BIOSTATISTICS AND BIOMODELLING			
Course Code	**1BMAT301**	Scheme	**2025**
Type of Course	**ASC**	Semester	**III**
Teaching Hours/Week (L:T:P)	**3:2:0**	CIE Marks	**50**
Total Hours of Pedagogy per semester L /T/P/SL&TW:	**42:28:0:50**	SEE Marks	**50**
Credits	**4**	Total Marks	**100**
Examination type (SEE)	**Theory**	Exam Hours	**3**

Course outcome (Course Skill Set)

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

CO1: Apply descriptive and inferential statistical methods to biological data.
CO2: Perform multivariate analysis and data visualization.
CO3: Construct mathematical models of biological systems.
CO4: Simulate biological processes using computational tools.
CO5: Analyse and interpret bio models for predictive biological applications.

Module-1

FUNDAMENTALS OF BIOSTATISTICS: Introduction, Scope and applications of biostatistics, Types of biological data, Measurement scales, Data collection methods, Sampling techniques. Frequency distributions. Measures of central tendency; Mean, Median, Mode, Measures of dispersion: Range, Variance, Standard deviation, Coefficient of variation. Data Visualization: Histograms, Box plots, Scatter plots, Heat Maps, Error bars. Biological Applications**:** Clinical data analysis, Ecological datasets, Omics data characterization

Number of Hours: 8

Module-2

STATISTICAL INFERENCE AND EXPERIMENTAL DESIGN: Probability and Distributions: Probability concepts, Binomial distribution, Poisson distribution, Normal distribution, Bayesian Probability. Hypothesis Testing: Null and alternative hypotheses, Type I and Type II errors, p-values and confidence intervals, Statistical Tests: Z-test, t-test, Chi-square test, F-test. Design of Experiments: Principles of experimental design, Replication, Randomization, Blocking, Analysis of Variance: One-way ANOVA, Two-way ANOVA, Post hoc tests, Biological Applications: Drug efficacy studies, Nutritional experiments, Agricultural biotechnology studies.

Number of Hours: 8

Module-3

REGRESSION AND MULTIVARIATE BIOSTATISTICS: Correlation Analysis: Pearson correlation, Spearman rank correlation, Partial correlation. Regression Analysis: Simple linear regression, Multiple regression, Logistic regression. Multivariate Analysis: Principal Component Analysis (PCA), Cluster analysis, Discriminant analysis, Factor analysis. Biological Applications: Gene expression studies, Environmental monitoring, Disease biomarker identification, multi-omics integration

Number of Hours: 8

Module-4

INTRODUCTION TO BIOMODELLING: Fundamentals of Mathematical Biology: Definition and significance, Deterministic and stochastic models, Static and dynamic systems, Mathematical Concepts, Differential equations, Difference equations, Matrix algebra, Population Models: Exponential growth model, Logistic growth model. Biological Applications: Disease outbreak prediction, Population ecology, Microbial growth

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kinetics.

Number of Hours: 8

Module-5

COMPUTATIONAL BIOMODELLING AND SYSTEMS BIOLOGY: Systems Biology Concepts: Biological networks, Network topology, Dynamic systems, Biomolecular Modelling, Enzyme kinetics models, Michaelis-Menten kinetics, Gene regulatory networks, Signal transduction pathways. Computational Simulation: Parameter estimation, Sensitivity analysis, Model validation, Optimization techniques. Introduction to AI in Biomodelling: Machine learning concepts, Predictive modelling, Data-driven biological modelling, Digital twins in biology and healthcare

Number of Hours: 8

Suggested Learning Resources: (Text Book/ Reference Book/ Manuals):

Text books:

1. Rosner B. *Fundamentals of Biostatistics*. 8th ed. Boston (MA): Cengage Learning; 2016. ISBN: 9781305268920.
2. Montgomery DC. *Design and Analysis of Experiments*. 10th ed. Hoboken (NJ): John Wiley & Sons; 2019. doi:10.1002/9781119722106.
3. Otto SP, Day T. *A Biologist's Guide to Mathematical Modelling in Ecology and Evolution*. Princeton (NJ): Princeton University Press; 2007. ISBN: 9780691123448.

Reference books / Manuals:

1. Edelstein-Keshet L. *Mathematical Models in Biology*. Philadelphia (PA): Society for Industrial and Applied Mathematics (SIAM); 2005. doi:10.1137/1.9780898719147.
2. Alon U. *An Introduction to Systems Biology: Design Principles of Biological Circuits*. 2nd ed. Boca Raton (FL): Chapman and Hall/CRC; 2019. ISBN: 9781439837177.
3. Hair JF Jr, Black WC, Babin BJ, Anderson RE. *Multivariate Data Analysis*. 8th ed. Andover (UK): Cengage Learning; 2019. ISBN: 9781473756540.

Web links and Video Lectures (e-Resources):

- https://onlinecourses.nptel.ac.in/noc21_bt32/preview
- https://onlinecourses-archive.nptel.ac.in/noc18_ma18/preview
- https://ocw.mit.edu/
- https://www.khanacademy.org/math/statistics-probability
- https://www.youtube.com/@mitocw
- https://www.edx.org/learn/biostatistics

Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

1. Outcome-Based and Active Learning
2. Case Studies and Real-World Biological Data Analysis
3. Hands-on Training Using Statistical and Modelling Software
4. Project-Based and Collaborative Learning
5. Continuous Formative Assessment with Feedback

6. Blended Learning and Digital Resources

Assessment Structure:

The assessment in each course is divided equally between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each carrying 50% weightage.

- To qualify and become eligible to appear for SEE, in the **CIE**, a student must score at least **40% of 50 marks**, i.e., **20 marks**.
- To pass the **SEE**, a student must score at least **35% of 50 marks**, i.e., **18 marks**.
- Notwithstanding the above, a student is considered to have **passed the course,** provided the combined total of **CIE and SEE** is at least **40 out of 100 marks**.

Continuous Comprehensive Assessments (CCA) + Internal Assessment Test (IA) = Continuous Internal Evaluation CIE [25+25=50 marks]

A minimum of **two Internal Assessment Tests (IA)** shall be conducted, carrying a total of **25 marks**.

In addition, **Continuous Comprehensive Assessment (CCA)** shall be conducted for a total of **25 marks**.

It is recommended to include **a maximum of two learning activities** as part of the CCA to foster the **holistic development of students**. These activities shall be:

Sl. No.	Name of the Learning activity	Maximum Marks
1.	Assignment	10
2.	Quiz/Seminar/Case Study/Project based learning	15

Rubrics for Learning Activity (Based on the nature of learning activity, design the rubrics for each activity):

Assignment (10 Marks)

Performance Indicator (CO/PO Mapping)	Superior (5)	Good (4)	Fair (3)	Needs Improvement (2)	Unacceptable (1)
PI-1: Conceptual Understanding (CO1, CO2 / PO1)	Excellent understanding with accurate explanations	Good understanding with minor errors	Satisfactory understanding	Limited understanding	Poor understanding
PI-2: Problem Solving & Presentation (CO3, CO4, CO5 / PO2, PO10)	Accurate calculations, logical presentation and timely submission	Minor errors	Satisfactory work	Incomplete or poorly presented	Not submitted

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Quiz / Seminar / Case Study / Project-Based Learning (15 Marks)

Performance Indicator (CO/PO Mapping)	Superior (5)	Good (4)	Fair (3)	Needs Improvement (2)	Unacceptable (1)
PI-1: Technical Knowledge (CO1–CO5 / PO1)	Excellent conceptual knowledge	Good knowledge	Satisfactory knowledge	Limited knowledge	Poor knowledge
PI-2: Analytical & Problem-Solving Skills (CO3, CO4 / PO2, PO4)	Excellent analysis and application	Good analysis	Basic analysis	Limited analysis	Unable to analyze
PI-3: Communication & Teamwork (CO5 / PO9, PO10)	Excellent communication and teamwork	Good communication	Satisfactory communication	Poor communication	No participation

Suggested Learning Activities may include (but are not limited to):

- Course Project
- Case Study Presentation
- Programming Assignment
- Tool/Software Exploration
- Literature Review
- Open Book Test (preferably at RBL4 and RBL5 levels)
- GATE-based Aptitude Test
- Assignment (at RBL3, RBL4, or RBL5 levels)
- Any other relevant and innovative academic activity
- Use of MOOCs and Online Platforms

Suggested Innovative Delivery Methods may include (but are not limited to):

- Flipped Classroom
- Problem-Based Learning (PBL)
- Case-Based Teaching
- Simulation and Virtual Labs
- Partial Delivery of course by Industry expert/ industrial visits
- ICT-Enabled Teaching
- Role Play

Team Work (TW) and Self Learning (SL) components in Number of Hours per semester

Team work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)

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Sl. No.	Team Work (TW) Activity	Number of Hours / Semester
1.	Assignments, Seminars, Micro projects, Industrial visits, any other student activities.	25
SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.		
Sl. No.	**Self-Learning (SL) Activity**	**Number of Hours / Semester**
1.	NPTEL, MIT, MOOCs, spoken tutorials, online educational resources.	25

Continuous Internal Evaluation (CIE)

1. The CIE marks shall be decided based on internal tests and other outcome-based activities. The continuous internal evaluation shall be carried out by the teacher handling the course.
2. Out of 50 marks earmarked for CIE, 25 marks shall be assigned for internal tests. The first test shall be conducted after completing two modules of the syllabus and the second one after completing the remaining three modules.
3. The remaining 25 marks shall be assigned for Continuous Course Assessment (CCA), conducted as per the rubrics listed in the assessment section of the respective syllabus.
4. A student shall obtain a minimum of 40% marks or 20 out of 50 marks allotted to CIE to become eligible to appear for the SEE.

Passing requirement in SEE

1. For a pass in the Semester End Examination (SEE), a student shall secure a minimum of 35 marks out of 100.
2. For the declaration of a pass grade, the sum of the Continuous Internal Evaluation (CIE) marks (out of 50) marks and the SEE marks scaled down to 50 shall be greater than or equal to 40 marks.
3. If the total (CIE + SEE) is less than 40 marks, the student shall be awarded the grade 'F' (Fail).

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UNIT OPERATIONS + LAB			
Course Code	**1BBT302**	Scheme	**2025**
Type of course	**IPCC**	Semester	**III**
Teaching Hours/Week (L:T:P)	**3:0:2**	CIE Marks	**50**
Total Hours of Pedagogy L:T:P:SL:TW	**42:0:28:50**	SEE Marks	**50**
Credits	**4**	Total Marks	**100**
Type of Examination (IPCC):	**Theory- CIE+SEE and Lab-CIE only.**	Exam Hours	**3**

Course outcome (Course Skill Set)

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

CO1: Understand the principles of fluid statics, fluid flow and momentum transfer to solve biotechnology process problems.

CO2: Learn the flow measurement systems, pumps and particulate processing operations used in bioprocess industries.

CO3: Discuss the conductive, convective and industrial heat-transfer systems and heat exchangers.

CO4: Apply diffusion and mass-transfer principles to biological and chemical separation processes.

CO5: Assess the distillation, extraction and drying operations relevant to biotechnology industries.

Module-1

BIOPROCESS HYDRODYNAMICS: Fluid properties; rheological behaviour of fluids; Newton's law of viscosity; Newtonian and non-Newtonian fluids. Pascal's law, hydrostatic equilibrium, variation of pressure with height, barometric equation, pressure measurements. Euler's equation and Bernoulli's equation; Laminar and turbulent flow, Reynolds experiment, Reynolds number and flow regime characterization. Flow through stagnant fluids, Laminar flow through circular, Hagen Poiseuille equation settling and sedimentation principles; industrial sedimentation equipment including cyclones and thickeners. Conceptual numericals.

Number of Hours: 8

Module-2

PROCESS MEASUREMENT: Principles and operation of flow measuring devices including Orifice meter, Venturimeter and Rotameter; flow rate measurement and related derivations. Fluid Transportation: Centrifugal and reciprocating pumps; pump characteristics, performance evaluation and energy requirements. Particulate Technology: Size reduction principles, crushing laws, sieve analysis, characterization of particulate solids, average particle size, differential and cumulative particle size analysis, working principle of ball mill. Solid-Liquid Separation: Principles of filtration, types of filtration processes, filtration equipment including plate-and-frame filter press and rotary drum filter. Conceptual Numericals.

Number of Hours: 8

Module-3

THERMAL PROCESSING: Modes of heat transfer—conduction, convection and radiation. Conduction: Steady-state heat conduction through single-layer and multi-layer walls, cylindrical systems, insulation and critical thickness of insulation. Convection and Condensation: Natural and forced convection, heat transfer coefficients, log mean temperature difference (LMTD), individual and overall heat transfer coefficients, fouling factor, film-wise and drop-wise condensation (no derivation). Heat Transfer Equipment: Construction, working principles and applications of double-pipe and shell-and-tube heat exchangers. Conceptual Numericals.

Number of Hours: 8

Module-4

MOLECULAR TRANSPORT: Diffusion: Fick's law of diffusion, types of diffusion, steady-state molecular diffusion in fluids at rest and laminar flow systems (stagnant, unidirectional and bidirectional diffusion).Mass Transfer Coefficients: Measurement of diffusivity, mass transfer coefficients and their correlations. Applications: Mass transfer operations in bioprocess industries. Conceptual Numericals.

Number of Hours: 8

Module-5

BIOPRODUCT RECOVERY: Liquid-Liquid Extraction: Equilibrium principles and stage-wise extraction systems including belt and basket extractors. Distillation: Methods of distillation and separation of binary mixtures using the McCabe-Thiele method. Drying: Principle of Batch and continuous drying operations, Rotary and spray driers

Number of Hours: 8

PRACTICAL COMPONENTS OF IPCC

FIXED SET OF EXPERIMENTS

1. Batch Sedimentation
2. Flow through packed bed
3. Flow measurements using Venturi /Orifice meter
4. Ball Mill and Sieve Analysis
5. Natural convection in bare tubes
6. Heat transfer in packed bed / DPHE
7. Mass transfer coefficient in Humidification and Dehumidification
8. Diffusion of organic solvent (CCl_4) in air
9. Effect of temperature on the diffusion co-efficient
10. Liquid-Liquid Extraction
11. Distillation of binary mixtures
12. Tray drying characteristics

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Suggested Learning Resources: (Text Book/ Reference Book/ Manuals):

Text books:

1. Unit operations in Chemical Engineering, Warren L. McCabe, Julian, C. Smith & Peter Harriot, McGraw-Hill Education (India) Edition, 2014
2. Principles of Unit Operations Alan S Foust, L.A. Wenzel, C. W. Clump, L. Maus, and L. B. Anderson John Wiley & Sons, 2nd edition, 2008.
3. Unit Operations of Chemical Engineering, Vol I&II Chattopadhyaya Khanna Publishers, Delhi-6 1996.

Reference books / Manuals:

1. Fluid Mechanics, K L Kumar S Chand & Company Ltd, 2008.
2. Introduction to Chemical Engineering, Badger W.I. and Banchero, J.T., Tata McGraw Hill New York. 1997.
3. Heat Transfer J P Holman Mc Graw Hill International Ed., 10th Edition, 2010.

Web links and Video Lectures (e-Resources):

- https://nptel.ac.in/courses/103103155
- https://nptel.ac.in/courses/103107127
- https://www.youtube.com/watch?v=ntjyr9kXuCs
- https://onlinecourses.nptel.ac.in/noc20_ch27/preview
- https://www.classcentral.com/course/swayam-mechanical-unit-operations-14193
- https://www.isa-lille.com/academics/master-programs/food-science/course-unit-operations/N

Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

1. Concept-Based Interactive Teaching
2. Simulation and Process Modelling
3. Laboratory Experiments and Hands-on Demonstrations
4. Industry-Oriented Case Studies and Plant Exposure
5. Project-Based and Collaborative Learning
6. Continuous Assessment with Constructive Feedback

Assessment Structure:

The assessment for each course is equally divided between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each component carrying **50% weightage** (i.e., 50 marks each).

The CIE Theory component will be **25 marks** and CIE Practical component will be **25 marks**.

The CIE Theory component consists of IA tests for 25 marks. The CIE Practical component for continuous assessments will be for 15 marks through rubrics and for lab tests will be for 10 marks.

- To qualify and become eligible to appear for SEE, in the **CIE theory component**, a student must score at least **40% of 25 marks**, i.e., **10 marks**.
- To qualify and become eligible to appear for SEE, in the **CIE Practical component**, a student

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must secure **a minimum of 40% of 25 marks**, i.e., **10 marks**.

- To pass the **SEE**, a student must secure **a minimum of 35% of 50 marks**, i.e., **18 marks**.
- A student is deemed to have **successfully completed the course** if the **combined total of CIE and SEE is at least 40 out of 100 marks**.

CIE Practical component:

The CIE marks awarded in the case of the Practical component shall be based on the continuous evaluation of the laboratory report using a defined set of rubrics. Each experiment report can be evaluated for 30 marks. The summation of all the experiments marks to be scaled down to 15 marks.

The laboratory test (duration 03 hours) at the end of the last week of the semester /after completion of all the experiments (whichever is early) shall be conducted for 50 marks and scaled down to 10 marks. For laboratory test, the student is required to conduct one experiment.

Rubrics for Learning Activity (Based on the nature of learning activity, design the rubrics for each activity):

Performance Indicator	Superior (5)	Good (4)	Fair (3)	Needs Improvement (2)	Unacceptable (1)
PI-1: Conceptual Understanding (CO1/PO1)	Excellent understanding	Good understanding	Satisfactory	Limited	Poor
PI-2: Experimental Planning (CO2/PO2)	Independent planning	Minor guidance	Moderate guidance	Extensive guidance	Unable
PI-3: Laboratory Skills (CO3/PO5)	Accurate execution	Minor errors	With guidance	Frequent errors	Unable
PI-4: Data Analysis (CO4/PO4)	Accurate analysis	Minor errors	Basic analysis	Limited	None
PI-5: Teamwork (CO5/PO9)	Excellent	Good	Average	Limited	Poor

Rubrics for CIE – Continuous assessment:

Performance Indicator	Superior (5)	Good (4)	Fair (3)	Needs Improvement (2)	Unacceptable (1)
PI-1: Theory Tests (CO1/PO1)	90–100%	75–89%	60–74%	40–59%	<40%
PI-2: Assignments & Record (CO2/PO10)	Complete & timely	Minor errors	Satisfactory	Incomplete	Not submitted
PI-3: Laboratory Performance (CO3/PO5)	Independent	Minor guidance	Moderate guidance	Significant guidance	Unable
PI-4: Viva Voce (CO4/PO1)	Excellent	Good	Basic	Limited	Unable
PI-5: Participation (CO5/PO9)	Excellent	Good	Average	Poor	None

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Rubrics for SEE / CIE Test:

Performance Indicator	Superior (5)	Good (4)	Fair (3)	Needs Improvement (2)	Unacceptable (1)
PI-1: Conceptual Knowledge (CO1/PO1)	Excellent	Good	Adequate	Limited	Poor
PI-2: Problem Solving (CO2/PO2)	Accurate	Minor errors	Basic	Frequent errors	Unable
PI-3: Analytical Ability (CO3/PO4)	Excellent	Good	Basic	Limited	None
PI-4: Application (CO4/PO2)	Excellent	Good	Basic	Limited	Unable
PI-5: Communication (CO5/PO10)	Excellent	Good	Satisfactory	Poor	Incomplete

Suggested rubrics for Practical continuous assessment:

Performance Indicators	**Excellent**	**Very Good**	**Good**	**Satisfactory**
Fundamental Knowledge (4) (PO1)	The student has well depth knowledge of the topics related to the course (4)	Student has good knowledge of some of the topics related to course (3)	Student is capable of narrating the answer but not capable to show in depth knowledge (2)	Student has not understood the concepts clearly (1)
Design Of Experiment (5) (PO2 & PO3)	Student is capable of discussing more than one design for his/her problem statement and capable of proving the best suitable design with proper reason (5)	Student is capable of discussing few designs for his/her problem statement but not capable of selecting best (4)	Student is capable of discussing single design with its merits and de-merits (3)	Student is capable of explaining the design (1-2)
Implementation (8) (PO3 & PO8)	Student is capable of implementing the design with best suitable algorithm considering optimal solution. (7-8)	Student is capable of implementing the design with best suitable algorithm and should be capable of explaining it (5-6)	Student is capable of implementing the design with proper explanation. (3-4)	Student is capable of implementing the design. (1-2)
Result &Analysis (5) (PO4)	Student is able to run the program on various cases and compare the result with proper analysis. (5)	Student will be able to run the program for all the cases. (4)	Student will be able to run the code for few cases and analyze the output (3)	Student will be able to run the program but not able to analyze the output (1-2)

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Demonstration (8) (PO9)	The lab record is well-organized, with clear sections (e.g., Introduction, Method, Results, Conclusion). Transitions between sections are smooth. (7-8)	The lab record is organized, with clear sections, but some sections are not well-defined. (5-6)	The lab record lacks clear organization or structure. Some sections are unclear or incomplete. (3-4)	The lab record is poorly organized, with missing or unclear sections. (1-2)

Note: Can add Engineering & IT tool usage based on the nature of the course

Suggested Learning Activities may include (but are not limited to):

- Course Project
- Case Study Presentation
- Programming Assignment
- Tool/Software Exploration
- Literature Review
- Open Book Test (preferably at RBL4 and RBL5 levels)
- GATE-based Aptitude Test
- Assignment (at RBL3, RBL4, or RBL5 levels)
- Any other relevant and innovative academic activity
- Use of MOOCs and Online Platforms

Suggested Innovative Delivery Methods may include (but are not limited to):

- Flipped Classroom
- Problem-Based Learning (PBL)
- Case-Based Teaching
- Simulation and Virtual Labs
- Partial Delivery of course by Industry expert/ industrial visits
- ICT-Enabled Teaching
- Role Play

Team Work (TW) and Self Learning (SL) components in Number of Hours per semester		
Team work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)		
Sl. No.	**Team Work (TW) Activity**	**Number of Hours / Semester**
1.	Assignments, Seminars, Micro projects, Industrial visits, any other student activities.	25
SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.		
Sl. No.	**Self-Learning (SL) Activity**	**Number of Hours / Semester**
1.	NPTEL, MIT, MOOCs, spoken tutorials, online educational resources.	25

Continuous Internal Evaluation (CIE)
(i)Theory component

The CIE marks of 25 shall be earmarked for two tests.
The first test shall be conducted after completing two modules of the syllabus and the second one after completing the rest three modules.
Each test shall be conducted for 25 marks. The average of the two tests scaled down to 25 marks shall constitute the test marks for a maximum of 25 marks.

