), Synthesis(Arc discharge, Laser ablation, Chemical Vapor Deposition (CVD), Pyrolysis), Properties, Applications in biosensing, imaging, and therapy, Inorganic nanomaterials: types (Quantum dots, Gold nanoparticles, Silver nanoparticles, Silica nanoparticles), Synthesis (Sol-gel, Hydrothermal, Co-precipitation), Properties and Applications.		
Unit 3	**Nanocharecterization tool and techniques:**	**13 Hrs**
Principles and applications of: Surface Plasmon Resonance (SPR), Spectroscopy (UV and FTIR), Zeta potential, Dynamic Light Scattering (DLS), X-ray diffraction (XRD), Transmission Electron Microscopy (TEM), Scanning Electron Microscope (SEM), Scanning Probe Microscopy (STM and AFM), Improved diagnostic devices (Nanowires and Cantilever).		
Unit 4	**Biomaterials and polymers:**	**12 Hrs**
Classification of biomaterials and biomedical polymers, Synthesis and characterization of different classes of biomaterials and polymers, their uses in Pharmaceutical, Cardiovascular, Ophthalmologic and Orthopaedic areas. Biocompatibility and degradation behaviour.		
Unit 5	**Application of Nanobiotechnology in Biological and Medical Sciences:**	**10 Hrs**
Micro and Nano biosensor, Nano-imaging agents (contrast agents, fluorescent labels), Quantum dots technology and its applications, Carbon dots, Drug delivery tools through nanotechnology (Liposomes, Nanoparticles, Dendrimers). Case study of tumour targeting through nanotechnology, Regulatory, ethical, and safety considerations in medical nanotech.		
Total		**60 Hrs**

Textbook:

1. Nanotechnology by Mark Ratner and Daniel Ratner, Pearson Education-2003
2. Guozhong Cao ,"Nanostructures and Nanomaterials , synthesis , properties and applications" , Imperial College Press ,2004.
3. Hari Singh Nalwa, "Nanostructured Materials and Nanotechnology",Academic Press, 2002

Reference Books:

1. Microfabrication and Nanomanufacturing-Mark James Jackson-2018
2. MEMS and Nanotechnology –Based sensors and devices communication, Medical and Aerospace applications -A.R.Jha-2008
3. Drug Delivery: Engineering Principles for Drug Therapy, M. Salzman-2001

Self-Study Content Links:		**Duration (in Hrs)**
MOOCs	https://nptel.ac.in/courses/102107557	36-48 Hrs

	https://nptel.ac.in/courses/102104069 https://nptel.ac.in/courses/118104008 https://nptel.ac.in/courses/118102003	36-48 Hrs 36-48 Hrs 36-48 Hrs
Video Lectures		
Web References		
NPTEL/ Youtube/ Faculty Video Link:		

Course Code: BBT0618	Course Name: Metabolic Engineering	L	T	P	C
Course Offered in: B. Tech. Biotechnology		3	0	0	3

Prerequisite: Basic knowledge of Biochemical Engineering

Course Objective:

To introduce students to metabolic engineering and its significance, provide foundational knowledge of metabolic flux analysis, familiarize them with experimental methods for flux determination, impart skills in computational modeling of biological networks, and highlight industrial applications of primary and secondary metabolites.

Course Outcome: After completion of this course students will be able to:		**Bloom's Level**
CO 1	Understanding the metabolic engineering and its importance	K2
CO2	Understand the metabolic flux analysis.	K2
CO3	Illustrate metabolic flux by using different analytic techniques.	K2
CO4	Apply the Computational modelling of biological networks	K3
CO5	Analyze effective strategies to implement genetic manipulations and Pathway engineering strategies for industrial applications.	K4

CO-PO Mapping (Scale 1: Low, 2: Medium, 3: High)

CO/ PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	2	2	2	1	2	1	2	1	2	3	2	2
CO2	3	3	2	1	2	1	2	1	1	1	2	3	3	2
CO3	3	3	2	2	2	2	2	1	1	1	1	3	3	2
CO4	3	2	2	2	1	1	2	2	1	2	2	3	2	2
CO5	3	3	3	2	2	2	2	1	1	2	2	3	3	2

Course Contents / Syllabus

Unit 1	**Introduction to Metabolic Engineering and its importance**	**10 Hrs**

Introduction to Enzymes and metabolism, Stoichiometry of cellular reactions, dynamic mass balance, yield coefficients and linear rate equations, Black box model, Different models for cellular Reactions-Induction-

Jacob Monod Model and its regulation, Differential regulation by isoenzymes, Concerted or cumulative feedback regulation. Regulation in branched pathways, Permeability, and transport of metabolites		
Unit 2	**Metabolic flux analysis**	**09 Hrs**
Introduction to Metabolic flux analysis (MFA), Isotopic steady state methods (13C MFA) and Isotopic non-steady state methods, Dynamic metabolic flux analysis, Building stoichiometric matrix; Steady state and pseudo steady state assumptions; Using different optimizing functions to solve linear programming problem; understanding flux cone and constraints; Introducing additional constraints from thermodynamics		
Unit 3	**Experimental determination of metabolic fluxes**	**08 Hrs**
Technical developments in labels distribution analysis; Nuclear Magnetic Resonance spectroscopy (NMR)and Gas chromatography along with mass spectroscopy (GC-MS) based methods for flux determination, C13 labelling, Flux sampling, Optknock, Optstrain		
Unit 4	**Computational modelling of biological networks**	**08 Hrs**
Introduction to MATLAB, Creating MATLAB variables, Using MATLAB as a calculator, Main features of MATLAB and capabilities of MATLAB, Synthetic circuit design, MOMA, iFBA, dFBA; Enhancement of product yield and productivity.		
Unit 5	**Industrial applications**	**10 Hrs**
Pathway engineering strategies for overproduction of some commercially important primary and secondary metabolites or industrially relevant enzymes and recombinant proteins, bioconversion- applications and factors affecting bioconversion, mixed or sequential bioconversions, regulation of enzyme production, strain selection and improvement, the modification of existing or the introduction of entirely new metabolic pathways, CRISPR-CAS system		
Total		**45 Hrs**
Textbook: 1. Metabolic Engineering: Principles and Methodologies by Gregory N. Stephanopoulus, Aristos A. Aristidou, and Jens Nielsen. 2. Pathway Analysis and Optimization in Metabolic Engineering by Néstor V. Torres and Eberhard O. Voit. 3. The Metabolic Pathway Engineering Handbook by Christina D. Smolke.		
Reference Books: 1. Biochemical Engineering by Harvey W. Blanch and Douglas S. Clark. 2. Principles of Fermentation Technologies by Stanbury P and Whitaker A 3. Fermentation and Enzyme Technology by Wang DIC		