(ii) Laboratory component

Out of 25 marks, 15 marks shall be assigned for assessment as per the rubrics listed in the course syllabus.
The remaining 10 marks shall be based on the practical test conducted by two Internal examiners appointed by the HoD. The allotment of marks shall be as per the rubrics defined for regular class work and practical test as indicated in the Table – ICs/IPCCs 1.

(iii) To qualify and become eligible to appear for the SEE of the IC/IPCC, a student shall secure at least 40 % of 25 marks, i.e., 10 marks, in the CIE theory component, and at least 40 % of 25 marks, i.e., 10 marks in the CIE Practical component.

Table – ICs/IPCCs 1 Distribution of marks

Component	Description	Marks
Allotment of marks for regular class work		
Ability in Conducting Experiments	Initiative, skill, safety practices, teamwork, and independent handling of equipment during regular lab sessions.	5 marks
Laboratory Record / Journal	Regular and neat maintenance of lab record, accuracy of results, and timely submission.	10 marks
	Subtotal	**15**
Allotment of marks for CIE practical test		
Laboratory Test / Experiment Performance	Ability to set up apparatus, follow procedure, take observations, and obtain correct results in the test experiment.	5 marks
Viva-Voce	Understanding of theory, concepts, and experimental procedure; ability to explain results and answer related questions.	5 marks
	Subtotal	**10**
	Total	**25**

Passing requirement in SEE

For a pass in the Semester End Examination (SEE), a student shall secure a minimum of 35 marks out of 100.
For the declaration of a pass grade, the sum of the Continuous Internal Evaluation (CIE) marks (out of 50) marks and the SEE marks scaled down to 50 shall be greater than or equal to 40 marks.
If the total (CIE + SEE) is less than 40 marks, the student shall be awarded the grade 'F' (Fail).

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MICROBIOLOGY			
Course Code	**1BBT303**	Scheme	**2025**
Type of Course	**PCC**	Semester	**IV**
Teaching Hours/Week (L:T:P)	**3:0:0**	CIE Marks	**50**
Total Hours of Pedagogy per semester L /T/P/SL&TW:	**42:28:0:50**	SEE Marks	**50**
Credits	**4**	Total Marks	**100**
Examination type (SEE)	**Theory**	Exam Hours	**03**

Course outcome (Course Skill Set)

At the end of the course, the student will be able to:
CO1: Classify microorganism along with their structural and functional roles
CO2: Apply learning of microscopy and microbial techniques in identification and enumeration
CO3: Describe and relate the occurrence of microbes caused diseases.

CO4: Apply principles of food and dairy microbiology in food fermentation, functional foods and food safety management.
CO5 Explain the occurrence and role of general microflora of air, water and soil.

Module-1

FUNDAMENTALS OF MICROBIOLOGY

Scope and History of Microbiology, Microbial diversity and classification, Structure of Bacteria, Viruses, Fungi, Protozoa, Algae. General features of Rickettsia, Mycoplasma, Chlamydia, Prions, Spirochetes, Actinomycetes. Introduction to microbial genomics and genetics, Microbial growth and metabolism (EMP, HMP, ED, TCA and ETC), Sterilization methods, pure culture techniques, identification and characterization of microorganisms via staining and biochemical analysis.

Number of Hours: 8

Module-2

TECHNIQUES IN MICROBIOLOGY (Conventional to Emerging): Microscopy, Bright-Field, Dark-Field, Phase-Contrast, Acoustic, Fluorescence, Electron Microscopy: SEM, TEM. Micrometry, Nucleic acid extraction, PCR and RT-PCR , Real-time PCR (qPCR) , Sequencing methods (Sanger and NGS), MALDI-TOF , Flow cytometry, Metagenomics and microbiome analysis CRISPR, Role of AI in microbiology.

Number of Hours: 8

Module-3

DISEASES MICROBIOLOGY AND CLINICAL MYCOLOGY: Bacteriology and Virology Common diseases caused by Bacteria (TB, Cholera, Typhoid, Pneumonia, Plague, Diphtheria, Gonorrhoea and syphilis), Viruses (Polio, H1N1, SARS, Covid-19, HIV, Hepatitis), Clinical Protozoalogy: (Malaria, Leishmaniasis and Amebiasis), Clinical Mycology: Fundamentals of mycology, serology of fungal diseases, Opportunistic fungal infections, Clinical significance of Candidiasis, Aspergillosis, Cryptococcosis, Antifungal agents and resistance, cultural and microscopic diagnosis and identification.

Number of Hours: 8

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Module-4

FOOD AND DAIRY MICROBIOLOGY: Food Microbiology: Sources of microbial contamination in foods, Food preservation, Food fermentation: Principles, Microbes in fermented foods, Dairy Microbiology: Microbiology of dairy products, starter cultures, Fermented dairy products: yogurt, cheese, kefir, Functional foods Probiotics, prebiotics, and synbiotics, Postbiotics and their emerging applications, Food Mycology with relevance to upstream bioprocessing : Introduction to Upstream Processing, Mushroom biotechnology , Mycoprotein production , Role of yeast and mold in bread and brewery, Regulatory authorities(FDA, FSSAI, HACCP).

Number of Hours: 8

Module-5

ENVIRONMENT AND INDUSTRIAL MICROBIOLOGY: Aerobiology, Air sampling techniques. Microbiology of potable water and wastewater treatment. Microbiology of soil, Agricultural applications: Biofertilizers, VAM, Rhizobium. Role of bacteria and fungi in Bioremediation., **Industrially important fungi and bacteria:** Production of penicillin and streptomycin, screening of yeasts and molds, Production of citric acid, Fungal alpha amylase, lipase, Yeast Single cell protein production, production of alcohol.

Number of Hours: 8

Suggested Learning Resources: (Text Book/ Reference Book/ Manuals):

Text books:

1. Pelczar MJ Jr, Chan ECS, Kreig NR 2001, Microbiology McGraw Hill Education; 5th edition, India
2. Prescott LM, Harley JP, Klein DA (2012) Microbiology, 8th Edn. McGraw- Hill Publications, USA

Reference books / Manuals:

1. General Microbiology: Roger Y Stanier, John L Ingraham, and Mark L Wheels Macmillan Press Ltd,
   V Edition (International Edition). 1999.
2. Textbook of Microbiology,Ananthanarayan and Paniker, Orient Blackswan, 2006.
3. Microbiology, Michael J Pelczar, J R Chan ECS, Noel R Krieg Tata McGraw-Hill Education Pvt. 2013.
4. Industrial Microbiology, Prescott and Dunn, CBS Pub. 4th Edition, 2004.
5. Microbiology: Principles and Explorations, Black J, 7th Edn. John Wiley and Sons, USA. 2010

Web links and Video Lectures (e-Resources):

- https://www.udemy.com/course/basics-of-medical-microbiology/
- https://www.edx.org/learn/microbiology
- https://www.coursera.org/courses?query=microbiology
- https://www.futurelearn.com/courses/introduction-to-microbiology
- https://alison.com/course/introduction-to-microbiology
- https://www.hsph.harvard.edu/nutritionsource/microbiome/
- http://books.pakchem.net/microbiology-books.html
- http://www.austincc.edu/rohde/noteref.htm

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Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

1. Inquiry-Based Microbiology Laboratory Sessions
2. Clinical, Environmental, and Industrial Case Studies
3. Microbial Identification and Diagnostic Exercises
4. Research Article Discussions and Journal Clubs
5. Mini Research Projects on Microbial Applications
6. Simulation of Microbiology Laboratory and Biosafety Practices
7. Exposure to Advanced Microbiological Techniques and Industry
8. Continuous Competency-Based Assessment

Assessment Structure:

The assessment in each course is divided equally between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each carrying 50% weightage.

- To qualify and become eligible to appear for SEE, in the **CIE**, a student must score at least **40% of 50 marks**, i.e., **20 marks**.
- To pass the **SEE**, a student must score at least **35% of 50 marks**, i.e., **18 marks**.

Notwithstanding the above, a student is considered to have **passed the course,** provided the combined total of **CIE and SEE** is at least **40 out of 100 marks**.

Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal Evaluation CIE [25+25=50 marks]

A minimum of **two Internal Assessment Tests(IA)** shall be conducted, carrying a total of **25 marks**.

In addition, **Continuous Comprehensive Assessment (CCA)** shall be conducted for a total of **25 marks**.

It is recommended to include **a maximum of two learning activities** as part of the CCA to foster the **holistic development of students**. These activities shall be:

Sl. No.	Name of the Learning activity	Maximum Marks
1.	Assignment	10
2.	Quiz/Seminar/Case Study/Project based learning	15

Rubrics for Learning Activity (Based on the nature of learning activity, design the rubrics for each activity):

Assignment (10 Marks)

Performance Indicator (CO/PO Mapping)	Superior (5)	Good (4)	Fair (3)	Needs Improvement (2)	Unacceptable (1)

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PI-1: Conceptual Understanding (CO1, CO2 / PO1)	Excellent understanding with accurate explanations	Good understanding with minor errors	Satisfactory understanding	Limited understanding	Poor understanding
PI-2: Problem Solving & Presentation (CO3, CO4, CO5 / PO2, PO10)	Accurate calculations, logical presentation and timely submission	Minor errors	Satisfactory work	Incomplete or poorly presented	Not submitted

Quiz / Seminar / Case Study / Project-Based Learning (15 Marks)

Performance Indicator (CO/PO Mapping)	Superior (5)	Good (4)	Fair (3)	Needs Improvement (2)	Unacceptable (1)
PI-1: Technical Knowledge (CO1–CO5 / PO1)	Excellent conceptual knowledge	Good knowledge	Satisfactory knowledge	Limited knowledge	Poor knowledge
PI-2: Analytical & Problem-Solving Skills (CO3, CO4 / PO2, PO4)	Excellent analysis and application	Good analysis	Basic analysis	Limited analysis	Unable to analyze
PI-3: Communication & Teamwork (CO5 / PO9, PO10)	Excellent communication and teamwork	Good communication	Satisfactory communication	Poor communication	No participation

Suggested Learning Activities may include (but are not limited to):

- Course Project
- Case Study Presentation
- Programming Assignment
- Tool/Software Exploration
- Literature Review
- Open Book Test (preferably at RBL4 and RBL5 levels)
- GATE-based Aptitude Test
- Assignment (at RBL3, RBL4, or RBL5 levels)
- Any other relevant and innovative academic activity
- Use of MOOCs and Online Platforms

Suggested Innovative Delivery Methods may include (but are not limited to):

- Flipped Classroom
- Problem-Based Learning (PBL)

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- Case-Based Teaching
- Simulation and Virtual Labs
- Partial Delivery of course by Industry expert/ industrial visits
- ICT-Enabled Teaching
- Role Play

Team Work (TW) and Self Learning (SL) components in Number of Hours per semester		
Team work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)		
Sl. No.	**Team Work (TW) Activity**	**Number of Hours / Semester**
2.	Assignments, Seminars, Micro projects, Industrial visits, any other student activities.	24
SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.		
Sl. No.	**Self-Learning (SL) Activity**	**Number of Hours / Semester**
2.	NPTEL, MIT, MOOCs, spoken tutorials, online educational resources.	24

Continuous Internal Evaluation (CIE)

1. The CIE marks shall be decided based on internal tests and other outcome-based activities. The continuous internal evaluation shall be carried out by the teacher handling the course.
2. Out of 50 marks earmarked for CIE, 25 marks shall be assigned for internal tests. The first test shall be conducted after completing two modules of the syllabus and the second one after completing the remaining three modules.
3. The remaining 25 marks shall be assigned for Continuous Course Assessment (CCA), conducted as per the rubrics listed in the assessment section of the respective syllabus.
4. A student shall obtain a minimum of 40% marks or 20 out of 50 marks allotted to CIE to become eligible to appear for the SEE.

Passing requirement in SEE

1. For a pass in the Semester End Examination (SEE), a student shall secure a minimum of 35 marks out of 100.
2. For the declaration of a pass grade, the sum of the Continuous Internal Evaluation (CIE) marks (out of 50) marks and the SEE marks scaled down to 50 shall be greater than or equal to 40 marks.
3. If the total (CIE + SEE) is less than 40 marks, the student shall be awarded the grade 'F' (Fail).

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STRUCTURAL BIOLOGY & BIOANALYTICAL TECHNIQUES			
Course Code	**1BBT304**	Scheme	**2025**
Type of Course	**PCC**	Semester	**III**
Teaching Hours/Week (L:T:P)	**3:0:0**	CIE Marks	**50**
Total Hours of Pedagogy per semester L /T/P/SL&TW:	**42:0:0:48**	SEE Marks	**50**
Credits	**3**	Total Marks	**100**
Examination type (SEE)	**Theory**	Exam Hours	**03**

At the end of the course, the student will be able to:
CO1: Explain the structure, conformation, folding, and functional organization of proteins.
CO2: Analyze the structure and conformational properties of nucleic acids and biological membranes.
CO3: Apply biophysical techniques for the characterization and analysis of biomolecules.
CO4: Interpret spectroscopic data for structural elucidation of biological molecules.
CO5: Explain the principles and applications of electrophoretic and chromatographic techniques for biomolecular separation and analysis

Module-1

STRUCTURE AND CONFORMATION OF PROTEINS: Composition and primary structures of proteins, peptide geometries, phi, psi, omega angles, Ramachandran or steric contour diagram, allowed chi angles of side chains in proteins, Conformational analysis and forces that determine protein structures, hydrogen bonding, disulphide bonds, hydrophobic interactions, Van der Waals forces. Secondary structures: alpha helices, beta sheets, turns. Thermodynamic aspects of protein folding. Relationship between the primary, secondary, and tertiary structure of proteins. Structure of IgG, fibrous proteins (structure of collagen, keratin). Quaternary structures – dimers (homo & heterodimers), trimers, tetramers; Popular Protein folds, structural families and classes, multifunctional domains (qualitative examples).

Number of Hours: 8 hrs

Module-2

STRUCTURE AND CONFORMATION OF NUCLEIC ACIDS AND BIOMEMBRANES: General characteristics of nucleic acid structures (A, T, G, C, U), forces and stabilizing geometries, glycosidic bond, rotational isomers. Stabilizing ordered forms of DNA (A, B and Z), base pairing types, base stacking, tertiary structure of DNA (Supercoiled DNA), Melting of the DNA double helix (Hyperchromicity), Interaction with small ions and small molecules. Ribose puckering and Tertiary structure of tRNA. Structure and conformational properties of cell membranes, Singer and Nicholson model, integral proteins in membranes, conformational variations during ion transport, Signal transduction and molecular reception (qualitative)

Number of Hours: 8 hrs

Module-3

BIOPHYSICAL TECHNIQUES: Rayleigh scattering, ultra-centrifugation, viscometry. Electronmicroscopy (SEM, TEM, AFM), luminescence (fluorescence & phosphorescence), Calorimetry, DSC, Mass spectrometry, MALDI-TOF, Voltage Clamp and Patch Clamp (measurements of membrane potentials). Flow cytometry.

Number of Hours: 8 hrs

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Module-4
SPECTROSCOPIC TECHNIQUES:X-ray diffraction: structure determination via single crystal diffraction, fibre diffraction; Neutron diffraction. XPS, XAFS. NMR spectroscopy (structure determination). ORD/CD, UV, IR, Laser Raman, ESR/EPR. Number of Hours: 8 hrs
Module-5
ELECTROPHORETIC TECHNIQUES: Agarose gel electrophoresis, gradient electrophoresis, horizontal and vertical gel electrophoresis, isoelectric focusing, immune electrophoresis. Capillary electrophoresis and applications. Chromatographic Techniques: Normal phase, adsorption, reverse phase, ion exchange, size exclusion, hydrophobic interaction, bio-affinity and pseudo affinity techniques. GC, Paper chromatography, TLC and HPLC and their applications. Number of Hours: 8 hrs
Suggested Learning Resources: (Text Book/ Reference Book/ Manuals): **Text books:** 4. Biophysical Chemistry by Cantor R. and Schimmel P.R, W. H. Freeman. 5. Physical Biochemistry by David Freifelder, W H Freeman and Company. 6. Biophysical Principles of Structure & Function by Fred M. Snell & Sidney Shulman 7. Introduction to Protein Structure by Carl Branden and John Tooze, Garland Publishing. 8. Proteins Structure – A Practical Approach by Creighton, Oxford University Press. **Reference books / Manuals:** 1. Physical Chemistry: Principles and Applications in Biological Sciences by Tinoco and others, Prentice Hall 2. Biophysics – An Introduction by Cotterill, Wiley Student Edition. 3. Foundations of Biophysics by A.L. Stanford, Academic Press. 4. Principles of protein structure by G Schulz and R H Schrimer, Springer Verlag. 5. Principles of nucleic acid structure by Sanger, Springer Verlag. 6. Introduction to Protein Science by Arthur M Lesk, Oxford University Press. 7. Biological Spectroscopy by J. D. Campbell and R. A.Dwek, Plenum Press
Web links and Video Lectures (e-Resources): 1. https://onlinecourses.nptel.ac.in/noc21_bt14/preview 2. https://www.digimat.in/nptel/courses/video/102107086/L11.html 3. https://www.digimat.in/nptel/courses/video/102107028/L01.html 4. https://nptel.ac.in/courses/102106065 5. https://nptel.ac.in/courses/102106068 6. https://archive.nptel.ac.in/noc/courses/noc18/SEM1/noc18-bt01/

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Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

1. Interactive lectures using multimedia presentations and molecular visualization tools.
2. ICT-enabled teaching through animations, simulations, and virtual laboratories.
3. Demonstration of biophysical and spectroscopic instruments using videos and virtual tours.
4. Flipped classroom with NPTEL/MOOC video lectures and guided discussions.
5. Case studies on protein structure, biomolecular interactions, and structural biology.
6. Group discussions and seminars on recent advances in biophysical techniques.
7. Problem-solving sessions involving spectroscopic and chromatographic data analysis.
8. Journal article reviews and presentations on contemporary research.
9. Mini-projects on applications of electrophoresis, chromatography, and spectroscopy.
10. Self-learning through online quizzes, assignments, and literature surveys.

Assessment Structure:

The assessment in each course is divided equally between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each carrying 50% weightage.

- To qualify and become eligible to appear for SEE, in the **CIE**, a student must score at least **40% of 50 marks**, i.e., **20 marks**.
- To pass the **SEE**, a student must score at least **35% of 50 marks**, i.e., **18 marks**.
- Notwithstanding the above, a student is considered to have **passed the course,** provided the combined total of **CIE and SEE** is at least **40 out of 100 marks**.

Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal EvaluationCIE [25+25=50 marks]

A minimum of **two Internal Assessment Tests (IA)** shall be conducted, carrying a total of **25 marks**.

In addition, **Continuous Comprehensive Assessment (CCA)** shall be conducted for a total of **25 marks**.

It is recommended to include **a maximum of two learning activities** as part of the CCA to foster the **holistic development of students**. These activities shall be:

Sl. No.	Name of the Learning activity	Maximum Marks
1.	Assignment	10
2.	Quiz/Seminar/Case Study/Project based learning	15

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Rubrics for Learning Activity (Based on the nature of learning activity, design the rubrics for each activity):

Assignment (10 Marks)

Performance Indicator (CO/PO Mapping)	Superior (5)	Good (4)	Fair (3)	Needs Improvement (2)	Unacceptable (1)
PI-1: Conceptual Understanding (CO1, CO2 / PO1)	Excellent understanding with accurate explanations	Good understanding with minor errors	Satisfactory understanding	Limited understanding	Poor understanding
PI-2: Problem Solving & Presentation (CO3, CO4, CO5 / PO2, PO10)	Accurate calculations, logical presentation and timely submission	Minor errors	Satisfactory work	Incomplete or poorly presented	Not submitted

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Quiz / Seminar / Case Study / Project-Based Learning (15 Marks)

Performance Indicator (CO/PO Mapping)	Superior (5)	Good (4)	Fair (3)	Needs Improvement (2)	Unacceptable (1)
PI-1: Technical Knowledge (CO1–CO5 / PO1)	Excellent conceptual knowledge	Good knowledge	Satisfactory knowledge	Limited knowledge	Poor knowledge
PI-2: Analytical & Problem-Solving Skills (CO3, CO4 / PO2, PO4)	Excellent analysis and application	Good analysis	Basic analysis	Limited analysis	Unable to analyze
PI-3: Communication & Teamwork (CO5 / PO9, PO10)	Excellent communication and teamwork	Good communication	Satisfactory communication	Poor communication	No participation

Suggested Learning Activities may include (but are not limited to):

- Course Project
- Case Study Presentation
- Programming Assignment
- Tool/Software Exploration
- Literature Review
- Open Book Test (preferably at RBL4 and RBL5 levels)
- GATE-based Aptitude Test
- Assignment (at RBL3, RBL4, or RBL5 levels)
- Any other relevant and innovative academic activity
- Use of MOOCs and Online Platforms

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Suggested Innovative Delivery Methods may include (but are not limited to):

- Flipped Classroom
- Problem-Based Learning (PBL)
- Case-Based Teaching
- Simulation and Virtual Labs
- Partial Delivery of course by Industry expert/ industrial visits
- ICT-Enabled Teaching
- Role Play

Team Work (TW) and Self Learning (SL) components in Number of Hours per semester		
Team work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)		
Sl. No.	**Team Work (TW) Activity**	**Number of Hours / Semester**
1.	Assignments, Seminars, Micro projects, Industrial visits, any other student activities.	24
SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.		
Sl. No.	**Self-Learning (SL) Activity**	**Number of Hours / Semester**
2.	NPTEL, MIT, MOOCs, spoken tutorials, online educational resources.	24

Continuous Internal Evaluation (CIE)

1. The CIE marks shall be decided based on internal tests and other outcome-based activities. The continuous internal evaluation shall be carried out by the teacher handling the course.
2. Out of 50 marks earmarked for CIE, 25 marks shall be assigned for internal tests. The first test shall be conducted after completing two modules of the syllabus and the second one after completing the remaining three modules.
3. The remaining 25 marks shall be assigned for Continuous Course Assessment (CCA), conducted as per the rubrics listed in the assessment section of the respective syllabus.
4. A student shall obtain a minimum of 40% marks or 20 out of 50 marks allotted to CIE to become eligible to appear for the SEE.

Passing requirement in SEE

5. For a pass in the Semester End Examination (SEE), a student shall secure a minimum of 35 marks out of 100.
6. For the declaration of a pass grade, the sum of the Continuous Internal Evaluation (CIE) marks (out of 50) marks and the SEE marks scaled down to 50 shall be greater than or equal to 40 marks.
7. If the total (CIE + SEE) is less than 40 marks, the student shall be awarded the grade 'F' (Fail).

PYTHON PROGRAMMING FOR LIFE SCIENCES			
Course Code	**1BBT305**	Scheme	**2025**
Type of Course	**PCC**	Semester	**III**
Teaching Hours/Week (L:T:P)	**3:0:0**	CIE Marks	**50**
Total Hours of Pedagogy per semester L /T/P/SL&TW:	**42:0:0:48**	SEE Marks	**50**
Credits	**3**	Total Marks	**100**
Examination type (SEE)	**Theory**	Exam Hours	**03**

Course outcome (Course Skill Set)

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

CO1: Understand the fundamentals of Python programming for biological applications.

CO2: Comprehend the data processing, visualization, and automation tools for life sciences.

CO3: Develop computational thinking and data-handling skills to address relevant problems.

CO4: Build suitable applications for bioinformatics and data-driven biology work-flows.

Module-1

INTRODUCTION TO PYTHON AND COMPUTATIONAL THINKING: Python environment setup and execution of programs using Python IDE/Jupyter Notebook; variables, identifiers, data types (integer, float, Boolean, string), type conversion, operators and expressions; input and output operations; comments and good programming practices. Applications in biological computations including unit conversions, calculation of concentrations, and basic experimental data handling.

Number of Hours: 8

Module-2

CONTROL STRUCTURES AND SEQUENCE PROCESSING: Conditional and iterative programming using if, if–else, nested conditions, for and while loops; loop control statements (break, continue, pass); string operations and methods; lists and tuples; representation and manipulation of biological sequences such as DNA, RNA and proteins. Applications include sequence validation, GC content calculation, and pattern searching.

Number of Hours: 8

Module-3

FUNCTIONS AND MODULAR PROGRAMMING: Concept of functions, function definition and invocation, parameters and return values, variable scope, recursive and iterative approaches (overview), importing and using Python modules, debugging and exception handling. Applications include development of reusable functions for biological calculations, enzyme kinetics, and molecular property estimation.

Number of Hours: 8

Module-4

DATA STRUCTURES AND FILE HANDLING: Advanced data structures including dictionaries and sets; list comprehensions; file handling operations for reading and writing text and CSV files; data parsing and manipulation techniques; introduction to biological data formats such as FASTA and tabular experimental datasets. Applications include gene frequency analysis and biological data organization.

Number of Hours: 8

Module-5

PYTHON FOR BIOLOGICAL DATA ANALYSIS AND VISUALIZATION: Introduction to scientific computing using NumPy and Pandas; creation and manipulation of Data Frames; data cleaning and pre-processing; visualization of biological data using Matplotlib including line plots, bar charts, histograms and scatter plots; analysis and interpretation of simple biological datasets for

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experimental and bioinformatics applications.

Number of Hours: 8

Suggested Learning Resources: (Text Book/ Reference Book/ Manuals):

Text books:

1. Think Python: How to Think Like a Computer Scientist. Allen B. Downey. Shroff O'Reilly Publishers, 2ndedition,2016.
2. An Introduction to Python –Revised and updated for Python 3.2. Guido van Rossumand Fred L. Drake Jr Network Theory Ltd., 2011.
3. Introduction to Programming in Python: An Inter-disciplinary Approach. Robert Sedgewick, Kevin Wayne, Robert Dondero Pearson India Education Services Pvt. Ltd, 2016.
4. Fundamentals of Python: First Programs. Kenneth A. Lambert CENGAGE Learning, 2012.

Reference books / Manuals:

1. Raschka, S., Liu, Y., & Mirjalili, V. Machine Learning with Python and Scikit-Learn, Keras, and TensorFlow, 4th Edition, Packt Publishing, 2025.

2. Python for the Life Sciences: A Gentle Introduction to Python for Life Scientists. Alexander Lancaster and Godon Webster. First edition. APress, 2019.

3. Python Programming for Biology: Bioinformatics and Beyond. Tim J. Stevens & Wayne Boucher. Cambridge University Press. First Edition, 2015.

4. Hands on Data Science for Biologists Using Python. Yasha Hasija, Rajkumar Chakraborty. CRC Press. 2021.

5. Applied Python Programming for Life Scientists: From Fundamentals to Algorithmic Thinking and Data Driven Discovery. Ryan Moore, 2025.

Web links and Video Lectures (e-Resources):

- https://nptel.ac.in/courses/106106182
- https://www.youtube.com/watch?v=_uQrJ0TkZlc
- https://www.udemy.com/course/pythonforbeginners/
- https://www.udemy.com/topic/python/
- https://www.coursera.org/courses?query=python
- https://www.freecodecamp.org/news/best-python-courses/
- https://www.codecademy.com/catalog/language/python
- https://www.edx.org/learn/python

Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

1. **Interactive lectures with biological examples** to explain Python programming concepts using life science applications.
2. **Hands-on Python laboratory sessions** for coding practice, debugging, and biological data processing.
3. **Case study-based learning** using real-world bioinformatics and biological data analysis problems.

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4. **Project-based learning** involving the development of Python applications for life sciences.
5. **Data visualization exercises** using Python libraries to analyze and present biological datasets.
6. **Coding challenges and debugging exercises** to strengthen computational thinking and programming skills.
7. **Flipped classroom approach** with pre-class learning materials and in-class problem-solving activities.
8. **Peer programming and collaborative learning** to promote teamwork, code review, and knowledge sharing.
9. **Integration of open-source Python libraries and biological databases** for authentic computational biology applications.
10. **Continuous assessment and constructive feedback** through quizzes, assignments, laboratory exercises, and projects.
11. **Industry and research-oriented demonstrations** showcasing Python applications in bioinformatics, genomics, and computational biology.
12. **Capstone application development** integrating programming, data analysis, visualization, and workflow automation for life science problems.

Assessment Structure:

The assessment in each course is divided equally between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each carrying 50% weightage.

- To qualify and become eligible to appear for SEE, in the **CIE**, a student must score at least **40% of 50 marks**, i.e., **20 marks**.
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Sl. No.	Name of the Learning activity	Maximum Marks
1.	Assignment	10
2.	Quiz/Seminar/Case Study/Project based learning	15

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Rubrics for Learning Activity (Based on the nature of learning activity, design the rubrics for each activity):

Assignment (10 Marks)

Performance Indicator (CO/PO Mapping)	Superior (5)	Good (4)	Fair (3)	Needs Improvement (2)	Unacceptable (1)
PI-1: Conceptual Understanding (CO1, CO2 / PO1)	Excellent understanding with accurate explanations	Good understanding with minor errors	Satisfactory understanding	Limited understanding	Poor understanding
PI-2: Problem Solving & Presentation (CO3, CO4, CO5 / PO2, PO10)	Accurate calculations, logical presentation and timely submission	Minor errors	Satisfactory work	Incomplete or poorly presented	Not submitted

Quiz / Seminar / Case Study / Project-Based Learning (15 Marks):

Performance Indicator (CO/PO Mapping)	Superior (5)	Good (4)	Fair (3)	Needs Improvement (2)	Unacceptable (1)
PI-1: Technical Knowledge (CO1–CO5 / PO1)	Excellent conceptual knowledge	Good knowledge	Satisfactory knowledge	Limited knowledge	Poor knowledge
PI-2: Analytical & Problem-Solving Skills (CO3, CO4 / PO2, PO4)	Excellent analysis and application	Good analysis	Basic analysis	Limited analysis	Unable to analyze
PI-3: Communication & Teamwork (CO5 / PO9, PO10)	Excellent communication and teamwork	Good communication	Satisfactory communication	Poor communication	No participation

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Suggested Learning Activities may include (but are not limited to):

- Course Project
- Case Study Presentation
- Programming Assignment
- Tool/Software Exploration
- Literature Review
- Open Book Test (preferably at RBL4 and RBL5 levels)
- GATE-based Aptitude Test
- Assignment (at RBL3, RBL4, or RBL5 levels)
- Any other relevant and innovative academic activity
- Use of MOOCs and Online Platforms

Suggested Innovative Delivery Methods may include (but are not limited to):

- Flipped Classroom
- Problem-Based Learning (PBL)
- Case-Based Teaching
- Simulation and Virtual Labs
- Partial Delivery of course by Industry expert/ industrial visits
- ICT-Enabled Teaching
- Role Play

Term Work (TW) and Self Learning (SL) components in Number of Hours per semester

Term work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)

Sl. No.	Term Work (TW) Activity	Number of Hours / Semester
1.	Assignments, Seminars, Micro projects, Industrial visits, any other student activities.	24

SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.

Sl. No.	Self-Learning (SL) Activity	Number of Hours / Semester
2.	NPTEL, MIT, MOOCs, spoken tutorials, online educational resources.	24

Continuous Internal Evaluation (CIE)

1. The CIE marks shall be decided based on internal tests and other outcome-based activities. The continuous internal evaluation shall be carried out by the teacher handling the course.
2. Out of 50 marks earmarked for CIE, 25 marks shall be assigned for internal tests. The first test shall be conducted after completing two modules of the syllabus and the second one after completing the remaining three modules.
3. The remaining 25 marks shall be assigned for Continuous Course Assessment (CCA), conducted as per the rubrics listed in the assessment section of the respective syllabus.
4. A student shall obtain a minimum of 40% marks or 20 out of 50 marks allotted to CIE to become eligible to appear for the SEE.

Passing requirement in SEE

5. For a pass in the Semester End Examination (SEE), a student shall secure a minimum of 35 marks out of 100.
6. For the declaration of a pass grade, the sum of the Continuous Internal Evaluation (CIE) marks (out of 50) marks and the SEE marks scaled down to 50 shall be greater than or equal to 40 marks.
7. If the total (CIE + SEE) is less than 40 marks, the student shall be awarded the grade 'F' (Fail).

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MICROBIOLOGY LABORATORY			
Course Code	**1BBTL306**	Scheme	**2025**
Type of Course	**PCCL**	Semester	**III**
Teaching Hours/Week (L:T:P)	**0:0:2**	CIE Marks	**50**
Total Hours of Pedagogy L:T:P:SLTW	**0:0:28:2**	SEE Marks	**50**
Credits	**1**	Total Marks	**100**
Examination type (SEE)	**Practical**	Exam Hours	**02**

Course outcome (Course Skill Set)

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

CO1: Operate equipment used in a microbiology laboratory.

CO2: Prepare growth media and isolate microorganisms from various sources.

CO3: Perform aseptic transfers of microorganisms.

CO4: Identify microorganisms using morphological and physiological tests.

CO5: Carry out antibiotic susceptibility testing of bacteria.

Note:

1. The laboratory syllabus consists of PART-A and PART-B. While PART-A has 6 conventional experiments, PART-B has 6 typical open-ended experiments. The maximum marks for the laboratory course are 100.
2. Both PART-A and PART-B are considered for CIE and SEE.
3. Students have answer 1(one) question from PART-A and 1(one) question from PART-B.
   a. The questions set for SEE shall be from among the experiments under PART-A. It is evaluated for **70 marks** out of the maximum 100 marks.
   b. The open-ended question set for SEE shall be any other open-ended question and not selected from the experiments under PART-A. It shall be evaluated for **30 marks.**
4. For Continuous Internal Evaluation (CIE) during the semester, classwork shall typically include open-ended questions from **Part-B**, along with other similar questions designed to enhance the students' skills.

PART – A
FIXED SET OF EXPERIMENTS

1. Aseptic techniques in laboratory preparations and analysis: Sterilisation, disinfection and sanitisation.
2. Direct microscopic observations of bacterial shape – cocci, rods, chains, fungal spores, mycelium, yeast budding.
3. Pure culture technique: Streak plate, spread plate and pour plate methods
4. **Fixation and staining: Isolation of microbes using staining techniques (Simple, Gram staining, and spore staining).**
5. Isolation and enumeration of bacteria from soil by the serial dilution-agar plating method
6. Isolation of fungi and Lactophenol cotton blue mounting of fungi

PART – B
OPEN ENDED EXPERIMENTS

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Open-ended experiments are a type of laboratory activity where the outcome is not predetermined and students are given the freedom to explore, design, and conduct the experiment based on the problem statements as per the concepts defined by the course coordinator. It encourages creativity, critical thinking, and inquiry-based learning.

Concept 1: Qualitative tests for amino acids and proteins

Concept 2: Estimation of lactic acid by Lactobacillus species

Concept 3: Biochemical Characterization of bacteria: IMViC, Starch hydrolysis, carbohydrate assimilation

Concept 4: Biochemical Characterization of bacteria: Catalase, Urease, hydrogen sulphide, Gelatine Liquefaction tests.

Concept 5**:** Bacterial Growth curve studies.

Concept 6: Antibiotic susceptibility test of a selected bacterium

Suggested Learning Resources: (Text Book/ Reference Book/ Manuals):

Text books:

1. Aneja, K.R. (2018). Laboratory Manual of Microbiology and Biotechnology.2nd Edition, Medtech
2. Harley, J. (2016). Laboratory Exercises in Microbiology. 10th Edition, McGraw-Hill

Reference books / Manuals:

1. Experiments in Microbiology, Plant Pathology and Biotechnology by K. R. Aneja, New Age International, 2003
2. Microbiology: A Lab Manual by Cappuccino, Pearson Education, 2007
3. Manual of Microbiology: Tools & Techniques by Kanika Sharma, Ane Books Private Limited, New Delhi, II EdItion 2011, Reprinted 2020
4. Lab Ref Jane Roskams, Linda Rodgers, Cold Spring Harbor, N.Y., 2002

Web links and Video Lectures (e-Resources):

- https://www.youtube.com/watch?v=bm99zrq3ijo (Video on Streak-plate method for isolation of pure culture)
- https://www.youtube.com/watch?v=vlnIDGmgQfk (Video on Gram's staining of bacteria)
- https/www.mheducation.com/highered/microbiology.html
- https://asm.org/Articles/2020/December/Virtual-Resources-to-Teach-Microbiology-Techniques
- https://www.cnm.edu/programs-of-study/math-science-engineering/microbiology-lab-manual
- http://faculty.collin.edu/dcain/CCCCD%20Micro/tutorial.htm

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- https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4844744

Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

1. Hands-on Laboratory Training with Good Microbiological Practices (GMP)
2. Inquiry-Based Experimental Learning
3. Microbial Identification and Diagnostic Exercises
4. Case-Based Laboratory Investigations
5. Integration of Virtual Laboratories and Digital Resources
6. Mini Projects and Collaborative Laboratory Learning

Assessment Structure:

The assessment for each course is equally divided between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each component carrying **50% weightage** (i.e., 50 marks each).

The CIE marks awarded shall be based on the continuous evaluation of the laboratory report using a defined set of rubrics. Each experiment report can be evaluated for 30 marks. Total marks for the all report shall be scaled down to 30 marks. The laboratory test (duration 03 hours) at the end of the last week of the semester /after completion of all the experiments (whichever is early) shall be conducted for 50 marks and Marks scored shall be scaled down to 20 marks. Final average of marks for report and test shall be out of 50 marks.

For both CIE and SEE, the student is required to conduct one experiment each from both Part A and Part B.

Rubrics for CIE – Continuous assessment:

Performance Indicator (CO/PO Mapping)	Superior (5)	Good (4)	Fair (3)	Needs Improvement (2)	Unacceptable (1)
PI-1: Laboratory Preparation & Fundamental Knowledge (CO1/PO1)	Excellent understanding of theory and protocol	Good understanding	Satisfactory understanding	Limited understanding	Poor understanding
PI-2: Experimental	Performs accurately and	Minor guidance	Moderate guidance	Frequent errors	Unable to perform

Skills & Aseptic Techniques (CO2/PO2, PO5)	independently				
PI-3: Data Recording, Analysis & Interpretation (CO3/PO4)	Accurate observations and analysis	Minor errors	Basic interpretation	Limited interpretation	No interpretation
PI-4: Laboratory Record & Documentation (CO1, CO4/PO10)	Complete and organized	Good	Satisfactory	Incomplete	Not submitted
PI-5: Scientific Communication & Teamwork (CO4/PO9, PO10)	Excellent	Good	Satisfactory	Poor	No participation

Rubrics for SEE / CIE Test:

Performance Indicator (CO/PO Mapping)	Superior (5)	Good (4)	Fair (3)	Needs Improvement (2)	Unacceptable (1)
PI-1: Understanding of Experimental Principle (CO1/PO1)	Excellent	Good	Satisfactory	Limited	Poor
PI-2: Experimental Execution (CO2/PO2, PO5)	Independent execution	Minor procedural errors	With guidance	Significant errors	Unable
PI-3: Observation, Result & Interpretation (CO3/PO4)	Accurate and scientific	Minor errors	Basic	Limited	Incorrect
PI-4: Open-ended Problem	Independent design	Good approach	Basic solution	Limited	Unable

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Solving (CO4/PO2, PO4)					
PI-5: Viva Voce & Scientific Communication (CO1–CO4/PO10)	Excellent	Good	Satisfactory	Limited	Unable

- To qualify and become eligible to appear for SEE, in the **CIE component**, a student must secure **a minimum of 40% of 50 marks**, i.e., **20 marks**.
- To pass the **SEE component**, a student must secure **a minimum of 35% of 50 marks**, i.e., **18 marks**.
- A student is deemed to have **successfully completed the course** if the **combined total of CIE and SEE is at least 40 out of 100 marks**.

Rubrics suggested for Practical continuous assessment

Performance Indicators	**Excellent**	**Very Good**	**Good**	**Satisfactory**
Fundamental Knowledge (4) (PO1)	The student has well depth knowledge of the topics related to the course (4)	Student has good knowledge of some of the topics related to course (3)	Student is capable of narrating the answer but not capable to show in depth knowledge(2)	Student has not understood the concepts clearly (1)
Design Of Experiment (5) (PO2 & PO3)	Student is capable of discussing more than one design for his/her problem statement and capable of proving the best suitable design with proper reason (5)	Student is capable of discussing few designs for his/her problem statement but not capable of selecting best(4)	Student is capable of discussing single design with its merits and de-merits(3)	Student is capable of explaining the design (1-2)
Implementation (8) (PO3 & PO8)	Student is capable of implementing the design with best suitable algorithm considering optimal solution. (7-8)	Student is capable of implementing the design with best suitable algorithm and should be capable of explaining it (5-6)	Student is capable of implementing the design with proper explanation.(3-4)	Student is capable of implementing the design. (1-2)

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Result &Analysis (5) (PO4)	Student is able to run the program on various cases and compare the result with proper analysis. (5)	Student will be able to run the program for all the cases.(4)	Student will be able to run the code for few cases and analyze the output.(3)	Student will be able to run the program but not able to analyze the output.(1-2)
Demonstration (8) (PO9)	The lab record is well-organized, with clear sections (e.g., Introduction, Method, Results, Conclusion). Transitions between sections are smooth. (7-8)	The lab record is organized, with clear sections, but some sections are not well-defined. (5-6)	The lab record lacks clear organization or structure. Some sections are unclear or incomplete. (3-4)	The lab record is poorly organized, with missing or unclear sections. (1-2)

Note: Can add Engineering & IT tool usage based on the nature of the course

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LAB SAFETY & GLP (GOOD LABORATORY PRACTICES)			
Course Code	**1BBTL307A**	Scheme	**2025**
Type of Course	**AEC**	Semester	**III**
Teaching Hours/Week (L:T:P)	**0:0:2**	CIE Marks	**50**
Total Hours of Pedagogy L:T:P:SL:TW	**0:0:28:2**	SEE Marks	**50**
Credits:	**1**	Total Marks	**100**
Type of Examination	**Practical**	Exam Hours	**2**

Course outcome (Course Skill Set)

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

CO1: Identify laboratory hazards and implement appropriate safety measures.
CO2: Demonstrate proper use of personal protective equipment and safety devices.
CO3: Apply emergency response procedures for laboratory accidents and incidents.
CO4: Follow Good Laboratory Practices (GLP) for conducting and documenting experiments.

SET OF EXPERIMENTS

1. Study of Laboratory Safety Rules, Regulations, and Safety Signages.
2. Identification of Laboratory Hazards and Risk Assessment Procedures.
3. Demonstration and Proper Use of Personal Protective Equipment (PPE).
4. Study and Interpretation of Safety Data Sheets (SDS/MSDS) for Chemicals.
5. Safe Handling, Labeling, Storage, and Transportation of Laboratory Chemicals.
6. Operation and Demonstration of Laboratory Safety Equipment (Eyewash Station, Safety Shower, Fume Hood, First-Aid Kit).
7. Fire Safety Training and Use of Different Types of Fire Extinguishers.
8. Emergency Response and Evacuation Drill for Laboratory Accidents.
9. Good Laboratory Practices (GLP): Documentation, Record Keeping, and Logbook Maintenance.
10. Laboratory Waste Segregation, Treatment, and Disposal Procedures.
11. Preparation and Implementation of Laboratory Safety Checklists and Safety Audits.
12. Comprehensive Laboratory Safety Audit and Submission of Compliance Report.

Suggested Learning Resources: (Text Book/ Reference Book/ Manuals):

Text books:

1. Furr, A.K., *CRC Handbook of Laboratory Safety*, CRC Press.
2. DiBerardinis, L.J., *Guidelines for Laboratory Design: Health, Safety and Environmental Considerations*, Wiley.

Reference books / Manuals:

1. Kirk-Othmer, *Encyclopedia of Chemical Technology – Laboratory Safety*.
2. Prudent Practices in the Laboratory, National Research Council, National Academies Press.

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Web links and Video Lectures (e-Resources):

- https://www.oecd.org/chemicalsafety/testing/good-laboratory-practiceglp.htm
- https://www.who.int
- https://nptel.ac.in

Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

1. **Demonstrations and Laboratory Simulations**

   Conduct practical demonstrations of safety equipment, emergency procedures, and GLP practices to provide experiential learning.

2. **Case Studies and Incident Analysis**

Analyze real laboratory accidents and safety incidents to develop hazard identification, risk assessment, and problem-solving skills.

3. **Safety Audits and Collaborative Learning Activities**

   Engage students in laboratory inspections, safety audits, group discussions, and peer evaluations to promote active participation and safety awareness.

Assessment Structure:

The assessment for each course is equally divided between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each component carrying **50% weightage** (i.e., 50 marks each).

The CIE marks awarded shall be based on the continuous evaluation of the laboratory report using a defined set of rubrics. Each experiment report can be evaluated for 30 marks. Total marks for the all report shall be scaled down to 30 marks. The laboratory test (duration 03 hours) at the end of the last week of the semester /after completion of all the experiments (whichever is early) shall be conducted for 50 marks and Marks scored shall be scaled down to 20 marks. Final average of marks for report and test shall be out of 50 marks.