Self-Study Content Links:		**Duration (in Hrs)**
MOOCs	https://nptel.ac.in/courses/102105086	**40 Hrs**
Video Lectures		

Web References		
NPTEL/ Youtube / Faculty Video Link:		
Unit 1	https://www.youtube.com/watch?v=xF_WotEWJA0	
Unit 2	https://www.youtube.com/watch?v=x2URHbJfHDk	
Unit 3	https://www.youtube.com/watch?v=ndThuqVumAk	
Unit 4	https://www.youtube.com/watch?v=ndThuqVumAk	
Unit 5	https://www.youtube.com/watch?v=ndThuqVumAk	

Course Code: BBT0616	Course Name: Deep Learning for Biotechnology	L	T	P	C
Course Offered in: Department of Biotechnology		3	0	0	3

Prerequisite: Basic knowledge of Machine Learning along with programming

Course Objective: This course aims to build a strong foundation in Deep learning (DL) by introducing its basic concepts and the essential linear algebra underlying DL models. It provides in-depth knowledge of various machine learning techniques and algorithms, along with practical insights into applying DL to real-world problems.

Course Outcome: After completion of the course, the student will be able to		**Bloom's Level**
CO1	Explain deep learning fundamentals and Artificial Neural Network models.	K2
CO2	Apply training and optimization techniques in deep learning.	K3
CO3	Develop Convolutional Neural Network models for biomedical images.	K3
CO4	Implement Recurrent Neural Network models for biological sequences.	K3
CO5	Apply deep learning applications in biotechnology and healthcare.	K3

CO-PO Mapping (Scale 1: Low, 2: Medium, 3: High)

CO/ PO o	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO 10**	**PO 11**	**PS O1**	**PS O2**	**PS O3**
CO1	3	2	1	1	1	1	1	1	1	1	1	2	2	1
CO2	2	3	1	2	2	1	1	1	1	1	1	2	2	1
CO3	2	3	3	2	3	1	1	1	1	1	1	3	2	2
CO4	2	3	2	2	3	1	1	1	1	1	1	3	3	2
CO5	2	3	2	3	2	1	1	2	1	1	2	2	3	3

Course Contents / Syllabus

Unit 1	**Introduction to Deep Learning and Neural Networks**	**9 Hrs**

Introduction to Artificial Intelligence, Machine Learning and Deep Learning, Biological Inspiration of Neural Networks, Perceptron Model, Artificial Neural Networks, Single Layer and Multi-Layer Networks, Network Architecture, Input Layer, Hidden Layer, Output Layer, Forward Propagation, Weight and Bias, Activation Functions, Loss Functions, Training and Testing of Neural Networks.

Case Study: Disease Risk Prediction using Artificial Neural Networks

Unit 2	**Training and Optimization of Deep Neural Networks**	**9 Hrs**

Architecture of Deep Neural Networks (DNN), Backpropagation, Gradient Descent Optimization, Batch Learning, Stochastic Learning, Mini-Batch Learning, Learning Rate, Optimization Algorithms, Model Training and Validation, Overfitting, Underfitting, Regularization Techniques, Dropout, Batch Normalization, Performance Evaluation. **Case Study: Optimization of Cancer Classification Models**		
Unit 3	**Convolutional Neural Networks for Biotech Image Analysis**	**9 Hrs**
Convolutional Neural Networks, Convolution Operation, Filters, Kernels, Feature Maps, Padding, Stride, Pooling Layers, Feature Extraction, CNN Architecture, Image Classification, Transfer Learning, Biomedical Image Analysis, Histopathology Image Analysis, Medical Image Classification. **Case Study: Skin Cancer Detection using Convolutional Neural Networks**		
Unit 4	**Recurrent Neural Networks for Biological Sequence Analysis**	**9 Hrs**
Recurrent Neural Networks, Sequence Modelling, Hidden States, Temporal Dependencies, Vanishing Gradient Problem, Long Short-Term Memory, Gated Recurrent **Unit**, Sequence Prediction, DNA Sequence Analysis, Protein Sequence Modelling, Time-Series Biological Data Analysis. **Case Study: DNA Sequence Classification using Recurrent Neural Networks**		
Unit 5	**Application of Deep Learning in Biotechnology**	**9 Hrs**
Autoencoders, Feature Learning, Transfer Learning, Feature Embedding, Explainable Artificial Intelligence, Multimodal Learning, Drug Discovery, Genomics Analysis, Precision Medicine, Protein Function Prediction, Medical Diagnosis Systems, Intelligent Healthcare Analytics. **Case Study: AI-based Drug Response Prediction for Precision Medicine**		
	Total	**45 Hrs**

Textbook:

S.No	**Book Title with publication agency & year**	**Author**
1	Deep Learning (MIT Press, 2016)	Ian Goodfellow and Yoshua Bengio Aaron Courville.
2	Neural Networks and Deep Learning, Determination Press, : 2015.	Michael Nielson
3	Neural Networks: A Classroom Approach	TataMcGraw-Hill, Satish Kumar

Self-Study Content Links:		**Duration (in Hrs)**
MOOCs	https://infyspringboard.onwingspan.com/web/en/app/toc/lex_auth_01274814254931148859_shared/overview	35 Hrs

Video Lectures		
Web References	Foundations of Deep Learning: Concepts and Applications, IISc Bangalore RV University Prof. Sriram Ganapathy Prof. Ashwini Kodipalli Prof. Baishali Garai https://nptel.ac.in/courses/106108840	55 Hrs

NPTEL/ Youtube/ Faculty Video Link:	
Deep Learning (Infosys Springboard)	https://infyspringboard.onwingspan.com/web/en/app/toc/lex_auth_01274814254931148859_shared/overview
NPTEL Course- Deep Learning	nptel.ac.in/courses/106105215

Course Code: BBT0615	Course Name: Bioremediation Technology	L	T	P	C
Course Offered in: B.Tech . Biotechnology		3	0	0	3

Prerequisite: Basic knowledge of microbiology, environmental biotechnology, biochemistry, chemistry, and bioprocess principles.

Course Objective:

To provide a comprehensive understanding of the principles, mechanisms, and advanced applications of bioremediation by exploring microbial, plant-, and fungi-based remediation strategies, in situ and ex situ technologies, molecular tools, and emerging approaches for the treatment of environmental pollutants, including heavy metals, nuclear waste, and e-waste.