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Rubrics for CIE – Continuous assessment:

Performance Indicator (CO/PO Mapping)	Superior (5)	Good (4)	Fair (3)	Needs Improvement (2)	Unacceptable (1)
PI-1: Laboratory Preparation & Fundamental Knowledge (CO1/PO1)	Excellent understanding of theory and protocol	Good understanding	Satisfactory understanding	Limited understanding	Poor understanding
PI-2: Experimental Skills & Aseptic Techniques (CO2/PO2, PO5)	Performs accurately and independently	Minor guidance	Moderate guidance	Frequent errors	Unable to perform
PI-3: Data Recording, Analysis & Interpretation (CO3/PO4)	Accurate observations and analysis	Minor errors	Basic interpretation	Limited interpretation	No interpretation
PI-4: Laboratory Record & Documentation (CO1, CO4/PO10)	Complete and organized	Good	Satisfactory	Incomplete	Not submitted
PI-5: Scientific Communication & Teamwork (CO4/PO9, PO10)	Excellent	Good	Satisfactory	Poor	No participation

Rubrics for SEE / CIE Test:

Performance Indicator (CO/PO Mapping)	Superior (5)	Good (4)	Fair (3)	Needs Improvement (2)	Unacceptable
PI-1: Understanding of Experimental Principle (CO1/PO1)	Excellent	Good	Satisfactory	Limited	Poor
PI-2: Experimental Execution (CO2/PO2, PO5)	Independent execution	Minor procedural errors	With guidance	Significant errors	Unable
PI-3: Observation, Result & Interpretation (CO3/PO4)	Accurate and scientific	Minor errors	Basic	Limited	Incorrect
PI-4: Open-ended Problem Solving	Independent design	Good approach	Basic solution	Limited	Unable

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(CO4/PO2, PO4)						
PI-5: Viva Voce & Scientific Communication (CO1–CO4/PO10)	Excellent	Good	Satisfactory	Limited	Unable	

- To qualify and become eligible to appear for SEE, in the **CIE component**, a student must secure **a minimum of 40% of 50 marks**, i.e., **20 marks**.
- To pass the **SEE component**, a student must secure **a minimum of 35% of 50 marks**, i.e., **18 marks**.
- A student is deemed to have **successfully completed the course** if the **combined total of CIE and SEE is at least 40 out of 100 marks**.

Rubrics suggested for Practical continuous assessment

Performance Indicators	**Excellent**	**Very Good**	**Good**	**Satisfactory**
Fundamental Knowledge (4) (PO1)	The student has well depth knowledge of the topics related to the course (4)	Student has good knowledge of some of the topics related to course (3)	Student is capable of narrating the answer but not capable to show in depth knowledge(2)	Student has not understood the concepts clearly (1)
Design Of Experiment (5) (PO2 & PO3)	Student is capable of discussing more than one design for his/her problem statement and capable of proving the best suitable design with proper reason (5)	Student is capable of discussing few designs for his/her problem statement but not capable of selecting best(4)	Student is capable of discussing single design with its merits and de-merits(3)	Student is capable of explaining the design (1-2)
Implementation (8) (PO3 & PO8)	Student is capable of implementing the design with best suitable algorithm considering optimal solution. (7-8)	Student is capable of implementing the design with best suitable algorithm and should be capable of explaining it (5-6)	Student is capable of implementing the design with proper explanation.(3-4)	Student is capable of implementing the design. (1-2)

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Result &Analysis (5) (PO4)	Student is able to run the program on various cases and compare the result with proper analysis. (5)	Student will be able to run the program for all the cases.(4)	Student will be able to run the code for few cases and analyze the output.(3)	Student will be able to run the program but not able to analyze the output.(1-2)
Demonstration (8) (PO9)	The lab record is well-organized, with clear sections (e.g., Introduction, Method, Results, Conclusion). Transitions between sections are smooth. (7-8)	The lab record is organized, with clear sections, but some sections are not well-defined. (5-6)	The lab record lacks clear organization or structure. Some sections are unclear or incomplete. (3-4)	The lab record is poorly organized, with missing or unclear sections. (1-2)

Note: Can add Engineering & IT tool usage based on the nature of the course

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DESIGN OF EXPERIMENTS LAB (USING RELEVANT ONLINE TOOLS)			
Course Code	**1BBTL307B**	Scheme	**2025**
Type of Course	**AEC Lab**	Semester	**4**
Teaching Hours/Week (L:T:P)	**0:0:2**	CIE Marks	**50**
Total Hours of Pedagogy L:T:P:SL&TW	**0:0:28:2**	SEE Marks	**50**
Credits	**1**	Total Marks	**100**
Type of Examination	**Practical**	Exam Hours	**2**

Course outcome (Course Skill Set)

At the end of the course, the student will be able to:
CO1: Apply the principles of randomization, replication, and blocking to design biological experiments.
CO2: Perform classical experimental designs such as CRD, RBD, Latin Square Design, and factorial designs.
CO3: Use statistical software (e.g., Excel or R) for data analysis and interpretation.
CO4: Optimize biotechnology processes and communicate experimental findings through technical reports.

SET OF EXPERIMENTS

1. Statistical software (Excel/R/SPSS/Minitab) and descriptive statistics using biological data using Excel
2. Probability distributions using Excel
3. Correlation and regression using Excel
4. Analysis of Completely Randomized Design (CRD) using microbial growth under different carbon sources using Excel
5. Randomized Complete Block Design (RCBD) for evaluating plant tissue culture growth under different media compositions using Excel
6. Latin Square Design for studying effects of nutrient media while controlling row and column variation using R
7. Two-factor Full Factorial Design for optimization of fermentation parameters (Temperature × pH) using R
8. Three-factor factorial design for enzyme production (Temperature × pH × Agitation) using R
9. Fractional factorial design using R
10. Plackett–Burman Design for screening significant factors affecting microbial biomass production using R
11. Development of Response Surface Model and contour plots for optimizing enzyme activity using R
12. DOE mini-project using Excel and R

Suggested Learning Resources: (Text Book/ Reference Book/ Manuals):

Text books:

1. Montgomery, D. C. *Design and Analysis of Experiments*. Wiley.
2. Box, G. E. P., Hunter, J. S., & Hunter, W. G. *Statistics for Experimenters: Design, Innovation, and Discovery*. Wiley.
3. Montgomery, D. C., & Runger, G. C. *Applied Statistics and Probability for Engineers*. Wiley.

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Reference books / Manuals:

1. Zar, J. H. *Biostatistical Analysis*. Pearson.
2. Sokal, R. R., & Rohlf, F. J. *Biometry*. W. H. Freeman.
3. Dean, A., Voss, D., & Draguljić, D. *Design and Analysis of Experiments*. Springer.
4. Myers, R. H., Montgomery, D. C., & Anderson-Cook, C. M. *Response Surface Methodology: Process and Product Optimization Using Designed Experiments*. Wiley.

Web links and Video Lectures (e-Resources):

- https://www.nptel.ac.in/courses/103105102
- https://onlinecourses.nptel.ac.in/
- https://ocw.mit.edu/
- https://www.jmp.com/en/academic
- https://support.minitab.com/en-us/minitab/help-and-how-to/statistical-modeling/doe/
- https://www.itl.nist.gov/div898/handbook/pri/pri.htm
- https://www.oecd.org/chemicalsafety/testing/good-laboratory-practiceglp.htm
- https://www.coursera.org/search?query=design%20of%20experiments

Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

1. Interactive lectures on experimental design concepts and applications.
2. Hands-on laboratory experiments using standard experimental designs.
3. Software-based data analysis using Excel and R.
4. Case study and problem-based learning for biotechnology applications.
5. Mini projects on experimental design and process optimization.
6. Collaborative learning through group experiments and discussions.
7. Continuous assessment through lab records, quizzes, and viva voce.
8. Technical report writing and presentations to enhance scientific communication.

Assessment Structure:

The assessment for each course is equally divided between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each component carrying **50% weightage** (i.e., 50 marks each).

The CIE marks awarded shall be based on the continuous evaluation of the laboratory report using a defined set of rubrics. Each experiment report can be evaluated for 30 marks. Total marks for the all report shall be scaled down to 30 marks. The laboratory test (duration 03 hours) at the end of the last week of the semester /after completion of all the experiments (whichever is early) shall be conducted for 50 marks and Marks scored shall be scaled down to 20 marks. Final average of marks for report and test shall be out of 50 marks.

Rubrics for CIE – Continuous assessment:

Performance Indicator (CO/PO Mapping)	Superior (5)	Good (4)	Fair (3)	Needs Improvement (2)	Unacceptable (1)
PI-1: Laboratory Preparation & Fundamental Knowledge (CO1/PO1)	Excellent understanding of theory and protocol	Good understanding	Satisfactory understanding	Limited understanding	Poor understanding
PI-2:	Performs	Minor	Moderate	Frequent	Unable to

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Experimental Skills & Aseptic Techniques (CO2/PO2, PO5)	accurately and independently	guidance	guidance	errors	perform
PI-3: Data Recording, Analysis & Interpretation (CO3/PO4)	Accurate observations and analysis	Minor errors	Basic interpretation	Limited interpretation	No interpretation
PI-4: Laboratory Record & Documentation (CO1, CO4/PO10)	Complete and organized	Good	Satisfactory	Incomplete	Not submitted
PI-5: Scientific Communication & Teamwork (CO4/PO9, PO10)	Excellent	Good	Satisfactory	Poor	No participation

Rubrics for SEE / CIE Test:

Performance Indicator (CO/PO Mapping)	Superior (5)	Good (4)	Fair (3)	Needs Improvement (2)	Unacceptable (1)
PI-1: Understanding of Experimental Principle (CO1/PO1)	Excellent	Good	Satisfactory	Limited	Poor
PI-2: Experimental Execution (CO2/PO2, PO5)	Independent execution	Minor procedural errors	With guidance	Significant errors	Unable
PI-3: Observation, Result & Interpretation (CO3/PO4)	Accurate and scientific	Minor errors	Basic	Limited	Incorrect
PI-4: Open-ended Problem Solving (CO4/PO2, PO4)	Independent design	Good approach	Basic solution	Limited	Unable
PI-5: Viva Voce & Scientific Communication (CO1–CO4/PO10)	Excellent	Good	Satisfactory	Limited	Unable

- To qualify and become eligible to appear for SEE, in the **CIE component**, a student must secure **a minimum of 40% of 50 marks**, i.e., **20 marks**.
- To pass the **SEE component**, a student must secure **a minimum of 35% of 50 marks**, i.e., **18 marks**.
- A student is deemed to have **successfully completed the course** if the **combined total of CIE and SEE is at least 40 out of 100 marks**

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Rubrics suggested for Practical continuous assessment				
Performance Indicators	**Excellent**	**Very Good**	**Good**	**Satisfactory**
Fundamental Knowledge (4) (PO1)	The student has well depth knowledge of the topics related to the course (4)	Student has good knowledge of some of the topics related to course (3)	Student is capable of narrating the answer but not capable to show in depth knowledge (2)	Student has not understood the concepts clearly (1)
Design Of Experiment (5) (PO2 & PO3)	Student is capable of discussing more than one design for his/her problem statement and capable of proving the best suitable design with proper reason (5)	Student is capable of discussing few designs for his/her problem statement but not capable of selecting best (4)	Student is capable of discussing single design with its merits and de-merits (3)	Student is capable of explaining the design (1-2)
Implementation (8) (PO3 & PO8)	Student is capable of implementing the design with best suitable algorithm considering optimal solution. (7-8)	Student is capable of implementing the design with best suitable algorithm and should be capable of explaining it (5-6)	Student is capable of implementing the design with proper explanation. (3-4)	Student is capable of implementing the design. (1-2)
Result &Analysis (5) (PO4)	Student is able to run the program on various cases and compare the result with proper analysis. (5)	Student will be able to run the program for all the cases. (4)	Student will be able to run the code for few cases and analyze the output. (3)	Student will be able to run the program but not able to analyze the output. (1-2)
Demonstration (8) (PO9)	The lab record is well-organized, with clear sections (e.g., Introduction, Method, Results, Conclusion). Transitions between sections are smooth. (7-8)	The lab record is organized, with clear sections, but some sections are not well-defined. (5-6)	The lab record lacks clear organization or structure. Some sections are unclear or incomplete. (3-4)	The lab record is poorly organized, with missing or unclear sections. (1-2)

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R PROGRAMMING FOR BIOLOGISTS(LABORATORY)			
Course Code	**1BBTL307C**	Scheme	**2025**
Type of Course	**AEC**	Semester	**III**
Teaching Hours/Week (L:T:P)	**0:0:2**	CIE Marks	**50**
Total Hours of Pedagogy L:T:P:SLTW	**0:0:28:2**	SEE Marks	**50**
Credits	**1**	Total Marks	**100**
Examination type (SEE)	**Practical**	Exam Hours	**02**

Course outcome (Course Skill Set)

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

CO1: Understand the fundamentals of R programming and its applications in biological sciences.
CO2: Gain relevant skills in handling, processing, and managing biological datasets using R.
CO3: Apply statistical and analytical methods for needful visualization and interpretation of biological data.
CO4: Perform basic computational and data-driven analysis for biological and bioinformatics applications.
CO5: Develop computational workflows for biological problems using R programming tools.

Note:

1. The laboratory syllabus consists of PART-A and PART-B. While PART-A has 6 conventional experiments, PART-B has 6 typical open-ended experiments. The maximum marks for the laboratory course are 100.
2. Both PART-A and PART-B are considered for CIE and SEE.
3. Students have answer 1(one) question from PART-A and 1(one) question from PART-B.
   c. The questions set for SEE shall be from among the experiments under PART-A. It is evaluated for **70 marks** out of the maximum 100 marks.
   d. The open-ended question set for SEE shall be any other open-ended question and not selected from the experiments under PART-A. It shall be evaluated for **30 marks.**
4. For Continuous Internal Evaluation (CIE) during the semester, classwork shall typically include open-ended questions from **Part-B**, along with other similar questions designed to enhance the students' skills.

SET OF EXPERIMENTS

1. A) Installation of R and RStudio Environment and Execution of Basic Commands.
   B) Study of Variables, Data Types, Operators and Input–Output Functions in R.
2. Development of Programs using Conditional Statements, Loops and User-Defined Functions.
3. Implementation of Data Structures in R: Vectors, Matrices, Lists, Factors and Data Frames.
4. String Manipulation and Biological Sequence Processing using R.
5. Import, Export and Management of Biological Data Files (CSV and Text Formats).
6. Data Cleaning, Filtering and Transformation of Biological Datasets.
7. Exploratory Data Analysis and Descriptive Statistical Analysis using R.
8. Data Visualization using Bar Charts, Histograms, Box Plots, Line Charts and Scatter Plots.
9. Correlation and Regression Analysis for Biological Data Interpretation.
10. Hypothesis Testing and Statistical Analysis using R.
11. Analysis and Interpretation of Biological Datasets using R Programming.
12. Implementation of Clustering Techniques (K-Means) for Biological Data Analysis.

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Suggested Learning Resources: (Text Book/ Reference Book/ Manuals):

Text books:

1. R For Dummies 2nd Edition by Andrie de Vries and Joris Meys, 2015.
2. R in a Nutshell 2e: A Desktop Quick Reference. Joseph Adler, 2012.
3. Learning R: A Step-By-Step Function Guide to Data Analysis. Richard Cotton, 2013.
4. R Programming for Beginners: Fast and Easy Learning. Ruby Steven Keller, 2016

Reference books / Manuals:

1. Data Analysis for the Life Sciences with R. Rafael A. Irizarry, Michael I. Love, 1st Edition. CRC Press. 2017
2. R Programming for Bioinformatics. David Blei, David Madigan, Marina Meila, Fionn Murtagh, and Royal Holloway.Chapman & Hall/CRCPress. 2021.
3. R for Biologists: Learn R programming from scratch | No prior coding experience required | An absolute beginner's guide (Biotechnology Books). Roohi Bansal 2024.

Web links and Video Lectures (e-Resources):

https://nptel.ac.in/courses/111104100
https://www.youtube.com/watch?v=fDRa82lxzaU
https://www.udemy.com/topic/r-programming-language
https://www.udemy.com/course/r-programming/
https://www.mygreatlearning.com/great-lakes-pgpdsba?
https://www.coursera.org/learn/r-programming
https://www.edx.org/learn/r-programming
https://www.udemy.com/topic/r-programming-language/

Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

1. Interactive lectures on R programming concepts with biological science examples.
2. Hands-on R programming laboratory sessions for biological data handling and analysis.
3. Case study-based learning using real-world biological and bioinformatics datasets.
4. Mini projects on statistical analysis, data visualization, and computational workflows using R.
5. Continuous assessment and feedback through coding exercises, quizzes, lab assignments, and project presentations.

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Assessment Structure:

The assessment for each course is equally divided between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each component carrying **50% weightage** (i.e., 50 marks each).

The CIE marks awarded shall be based on the continuous evaluation of the laboratory report using a defined set of rubrics. Each experiment report can be evaluated for 30 marks. Total marks for the all report shall be scaled down to 30 marks. The laboratory test (duration 03 hours) at the end of the last week of the semester /after completion of all the experiments (whichever is early) shall be conducted for 50 marks and Marks scored shall be scaled down to 20 marks. Final average of marks for report and test shall be out of 50 marks.

For both CIE and SEE, the student is required to conduct one experiment each from both Part A and Part B.

Rubrics for CIE – Continuous assessment:

Performance Indicator (CO/PO Mapping)	Superior (5)	Good (4)	Fair (3)	Needs Improvement (2)	Unacceptable (1)
PI-1: Laboratory Preparation & Fundamental Knowledge (CO1/PO1)	Excellent understanding of theory and protocol	Good understanding	Satisfactory understanding	Limited understanding	Poor understanding
PI-2: Experimental Skills & Aseptic Techniques (CO2/PO2, PO5)	Performs accurately and independently	Minor guidance	Moderate guidance	Frequent errors	Unable to perform
PI-3: Data Recording, Analysis & Interpretation (CO3/PO4)	Accurate observations and analysis	Minor errors	Basic interpretation	Limited interpretation	No interpretation
PI-4: Laboratory Record & Documentation (CO1, CO4/PO10)	Complete and organized	Good	Satisfactory	Incomplete	Not submitted
PI-5: Scientific Communication & Teamwork (CO4/PO9, PO10)	Excellent	Good	Satisfactory	Poor	No participation

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Rubrics for SEE / CIE Test:

Performance Indicator (CO/PO Mapping)	Superior (5)	Good (4)	Fair (3)	Needs Improvement (2)	Unacceptable (1)
PI-1: Understanding of Experimental Principle (CO1/PO1)	Excellent	Good	Satisfactory	Limited	Poor
PI-2: Experimental Execution (CO2/PO2, PO5)	Independent execution	Minor procedural errors	With guidance	Significant errors	Unable
PI-3: Observation, Result & Interpretation (CO3/PO4)	Accurate and scientific	Minor errors	Basic	Limited	Incorrect
PI-4: Open-ended Problem Solving (CO4/PO2, PO4)	Independent design	Good approach	Basic solution	Limited	Unable
PI-5: Viva Voce & Scientific Communication (CO1–CO4/PO10)	Excellent	Good	Satisfactory	Limited	Unable

- To qualify and become eligible to appear for SEE, in the **CIE component**, a student must secure **a minimum of 40% of 50 marks**, i.e., **20 marks**.
- To pass the **SEE component**, a student must secure **a minimum of 35% of 50 marks**, i.e., **18 marks**.
- A student is deemed to have **successfully completed the course** if the **combined total of CIE and SEE is at least 40 out of 100 marks**.

Rubrics suggested for Practical continuous assessment

Performance Indicators	**Excellent**	**Very Good**	**Good**	**Satisfactory**
Fundamental Knowledge (4) (PO1)	The student has well depth knowledge of the topics related to the course (4)	Student has good knowledge of some of the topics related to course (3)	Student is capable of narrating the answer but not capable to show in depth knowledge (2)	Student has not understood the concepts clearly (1)

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Design Of Experiment (5) (PO2 & PO3)	Student is capable of discussing more than one design for his/her problem statement and capable of proving the best suitable design with proper reason (5)	Student is capable of discussing few designs for his/her problem statement but not capable of selecting best (4)	Student is capable of discussing single design with its merits and de-merits (3)	Student is capable of explaining the design (1-2)
Implementation (8) (PO3 & PO8)	Student is capable of implementing the design with best suitable algorithm considering optimal solution. (7-8)	Student is capable of implementing the design with best suitable algorithm and should be capable of explaining it (5-6)	Student is capable of implementing the design with proper explanation. (3-4)	Student is capable of implementing the design. (1-2)
Result &Analysis (5) (PO4)	Student is able to run the program on various cases and compare the result with proper analysis. (5)	Student will be able to run the program for all the cases. (4)	Student will be able to run the code for few cases and analyze the output. (3)	Student will be able to run the program but not able to analyze the output. (1-2)
Demonstration (8) (PO9)	The lab record is well-organized, with clear sections (e.g., Introduction, Method, Results, Conclusion). Transitions between sections are smooth. (7-8)	The lab record is organized, with clear sections, but some sections are not well-defined. (5-6)	The lab record lacks clear organization or structure. Some sections are unclear or incomplete. (3-4)	The lab record is poorly organized, with missing or unclear sections. (1-2)

Note: Can add Engineering & IT tool usage based on the nature of the course

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WATER ANALYSIS LAB			
Course Code	**1BBTL307D**	Scheme	**2025**
Type of Course	**AEC**	Semester	**III**
Teaching Hours/Week (L:T:P)	**0:0:2**	CIE Marks	**50**
Total Hours of Pedagogy L:T:P:SL:TW	**0:0:28:2**	SEE Marks	**50**
Credits	**1**	Total Marks	**100**
Type of Examination	**Practical**	Exam Hours	**2**

Course outcome (Course Skill Set)

At the end of the course, the student will be able to:
CO1: Measure the physical and chemical purity of water using standard laboratory meters and titrations.
CO2: Identify common bacterial contaminants in water using basic staining and selective agar media.
CO3: Compare experimental results with BIS (IS 10500) drinking water standards.

SET OF EXPERIMENTS

1. **Physical Quality Testing:** Determination of pH, Turbidity, and Total Dissolved Solids (TDS) of various water samples using digital meters.
2. **Alkalinity Estimation:** Determination of Total Alkalinity of water by standard acid-base titration.
3. **Acidity Dynamics:** Determination of total acidity and dissolved Free Carbon Dioxide (CO_2) in water samples.
4. **Hardness Estimation:** To determine total hardness of given sample of water.
5. **Chloride Quantification:** To determine chloride content and residual chlorine of given sample of water.
6. **Dissolved Oxygen (DO) Analysis:** Determination of DO in water using Winkler's chemical titration method or a digital DO probe.
7. **Total Viable Count (Bioburden):** Estimation of total heterotrophic bacterial count in water using the Spread Plate technique.
8. **Sanitary Indicator Assessment:** Determination of the Most Probable Number (MPN) of Coliforms using lactose fermentation broth.
9. **Target Organism Confirmation:** Identification of *Escherichia coli* colonies on Eosin Methylene Blue (EMB) Agar.
10. **Pathogen Screening (Opportunistic):** Detection and visual verification of *Pseudomonas species* using selective Cetrimide Agar.
11. **Pathogen Screening (Hygiene Indicator):** Detection and biochemical checking of *Staphylococcus species* using Mannitol Salt Agar (MSA).
12. **Field Assay Demonstration:** Testing immediate field-level water safety using a ready-to-use commercial rapid kit or colour-change test strip

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Suggested Learning Resources: (Text Book/ Reference Book/ Manuals):

Text books:

1. Manual of Methods of Analysis of Foods: Water, Food Safety and Standards Authority of India (FSSAI), Ministry of Health and Family Welfare, Government of India, 2016.
2. Handbook of Water Analysis, Leo M.L. Nollet, Leen S. P. De Gelder, CRC Press, 3rd Edition, 2013.
3. Microbiological Examination of Water and Wastewater, Maria Csuros, Csaba Csuros, CRC Press, 1st Edition, 1999.