Course Outcome: After completion of this course students will be able to:		**Bloom's Level**
CO 1	Understand the principles, types, and limitations of bioremediation	K2
CO2	Compare and evaluate different bioremediation strategies	K4
CO3	Demonstrate the ability to select and design appropriate bioremediation methods	K2
CO4	Analyze microbial and enzymatic mechanisms in heavy metal detoxification, bioleaching, and microbial enhanced oil recovery	K4
CO5	Assess microbial approaches for nuclear waste, hydrocarbon, and e-waste remediation through real-world case studies and emerging contaminant challenges.	K4

CO-PO Mapping (Scale 1: Low, 2: Medium, 3: High)

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

Course Contents / Syllabus

Unit 1	**Fundamentals of Bioremediation and Environmental Pollutants**	**09 h**

Principles and types of bioremediation, Mechanisms and microbial processes in bioremediation, Role of microbes and metabolic pathways, Key factors influencing bioremediation, Limitations of bioremediation, Mycoremediation and phytoremediation techniques, Xenobiotics and persistent pollutants, Environmental impacts of dyes, detergents, PAHs, aliphatic hydrocarbons, oil spills, heavy metals, antibiotics, VOCs, and radioactive pollutants		
Unit 2	**Bioremediation Strategies and Technologies**	**09 Hrs**
Overview of bioremediation strategies, Biostimulation and bioaugmentation, In situ and ex situ technologies – bioventing, biosparging, biostripping, biosorption barriers, Biofilters and bioreactors – design and application, Soil bioreactors – dry and slurry, Aerobic and anaerobic remediation systems, Composting and land farming, Fungal bioremediation and enzymatic mechanisms, Molecular tools in bioremediation		
Unit 3	**Bioremediation Project Management and Environmental Applications**	**09 Hrs**
Steps in managing bioremediation projects, Defining goals and site characterization, Method selection and process design, Aerobic and anaerobic field applications, Vadose zone transport and natural attenuation, Remediation in surface soils, freshwater, and marine systems, Groundwater bioremediation, Water purification using reverse osmosis, membrane filtration, and desalination technologies		
Unit 4	**Microbial and Nano-based Metal Remediation Technologies**	**09 Hrs**
Microbial oxidation and detoxification of heavy metals, Bioleaching, biomining, and related microbes, Bio-oxidation of pyrite, chalcopyrite, and sphalerite, Role of enzymes, siderophores, metallothioneins, and biosurfactants, Fungal pathways for metal remediation, Coal desulfurization by microbes, Biosorption using microbial biomass, Nano-sponges and nanomaterials for metal recovery, Microbial enhanced oil recovery (MEOR)		
Unit 5	**Bioremediation of Nuclear Waste, Hydrocarbons, and Emerging Contaminants**	**09 Hrs**
Microbial strategies for nuclear waste remediation, Heavy metal and actinide removal using microbes, Types and impacts of nuclear waste, In situ disposal approaches and case studies, Bioremediation of hydrocarbon-contaminated sites, Degradation pathways for hydrocarbons, Microbial interventions in e-waste treatment, Case studies on e-waste industry remediation, Bioremediation of emerging and persistent environmental contaminants		
Total		**45 Hrs**
Textbook: 1. Environmental Biotechnology: Principles and Applications. by Bruce E. Rittmann and Perry L. McCarty 2. Microbial Biodegradation and Bioremediation: Techniques and Case Studies for Environmental Pollution by Surajit Das		
Reference Books: 1. Bioremediation Technology: Recent Advances by M.H. Fulekar		
Self-Study Content Links:		**Duration (in Hrs)**

MOOCs	https://nptel.ac.in/courses/102105088	40 Hrs
Video Lectures		
Web References	https://archive.nptel.ac.in/content/storage2/courses/113108055/Unit8/lecture39.pdf	4 Hrs

NPTEL/ Youtube / Faculty Video Link:

Unit 1	https://www.youtube.com/watch?v=C2HTgEJDpCUandpp=ygU7RnVuZGFtZW50YWxzIG9mIEJpb3JlbWVkaWF0aW9uIGFuZCBFbnZpcm9ubWVudGFsIFBvbGx1dGFudHM%3D
Unit 2	https://www.youtube.com/watch?v=aYvOstG_ynYandpp=ygUqQmlvcmVtZWRpYXRpb24gU3RyYXRlZ2llcyBhbmQgVGVjaG5vbG9naWVz
Unit 3	https://www.youtube.com/watch?v=yCkC82nurfgandpp=ygVAQmlvcmVtZWRpYXRpb24gUHJvamVjdCBNYW5hZ2VtZW50IGFuZCBFbnZpcm9ubWVudGFsIEFwcGxpY2F0aW9ucw%3D%3D
Unit 4	https://www.youtube.com/watch?v=I1GVotFa7Hsandpp=ygU3TWljcm9iaWFsIGFuZCBOYW5vLWJhc2VkIE1ldGFsIFJlbWVkaWF0aW9uIFRlY2hub2xvZ2llcw%3D%3D
Unit 5	https://www.youtube.com/watch?v=P3qSmpW3Fcwandpp=ygVIQmlvcmVtZWRpYXRpb24gb2YgTnVjbGVhciBXYXN0ZSwgSHlkcm9jYXJib25zLCBhbmQgRW1lcmdpbmcgQ29udGFtaW5hbnRz

Course Code: BBT0611	Course Name: Bioreactor Analysis and Design	L	T	P	C
Course Offered in: Biotechnology		3	0	0	3

Prerequisite: Students should have basic knowledge of Bioprocess engineering

Course Objective:

To equip students with the knowledge and skills to design, analyze, and optimize bioreactors for efficient and scalable bioprocesses

Course Outcome: After completion of the course, the student will be able to

Course Outcome: After completion of this course students will be able to:		**Bloom's Level**
CO 1	Explain the structural and functional differences among various bioreactor configurations	K2
CO2	Apply knowledge of material properties to select suitable construction materials for bioreactors.	K3
CO3	Apply aseptic techniques to maintain sterile environments in bioprocess operations	K3
CO4	Analyze instrumentation and control systems in bioreactors to assess their effectiveness in maintaining optimal process conditions	K4
CO5	Analyze bioreactor designs and associated cost estimations to optimize configurations for diverse bioprocess applications.	K4

CO-PO Mapping (Scale 1: Low, 2: Medium, 3: High)

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

Course Contents / Syllabus

Unit 1	**Bioreactor Configurations**	**10 Hrs**

Stirred Tank Reactor, Bubble Column Reactor, Airlift Reactor, Stirred and Air-Driven Reactors: Comparison of Operating Characteristics, Packed Bed Reactor, Fluidized Bed Reactor, Trickle Bed Reactor