Reference books / Manuals:

1. Water Analysis: A Practical Guide to Physico-Chemical, Chemical and Microbiological Water Examination and Quality Assurance, W. Fresenius, K. E. Quentin, W. Schneider (Eds.), Springer-Verlag, 1988.
2. Laboratory Manual for the Chemical and Estimation of Water and Wastewater, APHA, AWWA, WEF, Washington DC.

Web links and Video Lectures (e-Resources):

1. FSSAI Analytical Manuals: FSSAI Water Analysis Manual Portal. https://fssai.gov.in/upload/uploadfiles/files/Manual_Water_Analysis_09_01_2017(1).pdf
2. Bureau of Indian Standards: BIS Portal - Drinking Water Specifications IS 10500:2012, https://www.bis.gov.in/?lang=hi
3. APHA Standard Methods: Standard Methods for the Examination of Water and Wastewater Platform
4. NPTEL/Swayam Courses: Video lectures on "Wastewater Treatment and Water Quality Analysis.https://in.video.search.yahoo.com/search/video?fr=mcafee&p=NPTEL%2FSwayam+Courses%3A+Video+lectures+on+%22Wastewater+Treatment+and+Water+Quality+Analysis%22.&type=E211IN739G0#id=0&vid=b04ffec461f22a87ac12dac0e638d9ff&action=click

Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes within the strict 2-hour constraint:

1. **The "Rolling Culture" Lab Design:** To respect the 2-hour practical limit for incubation-dependent experiments (Experiments 7–11), a dual-action process must be implemented. Students will actively inoculate or streak their fresh water samples during the first 15 minutes of the session to learn the physical technique. They will then spend the remaining time analyzing, counting, and executing biochemical confirmation steps on pre-incubated plates or positive culture tubes prepared 24 to 48 hours earlier by the laboratory staff.
2. **Visual Endpoint Anchoring & Pre-Lab Snippets**: Prior to starting chemical titrations

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(Experiments 2–5), students should be provided with brief 2-minute visual clip demonstrations or color charts displaying the exact, sharp color transitions (e.g., wine-red to distinct blue for EDTA; yellow to brick-red for Mohr's method). This drastically reduces observation errors and minimizes repeated trial runs, ensuring completion within the stipulated laboratory hours.

3. **Mock Quality Control (QC) Clearance Exercises:** For every experiment, students should not just record a final number in their logs. They must actively compare their experimental values against a master classroom chart of the BIS (IS 10500:2012) Acceptable Limits. Every laboratory report should conclude with an industry-style "Pass/Fail Clearance Statement" indicating whether the tested sample is safe for human consumption or processing plant usage.

Assessment Structure:

The assessment for each course is equally divided between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each component carrying **50% weightage** (i.e., 50 marks each).

The CIE marks awarded shall be based on the continuous evaluation of the laboratory report using a defined set of rubrics. Each experiment report can be evaluated for 30 marks. Total marks for the all report shall be scaled down to 30 marks. The laboratory test (duration 03 hours) at the end of the last week of the semester /after completion of all the experiments (whichever is early) shall be conducted for 50 marks and Marks scored shall be scaled down to 20 marks. Final average of marks for report and test shall be out of 50 marks.

Rubrics for CIE – Continuous assessment:

Performance Indicator (CO/PO Mapping)	Superior (5)	Good (4)	Fair (3)	Needs Improvement (2)	Unacceptable (1)
PI-1: Laboratory Preparation & Fundamental Knowledge (CO1/PO1)	Excellent understanding of theory and protocol	Good understanding	Satisfactory understanding	Limited understanding	Poor understanding
PI-2: Experimental Skills & Aseptic Techniques (CO2/PO2, PO5)	Performs accurately and independently	Minor guidance	Moderate guidance	Frequent errors	Unable to perform
PI-3: Data Recording, Analysis & Interpretation (CO3/PO4)	Accurate observations and analysis	Minor errors	Basic interpretation	Limited interpretation	No interpretation
PI-4: Laboratory Record &	Complete and organized	Good	Satisfactory	Incomplete	Not submitted

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Documentation (CO1, CO4/PO10)					
PI-5: Scientific Communication & Teamwork (CO4/PO9, PO10)	Excellent	Good	Satisfactory	Poor	No participation

Rubrics for SEE / CIE Test:

Performance Indicator (CO/PO Mapping)	Superior (5)	Good (4)	Fair (3)	Needs Improvement (2)	Unacceptable (1)
PI-1: Understanding of Experimental Principle (CO1/PO1)	Excellent	Good	Satisfactory	Limited	Poor
PI-2: Experimental Execution (CO2/PO2, PO5)	Independent execution	Minor procedural errors	With guidance	Significant errors	Unable
PI-3: Observation, Result & Interpretation (CO3/PO4)	Accurate and scientific	Minor errors	Basic	Limited	Incorrect
PI-4: Open-ended Problem Solving (CO4/PO2, PO4)	Independent design	Good approach	Basic solution	Limited	Unable
PI-5: Viva Voce & Scientific Communication (CO1–CO4/PO10)	Excellent	Good	Satisfactory	Limited	Unable

- To qualify and become eligible to appear for SEE, in the **CIE component**, a student must secure **a minimum of 40% of 50 marks**, i.e., **20 marks**.
- To pass the **SEE component**, a student must secure **a minimum of 35% of 50 marks**, i.e., **18 marks**.
- A student is deemed to have **successfully completed the course** if the **combined total of CIE and SEE is at least 40 out of 100 marks**.

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Rubrics suggested for Practical continuous assessment				
Performance Indicators	**Excellent**	**Very Good**	**Good**	**Satisfactory**
Fundamental Knowledge (4) (PO1)	The student has well depth knowledge of the topics related to the course (4)	Student has good knowledge of some of the topics related to course (3)	Student is capable of narrating the answer but not capable to show in depth knowledge(2)	Student has not understood the concepts clearly (1)
Design Of Experiment (5) (PO2 & PO3)	Student is capable of discussing more than one design for his/her problem statement and capable of proving the best suitable design with proper reason (5)	Student is capable of discussing few designs for his/her problem statement but not capable of selecting best(4)	Student is capable of discussing single design with its merits and de-merits(3)	Student is capable of explaining the design (1-2)
Implementation (8) (PO3 & PO8)	Student is capable of implementing the design with best suitable algorithm considering optimal solution. (7-8)	Student is capable of implementing the design with best suitable algorithm and should be capable of explaining it (5-6)	Student is capable of implementing the design with proper explanation.(3-4)	Student is capable of implementing the design. (1-2)
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Demonstration (8) (PO9)	The lab record is well-organized, with clear sections (e.g., Introduction, Method, Results, Conclusion). Transitions between sections are smooth. (7-8)	The lab record is organized, with clear sections, but some sections are not well-defined. (5-6)	The lab record lacks clear organization or structure. Some sections are unclear or incomplete. (3-4)	The lab record is poorly organized, with missing or unclear sections. (1-2)

Note: Can add Engineering & IT tool usage based on the nature of the course

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COMMUNITY PROJECT (PROJECT BASED LEARNING) SOCIETAL PROJECT [Common to all disciplines of Engineering]			
Course Code	**1BCP308**	Scheme	**2025**
Type of Course	**SDC**	Semester	**III**
Teaching Hours/Week (L :T : P)	**30 (0:0:0)**	CIE Marks	**50**
Total Hours of Pedagogy CI(L :T):LI(P):SL:TW	**30 (0:0:0:30)**	SEE Marks	**50**
Credits	**1**	Total Marks	**100**
Type of Examination	**Practical**	Exam Hours	**02**

Course objective:

Rapid urbanisation, population growth, environmental concerns, energy demand, water scarcity, waste management, transportation issues and rural development challenges have created practical problems affecting communities and public welfare. This course aims to integrate technical knowledge, field exposure and societal engagement so that students identify real community issues, frame problem statements and attempt appropriate, feasible and sustainable engineering responses within the scope of a one-semester project.

Course outcome (Course Skill Set):

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

1. **CO1 (L2 – Understand):** Identify and analyse societal problems through field interaction and technical assessment.
2. **CO2 (L3 – Apply):** Develop skills in project planning, field survey, data collection, implementation, documentation and reporting.
3. **CO3 (L4 – Analyse):** Formulate feasible engineering problem statements and solutions considering practical constraints and sustainability aspects.
4. **CO4 (L3 – Apply):** Apply principles of environmental responsibility, ethics and societal welfare in engineering practice through community-oriented interventions.
5. **CO5 (L4 – Analyse):** Exhibit multidisciplinary learning and problem-solving ability based on collected data, user feedback and baseline conditions.
6. **CO6 (L5 – Evaluate):** Demonstrate teamwork and communication skills while interacting with technical and non-technical stakeholders and reflect on project impact on society.

Restrictions and professional conduct:

Community / Societal Projects shall remain **academic, socially responsible, technically focused, and politically neutral**. Students and faculty shall maintain professionalism, ethical conduct, public respect and institutional integrity while interacting with communities, public groups, organisations and stakeholders.

Students and faculty **shall avoid** the following during project execution:

- Association with political party activities, campaigns or propaganda.
- Participation in activities that may disturb communal harmony, public order or institutional reputation.
- Use of the project platform for personal, political, ideological or commercial promotion.
- Disrespectful, discriminatory or unethical interaction with community members or stakeholders.

Projects must also recognise constraints related to **cost, resources, environment and safety, and**

stakeholder behaviour/cooperation/acceptance when planning and implementing activities.

Sustainable Development Goals

The faculty shall encourage students to undertake community projects that align with and contribute towards satisfying the National Board of Accreditation (NBA) Criterion 3.6, namely, Evidence of Addressing Sustainable Development Goals (SDGs), which is a major

emphasis of the United Nations (UN). The Sustainable Development Goals (SDGs) are illustrated in the figure shown below:

SET OF PROJECT ACTIVITIES (TW/SL = 30 HOURS)

Methods for project identification:

Students may identify the project topic using one or more of the following methods:

- Interaction with local rural or urban stakeholders such as local leaders, corporation/municipality personnel, NGOs, panchayat representatives, etc.

  Review of issues highlighted in print and electronic media, and social networks (WhatsApp, Facebook, X, Instagram, etc.).
- After selecting a broad topic, students shall collect data, conduct a feasibility survey, estimate timelines and resources, approximate expenditure, and then define the problem statement and objectives clearly.

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Sl. No.	Project title	Measurable engineering outcome	Mapped POs	SDGs
1	Rural and urban water conservation and management systems	Prepare a site-specific water-saving plan, estimate water demand–supply gap, and propose a feasible conservation intervention with quantified savings.	PO1, PO2, PO3, PO4, PO10, PO11	SDG 6, SDG 11, SDG 12
2	Waste management and recycling	Conduct waste audit, classify waste streams, and design a segregation/recycling workflow with measurable reduction in mixed waste.	PO2, PO3, PO4, PO6, PO8, PO10	SDG 11, SDG 12, SDG 13
3	Afforestation	Identify a degraded area, prepare plantation layout, and demonstrate survival-rate tracking and maintenance schedule for saplings.	PO2, PO3, PO4, PO6, PO7, PO11	SDG 11, SDG 13, SDG 15
4	Biogas generation and power generation	Estimate organic waste availability, size a small biogas system, and document expected gas output or energy yield.	PO1, PO2, PO3, PO4, PO5, PO10	SDG 7, SDG 11, SDG 12
5	DPR for solar power rural plant	Prepare a DPR with load assessment, panel sizing, cost estimate, and projected energy generation and payback.	PO1, PO2, PO3, PO4, PO5, PO10	SDG 7, SDG 9, SDG 11
6	DPR for electrification of village/tribal community	Map unserved/underserved households, propose electrification layout, and estimate coverage, losses, and implementation cost.	PO1, PO2, PO3, PO4, PO10, PO11	SDG 7, SDG 9, SDG 10
7	DPR for rural drainage system	Survey drainage bottlenecks, develop a drainage layout, and estimate runoff handling capacity and flood-risk reduction.	PO1, PO2, PO3, PO4, PO6, PO10	SDG 6, SDG 9, SDG 11
8	Sustainability and environmental health projects	Assess local environmental health issues and propose interventions with measurable improvement in hygiene, safety, or resource use.	PO2, PO3, PO4, PO6, PO7, PO8	SDG 3, SDG 6, SDG 11, SDG 12
9	Plastic free campaigns	Measure plastic usage before and after awareness intervention and report percentage reduction or behavioural change.	PO2, PO3, PO6, PO7, PO8, PO10	SDG 11, SDG 12, SDG 13
10	Health and nutrition awareness	Conduct baseline and post-program awareness survey and document improvement in awareness score or adoption of healthier practices.	PO2, PO6, PO7, PO8, PO9, PO10	SDG 2, SDG 3, SDG 11
11	Societal projects involving health wellness	Identify a community health need and develop an awareness/service module with measurable participation and feedback outcomes.	PO2, PO3, PO6, PO8, PO9, PO10	SDG 3, SDG 11, SDG 17

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12	Air quality monitoring system	Collect air-quality data, compare with reference limits, and present trends along with possible mitigation suggestions.	PO2, PO3, PO4, PO5, PO6, PO10	SDG 3, SDG 11, SDG 13
13	Plastic waste reduction campaign	Track collection, segregation, and replacement actions, and quantify reduction in plastic waste generation or littering.	PO2, PO3, PO6, PO7, PO8, PO10	SDG 11, SDG 12, SDG 13
14	Urban greening projects	Prepare greening plan, identify planting locations, and assess environmental benefits such as shade, aesthetics, or heat mitigation.	PO2, PO3, PO4, PO6, PO7, PO11	SDG 11, SDG 13, SDG 15
15	Smart agriculture solution	Design a low-cost monitoring or irrigation support solution and estimate improvement in water use efficiency or crop support.	PO1, PO2, PO3, PO4, PO5, PO10	SDG 2, SDG 6, SDG 9
16	Smart irrigation system	Estimate crop water requirement, propose control logic, and quantify water savings compared with conventional irrigation.	PO1, PO2, PO3, PO4, PO5, PO10	SDG 2, SDG 6, SDG 12
17	Youth mentoring programmes	Deliver a structured mentoring activity and measure participation, engagement, and skill/awareness improvement.	PO6, PO8, PO9, PO10, PO11	SDG 4, SDG 10, SDG 17
18	Adult education	Conduct learner-needs assessment, prepare instructional content, and measure improvement in basic literacy or numeracy indicators.	PO6, PO8, PO9, PO10, PO11	SDG 4, SDG 10, SDG 17
19	Food security initiatives / cold storage system	Estimate storage need, design a simple cold-chain concept, and document reduction in spoilage or wastage.	PO1, PO2, PO3, PO4, PO5, PO10	SDG 2, SDG 9, SDG 12
20	Human rights awareness with legal systems	Prepare and deliver an awareness module and assess increase in legal awareness and access-to-rights understanding.	PO6, PO7, PO8, PO9, PO10	SDG 5, SDG 10, SDG 16
21	House tax collection through digital media	Develop a simple digital workflow or awareness support and measure improvement in compliance, convenience, or response time.	PO2, PO3, PO4, PO5, PO10, PO11	SDG 9, SDG 11, SDG 16
22	Use of application / application program	Build or demonstrate a useful community app and measure usability, adoption, or efficiency improvement.	PO1, PO3, PO4, PO5, PO9, PO10	SDG 9, SDG 11, SDG 17
23	Creation of Panchayat library	Plan the library model, catalogue resources, and measure usage, accessibility, or participation outcomes.	PO6, PO8, PO9, PO10, PO11	SDG 4, SDG 10, SDG 11, SDG 17

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Suggested Learning Resources:

Textbooks:

1. **Phadke, N. D**. Community Engagement and Social Innovation. 1st ed., Oxford University Press, New Delhi.
2. **Garg, N. R**. Project-Based Learning in Engineering Education. 1st ed., Pearson India Education Services, Noida.
3. **Gupta, A. and P. Singh.** Service Learning and Community Projects. 1st ed., McGraw-Hill Education (India), New Delhi.
4. **Wilson, G.** Practical Guide to Community Development Projects. 2nd ed., Routledge, London.

Reference books:

1. NPTEL courses on Project-Based Learning and Social Innovation.
2. SWAYAM courses on community engagement and sustainability.
3. UN Sustainable Development Goals portal: https://sdgs.un.org
4. MyGov India and local civic body portals for community initiatives.
5. YouTube resources on design thinking, social innovation, and community service learning.
6. NGO and government field-action case studies related to sanitation, water, health, education, and environment.

Web links and Video Lectures (e-Resources):

1. NPTEL courses on Engineering Geology (IIT Roorkee, IIT Kharagpur).
2. NPTEL courses on Soil Mechanics and Foundation Engineering (IIT Delhi, IIT Bombay).
3. Virtual Labs – Geotechnical Engineering Virtual Lab (IIT Kanpur): https://vlab.co.in
4. Geological Survey of India (GSI) – Maps, reports, and publications: https://www.gsi.gov.in
5. YouTube channels: Civil Engineering Essentials, The Engineering Classroom (soil mechanics experiments).
6. American Society of Civil Engineers (ASCE) – Geotechnical resources and standards

Teaching Learning Process:

The suggested TLP for Community / Societal Project is as follows;

Week / Phase	Teaching–Learning Activity	Faculty Role	Student Activity	Output / Evidence
1	Course introduction, objectives, ethics, conduct, and assessment briefing	Explain course scope, rules, rubrics, and expected deliverables	Understand course requirements and form teams	Team list, course plan
2	Community problem identification and topic selection	Guide topic framing and feasibility	Identify local issues through discussion and observation	Shortlisted project topic
3	Stakeholder interaction and preliminary survey	Demonstrate survey methods and stakeholder engagement	Collect initial data from community/users	Survey notes, interview record

4	Problem statement and objective formulation	Review and refine problem statement	Prepare problem statement, scope, and objectives	Approved problem statement
5	Literature/case study review and baseline analysis	Suggest relevant references and examples	Study existing solutions and compare approaches	Baseline analysis summary
6	Project planning and role assignment	Help teams organize tasks, timeline, and responsibilities	Plan activities, divide roles, and prepare schedule	Work plan / Gantt chart
7	Feasibility analysis and solution brainstorming	Check technical feasibility and practicality	Generate possible engineering solutions	Solution alternatives sheet
8	Selection of final solution and design approach	Review final concept and design logic	Finalize concept, methods, and expected outcome	Concept note / design outline
9	Data processing / calculations / sizing / mapping	Support computations and technical review	Analyze data, perform calculations, prepare maps/charts	Technical analysis sheet
10	Prototype / model / audit / DPR / app development	Monitor progress and correct technical issues	Develop the selected output	Working model / draft DPR / map / app
11	Testing, refinement, and implementation planning	Evaluate technical correctness and improvements	Test prototype or validate proposal with users	Test results / revised output
12	Field implementation / demonstration / awareness activity	Facilitate community interaction and documentation	Conduct implementation or demonstration	Photos, attendance, implementation record
13	Documentation of outcomes, feedback, and impact	Review report structure and completeness	Compile findings, stakeholder feedback, and observations	Draft report
14	Presentation preparation and viva practice	Conduct mock presentation and feedback	Prepare slides/poster and rehearse	Presentation deck
15	Final presentation, submission, and reflection	Evaluate performance using rubrics	Present project, submit report, reflect on learning	Final report, presentation, viva

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Assessment structure:

A. Continuous Internal Evaluation (CIE) – 50 marks

- Students, in batches of 3–4, shall undertake at least one project (or a combination of two related activities) aiming, as far as possible, at a logical implemented or implementable outcome.
- CIE will be conducted by a departmental committee (HoD/nominee, guide and one senior faculty) using the following rubrics totalling 50 marks:

CIE pass requirement:

- A student shall secure a minimum of 20 marks out of 50 in CIE to become eligible to appear for SEE.
- Students who fail to earn the required CIE marks may be given additional opportunities before closure of the semester; no re-doing of CIE is permitted after the end of the semester.

B. Semester End Examination (SEE) – 100 marks (scaled to 50)

- Examination duration: 2 hours.
- Maximum examination marks: 100 (entered as 100 in the VTU portal; the ITI-SMU module automatically scales 100 → 50 for result processing).
- The SEE shall be conducted batch-wise by a committee of three faculty: project guide, one faculty from the same department and one from a different department.

SEE pass requirement and overall passing rule:

- For a pass in SEE, a student shall secure minimum 35 marks out of 100.
- For declaration of a pass grade, the sum of CIE marks (out of 50) and scaled SEE marks (out of 50) shall be ≥ 40; otherwise, the student is awarded grade F (Fail).

CIE Rubric — Continuous Internal Evaluation (Total 50 marks):

Criterion	Weight (marks)	Excellent (Full marks)	Good	Fair	Needs Improvement
Problem identification & Relevance to society/industry/ community	8	Problem is clearly identified with strong evidence of societal relevance and well-defined scope.	Problem is relevant and scope is clear with adequate supporting evidence.	Problem defined but justification or evidence is weak.	Problem unclear or not relevant; little/no supporting evidence.
Formation of problem statement; Engineering approach, innovation & feasibility	10	Problem statement is precise; approach is sound, innovative and clearly feasible.	Problem statement adequate; approach feasible with minor gaps.	Problem statement partial; approach feasibility is marginal.	Problem statement missing or approach not feasible.
Interaction with stakeholders; Data collection, analysis & interpretation	8	Thorough stakeholder engagement; data collection is comprehensive; analysis is well-interpreted.	Good engagement; data and analysis adequate with minor gaps.	Limited engagement; data incomplete and analysis superficial.	Little/no stakeholder contact; insufficient or no data/ analysis.

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Project documentation; Clarity, organization & problem-solving demonstrated	10	Documentation is complete, well-organized, analytical, and shows strong problem-solving.	Documentation complete and clear with some analytical content.	Documentation basic with omissions; problem-solving limited.	Documentation missing/poorly organized; no clear problem-solving .
Communication & Presentation skills	6	Presentation is confident, structured, and answers queries fully; visuals effective.	Presentation clear and satisfactory; responds to most queries.	Presentation acceptable but lacks clarity or confidence; weak responses.	Presentation poor or absent; unable to respond.
Contribution & Benefit tosociety (impact, sustainability)	8	Clear, demonstrable societal benefit and sustainability; realistic path to implementation.	Benefit plausible; sustainability considered with minor gaps.	Limited or unclear societal benefit; sustainability not well addressed.	No evident benefit or sustainability; project not community-oriented.