Unit 2	Bioreactor Construction Materials	09 Hrs
Aseptic Operation, Bioreactor Inoculation and Sampling, Materials of Construction, Sparger Design, Evaporation Control, Impeller and its types, Stirrer glands and bearings, Baffles, Jackets, Power requirement for mixing, Agitation rate studies – Mixing time and Residence time distribution		
Unit 3	**Maintenance of Aseptic Conditions**	**09 Hrs**
Sterilization of the bioreactor, Sterilization of the air supply, Sterilization of the exhaust gas from a fermenter, Addition of inoculum, nutrients and other supplements, Sampling, Feed ports, Sensor Probes, Foam Control, Valves and their types		
Unit 4	**Instrumentation and Control**	**09 Hrs**
Temperature measurement and control, Flow measurement and control, Pressure measurement and control, Safety valves, Agitator shaft power, Rate of stirring, Dissolved oxygen measurement and control, pH measurement and control, Inlet and exit gas analysis		
Unit 5	**Bioreactor Design and Cost Estimation for Various Applications**	**08 Hrs**
Design considerations for plant and animal cell cultures, Waste treatment processes, Capital investments (Fixed and working capital), Types of capital cost estimates, Cost Indexes, Estimating equipment costs by scaling 6/10 Factor Rule		
Total		**45 Hrs**

Textbook:

1. Shuler M L, Kargi F, " Bioprocess Engineering- Basic Concepts" , 2nd ed, Prentice Hall of India Ltd. (2002)
2. Principles of fermentation technology/Peter F. Stanbury, Allan Whitaker, Stephen J. Hall. - 2nd ed. p. em.
3. Aiba S, Humphrey A E and Millis N F ,"Biochemical Engineering" , Academic Press (1973)

Reference Books:

1. Bailey J E and Ollis D F, "Biochemical Engineering Fundamentals" , McGraw Hill (1986)
2. Peters, M S and Timmerhaus K D,"Plant Design and Economics for Chemical Engineers", McGraw Hill, New York , 4th Edition (2003)
3. Ulrich , G D,"A Guide to Chemical Engineering Process Design and Economics", John Wiley (1984)

Self-Study Content Links:		**Duration (in Hrs)**
MOOCs	https://nptel.ac.in/courses/102106086	40 Hrs
Video Lectures		
Web References		

NPTEL/ Youtube/ Faculty Video Link:

Unit 1	https://youtu.be/nYrvAQ3IG84?si=x-xMjYo7Vs6hgChf

Unit 2	https://youtu.be/edHFCBL_Jx4?si=4fubocp3pE2Zl7gv
Unit 3	https://youtu.be/9oJnm0aS32c?si=wYmzkf7Ge889vepw
Unit 4	https://youtu.be/1nrdui8sF3c?si=PwKjrcvKzoN-GNya
Unit 5	https://youtu.be/XiWLYBvHBaA?si=7DRwd4Ke9lGx2tP3

Course Code: BBT0614N	Course Name: Machine learning	L	T	P	C
Course Offered in: Department of Biotechnology		3	0	0	3

Prerequisite: Basic knowledge of probability and linear algebra along with basic programming

Course Objective: To develop a strong foundation in Machine Learning concepts, workflow, and challenges. To apply and evaluate supervised, unsupervised, and ensemble learning techniques. To analyze and implement ML applications in biological sciences such as healthcare and genomics.

Course Outcome: After completion of the course, the student will be able to		Bloom's Level
CO1	Understand ML fundamentals, types, pipeline, and model performance concepts.	K2
CO2	Apply supervised learning methods and evaluate models using performance metrics.	K3
CO3	Use unsupervised learning techniques for clustering and pattern analysis.	K3
CO4	Apply ensemble techniques to improve model performance and accuracy	K3
CO5	Implement ML applications in biological and healthcare domains.	K3

CO-PO Mapping (Scale 1: Low, 2: Medium, 3: High)

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

Course Contents / Syllabus

Unit 1	INTRODUCTION TO MACHINE LEARNING	9 Hrs

Definition, History of ML, Introduction to Machine Learning, Types of Machine Learning, Machine Learning Pipeline, Application of Machine Learning, Challenges and Issues in Machine Learning. **Model Performance**: Underfitting and Overfitting, Bias-Variance Trade-Off.

Unit 2	SUPERVISED LEARNING AND ASSOCIATION RULE MINING	9 Hrs

Regression: Linear Regression, Logistic Regression, Evaluation of Regression: MAE, MSE, RMSE, R^2, Cost Function.Classification: Decision Trees: ID3, SVM, Evaluation of Classifiers: Confusion Matrix, F1 score, Accuracy, Recall, Precision, Precision-recall curve, ROC curve. Naïve Bayes Algorithm.

Unit 3	UNSUPERVISED LEARNING	9 Hrs

Introduction to clustering, K-Nearest Neighbor (KNN), hierarchical clustering (AGNES), partitional clustering (K-means), density-based clustering (DBSCAN), and Gaussian Mixture Models, with case study on gene expression clustering or patient stratification.		
Unit 4	**ENSEMBLE TECHNIQUES**	**9 Hrs**
Ensembles methods: Concept of ensemble learning, bagging and boosting techniques, Random Forest, and Gradient Boosting Machines, with case study on disease prediction or genomics data analysis.		
Unit 5	**APPLICATIONS**	**9 Hrs**
Applications of Machine Learning in Biological Sciences: Healthcare and clinical analytics, medical image analysis, drug discovery and development, bioinformatics and genomics, precision medicine, systems biology, agricultural biotechnology, epidemiology and public health, neuroscience, and environmental and ecological biology.		
		Total H: 45 Hrs

Textbook:		
S.No	**Book Title with publication agency & year**	**Author**
1	The Elements of Statistical Learning, Springer, 2017 (2nd Edition, corrected 12th printing, latest)	Trevor Hastie; Robert Tibshirani; Jerome H. Friedman
2	Introduction to Machine Learning using Python, Khanna Publishing House, 2019 (1st Edition, latest)	Jeeva Jose
3	Machine Learning, McGraw Hill Education, 1997 (1st Edition, latest)	Tom M. Mitchell
Reference Books:		
S.No	**Book Title with publication agency & year**	**Author**
1	Introduction to Machine Learning, MIT Press, 2020 (4th Edition, latest)	Ethem Alpaydin
2	Machine Learning, Khanna Book Publishing Co., 2019 (latest edition)	Rajiv Chopra
3	Pattern Recognition and Machine Learning, Springer, 2006 (latest edition)	Christopher M. Bishop
Self-Study Content Links:		**Duration (in Hrs)**
MOOCs	https://infyspringboard.onwingspan.com/web/en/app/toc/lex_auth_0135015603456081928794/overview	33 Hrs
Video Lectures		

Web References	Machine Learning for Engineering and science applications, IIT Madras Prof. Balaji Srinivasan Prof. Ganapathy Krishnamurthi nptel.ac.in/courses/106106198	48 Hrs

Course Code: BBT0617	Course Name: Environmental Microbiology and Metagenomics	L	T	P	C
Course Offered in: Biotechnology		3	0	0	3

Prerequisite: Basic knowledge of Plant physiology, growth development, cell biology, and Science

Course Objective:

To equip students with knowledge of microbial diversity, extremophiles, and their environmental roles, alongside molecular and metagenomic techniques to study microbial ecology, focusing on soil microbiomes, biofilms, and bioremediation for sustainable environmental management.

Course Outcome: After completion of the course, the student will be able to

CO1	Describe the diversity of microbes and their roles in maintaining environmental sustainability.	K2
CO2	Explain the characteristics of extremophiles and their applications in environmental cleanup.	K3
CO3	Apply molecular and metagenomic techniques to analyze microbial communities in environmental samples.	K3
CO4	Interpret metaproteomic data using mass spectrometry methods to study microbial ecology.	K4
CO5	Demonstrate the role of soil microbiomes and biofilms in bioremediation and pollutant removal.	K3

CO-PO Mapping (Scale 1: Low, 2: Medium, 3: High)

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

Course Contents / Syllabus

Unit 1	Microbial Diversity and Roles in Environmental Sustainability	09 Hrs
Biodiversity and microbial role in environmental balance, Role of microbes in biosphere sustainability, Culturable vs. unculturable microbes and ecological importance, Mycorrhiza – types and environmental applications, Photosynthetic microbes – anoxygenic (purple and green sulfur bacteria) and oxygenic (Cyanobacteria and Prochlorales), Methanogens – features and role in environmental processes.		
Unit 2	**Extremophiles and Archaea in Environmental Applications**	**09 Hrs**
Types of extremophiles – acidophiles, alkalophiles, psychrophiles, mesophiles, thermophiles, barophiles, osmophiles, halophiles, Role of extremophiles in environmental cleanup, Biomolecules from extremophiles for remediation, Molecular characteristics – genes, proteins, enzymes, Archaebacteria – classification, habitat, ecological roles, Environmental physiology and sustainability roles of archaea, Archaea in pollution control, Applications of magnetotactic bacteria in environmental systems.		
Unit 3	**Metagenomics and Molecular Techniques for Microbial Ecology**	**09 Hrs**
Introduction to metagenomics and its ecological importance, Types of metagenomics and workflow steps, Concept of environmental DNA (e-DNA), Studying microbial diversity using culture-based and independent methods, 16S-rDNA sequencing basics, Genetic fingerprinting techniques – T-RFLP, DGGE, RISA, LH-PCR, RAPD, Overview of DNA microarray and its environmental use, Whole-comm**Unit**y analysis – DNA-DNA reassociation, G+C content,		
Unit 4	**Metaproteomics and Mass Spectrometry in Environmental Microbiology**	**09 Hrs**
Definition and role of metaproteomics in microbial ecology, Gel-based methods – 2-DE, DIGE, BN-PAGE, Pros and cons of gel-based approaches, Gel-free methods – ICAT, iTRAQ, MudPIT, Protein microarrays and ICPL overview, COFRADIC method, Basics of mass spectrometry – MALDI and ESI, Applications in environmental protein studies, Computational tools for mass spec data analysis.		
Unit 5	**Soil Microbiome, Biofilms, and Bioremediation Strategies**	**09 Hrs**
Structure and function of the soil microbiome, Role of soil structure and physiology in microbial distribution, Microbial interactions and their influence on soil health, Soil microbiome and climate change resilience, Role of biofilms in bioremediation, Biofilm-based pollutant removal strategies, Biofilm survival in polluted conditions, Molecular tools to study biofilms, Case studies – chromium detoxification, PAH and pesticide degradation, Metagenomics in biofilm analysis, Advances in soil microbial metagenomic research		
	Total	**45 Hrs**

Textbook:

1. Joanne M Willey, Joanne Willey, "Prescott's Microbiology", McGraw-Hill Education; 9th edition, 2013.
2. Stephen P. Hunt and Frederick J. Livesey, "Functional Genomics", Oxford University Press, 2000.
3. R. M. Twyman, "Principles of Proteomics", Taylor and Francis, 2nd edition, 2008.
4. Diana Marco, Universidad Nacional de Cordoba, Argentina, "Metagenomics: Current Innovations and Future Trends", Caister Academic Press, 2011.
5. Maier, R.M., Pepper, I.L. and Gerba, "Environmental Microbiology", C.P. Academic Press, 2000.
6. Gavin Lear, "Biofilms in Bioremediation: Current Research and Emerging Technologies", Caister Academic Press, 2016.

Reference Books:

1. Joanne M Willey, Joanne Willey, “Prescott’s Microbiology”, McGraw-Hill Education; 9th edition, 2013.
2. Stephen P. Hunt and Frederick J. Livesey, “Functional Genomics”, Oxford University Press, 2000.
3. R. M. Twyman, “Principles of Proteomics”, Taylor and Francis, 2nd edition, 2008.
4. Diana Marco, Universidad Nacional de Cordoba, Argentina, “Metagenomics: Current Innovations and Future Trends”, Caister Academic Press, 2011.
5. Maier, R.M., Pepper, I.L. and Gerba, “Environmental Microbiology”, C.P. Academic Press, 2000.
6. Gavin Lear, “Biofilms in Bioremediation: Current Research and Emerging Technologies”, Caister Academic Press, 2016.

Self-Study Content Links:		**Duration (in Hrs)**
MOOCs	https://nptel.ac.in/courses/102105087	40 Hrs
Video Lectures		
Web References		

Lab Course Code: BBT0651N	Lab Course Name: Bioseparation Engineering Lab	L	T	P	C
Course Offered in: Biotechnology		0	0	4	2

Prerequisite: Students should possess a foundational understanding of microbiology and cell biology, basic chemistry lab skills, sterile technique familiarity, and awareness of laboratory safety and biosafety protocols.

Course Objective: The objective of this course is to provide students with hands-on experience in bioseparation engineering.