Notes for CIE rubric:

- Minimum CIE pass requirement: 20/50 to be eligible for SEE. [Use departmental committee (HoD/guide + senior faculty) to apply the rubric and record marks.]

SEE Rubric — Semester End Examination (Enter marks out of 100; scaled to 50 later):

Criterion	Weight (marks)	Excellent (Full marks)	Good	Fair	Needs Improvement
Problem identification & Relevance to society/industry/ community	16	Problem and relevance are articulated clearly with strong evidence and context.	Problem relevance clear with reasonable evidence.	Problem stated but evidence/ context weak.	Problem poorly defined or irrelevant.
Formation of problem statement; Engineering approach, innovation & feasibility	20	Problem statement is precise; approach demonstrates engineering depth, novelty and feasibility.	Approach is technically sound and feasible with minor limitations.	Approach basic; limited technical depth or feasibility concerns.	No viable engineering approach or infeasible plan.
Interaction with stakeholders; Data collection, analysis & interpretation	16	Excellent stakeholder engagement; rigorous data collection and insightful analysis.	Good engagement and acceptable analysis.	Superficial data collection and limited analysis.	Inadequate or no data; poor analysis.

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Project documentation; Clarity, technical rigor & problem-solving demonstrated	20	Report is comprehensive, technically rigorous, and demonstrates systematic problem-solving.	Report is complete and technically correct with minor gaps.	Report lacks technical depth or has notable omissions.	Report missing key elements or technically incorrect.
Communication, Presentation & Viva-voce responses	12	Candidate presents expertly, defends work persuasively and answers all queries correctly.	Good presentation and satisfactory answers to most queries.	Presentation adequate but fails to answer some technical questions.	Poor presentation and unable to defend work.
Contribution & Benefit to society; Impact assessment & sustainability	16	Clear, evidence-based assessment of social impact and Sustainability with scaling recommendations.	Reasonable impact discussion and sustainability considerations.	Limited evaluation of impactor sustainability.	No coherent assessment of impact or sustainability.

SEE pass rule:

- Student must secure at least 35/100 in SEE itself to be eligible for pass consideration.
- Final passing is based on CIE (out of 50) + SEE (scaled to 50) >= 40. Otherwise, grade F (Fail) is awarded.

Suggested implementation notes (for BoS / exam committees):

- Use numerical scores from the rubric and keep brief evaluator comments for each criterion.
- For team projects: record individual contribution within the documentation and adjust individual marks using a peer-evaluation sheet or guide's assessment.
- Maintain evidence (field notes, photos, questionnaires, DPRs, reports) as annexures for SEE moderation.
- Use standardized score sheet (spreadsheet) mapping rubric items to columns for easy aggregation and archival.

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BIOPROCESS PRINCIPLES & STOICHIOMETRY			
Course Code	**1BBT401**	Scheme	**2025**
Type of Course	**PCC**	Semester	**04**
Teaching Hours/Week (L:T:P)	**3:2:0**	CIE Marks	**50**
Total Hours of Pedagogy per semester L /T/P/SL&TW:	**42:28:0:50**	SEE Marks	**50**
Credits	**4**	Total Marks	**100**
Examination type (SEE)	**Theory**	Exam Hours	**3**

Course outcome (Course Skill Set)

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

CO1: Apply basic bioprocess calculations and concentration units.
CO2: Analyze gas–vapor systems using gas laws and humidity concepts.
CO3: Perform stoichiometric and material balance calculations.
CO4: Apply energy balance principles to chemical and bioprocess systems.
CO5: Explain bioprocess principles and microbial stoichiometry.

Module-1

INTRODUCTION TO BIOPROCESS CALCULATIONS:

Concept of atom and mole, expressing composition of mixtures in Solids, liquids and gases. Expressingcomposition of mixtures and solutions - Percentage by weight percentage, mole percentage and Volumepercentage; Normality, Molarity, Molality.

Number of Hours:8 hrs

Module-2

IDEAL GAS LAW AND VAPOUR-PRESSURE:

Dalton's law and Amagat's Law, Relationshipbetween partial pressure and mole fraction, Average molecular weight of gas mixture. Vapour- Pressure concept, effect of temperature on vapour pressure, TX-Y diagram, Raoult's law and Henry's law. Humidity concepts. Humidity chart

Number of Hours:8 hrs

Module-3

CHEMICAL EQUATION AND MATERIAL BALANCES :

Basics of chemical equation and stoichiometry, limiting reactant, excess reactant, conversion, selectivity, yield. Basic concepts involved in material balance calculations, material balance problems without chemical reactions: (Distillation, Extraction, Crystallization, Drying, Mixing and Evaporation) Basic concepts of recycle, bypass and purge streams.

Number of Hours:8 hrs

Module-4

ENERGY BALANCE:

General energy balance equation for steady state. Heat capacity, estimation of heat capacity for solids,liquids, gases and their mixtures. Enthalpy, Standard Heat of formation, standard heat of reaction, Standard heat of combustion and calorific value, Calculation of heat of reaction at elevated temperature.

Number of Hours:8 hrs

Module-5

BIOPROCESS PRINCIPLES & STOICHIOMETRY OF BIOPROCESS:

Historical development of bioprocess technology; Bioprocess principles and operations, generalized processflow sheets. General material balance equation for steady state (for manufacture of penicillin and ethanol) -outline of a bioprocess and the various (upstream and downstream) unit operations involved inbioprocesses. Stoichiometry of microbial growth and product formation.

Number of Hours:8 hrs

Suggested Learning Resources: (Text Book/ Reference Book/ Manuals):

Text books:

1. Basic Principles and Calculations in Chemical Engineering by Himmelblau D. M. Ed 6. PHI Publishers (6th Ed.), 1997.
2. Bioprocess Engineering, Basic concepts by Shuler & Kargi, PHI Publishers (2nd Ed.) 2002

Reference books / Manuals:

1. Chemical Process Principles Part – I by Hougen O. A., Waston K. M. and Ragatz R. A., Wiley, New York
2. Stoichiometry (SI Units) by Bhatt B. L. and Vora S. M. Tata McGraw Hill (3rd Ed.), 1996.

Web links and Video Lectures (e-Resources):

- NPTEL – Material and Energy Balances (IIT Madras) https://nptel.ac.in/courses/102106069
- NPTEL – Fundamentals of Bioprocess Engineering (IIT Guwahati) https://nptel.ac.in/courses/102103672
- NPTEL – Material & Energy Balance Computations (IIT Kharagpur) https://nptel.ac.in/courses/103105209
- MIT OpenCourseWare – Chemical Engineering Courses https://ocw.mit.edu
- NPTEL YouTube – Material and Energy Balances Playlist https://www.youtube.com/playlist?list=PLyqSpQzTE6M-QFqMp7_FJ_NuGCXDuHqvf

Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

1. Interactive lectures with real-world bioprocess case studies.
2. Problem-solving sessions on material and energy balance calculations.
3. ICT-enabled teaching using simulations, animations, and multimedia.
4. Flipped classroom with pre-class video lectures and discussions.
5. Group assignments and collaborative learning activities.
6. Tutorial sessions with numerical problem-solving.
7. Mini-projects based on industrial bioprocess applications.
8. Seminar presentations on recent advances in bioprocess engineering.
9. Industry-based case studies and process flow analysis.
10. Use of NPTEL/MOOC video lectures and online quizzes for self-learning.

AssessmentStructure:

The assessment in each course is divided equally between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each carrying 50% weightage.

- To qualify and become eligible to appear for SEE, in the **CIE**, a student must score at least **40% of 50 marks**, i.e., **20 marks**.
- To pass the **SEE**, a student must score at least **35% of 50 marks**, i.e., **18 marks**.
- Notwithstanding the above, a student is considered to have **passed the course,** provided the combined total of **CIE and SEE** is at least **40 out of 100 marks**.

Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal EvaluationCIE [25+25=50 marks]

A minimum of two Internal Assessment Tests(IA)shall be conducted, carrying a total of 25 marks.

In addition, Continuous Comprehensive Assessment (CCA) shall be conducted for a total of 25 marks.

It is recommended to include a maximum of two learning activities as part of the CCA to foster the holistic development of students. These activities shall be:

Sl. No.	Name of the Learning activity	Maximum Marks
1.	Assignment	10
2.	Quiz/Seminar/Casestudy/Project based learning	15

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Rubrics for Learning Activity (Based on the nature of learning activity, design the rubrics for each activity):

Assignment (10 Marks)

Performance Indicator (CO/PO Mapping)	Superior (5)	Good (4)	Fair (3)	Needs Improvement (2)	Unacceptable (1)
PI-1: Conceptual Understanding (CO1, CO2 / PO1)	Excellent understanding with accurate explanations	Good understanding with minor errors	Satisfactory understanding	Limited understanding	Poor understanding
PI-2: Problem Solving & Presentation (CO3, CO4, CO5 / PO2, PO10)	Accurate calculations, logical presentation and timely submission	Minor errors	Satisfactory work	Incomplete or poorly presented	Not submitted

Quiz / Seminar / Case Study / Project-Based Learning (15 Marks)

Performance Indicator (CO/PO Mapping)	Superior (5)	Good (4)	Fair (3)	Needs Improvement (2)	Unacceptable (1)
PI-1: Technical Knowledge (CO1–CO5 / PO1)	Excellent conceptual knowledge	Good knowledge	Satisfactory knowledge	Limited knowledge	Poor knowledge
PI-2: Analytical & Problem-Solving Skills (CO3, CO4 / PO2, PO4)	Excellent analysis and application	Good analysis	Basic analysis	Limited analysis	Unable to analyze
PI-3: Communication & Teamwork (CO5 / PO9, PO10)	Excellent communication and teamwork	Good communication	Satisfactory communication	Poor communication	No participation

Suggested Learning Activities may include (but are not limited to):

- Course Project
- Case Study Presentation
- Programming Assignment
- Tool/Software Exploration
- Literature Review
- Open Book Test (preferably at RBL4 and RBL5 levels)
- GATE-based Aptitude Test
- Assignment (at RBL3, RBL4, or RBL5 levels)
- Any other relevant and innovative academic activity
- Use of MOOCs and Online Platforms

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Suggested Innovative Delivery Methods may include (but are not limited to):

- Flipped Classroom
- Problem-Based Learning (PBL)
- Case-Based Teaching
- Simulation and Virtual Labs
- Partial Delivery of course by Industry expert/ industrial visits
- ICT-Enabled Teaching
- Role Play

Team Work (TW) and Self Learning (SL) components in Number of Hours per semester

Team work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)

Sl. No.	Team Work (TW) Activity	Number of Hours / Semester
1.	Assignments, seminars, micro projects, industrial visits, any other student activities etc.	25

SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.

Sl. No.	Self-Learning (SL) Activity	Number of Hours / Semester
1.	NPTEL,MIT,MOOCs, spoken tutorials, online educational resources etc.	25

Continuous Internal Evaluation (CIE)

1. The CIE marks shall be decided based on internal tests and other outcome-based activities. The continuous internal evaluation shall be carried out by the teacher handling the course.
2. Out of 50 marks earmarked for CIE, 25 marks shall be assigned for internal tests. The first test shall be conducted after completing two modules of the syllabus and the second one after completing the remaining three modules.
3. The remaining 25 marks shall be assigned for Continuous Course Assessment (CCA), conducted as per the rubrics listed in the assessment section of the respective syllabus.
4. A student shall obtain a minimum of 40% marks or 20 out of 50 marks allotted to CIE to become eligible to appear for the SEE.

Passing requirement in SEE

1. For a pass in the Semester End Examination (SEE), a student shall secure a minimum of 35 marks out of 100.
2. For the declaration of a pass grade, the sum of the Continuous Internal Evaluation (CIE) marks (out of 50) marks and the SEE marks scaled down to 50 shall be greater than or equal to 40 marks.
3. If the total (CIE + SEE) is less than 40 marks, the student shall be awarded the grade ‘F’ (Fail).

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BIOCHEMISTRY + Lab			
Course Code	**1BBT402**	Scheme	**2025**
Type of Course	**IPCC**	Semester	**04**
Teaching Hours/Week (L:T:P)	**3:0:2**	CIE Marks	**50**
Total Hours of Pedagogy per semester L /T/P/SL&TW:	**42:0:28:50**	SEE Marks	**50**
Credits	**4**	Total Marks	**100**
Examination type (SEE)	**Theory- CIE +SEE, and Lab- CIE only.**	Exam Hours	**03**

Course outcome (Course Skill Set)

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

CO1: Explain the structure, properties, and biological functions of biomolecules.

CO2: Apply the principles of bioenergetics and energy metabolism in biological systems.

CO3: Analyze carbohydrate metabolic pathways and their regulation in health and disease.

CO4Explain lipid metabolism, its regulation, and associated metabolic disorders.

CO5: Evaluate amino acid and nucleotide metabolism and relate metabolic disorders to biochemical pathways.

Module-1

BASIC CONCEPTS:

Chemical basis of life; chemical bonds and molecular interactions in biological systems; water and its biological significance; acids, bases, pH, pKa, Henderson–Hasselbalch equation, biological buffer systems and their properties; concentration units and preparation of solutions. Stereochemistry of carbon compounds including chirality, optical isomerism and stereoisomerism of biomolecules. Classification, structure, properties and biological functions of carbohydrates, lipids, amino acids, proteins and nucleic acids. Levels of protein structure and structure–function relationships.

Number of Hours:08 hrs

Module-2

BIOENERGETICS:

Introduction to bioenergetics and energy flow in living systems. Thermodynamic laws and their applications in biological systems. Standard free energy change (ΔG) and equilibrium constant. Coupled reactions and high-energy compounds. Structure, properties and biological significance of ATP. Biological oxidation and electron transport chain (ETC). ATP synthesis and chemiosmotic theory. Oxidative phosphorylation and energy balance during cellular respiration. Reactive oxygen species (ROS), oxidative stress and antioxidant defense mechanisms. Photosystems I and II, photophosphorylation, synthesis of ATP and NADPH during photosynthesis. Inhibitors and uncouplers of electron transport and oxidative phosphorylation.

Number of Hours: 08 hrs

Module-3

METABOLISM OF CARBOHYDRATE:

Carbohydrates as major sources of cellular energy. Glycolysis and its regulation under aerobic and anaerobic conditions. Pyruvate metabolism and fermentation pathways. Tricarboxylic Acid (TCA) Cycle, regulation and energetics. Amphibolic nature of the TCA cycle and anaplerotic reactions. Pentose Phosphate Pathway (PPP) and NADPH generation. Gluconeogenesis and its regulation. Calvin Cycle and carbon fixation in photosynthetic organisms. Glyoxylate cycle and its significance in plants and microorganisms. Disorders of carbohydrate metabolism including lactose intolerance, galactosemia and diabetes mellitus.

Number of Hours:08 hrs

Module-4

METABOLISM OF LIPID:

Structure, classification and biological significance of lipids. Digestion, absorption, mobilization and transport of fats. Biosynthesis of fatty acids with emphasis on palmitic acid synthesis, phospholipid biosynthesis and regulation. Biodegradation of triglycerides and fatty acids through β-oxidation and energetics of lipid metabolism. Physiology and metabolism of lipoproteins and apolipoproteins. Ketone body formation and utilization. Integration and regulation of lipid metabolism. Disorders of

lipid metabolism including atherosclerosis, ketosis and ketoacidosis, Gaucher disease and LDL-hypercholesterolemia.

Number of Hours: 08 hrs

Module-5

METABOLISM OF AMINO ACIDS & NUCLEIC ACIDS:

Biosynthesis of amino acids with emphasis on lysine, phenylalanine and glutamine. Catabolism of amino acids including transamination, deamination, decarboxylation and ammonia detoxification. Urea cycle and its regulation. Integration of amino acid metabolism with carbohydrate and lipid metabolism. Disorders of amino acid metabolism including phenylketonuria (PKU), alkaptonuria, tyrosinemia and maple syrup urine disease (MSUD). Biosynthesis, degradation and regulation of purine and pyrimidine nucleotides. De novo and salvage pathways of nucleotide biosynthesis. Disorders of nucleotide metabolism including gout, Lesch–Nyhan syndrome, hyperuricemia, hypouricemia and adenosine deaminase (ADA) deficiency.

Number of Hours:08 hrs

PRACTICAL COMPONENTS

1. Measurement of pH, volume, weight, concentration units, accuracy, precision, sensitivity, specificity, and preparation of Normal, Molar and Percentage solutions.
2. Determination of the titration curve and isoelectric point of amino acids using acid–base titration.
3. Qualitative analysis of carbohydrates using Molisch's/Benedict's/Fehling's/Barfoed's/ Seliwanoff's / Iodine tests.
4. Qualitative analysis of lipids using solubility/Sudan staining/emulsification/acrolein / unsaturation tests.
5. Qualitative analysis of amino acids and proteins using Ninhydrin/Biuret/Xanthoproteic/Millon's, Hopkins–Cole /Sakaguchi tests.
6. Determination of the saponification value and iodine value of lipids with error analysis.
7. Separation of chlorophyll pigments by paper chromatography and isolation of chloroplasts from plant leaves.
8. Quantitative estimation of reducing sugars by the DNS (3,5-dinitrosalicylic acid) method.
9. Quantitative estimation of amino acids by the Ninhydrin method.
10. Quantitative estimation of DNA by the Diphenylamine (DPA) method.
11. Quantitative estimation of proteins by the Lowry or Bradford method.
12. Quantitative estimation of urea by the Diacetyl Monoxime (DAM) method and iron by the 1,10-Phenanthroline colorimetric method.

Suggested Learning Resources: (Text Book/ Reference Book/ Manuals):

Text books:

1. Lehninger Principles of Biochemistry, David L. Nelson, Michael M. Cox, 6th / 7th Edition, W.H. Freeman, 2017
2. Principles of Biochemistry, Donald Voet, Judith G. Voet, Charlotte W. Pratt, 4th Edition, John Wiley & Sons, 2012.
3. Jereny M. Berg, John L. Tymoczko, Lubert Stryer (2006) Biochemistry, 6th Edn. W H Freeman Publisher, New York, USA

Reference Books:

1. Harper's Illustrated Biochemistry by Victor W. Rodwell, David Bender, Kathleen M. Botham, Peter J. Kennelly,P. Anthony Weil, Thirty-First Edition (A & L LANGE SERIES), 2018.
2. Biochemistry, U Satyanarayana, 5th Edition Books & Allied Ltd., 2017.
3. Biochemistry, Denise Ferrier, Lippincott, Williams & Wilkins, 2017.

Web links and Video Lectures (e-Resources):

VTU EDUSAT / SWAYAM / NPTEL / MOOCS / Coursera / MIT-open learning resource

- https://ocw.mit.edu/courses/7-012-introduction-to-biology-fall-2004/resources/lecture-2-biochemistry-1/
- https://onlinecourses.nptel.ac.in/noc22_cy06/preview
- https://ocw.mit.edu/courses/5-111-principles-of-chemical-science-fall-

2008/resources/lecture-36/
- https://cosmolearning.org/courses/biochemistry-i/video-lectures
- https://ocw.mit.edu/courses/7-012-introduction-to-biology-fall-2004/resources/lecture-2-biochemistry-1/
- https://onlinecourses.nptel.ac.in/noc22_cy06/preview
- https://www.udemy.com/course/introduction-to-biochemistry/
- https://www.edx.org/learn/biochemistry

Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

1. Interactive lectures using multimedia presentations and animations.
2. Demonstration-based laboratory sessions with hands-on experiments.
3. Case studies on biochemical pathways and metabolic disorders.
4. Problem-based learning through numerical and analytical exercises.
5. ICT-enabled teaching using virtual labs and simulation tools.
6. Flipped classroom with NPTEL/MOOC video lectures.
7. Group discussions, seminars, and student presentations.
8. Mini-projects on biochemical analysis and data interpretation.
9. Collaborative learning through peer instruction and laboratory teamwork.
10. Continuous assessment using quizzes, assignments, and practical demonstrations.

Assessment Structure:

The assessment for each course is equally divided between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each component carrying **50% weightage** (i.e., 50 marks each).

The CIE Theory component will be **25 marks** and CIE Practical component will be **25 marks**.

The CIE Theory component consists of IA tests for 25 marks. The CIE Practical component for continuous assessments will be for 15 marks through rubrics and for lab tests will be for 10 marks.

- To qualify and become eligible to appear for SEE, in the **CIE theory component**, a student must score at least **40% of 25 marks**, i.e., **10 marks**.
- To qualify and become eligible to appear for SEE, in the **CIE Practical component**, a student must secure **a minimum of 40% of 25 marks**, i.e., **10 marks**.
- To pass the **SEE**, a student must secure **a minimum of 35% of 50 marks**, i.e., **18 marks**.
- A student is deemed to have **successfully completed the course** if the **combined total of CIE and SEE is at least 40 out of 100 marks**.

CIE Practical component:

The CIE marks awarded in the case of the Practical component shall be based on the continuous evaluation of the laboratory report using a defined set of rubrics. Each experiment report can be evaluated for 30 marks. The summation of all the experiments marks to be scaled down to 15 marks.

The laboratory test (duration 03 hours) at the end of the last week of the semester /after completion of all the experiments (whichever is early) shall be conducted for 50 marks and scaled down to 10 marks. For laboratory test, the student is required to conduct one experiment.