		Bloom's Level
CO1	Explain the principles of centrifugation, chromatography, filtration, crystallization, and membrane separation techniques used in biomolecule processing.	K2
CO2	Apply suitable bioseparation techniques for the isolation, extraction, concentration, and purification of biomolecules	K3
CO3	Perform and analyze biomolecule separation and recovery processes	K4
CO4	Analyze and interpret experimental results to determine the efficiency, purity, and recovery of biomolecules	K4

Course Outcome: After completion of the course, the student will be able to

CO-PO Mapping (Scale 1: Low, 2: Medium, 3: High)

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	2	2	2	3	3	3	2	2	3	2	2
CO2	3	2	2	2	2	2	3	3	3	2	2	3	3	2
CO3	3	3	2	3	3	2	3	3	3	2	3	3	3	2
CO4	3	3	2	3	3	2	3	3	3	2	3	3	3	2

List of Practical's (Indicative and Not Limited To)	CO
1. Isolation and separation of plant/bacterial DNA using centrifugation and biochemical methods.	CO2, CO4
2. Isolation of the plant cell organelles using centrifugation methods.	CO2
3. Separation of the proteins with suitable chromatography methods	CO3, CO4

4. Isolation of the photosynthetic pigments using centrifugation methods.	CO2
5. Separation of the biolipids using TLC	CO3
6. Separation and concentration of proteins using filtration and ultrafiltration method	CO3, CO4
7. Isolation and separation of plant/bacterial RNA using centrifugation and biochemical methods	CO2, CO4
8. Extraction of lactose from milk by crystallization	CO3, CO4
9. Determine the effect of flocculating agents on the settling of suspended particles	CO1
10. Demonstration of the working principle of Lyophilizer	CO1
11. Study the extraction of Natural Pigments from Beetroot, Spinach, and Turmeric Using Solvent Extraction Techniques.	CO2, CO4
12. Study of Adsorptive Removal of Food Dye Using Activated Charcoal	CO1, CO4
13. Demonstration of Biomolecule Separation by Dialysis Membrane Technique.	CO1
14. Determine the Crystallization of Sodium Chloride from Saturated Solution	CO1, CO4
	Total = 60 Hrs

Lab Course Code: BBT0653Z	Lab Course Name Nanobiotechnology Lab	L	T	P	C
Course Offered in: Biotechnology		**0**	**0**	**4**	**2**

Prerequisite: Basics of biochemistry and molecular biology

Course Objective:

To equip students with practical knowledge of nanoscience and nanobiotechnology through nanomaterial synthesis, fabrication, characterization, and analytical techniques relevant to biological applications.

Course Outcome: After completion of the course, the student will be able to

		Bloom's Level
CO1	Understand the basics of nanoscience, nanobiotechnology and nanotechnology	K2
CO2	Explain nanoparticle synthesis and characterization methods.	K2
CO3	Perform synthesis and biological evaluation of nanoparticles.	K3
CO4	Analyze nanoparticle properties and interactions.	K4

CO-PO Mapping (Scale 1: Low, 2: Medium, 3: High)

CO/ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PSO 1	PSO 2	PSO 3
CO1	3	3	3	2	3	2	2	2	2	3	2	3	3	3
CO2	3	2	1	2	3	1	1	1	1	1	2	3	2	2
CO3	3	3	2	3	3	2	2	2	1	1	2	3	3	2
CO4	2	3	2	3	3	1	1	1	2	1	2	2	2	3

List of Practical's (Indicative and Not Limited To)	**CO Mapping**
1. Demonstration of Nanoscience and nanobiotechnology (Size comparative analysis)	CO1
2. Synthesis of carbon nanotubes from carbon source.	CO2
3. Chemical synthesis of silver oxide nanoparticles; UV-Visible absorption of the colloidal solution and estimation of size by curve fitting.	CO3, CO4
4. Biological synthesis of silver oxide nanoparticles; UV-Visible absorption of the colloidal solution and estimation of size by curve fitting.	CO3, CO4
5. Sol gel synthesis of zinc oxide nanoparticles.	CO2, CO3

6. Synthesis of Bi-metallic nanoparticles.		CO3
7. Synthesis of carbon dots from microwave pyrolysis method.		CO3
8. Synthesis of Gold nanoparticles.		CO2
9. Synthesis of Iron oxide nanoparticles.		CO2
10. Chemical synthesis of CuO Nanoparticles: UV –Visible absorption of the colloidal solution.		CO3, CO4
11. Antibacterial activities of silver and zinc nanoparticles, against bacterial cultures performed by standard disc diffusion method		CO3, CO4
12. Nature of Interaction between nanoparticles and Bacterial Cell (*E. coli* and *B. subtilis*).		CO4
13. Nanoparticles toxicity estimation in percentage as in vitro methods		CO3, CO4
14. Demonstration of nano characterization tools and techniques.		CO2, CO4
		Total H: 60 Hrs
Self-Study Content Links:		**Duration (in Hrs)**
MOOCs		
Video Lectures		
Web References		

Lab Course Code: BBT0618P	Lab Course Name: Metabolic Engineering Lab	L	T	P	C
Course Offered in: Biotechnology		0	0	2	1

Prerequisite: Basics of biochemistry

Course Objective:

To develop a strong foundation in metabolic engineering by enabling students to apply gene editing, metabolic pathway optimization, flux analysis, and bioprospecting techniques for the efficient and cost-effective production of industrially important biomolecules, including antibiotics, biofuels, and other value-added products.

Course Outcome: After completion of the course, the student will be able to

		Bloom's Level
CO1	Illustrate metabolic engineering for cost-effective production of antibiotics and biofuels.	K2
CO2	Demonstrate strain engineering techniques to enhance microbial production of target compounds.	K3
CO3	Analyze metabolic flux models for correlating experimental data with predicted pathways.	K4

CO-PO Mapping (Scale 1: Low, 2: Medium, 3: High)

CO/PO	PO1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO1 1	PSO1	PSO2	PSO3
CO1	3	2	-	1	2	-	1	2	2	2	3	1	-	2
CO2	3	2	2	2	3	-	-	2	1	2	2	1	2	3
CO3	3	3	2	3	3	1	1	1	2	1	3	2	1	3

List of Practical's (Indicative and Not Limited To)	CO Mapping
1. Develop engineering strategies to boost production of industrially relevant compound in E. coli.	CO2
2. Strain engineering (deletion or overexpression of genes) to boost production of target compound followed by metabolite extraction and quantification.	CO2
3. Demonstration of feed-back regulation and product inhibition.	CO1
4. Development of a flux model and correlation of the model with experimental data.	CO1

5.	Demonstration of effect of addition of supplement to enhance enzyme activity in fungal strain.	CO3
6.	Demonstration of metabolic engineering approach for low cost antibiotics	CO1
7.	Demonstration of metabolic engineering approach for low cost biofuel production	CO1
8.	To build stoichiometric matrix for glycolytic reactions	CO3
9.	Redirecting the metabolic pathway in *E.coli* towards increased succinic acid production as well as reducing formation of other metabolites.	CO2
10.	Bioprospecting of microbial strain to enhance bioethanol production	CO1
		Total H: 30 Hrs

Lab Course Code: BBT0616P	Lab Course Name: Deep Learning for Biotechnology Lab	L	T	P	C
		0	0	2	1

Applicable in Department: of Biotechnology

Course Objective: To equip students with the knowledge of deep learning models and their applications in biological data analysis, healthcare, genomics, and intelligent diagnostic systems.

Course Outcome: After completion of this course students will be able to:		**Bloom's Level**
CO1	Understand and implement fundamental neural network models, activation functions, and optimization techniques using Python and TensorFlow/Keras.	K3
CO2	Develop and evaluate ANN and DNN models for healthcare and biological data analysis applications.	K4
CO3	Apply CNN, RNN, LSTM and transfer learning techniques for biomedical and healthcare image classification tasks.	K4

CO-PO Mapping:

CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	1	2	3	1	1	1	1	1	1	3	3	3
CO2	3	3	2	3	3	1	1	1	1	2	1	2	2	3
CO3	2	3	2	3	3	1	1	1	1	2	1	3	2	3

List of Practical's (Indicative and Not Limited To)		**CO Mapping**
1.	Create a simple perceptron model for binary classification using Python and TensorFlow/Keras.	CO1
2.	Implement and compare Sigmoid, ReLU, and Tanh activation functions using sample biological data.	CO1
3.	Train a simple ANN model for disease risk prediction using a healthcare dataset.	CO1, CO2
4.	Train a Deep Neural Network (DNN) using different learning rates and compare accuracy and loss.	CO1, CO2

5.	Apply Dropout and Batch Normalization in a ANN model and compare performance.	CO1, CO2
6.	To study the effect of different activation and loss functions in neural networks.	CO1
7.	Build a CNN model for classification of biomedical or cell images.	CO3
8..	Use a pre-trained CNN model (VGG16/ResNet) for skin cancer or histopathology image classification.	CO3
9.	Implement a simple RNN/LSTM model for DNA sequence classification.	CO3
10.	Develop an LSTM model for predicting biological signals or patient health trends over time.	CO3
		Total H: 60 Hrs

Lab Course Code: BBT0615P	Lab Course Name: Bioremediation Technology Lab	L	T	P	C
Course Offered in: Biotechnology		0	0	2	1

Prerequisite: Basics of microbiology

Course Objective:

To provide students with practical experience in applying microbial technologies for environmental bioremediation.

Course Outcome: After completion of the course, the student will be able to

		Bloom's Level
CO1	Understand the role of microorganisms in environmental pollutant removal.	K2
CO2	Demonstrate skills in isolating and characterizing environmental microbes.	K3
CO3	Apply bioremediation techniques for waste, dye, and heavy metal treatment.	K3

CO-PO Mapping (Scale 1: Low, 2: Medium, 3: High)

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

List of Practical's (Indicative and Not Limited To)	CO Mapping
1. Biodegradation of oil using Soil bacteria to observe microbial activity in degrading oil from soil.	CO1, CO2, CO3
2. Heavy metal biosorption using fungal biomass to evaluate the potential of fungal biomass for the biosorption of heavy metals from contaminated water.	CO1, CO3
3. Biofilm formation Assay to assess the ability of microorganisms to form biofilms on surfaces under laboratory conditions.	CO1, CO2
4. Composting of organic waste using microbial inoculants to study the effectiveness of microbial inoculants in enhancing the composting process of organic waste.	CO1, CO3
5. Dye degradation using microbial consortia to evaluate the efficiency of microbial consortia in degrading synthetic dyes from contaminated solutions.	CO1, CO2, CO3

6. Phytoremediation using mustard or spinach plants to demonstrate metal absorption by plants.	CO1, CO3
7. Bioremediation of detergents in wastewater to assess the potential of microorganisms in degrading detergents present in wastewater through bioremediation.	CO1, CO3
8. Biosorption using orange peel or sawdust to observe biosorption of heavy metals.	CO3
9. Bioreactor setup for bioremediation of dyes to design and operate a bioreactor system for evaluating the microbial bioremediation of synthetic dyes from wastewater.	CO1, CO2, CO3
10. Metal recovery from simulated E-Waste using microbial methods to investigate the efficiency of microbial processes in recovering heavy metals from simulated e-waste materials.	CO1, CO3
	Total H: 30 Hrs

Course Code: BBT0655	Course Name: MATLAB for Biotechnology	L	T	P	C
		0	0	6	3

Course Offered in: Biotechnology

Prerequisite: Introduction to Programming (any language), Fundamentals of Bioinformatics, Molecular Biology or Biochemistry, Linear Algebra and Basic Statistics

Course Objective:

To develop proficiency in using MATLAB for bioinformatics applications by enabling students to analyze and visualize biological data, perform sequence and structural analyses, interpret gene expression data, and apply computational techniques to solve biological research problems.

Course Outcome: After completion of the course, the student will be able to

		Bloom's Level
CO1	Demonstrate proficiency in using MATLAB for basic programming, matrix operations, and data visualization relevant to bioinformatics applications.	K2
CO2	Apply MATLAB tools for sequence alignment, analysis, and interpretation using the Bioinformatics Toolbox.	K3
CO3	Analyze microarray data and perform gene expression studies using relevant MATLAB commands and toolboxes.	K4
CO4	Construct and interpret phylogenetic trees based on sequence similarity and distance matrices using MATLAB functions.	K5
CO5	Perform structural bioinformatics tasks using MATLAB.	K6

CO-PO Mapping (Scale 1: Low, 2: Medium, 3: High)