Rubrics for Learning Activity (Based on the nature of learning activity, design the rubrics for each activity):

Performance Indicator	Superior (5)	Good (4)	Fair (3)	Needs Improvement (2)	Unacceptable (1)
PI-1: Conceptual Understanding (CO1/PO1)	Excellent understanding	Good understanding	Satisfactory	Limited	Poor
PI-2: Experimental Planning (CO2/PO2)	Independent planning	Minor guidance	Moderate guidance	Extensive guidance	Unable
PI-3: Laboratory Skills (CO3/PO5)	Accurate execution	Minor errors	With guidance	Frequent errors	Unable
PI-4: Data Analysis (CO4/PO4)	Accurate analysis	Minor errors	Basic analysis	Limited	None
PI-5: Teamwork (CO5/PO9)	Excellent	Good	Average	Limited	Poor

Rubrics for CIE – Continuous assessment:

Performance Indicator	Superior (5)	Good (4)	Fair (3)	Needs Improvement (2)	Unacceptable (1)
PI-1: Theory Tests (CO1/PO1)	90–100%	75–89%	60–74%	40–59%	<40%
PI-2: Assignments & Record (CO2/PO10)	Complete & timely	Minor errors	Satisfactory	Incomplete	Not submitted
PI-3: Laboratory Performance (CO3/PO5)	Independent	Minor guidance	Moderate guidance	Significant guidance	Unable
PI-4: Viva Voce (CO4/PO1)	Excellent	Good	Basic	Limited	Unable
PI-5: Participation (CO5/PO9)	Excellent	Good	Average	Poor	None

Rubrics for SEE / CIE Test:

Performance Indicator	Superior (5)	Good (4)	Fair (3)	Needs Improvement (2)	Unacceptable (1)
PI-1: Conceptual Knowledge (CO1/PO1)	Excellent	Good	Adequate	Limited	Poor
PI-2: Problem Solving (CO2/PO2)	Accurate	Minor errors	Basic	Frequent errors	Unable
PI-3: Analytical Ability (CO3/PO4)	Excellent	Good	Basic	Limited	None
PI-4: Application (CO4/PO2)	Excellent	Good	Basic	Limited	Unable
PI-5: Communication (CO5/PO10)	Excellent	Good	Satisfactory	Poor	Incomplete

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Suggested rubrics for Practical continuous assessment:

Performance Indicators	Excellent	Very Good	Good	Satisfactory
Fundamental Knowledge (4) (PO1)	The student has well depth knowledge of the topics related to the course (4)	Student has good knowledge of some of the topics related to course (3)	Student is capable of narrating the answer but not capable to show in depth knowledge (2)	Student has not understood the concepts clearly (1)
Design Of Experiment (5) (PO2 & PO3)	Student is capable of discussing more than one design for his/her problem statement and capable of proving the best suitable design with proper reason (5)	Student is capable of discussing few designs for his/her problem statement but not capable of selecting best (4)	Student is capable of discussing single design with its merits and de-merits (3)	Student is capable of explaining the design (1-2)
Implementation (8) (PO3 & PO8)	Student is capable of implementing the design with best suitable algorithm considering optimal solution. (7-8)	Student is capable of implementing the design with best suitable algorithm and should be capable of explaining it (5-6)	Student is capable of implementing the design with proper explanation. (3-4)	Student is capable of implementing the design. (1-2)
Result &Analysis (5) (PO4)	Student is able to run the program on various cases and compare the result with proper analysis. (5)	Student will be able to run the program for all the cases. (4)	Student will be able to run the code for few cases and analyze the output (3)	Student will be able to run the program but not able to analyze the output (1-2)
Demonstration (8) (PO9)	The lab record is well-organized, with clear sections (e.g., Introduction, Method, Results, Conclusion). Transitions between sections are smooth. (7-8)	The lab record is organized, with clear sections, but some sections are not well-defined. (5-6)	The lab record lacks clear organization or structure. Some sections are unclear or incomplete. (3-4)	The lab record is poorly organized, with missing or unclear sections. (1-2)

Note: Can add Engineering & IT tool usage based on the nature of the course

Suggested Learning Activities may include (but are not limited to):

- Course Project
- Case Study Presentation
- Programming Assignment
- Tool/Software Exploration
- Literature Review
- Open Book Test (preferably at RBL4 and RBL5 levels)
- GATE-based Aptitude Test
- Assignment (at RBL3, RBL4, or RBL5 levels)
- Any other relevant and innovative academic activity
- Use of MOOCs and Online Platforms

Suggested Innovative Delivery Methods may include (but are not limited to):

- Flipped Classroom
- Problem-Based Learning (PBL)

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- Case-Based Teaching
- Simulation and Virtual Labs
- Partial Delivery of course by Industry expert/ industrial visits
- ICT-Enabled Teaching
- Role Play

Term Work (TW) and Self Learning (SL) components in Number of hours per semester		
Term work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)		
Sl. No.	**Term Work (TW) Activity**	**Number of Hours / Semester**
1.	Assignments, seminars, micro projects, industrial visits, any other student activities etc.	25
SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.		
Sl. No.	**Self-Learning (SL) Activity**	**Number of Hours / Semester**
1.	NPTEL,MIT,MOOCs, spoken tutorials, online educational resources etc.	25

Continuous Internal Evaluation (CIE)

(i)Theory component

The CIE marks of 25 shall be earmarked for two tests.

The first test shall be conducted after completing two modules of the syllabus and the second one after completing the rest three modules.

Each test shall be conducted for 25 marks. The average of the two tests scaled down to 25 marks shall constitute the test marks for a maximum of 25 marks.

(ii) Laboratory component

Out of 25 marks, 15 marks shall be assigned for assessment as per the rubrics listed in the course syllabus.

The remaining 10 marks shall be based on the practical test conducted by two Internal examiners appointed by the HoD. The allotment of marks shall be as per the rubrics defined for regular class work and practical test as indicated in the Table – ICs/IPCCs 1.

(i) To qualify and become eligible to appear for the SEE of the IC/IPCC, a student shall secure at least 40 % of 25 marks, i.e., 10 marks, in the CIE theory component, and at least 40 % of 25 marks, i.e., 10 marks in the CIE Practical component.

Table – ICs/IPCCs 1 Distribution of marks		
Component	**Description**	**Marks**
Allotment of marks for regular class work		
Ability in Conducting Experiments	Initiative, skill, safety practices, teamwork, and independent handling of equipment during regular lab sessions.	5 marks
Laboratory Record / Journal	Regular and neat maintenance of lab record, accuracy of results, and timely submission.	10 marks
	Subtotal	**15**
Allotment of marks for CIE practical test		
Laboratory Test / Experiment Performance	Ability to set up apparatus, follow procedure, take observations, and obtain correct results in the test experiment.	5 marks
Viva-Voce	Understanding of theory, concepts, and experimental procedure; ability to explain results and answer related questions.	5 marks
	Subtotal	**10**
	Total	**25**

Passing requirement in SEE

For a pass in the Semester End Examination (SEE), a student shall secure a minimum of 35 marks out of 100.

For the declaration of a pass grade, the sum of the Continuous Internal Evaluation (CIE) marks (out of 50) marks and the SEE marks scaled down to 50 shall be greater than or equal to 40 marks.

If the total (CIE + SEE) is less than 40 marks, the student shall be awarded the grade 'F' (Fail

CELL AND MOLECULAR BIOLOGY			
Course Code	**1BBT403**	Scheme	**2025**
Type of Course	**PCC**	Semester	**04**
Teaching Hours/Week (L:T:P)	**3: 2 : 0**	CIE Marks	**50**
Total Hours of Pedagogy per semester L /T/P/SL&TW:	**42:28:0:50**	SEE Marks	**50**
Credits	**4**	Total Marks	**100**
Examination type (SEE)	**Theory**	Exam Hours	**3**

Course outcome (Course Skill Set)

Course outcome (Course Skill Set)

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

CO1: Explain the structure and function of cells, cell cycle regulation, cell signalling, and cancer biology.

CO2: Analyse DNA replication, repair, recombination, mutagenesis, and genome maintenance mechanisms.

CO3: Explain transcriptional mechanisms and post-transcriptional regulation of gene expression.

CO4: Describe translation, protein targeting, post-translational modifications, and protein degradation pathways.

CO5: Analyse the molecular mechanisms of gene regulation, epigenetics, and hormone-mediated control of gene expression in prokaryotes and eukaryotes.

Module-1

CELL: Structure of Prokaryotic and Eukaryotic cell. DNA as the Genetic material: Griffith, Hershey-Chase experiments. Cell cycle and its regulation, Mitosis and meiosis, Cell signalling: Reception, transduction and response. Programmed cell death. Cancer: Oncogenes, Tumour suppressor genes and their functions, signalling pathways involved in tumorigenesis

Number of Hours: 8 hrs

Module-2

CENTRAL DOGMA OF MOLECULAR BIOLOGY: Replication of DNA in Prokaryotic cell and Eukaryotic cell. Mechanism of action of telomerase, DNA damage, and repair: Base excision repair, mismatch excision repair, photo-reactivation, nucleotide excision, and SoS repair, (Case Study: Xeroderma pigmentosum and Ataxia telangiectasia). Mutagenesis. Homologous & non-homologous recombination, Transposons: DNA Transposons and retrotransposons.

Number of Hours: 8 hrs

Module-3

TRANSCRIPTION IN THE PROKARYOTIC AND EUKARYOTIC CELL: Initiation, elongation, and termination. Post transcription modification. Small interfering RNAs / miRNAs and its relevance. Alternative splicing. mRNA nuclear export, RNA editing, mRNA surveillance mechanism: NMD pathway. Case study.

Number of Hours: 8 hrs

Module-4

TRANSLATION IN THE PROKARYOTIC AND EUKARYOTIC CELL: Initiation, elongation, and termination. Post- translational modification of proteins. Secretory and non-secretory (Chloroplast and Mitochondria). Protein Targeting and Degradation; protein-sorting pathways in eukaryotic cells. Case study

Number of Hours: 8 hrs

Module-5

GENE REGULATION: Regulation of gene expression in prokaryotes (lac-operon and trp-operon). Positive and negative gene regulation in prokaryotes, mechanism of riboswitches. Regulation of gene expression in eukaryotes: Transcriptional, RNA processing, Translational, and Post-translational level. Epigenic regulation, Epigenetic changes in different diseases. Regulation of gene expression by Hormones (steroid hormone, auxin, and gibberellic acid) in eukaryote.

Number of Hours: 8 hrs

Suggested Learning Resources: (Text Book/ Reference Book/ Manuals):

Text books:

1. Molecular Cell Biology, Lodish H, Berk A, Kaiser CA, Krieger M, Bretscher A, Ploegh H, Martin KC, Yaffe
2. M, Amon A, 9th Edn, 2021, MacMillan, ISBN-978-1319426736, ISBN-978-1319365042.
3. Karp's Cell and Molecular Biology, 9th Edn, 2020, John Wiley & Sons Inc, ISBN-10:1119598249, ISBN-13: 978- 1119598244

Web links and Video Lectures (e-Resources):

- https://onlinecourses.nptel.ac.in/noc25_bt12/preview?utm_source=chatgpt.com
- https://ocw.mit.edu/courses/res-7-007-7-06x-cell-biology/?utm_source=chatgpt.com
- https://ocw.mit.edu/courses/res-7-008-7-28x-molecular-biology/?utm_source=chatgpt.com
- https://www.edx.org/learn/cell-biology?utm_source=chatgpt.com
- https://www.coursera.org/courses?query=cell+biology&utm_source=chatgpt.com
- https://www.youtube.com/@AmoebaSisters?utm_source=chatgpt.com
- https://www.udemy.com/topic/cell-biology/?utm_source=chatgpt.com
- https://www.youtube.com/@NPTELHRD?utm_source=chatgpt.com

Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

1. Interactive Learning Using Molecular Pathway Mapping
2. Case-Based Learning on Molecular and Genetic Disorders
3. Bioinformatics and Biological Database Exploration
4. Research Paper Review and Journal Club
5. Computational Visualization and Molecular Simulation
6. Collaborative Model Development and Problem-Based Learning
7. Continuous Competency-Based Assessment with Feedback

Assessment Structure:

The assessment in each course is divided equally between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each carrying 50% weightage.

- To qualify and become eligible to appear for SEE, in the **CIE**, a student must score at least **40% of 50 marks**, i.e., **20 marks**.
- To pass the **SEE**, a student must score at least **35% of 50 marks**, i.e., **18 marks**.
- Notwithstanding the above, a student is considered to have **passed the course,** provided the combined total of **CIE and SEE** is at least **40 out of 100 marks**.

Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal EvaluationCIE [25+25=50 marks]
A minimum of two Internal Assessment Tests(IA)shall be conducted, carrying a total of 25 marks.
In addition, Continuous Comprehensive Assessment (CCA) shall be conducted for a total of 25 marks.
It is recommended to include a maximum of two learning activities as part of the CCA to foster the holistic development of students. These activities shall be:

Sl. No.	Name of the Learning activity	Maximum Marks
1	Assignment	10
2	Quiz/Seminar/Case study/Project based learning	15

Rubrics for Learning Activity (Based on the nature of learning activity, design the rubrics for each activity):

Assignment (10 Marks)

Performance Indicator (CO/PO Mapping)	Superior (5)	Good (4)	Fair (3)	Needs Improvement (2)	Unacceptable (1)
PI-1: Conceptual Understanding (CO1, CO2 / PO1)	Excellent understanding with accurate explanations	Good understanding with minor errors	Satisfactory understanding	Limited understanding	Poor understanding
PI-2: Problem Solving & Presentation (CO3, CO4, CO5 / PO2, PO10)	Accurate calculations, logical presentation and timely submission	Minor errors	Satisfactory work	Incomplete or poorly presented	Not submitted

Quiz / Seminar / Case Study / Project-Based Learning (15 Marks)

Performance Indicator (CO/PO Mapping)	Superior (5)	Good (4)	Fair (3)	Needs Improvement (2)	Unacceptable (1)
PI-1: Technical Knowledge (CO1–CO5 / PO1)	Excellent conceptual knowledge	Good knowledge	Satisfactory knowledge	Limited knowledge	Poor knowledge
PI-2: Analytical & Problem-Solving Skills (CO3, CO4 / PO2, PO4)	Excellent analysis and application	Good analysis	Basic analysis	Limited analysis	Unable to analyze
PI-3: Communication & Teamwork (CO5 / PO9, PO10)	Excellent communication and teamwork	Good communication	Satisfactory communication	Poor communication	No participation

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Suggested Learning Activities may include (but are not limited to):

- Course Project
- Case Study Presentation
- Programming Assignment
- Tool/Software Exploration
- Literature Review
- Open Book Test (preferably at RBL4 and RBL5 levels)
- GATE-based Aptitude Test
- Assignment (at RBL3, RBL4, or RBL5 levels)
- Any other relevant and innovative academic activity
- Use of MOOCs and Online Platform

Suggested Innovative Delivery Methods may include (but are not limited to):

- Flipped Classroom
- Problem-Based Learning (PBL)
- Case-Based Teaching
- Simulation and Virtual Labs
- Partial Delivery of course by Industry expert/ industrial visits
- ICT-Enabled Teaching
- Role Play

Term Work (TW) and Self Learning (SL) components in Number of Hours per semester

Term work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)

Sl. No.	Term Work (TW) Activity	Number of Hours / Semester
1	Assignments, seminars, micro projects, industrial visits, any other student activities etc.	25

SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.

Sl. No.	Self-Learning (SL) Activity	Number of Hours / Semester
1	NPTEL,MIT,MOOCs, spoken tutorials, online educational resources etc.	25

Continuous Internal Evaluation (CIE)

1. The CIE marks shall be decided based on internal tests and other outcome-based activities. The continuous internal evaluation shall be carried out by the teacher handling the course.
2. Out of 50 marks earmarked for CIE, 25 marks shall be assigned for internal tests. The first test shall be conducted after completing two modules of the syllabus and the second one after completing the remaining three modules.
3. The remaining 25 marks shall be assigned for Continuous Course Assessment (CCA), conducted as per the rubrics listed in the assessment section of the respective syllabus.
4. A student shall obtain a minimum of 40% marks or 20 out of 50 marks allotted to CIE to become eligible to appear for the SEE.

Passing requirement in SEE

1. For a pass in the Semester End Examination (SEE), a student shall secure a minimum of 35 marks out of 100.
2. For the declaration of a pass grade, the sum of the Continuous Internal Evaluation (CIE) marks (out of 50) marks and the SEE marks scaled down to 50 shall be greater than or equal to 40 marks.
3. If the total (CIE + SEE) is less than 40 marks, the student shall be awarded the grade 'F' (Fail).

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CELL CULTURE TECHNIQUES			
Course Code	**1BBT404**	Scheme	**2025**
Type of Course	**PCC**	Semester	**04**
Teaching Hours/Week (L:T:P)	**3: 0 : 0**	CIE Marks	**50**
Total Hours of Pedagogy per semester L /T/P/SL&TW:	**42:0:0:48**	SEE Marks	**50**
Credits	**03**	Total Marks	**100**
Examination type (SEE)	**Theory**	Exam Hours	**03**

Course outcome (Course Skill Set)

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

CO1: Explain the fundamentals, principles, laboratory practices, and applications of plant and animal cell culture.

CO2: Prepare culture media and apply sterilization and aseptic techniques for plant and animal cell culture.

CO3: Establish, maintain, preserve, and evaluate plant and animal cell cultures using standard techniques.

CO4: Analyze the characterization, scale-up, and industrial applications of plant and animal cell culture systems.

CO5: Evaluate advanced cell culture technologies, regulatory guidelines, and emerging trends in plant and animal biotechnology.

Module - 1

FUNDAMENTALS OF PLANT AND ANIMAL CELL CULTURE:

History and milestones in plant and animal cell culture; principles of in vitro culture; cellular totipotency in plants and stem cell potency in animals; comparison of plant and animal cells for in vitro culture; organization and design of plant tissue culture and animal cell culture laboratories; laboratory infrastructure, essential equipment, clean room concepts, biosafety levels, Good Laboratory Practices (GLP), Good Cell Culture Practices (GCCP), laboratory documentation, ethics, biosafety regulations, and industrial applications of plant and animal cell culture.

Number of Hours: 8 hrs

Module-2

CULTURE MEDIA, STERILIZATION AND INOCULATION TECHNIQUES:

Nutritional requirements of cultured cells; composition, preparation and sterilization of plant culture me dia (MS, B5, White's, N6) and animal culture media (MEM, DMEM, RPMI-1640, Ham's F12); role of plant growth regulators, serum, hormones and growth factors; sterilization methods including moist heat, dry heat, filtration, UV irradiation and chemical sterilization; surface sterilization of explants and sterilizatio n of animal culture materials; aseptic handling using laminar airflow cabinet and biosafety cabinet; inoc ulation of plant explants and animal tissues/cells; contamination sources, detection and prevention, high lighting similarities and differences between plant and animal cell culturepractices.

Number of Hours: 8 hrs

Module-3

ESTABLISHMENT, MAINTENANCE AND PRESERVATION OF CELL CULTURES:

Selection of plant explants and animal tissues; initiation of primary cultures; callus culture, suspension culture, organ culture and micropropagation in plants; primary, adherent and suspension cultures in animals; incubation requirements including temperature, humidity, CO_2 concentration, photoperiod and light intensity; growth kinetics; subculturing techniques; cell counting and viability assessment; cryopreservation, cell banking and germplasm conservation; contamination diagnosis and troubleshooting with comparative analysis of maintenance and preservation techniques in plant and animal cell cultures.

Number of Hours: 8 hrs

Module-4

CHARACTERIZATION, SCALE-UP AND APPLICATIONS OF CELL CULTURE:

Morphological and molecular characterization of cultured cells; microscopy, cell viability, proliferation and cytotoxicity assays; scale-up of plant and animal cell cultures using shake flasks, microcarriers and bioreactors; production of secondary metabolites, synthetic seeds and transgenic plants; production of vaccines, monoclonal antibodies, recombinant proteins and cell-based therapeutics; applications in

agriculture, pharmaceuticals, diagnostics, regenerative medicine and environmental biotechnology with comparative evaluation of plant and animal cell culture production systems.

Number of Hours: 8 hrs

Module-5

ADVANCED CELL CULTURE TECHNOLOGIES AND EMERGING TRENDS:

Stem cell culture, induced pluripotent stem cells (iPSCs), organoids, spheroids and organ-on-chip systems; hairy root culture, plant molecular farming and genome editing using CRISPR-Cas; automation, robotics, artificial intelligence and image-based monitoring in cell culture laboratories; single-cell technologies; bioprocess digitalization; regulatory guidelines (FDA, EMA, CDSCO), GMP, intellectual property rights, bioethics, entrepreneurship, and future trends in plant and animal cell culture with emphasis on industrial and translational biotechnology..

Number of Hours: 8 hrs

Suggested Learning Resources: (Text Book/ Reference Book/ Manuals):

Text books:

1. Capes-Davis, A. (Ed.) Freshney's Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications, 8th Edition, Wiley-Blackwell, 2021. Covers modern animal cell culture techniques including stem cells, organoids, CRISPR, and 3D culture.
2. George, E. F., Hall, M. A. & De Klerk, G.-J. Plant Propagation by Tissue Culture, 4th Edition, Springer, 2023.
3. Trigiano, R. N. & Gray, D. J. (Eds.) Plant Tissue Culture, Development, and Biotechnology, CRC Press, 2022.
4. Bhojwani, S. S. & Dantu, P. *K.*Plant Tissue Culture: An Introductory Text,Revised Edition, Springer, 2013.

Reference Books:

1. Butler, M.Animal Cell Culture and Technology: The Basics, 2nd Edition, Garland Science/Taylor & Francis.
2. Gamborg, O. L. & Phillips, G. C.Plant Cell, Tissue and Organ Culture: Fundamental Methods, Springer.
3. Razdan, M. K.Introduction to Plant Tissue Culture, 3rd Edition, CRC Press.
4. Doyle, A. & Griffiths, J. B.Cell and Tissue Culture: Laboratory Procedures in Biotechnology, John Wiley & Sons.
5. Bhatia, S.Introduction to Pharmaceutical Biotechnology, 3rd Edition, IOP Publishing, 2018.
6. ATCC (American Type Culture Collection), Animal Cell Culture Guide and Cell Line Authentication Manual*, Latest Edition.*
7. Merck (Sigma-Aldrich), Cell Culture Handbook: Media Preparation and Aseptic Techniques, Latest Edition.
8. HiMedia Laboratories, Plant Tissue Culture Manual and Media Preparation Handbook, Latest Edition.

Web links and Video Lectures (e-Resources):

1. NPTEL – Cell Culture Technologies (IIT Kanpur) https://nptel.ac.in/courses/102104059
2. NPTEL – Introduction to Plant Tissue Culture (IIT Guwahati) https://nptel.ac.in/courses/102103016
3. NPTEL – Plant Cell Bioprocessing (IIT Madras) https://nptel.ac.in/courses/102106080
4. NPTEL Video Lectures – Cell Culture Technologies https://www.digimat.in/nptel/courses/video/102104059/L01.html
5. NPTEL Video Lectures – Plant Cell Bioprocessing https://www.digimat.in/nptel/courses/video/102106080/102106080.html

Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

- **Flipped Classroom and Interactive Lectures-**Pre-class learning through videos, NPTEL/SWAYAM modules, and scientific literature, followed by in-class discussions, concept mapping, and problem-solving sessions.
- **Demonstration and Virtual Laboratory-Based Learning-**Demonstration of aseptic techniques, media preparation, sterilization, inoculation, incubation, cryopreservation, and contamination control using laboratory demonstrations, virtual labs, and simulation tools.
- **Case Study and Problem-Based Learning (PBL)-**Analysis of real-world case studies from plant tissue culture, vaccine production, stem cell therapy, micropropagation, biopharmaceutical manufacturing, contamination incidents, and quality assurance practices to develop critical thinking and decision-making skills.
- **Industry-Oriented Collaborative Learning-**Student seminars, group discussions, research article reviews, industry expert talks, and mini-projects on emerging areas such as 3D cell culture, organoids, plant molecular farming, AI-assisted cell culture, bioreactors, and regulatory compliance.