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

CO5	3	3	2	3	3	-	-	2	1	2	3	2	-	3

Course Contents / Syllabus	
Unit 1 General Introduction	16 Hrs
Exercise 1: Getting started with MATLAB:- Fundamental of MATLAB, Scope of MATLAB, Importance to Engineers, MATLAB Environment, Workspace, Editor window and Command window, Variables Creation, Operations with variables, Assessing MATLAB help. Exercise 2: Basic control statements: if, else, switch, for loop, while loop, continue, break statements. Functions. Exercise 3: Matrices and arrays in MATLAB, decision making statements Exercise 4: Graphics in matlab, plotting, exporting, basics plotting functions Exercise 5: Solutions for AX=B, different types of solvers. Using symbolic math toolbox	
Unit 2 Sequence analysis	16 Hrs
Exercise 6: Bioinformatics toolbox: data formats, sequence analysis- basics. Exercise 7: Basic commands: nwalign, swalign, molviewer. Exercise 8: Microarrays: Fundamentals and examples. Exercise 9 Microarray toolbox basic commands: gprread, maimage, colormap, maskeddata.	
Unit 3 Gene Ontology usage	16 Hrs
Exercise 10: Gene Ontology: fundamentals Exercise 11: Basic commands in GO: classperf, crossvalind, knnclassify Exercise 12: Sequence analysis: Fundamentals Exercise 13: Basic Commands: seqconsensus, seqlogo, seqprofile, pdbplot Exercise 14: Learn to read FASTA files and align biological sequences	
Unit 4 Phylogenetic analysis	16 Hrs
Exercise 15: Compute Pairwise Distance Matrix. Exercise 16: Construct a Phylogenetic Tree Exercise 17: Basic concept of a scoring matrix, Similarity and distance matrix Exercise 18: Annotate and Customize Phylogenetic Tree	
Unit 5 Applications of MATLAB in Structural Bioinformatics	16 Hrs
Exercise 19: Load and Visualize a Protein Structure Exercise 20: Analyze Protein Secondary Structure Exercise 21: Calculate Bond Lengths and Angles	

Exercise 22: Compute and Visualize the Ramachandran Plot Exercise 23: Estimate the molecular surface and volume of a protein.	
Total	80 Hrs
Textbook: 1. Bioinformatics: Sequence and Genome Analysis by David W. Mount, 2ND EDITION 2. Bioinformatics: A Practical Guide to the Analysis of Genes and Protein.	
Reference Books: Bioinformatics for Dummies by Jean-Michel Claverie and Cedric Notredame, 2ND EDITION	
NPTEL/ Youtube/ Faculty Video Link:	
Unit 1	https://www.youtube.com/watch?v=zvyv_snBih8andpp=ygUmR2VuZXJhbCBJbnRyb2R1Y3Rpb24gb2YgYmlvaW5mb3JtYXRpY3M%3D
Unit 2	https://www.youtube.com/watch?v=rDhElW5ox6wandpp=ygUkRGF0YWJhc2UgU2VhcmNoaW5nIG9mIGJpb2luZm9ybWF0aWNz
Unit 3	https://www.youtube.com/watch?v=AgIMm4B_Ticandpp=ygUeU2NvcmluZyBNYXRyaWNzIEJpb2luZm9ybWF0aWNz
Unit 4	https://www.youtube.com/watch?v=Wj0OV2jf1VQandpp=ygUkUGh5bG9nZW5ldGljIGFuYWx5c2lzIEJpb2luZm9ybWF0aWNz0gcJCYsJAYcqIYzv
Unit 5	https://www.youtube.com/watch?v=z2XvrbRw7y8andpp=ygUeQXBwbGljYXRpb25zIG9mIEJpb2luZm9ybWF0aWNz

Lab Course Code: BBT0659X	Lab Course Name: Applied Research-based Mini Project	L	T	P	C
Course Offered in: All Engineering Programs		0	0	2	1

Prerequisite: Basic knowledge of programming, data structures, databases, and fundamental concepts of software development. Familiarity with tools and technologies for system development is desirable.

Course Objective:

This course aims to develop the ability to design and implement solutions for real-world problems using appropriate tools and technologies. It emphasizes system integration, performance evaluation, and effective documentation, along with promoting research skills through the preparation of a structured research paper.

Course Outcome: After completion of the course, the student will be able to

CO1: Identify and define a domain-specific real-world problem through literature review, objective formulation, and structured project planning suitable for research-based implementation.

CO2: Design, develop, and validate a functional prototype/model/system using appropriate tools, technologies, or methodologies while considering performance, ethics, safety, and reliability.

CO3: Document, analyze, and present project outcomes through a technical report and a structured research paper in IEEE/Scopus/UGC-approved format, demonstrating research communication and publication readiness.

CO-PO Mapping (Scale 1: Low, 2: Medium, 3: High)

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	3	2	2	2	-	-	1	2	2	1
CO2	3	3	3	3	3	1	1	2	3	2	2
CO3	2	2	2	2	2	-	-	2	3	3	2

Unit	Common Applied Research-Based Mini Project Activities (All Branches)	Expected Outcomes
Unit 1: Research Foundation & Project Planning	1. Identify domain-specific problem statement relevant to the branch. 2. Define objectives, hypothesis, and expected outcomes 3. Conduct literature review 4. Select suitable tools, technologies, software, datasets, laboratory methods, or platforms. 5. Design project methodology, workflow, or system/process architecture	Clear research problem formulation, defined objectives, foundational knowledge, and structured project roadmap
Unit 2: Development,	6. Develop core project components, models, experiments, prototypes, or processes.	Functional prototype/model/system/process

Design & Implementation	7. Integrate relevant modules such as software, hardware, simulation, experimentation, analysis, or field implementation. 8. Apply discipline-specific techniques such as coding, fabrication, experimentation, surveys, analytics, optimization, or modelling. 9. Incorporate safety, ethics, reliability, sustainability, and security considerations where applicable	with interdisciplinary implementation and practical technical skills
Unit 3: Testing, Validation & Optimization	10. Perform testing, experimentation, or validation of developed work. 11. Analyze performance, efficiency, feasibility, or effectiveness. 12. Apply analytical, computational, statistical, or intelligent techniques where relevant. 13. Optimize design, methodology, process, or implementation for improved outcomes	Validated and optimized project demonstrating performance improvement, technical analysis, and practical feasibility
Unit 4: Documentation, Research Publication & Presentation	14. Document project design, methodology, implementation, and results. 15. Prepare technical report/project dissertation. 16. Draft a research paper in standard format (Abstract, Introduction, Methodology, Results, Conclusion, References) 17. Format manuscript according to IEEE/Scopus/UGC-approved guidelines. 18. Include proper figures, tables, graphs, citations, and references 19. Present project findings through seminar/poster/presentation. 20. Demonstrate developed system/model/prototype/process. 21. Submit final project report and research paper for evaluation/publication consideration	Complete technical documentation, publishable-quality research paper, professional presentation skills, and final project submission