Assessment Structure:

The assessment in each course is divided equally between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each carrying 50% weightage.

- To qualify and become eligible to appear for SEE, in the **CIE**, a student must score at least **40% of 50 marks**, i.e., **20 marks**.
- To pass the **SEE**, a student must score at least **35% of 50 marks**, i.e., **18 marks**.
- Notwithstanding the above, a student is considered to have **passed the course,** provided the combined total of **CIE and SEE** is at least **40 out of 100 marks**.

Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal EvaluationCIE [25+25=50 marks]

A minimum of two Internal Assessment Tests(IA)shall be conducted, carrying a total of 25 marks. In addition, Continuous Comprehensive Assessment (CCA) shall be conducted for a total of 25 marks.

It is recommended to include a maximum of two learning activities as part of the CCA to foster the holistic development of students. These activities shall be:

Sl. No.	Name of the Learning activity	Maximum Marks
1	Assignment	10
2	Quiz/Seminar/Case study/Project based learning	15

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Rubrics for Learning Activity (Based on the nature of learning activity, design the rubrics for each activity):

Assignment (10 Marks)

Performance Indicator (CO/PO Mapping)	Superior (5)	Good (4)	Fair (3)	Needs Improvement (2)	Unacceptable (1)
PI-1: Conceptual Understanding (CO1, CO2 / PO1)	Excellent understanding with accurate explanations	Good understanding with minor errors	Satisfactory understanding	Limited understanding	Poor understanding
PI-2: Problem Solving & Presentation (CO3, CO4, CO5 / PO2, PO10)	Accurate calculations, logical presentation and timely submission	Minor errors	Satisfactory work	Incomplete or poorly presented	Not submitted

Quiz / Seminar / Case Study / Project-Based Learning (15 Marks)

Performance Indicator (CO/PO Mapping)	Superior (5)	Good (4)	Fair (3)	Needs Improvement (2)	Unacceptable (1)
PI-1: Technical Knowledge (CO1–CO5 / PO1)	Excellent conceptual knowledge	Good knowledge	Satisfactory knowledge	Limited knowledge	Poor knowledge
PI-2: Analytical & Problem-Solving Skills (CO3, CO4 / PO2, PO4)	Excellent analysis and application	Good analysis	Basic analysis	Limited analysis	Unable to analyze

Suggested Learning Activities may include (but are not limited to):

- Course Project
- Case Study Presentation
- Programming Assignment
- Tool/Software Exploration
- Literature Review
- Open Book Test (preferably at RBL4 and RBL5 levels)
- GATE-based Aptitude Test
- Assignment (at RBL3, RBL4, or RBL5 levels)
- Any other relevant and innovative academic activity
- Use of MOOCs and Online Platforms

Suggested Innovative Delivery Methods may include (but are not limited to):

- Flipped Classroom
- Problem-Based Learning (PBL)
- Case-Based Teaching
- Simulation and Virtual Labs
- Partial Delivery of course by Industry expert/ industrial visits
- ICT-Enabled Teaching
- Role Play

Term Work (TW) and Self Learning (SL) components in Number of Hours per semester

Term work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)

Sl. No.	Term Work (TW) Activity	Number of Hours / Semester
1	Assignments, seminars, micro projects, industrial visits, any other student activities etc.	24

SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.

Sl. No.	Self-Learning (SL) Activity	Number of Hours / Semester
1	NPTEL,MIT,MOOCs, spoken tutorials, online educational resources etc.	24

Continuous Internal Evaluation (CIE)

1. The CIE marks shall be decided based on internal tests and other outcome-based activities. The continuous internal evaluation shall be carried out by the teacher handling the course.
2. Out of 50 marks earmarked for CIE, 25 marks shall be assigned for internal tests. The first test shall be conducted after completing two modules of the syllabus and the second one after completing the remaining three modules.
3. The remaining 25 marks shall be assigned for Continuous Course Assessment (CCA), conducted as per the rubrics listed in the assessment section of the respective syllabus.
4. A student shall obtain a minimum of 40% marks or 20 out of 50 marks allotted to CIE to become eligible to appear for the SEE.

Passing requirement in SEE

1. For a pass in the Semester End Examination (SEE), a student shall secure a minimum of 35 marks out of 100.
2. For the declaration of a pass grade, the sum of the Continuous Internal Evaluation (CIE) marks (out of 50) marks and the SEE marks scaled down to 50 shall be greater than or equal to 40 marks.
3. If the total (CIE + SEE) is less than 40 marks, the student shall be awarded the grade 'F' (Fail).

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CELL AND MOLECULAR BIOLOGY LABORATORY			
Course Code	**1BBTL405**	Scheme	**2025**
Type of Course	**PCCL**	Semester	**04**
Teaching Hours/Week (L:T:P)	**0:0:2**	CIE Marks	**50**
Total Hours of Pedagogy L:T:P:SLTW	**0:0:28:2**	SEE Marks	**50**
Credits	**01**	Total Marks	**100**
Examination type (SEE)	**Practical**	Exam Hours	**02**

Course outcome (Course Skill Set)

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

1. Prepare laboratory buffers and isolate, quantify, and assess the quality of DNA and RNA from biological samples.
2. Perform fundamental molecular biology techniques including electrophoresis, plasmid isolation, PCR, restriction digestion, and bacterial transformation.
3. Analyze cell division and nucleic acid properties using microscopy and DNA melting experiments.
4. Design, execute, and interpret open-ended molecular biology experiments using scientific reasoning and laboratory skills.

Note:

1. The laboratory syllabus consists of PART-A and PART-B. While PART-A has 6 conventional experiments, PART-B has 6 typical open-ended experiments. The maximum marks for the laboratory course are 100.
2. Both PART-A and PART-B are considered for CIE and SEE.
3. Students have answer 1(one) question from PART-A and 1(one) question from PART-B.
   a. The questions set for SEE shall be from among the experiments under PART-A. It is evaluated for **70 marks** out of the maximum 100 marks.
   b. The open-ended question set for SEE shall be any other open-ended question and not selected from the experiments under PART-A. It shall be evaluated for **30 marks.**
4. For Continuous Internal Evaluation (CIE) during the semester, classwork shall typically include open-ended questions from **Part-B**, along with other similar questions designed to enhance the students' skills.

PART – A

FIXED SET OF EXPERIMENTS

1. Preparations of common molecular biology lab buffers (TAE, TBE, TE, Tris-Hcl etc.)
2. Isolation of genomic DNA from plant tissues.
3. Isolation of genomic DNA from microbial or animal sources.
4. Agarose gel electrophoresis of nucleic acids.
5. Quantification and purity assessment of DNA using spectrophotometry.
6. Isolation of total RNA from bacteria/plant/animal samples.

PART – B

OPEN ENDED EXPERIMENTS

Concept 1. Cell Division Studies – Mitosis (Onion root tip) &Meiosis (Onion Flower Buds)
Concept 2. Isolation of Plasmids from *E.coli*
Concept 3. Genetic transformation of *E.coli*
Concept 4. Hyperchromic effect of DNA and Melting Temperature (Tm)
Concept 5. Polymerase Chain Reaction
Concept 6. Restriction Digestion

Open-ended experiments are a type of laboratory activity where the outcome is not predetermined and students are given the freedom to explore, design, and conduct the experiment based on the problem statements as per the concepts defined by the course coordinator. It encourages creativity, critical thinking, and inquiry-based learning.

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Suggested Learning Resources: (Text Book/ Reference Book/ Manuals):

Text Books

1. Molecular Biology of the Cell – Bruce Alberts, Rebecca Heald, Karen Hopkin et al., Garland Science, 2022.
2. Molecular Cell Biology – Harvey Lodish et al., W. H. Freeman, 2021.
3. Lewin's Genes XII – Jocelyn E. Krebs, Elliot S. Goldstein, Stephen T. Kilpatrick, Jones & Bartlett Learning, 2020.

Reference Books / Manuals

1. Molecular Cloning: A Laboratory Manual – Michael R. Green and Joseph Sambrook, Cold Spring Harbor Laboratory Press, 2012.
2. Current Protocols in Molecular Biology – Frederick M. Ausubel et al., Wiley.
3. Principles and Techniques of Practical Biochemistry – Keith Wilson and John Walker, Cambridge University Press, 2018.
4. Gene Cloning and DNA Analysis: An Introduction – T. A. Brown, Wiley-Blackwell, 2020.
5. Laboratory Manual for Genetic Engineering – P. K. Gupta (or any equivalent institutional laboratory manual).

Web links and Video Lectures (e-Resources):

1. https://vlab.amrita.edu/?sub=3&brch=77
2. https://vlab.amrita.edu/index.php/oauth/?sub=3&brch=186
3. https://onlinecourses.nptel.ac.in/e-learning/preview/noc26_bt91
4. https://www.youtube.com/playlist?list=PLwdnzlV3ogoW9QiY4FJXeliA6Q_fJkaDS

Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

1. Inquiry-based and Open-ended Laboratory Experiments: Students design experimental procedures, optimize conditions, analyze results, and present findings to promote critical thinking and problem-solving skills.
2. Blended Learning with Virtual Labs and Flipped Classroom: Pre-lab video demonstrations, online quizzes, simulations, and case-study discussions are used before hands-on laboratory sessions to improve conceptual understanding and laboratory preparedness.

Assessment Structure:

The assessment for each course is equally divided between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each component carrying **50% weightage** (i.e., 50 marks each).

The CIE marks awarded shall be based on the continuous evaluation of the laboratory report using a defined set of rubrics. Each experiment report can be evaluated for 30 marks. Total marks for the all report shall be scaled down to 30 marks. The laboratory test (duration 03 hours) at the end of the last week of the semester /after completion of all the experiments (whichever is early) shall be conducted for 50 marks and Marks scored shall be scaled down to 20 marks. Final average of marks for report and test shall be out of 50 marks.

For both CIE and SEE, the student is required to conduct one experiment each from both Part A and Part B.

Rubrics for CIE – Continuous assessment:

Performance Indicator (CO/PO Mapping)	Superior (5)	Good (4)	Fair (3)	Needs Improvement (2)	Unacceptable (1)
PI-1: Laboratory Preparation & Fundamental Knowledge (CO1/PO1)	Excellent understanding of theory and protocol	Good understanding	Satisfactory understanding	Limited understanding	Poor understanding
PI-2: Experimental Skills	Performs accurately and independently	Minor guidance	Moderate guidance	Frequent errors	Unable to perform

&Aseptic Techniques (CO2/PO2, PO5)					
PI-3: Data Recording, Analysis & Interpretation (CO3/PO4)	Accurate observations and analysis	Minor errors	Basic interpretation	Limited interpretation	No interpretation
PI-4: Laboratory Record & Documentation (CO1, CO4/PO10)	Complete and organized	Good	Satisfactory	Incomplete	Not submitted
PI-5: Scientific Communication & Teamwork (CO4/PO9, PO10)	Excellent	Good	Satisfactory	Poor	No participation

Rubrics for SEE / CIE Test:

Performance Indicator (CO/PO Mapping)	Superior (5)	Good (4)	Fair (3)	Needs Improvement (2)	Unacceptable (1)
PI-1: Understanding of Experimental Principle (CO1/PO1)	Excellent	Good	Satisfactory	Limited	Poor
PI-2: Experimental Execution (CO2/PO2, PO5)	Independent execution	Minor procedural errors	With guidance	Significant errors	Unable
PI-3: Observation, Result & Interpretation (CO3/PO4)	Accurate and scientific	Minor errors	Basic	Limited	Incorrect
PI-4: Open-ended Problem Solving (CO4/PO2, PO4)	Independent design	Good approach	Basic solution	Limited	Unable
PI-5: Viva Voce & Scientific Communication (CO1–CO4/PO10)	Excellent	Good	Satisfactory	Limited	Unable

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- To qualify and become eligible to appear for SEE, in the **CIE component**, a student must secure **a minimum of 40% of 50 marks**, i.e., **20 marks**.
- To pass the **SEE component**, a student must secure **a minimum of 35% of 50 marks**, i.e., **18 marks**.
- A student is deemed to have **successfully completed the course** if the **combined total of CIE and SEE is at least 40 out of 100 marks**.

Rubrics suggested for Practical continuous assessment

Performance Indicators	Excellent	Very Good	Good	Satisfactory
Fundamental Knowledge (4) (PO1)	The student has well depth knowledge of the topics related to the course (4)	Student has good knowledge of some of the topics related to course (3)	Student is capable of narrating the answer but not capable to show in depth knowledge(2)	Student has not understood the concepts clearly (1)
Design Of Experiment (5) (PO2 & PO3)	Student is capable of discussing more than one design for his/her problem statement and capable of proving the best suitable design with proper reason (5)	Student is capable of discussing few designs for his/her problem statement but not capable of selecting best(4)	Student is capable of discussing single design with its merits and de-merits(3)	Student is capable of explaining the design (1-2)
Implementation (8) (PO3 & PO8)	Student is capable of implementing the design with best suitable algorithm considering optimal solution. (7-8)	Student is capable of implementing the design with best suitable algorithm and should be capable of explaining it (5-6)	Student is capable of implementing the design with proper explanation.(3-4)	Student is capable of implementing the design. (1-2)
Result &Analysis (5) (PO4)	Student is able to run the program on various cases and compare the result with proper analysis. (5)	Student will be able to run the program for all the cases.(4)	Student will be able to run the code for few cases and analyze the output.(3)	Student will be able to run the program but not able to analyze the output.(1-2)
Demonstration (8) (PO9)	The lab record is well-organized, with clear sections (e.g., Introduction, Method, Results, Conclusion). Transitions between sections are smooth. (7-8)	The lab record is organized, with clear sections, but some sections are not well-defined. (5-6)	The lab record lacks clear organization or structure. Some sections are unclear or incomplete. (3-4)	The lab record is poorly organized, with missing or unclear sections. (1-2)

Patent Search, Data Analysis and Research Methodology Lab			
Course Code	**1BBTL406A**	Scheme	**2025**
Type of Course	**Ability Enhancement Course (Laboratory)**	Semester	**04**
Teaching Hours/Week (L:T:P)	**0:0:2**	CIE Marks	**50**
Total Hours of Pedagogy L:T:P:SL:TW	**0:0:28:2**	SEE Marks	**50**
Credits	**01**	Total Marks	**100**
Type of Examination	**Practical**	Exam Hours	**02**

Course outcome (Course Skill Set)

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

1. Conduct systematic literature reviews and identify research gaps using scholarly databases.
2. Perform patent searches using national and international patent databases and analyze prior art.
3. Collect, organize, and process experimental or survey data using appropriate tools.
4. Apply statistical and analytical techniques to interpret research data and draw conclusions.

SET OF EXPERIMENTS

1. Identification of a Research problem and formulation of research objectives.
2. Literature survey using Google Scholar, Scopus, or other scholarly databases.
3. Citation management and reference generation using Mendeley/Zotero.
4. Plagiarism checking and interpretation of similarity reports.
5. Patent search using Google Patents.
6. Patent search using WIPO PATENTSCOPE and Indian Patent Advanced Search System (InPASS).
7. Patent classification study and prior-art analysis for a selected invention.
8. Preparation of a patent landscape and patent search report.
9. Design of a questionnaire and collection of primary research data.
10. Data cleaning, coding, and organization using spreadsheet tools.
11. Statistical analysis of data (descriptive statistics, correlation, and regression) using Excel/SPSS/R/Python.
12. Preparation and presentation of a technical research report with appropriate citations and conclusions.

Suggested Learning Resources: (Text Book/ Reference Book/ Manuals):

Text books:

1. Kothari, C.R. and Garg, G., *Research Methodology: Methods and Techniques*, New Age International Publishers.
2. Kumar, R., *Research Methodology: A Step-by-Step Guide for Beginners*, Sage Publications.
3. Creswell, J.W. and Creswell, J.D., *Research Design: Qualitative, Quantitative and Mixed Methods Approaches*, Sage Publications.

Reference books / Manuals:

1. Cooper, D.R. and Schindler, P.S., *Business Research Methods*, McGraw-Hill.
2. Zikmund, W.G., Babin, B.J., Carr, J.C., and Griffin, M., *Business Research Methods*, Cengage Learning.
3. Montgomery, D.C. and Runger, G.C., *Applied Statistics and Probability for Engineers*, Wiley.

Web links and Video Lectures (e-Resources):

1. **NPTEL – Research Methodology** https://nptel.ac.in
   Comprehensive video lectures on research design, literature review, research ethics, and technical writing.
2. **WIPO PATENTSCOPE** https://patentscope.wipo.int
   International patent database for patent search, prior-art analysis, and intellectual property learning.
3. **Google Patents** https://patents.google.com
   Free patent search platform with advanced search and patent analytics features.

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Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

1. **Hands-on Laboratory Sessions:** Students perform patent searches, literature reviews, and data analysis activities using real-world databases and software tools.
2. **Problem-Based Learning (PBL):** Students identify research problems, formulate objectives, and propose solutions through systematic investigation.
3. **Case Study Analysis:** Analysis of published patents, research papers, and innovation case studies to understand prior-art evaluation and research methodologies.

Assessment Structure:

The assessment for each course is equally divided between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each component carrying **50% weightage** (i.e., 50 marks each).

The CIE marks awarded shall be based on the continuous evaluation of the laboratory report using a defined set of rubrics. Each experiment report can be evaluated for 30 marks. Total marks for the all report shall be scaled down to 30 marks. The laboratory test (duration 03 hours) at the end of the last week of the semester /after completion of all the experiments (whichever is early) shall be conducted for 50 marks and Marks scored shall be scaled down to 20 marks. Final average of marks for report and test shall be out of 50 marks.

Rubrics for CIE – Continuous assessment:

Performance Indicator (CO/PO Mapping)	Superior (5)	Good (4)	Fair (3)	Needs Improvement (2)	Unacceptable (1)
PI-1: Laboratory Preparation & Fundamental Knowledge (CO1/PO1)	Excellent understanding of theory and protocol	Good understanding	Satisfactory understanding	Limited understanding	Poor understanding
PI-2: Experimental Skills & Aseptic Techniques (CO2/PO2, PO5)	Performs accurately and independently	Minor guidance	Moderate guidance	Frequent errors	Unable to perform
PI-3: Data Recording, Analysis & Interpretation (CO3/PO4)	Accurate observations and analysis	Minor errors	Basic interpretation	Limited interpretation	No interpretation
PI-4: Laboratory Record & Documentation (CO1, CO4/PO10)	Complete and organized	Good	Satisfactory	Incomplete	Not submitted
PI-5: Scientific Communication & Teamwork (CO4/PO9, PO10)	Excellent	Good	Satisfactory	Poor	No participation

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Rubrics for SEE / CIE Test:

Performance Indicator (CO/PO Mapping)	Superior (5)	Good (4)	Fair (3)	Needs Improvement (2)	Unacceptable (1)
PI-1: Understanding of Experimental Principle (CO1/PO1)	Excellent	Good	Satisfactory	Limited	Poor
PI-2: Experimental Execution (CO2/PO2, PO5)	Independent execution	Minor procedural errors	With guidance	Significant errors	Unable
PI-3: Observation, Result & Interpretation (CO3/PO4)	Accurate and scientific	Minor errors	Basic	Limited	Incorrect
PI-4: Open-ended Problem Solving (CO4/PO2, PO4)	Independent design	Good approach	Basic solution	Limited	Unable
PI-5: Viva Voce & Scientific Communication (CO1–CO4/PO10)	Excellent	Good	Satisfactory	Limited	Unable

- To qualify and become eligible to appear for SEE, in the **CIE component**, a student must secure **a minimum of 40% of 50 marks**, i.e., **20 marks**.
- To pass the **SEE component**, a student must secure **a minimum of 35% of 50 marks**, i.e., **18 marks**.
- A student is deemed to have **successfully completed the course** if the **combined total of CIE and SEE is at least 40 out of 100 marks**.

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Rubrics suggested for Practical Continuous Assessment				
Performance Indicators	**Excellent**	**Very Good**	**Good**	**Satisfactory**
Fundamental Knowledge (4) (PO1)	The student has well depth knowledge of the topics related to the course (4)	Student has good knowledge of some of the topics related to course (3)	Student is capable of narrating the answer but not capable to show in depth knowledge(2)	Student has not understood the concepts clearly (1)
Design Of Experiment (5) (PO2 & PO3)	Student is capable of discussing more than one design for his/her problem statement and capable of proving the best suitable design with proper reason (5)	Student is capable of discussing few designs for his/her problem statement but not capable of selecting best(4)	Student is capable of discussing single design with its merits and de-merits(3)	Student is capable of explaining the design (1-2)
Implementation (8) (PO3 & PO8)	Student is capable of implementing the design with best suitable algorithm considering optimal solution. (7-8)	Student is capable of implementing the design with best suitable algorithm and should be capable of explaining it (5-6)	Student is capable of implementing the design with proper explanation.(3-4)	Student is capable of implementing the design. (1-2)
Result &Analysis (5) (PO4)	Student is able to run the program on various cases and compare the result with proper analysis. (5)	Student will be able to run the program for all the cases.(4)	Student will be able to run the code for few cases and analyze the output.(3)	Student will be able to run the program but not able to analyze the output.(1-2)
Demonstration (8) (PO9)	The lab record is well-organized, with clear sections (e.g., Introduction, Method, Results, Conclusion). Transitions between sections are smooth. (7-8)	The lab record is organized, with clear sections, but some sections are not well-defined. (5-6)	The lab record lacks clear organization or structure. Some sections are unclear or incomplete. (3-4)	The lab record is poorly organized, with missing or unclear sections. (1-2)

Note: Can add Engineering & IT tool usage based on the nature of the course

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AI & ML in Biotechnology lab			
Course Code	**1BBTL406B**	Scheme	**2025**
Type of Course	**Ability Enhancement Course (Laboratory)**	Semester	**04**
Teaching Hours/Week (L:T:P)	**0:0:2**	CIE Marks	**50**
Total Hours of Pedagogy L:T:P:SLTW	**0:0:28:2**	SEE Marks	**50**
Credits	**01**	Total Marks	**100**
Examination type (SEE)	**Practical**	Exam Hours	**02**

Course outcome (Course Skill Set)

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

1. Familiarize themselves with globally recognized cloud platforms and web-servers (such as Google Colab, SwissADME, Morpheus, and ColabFold) for accelerating biological research and discovery options.
2. Preprocess diverse biological datasets (genomic sequences, clinical data, and molecular data) into AI-ready formats using popular online tools.
3. Gain hands-on experience in using diverse machine learning algorithms for classification, diagnostics, identification, grouping profiles and process optimization.
4. Cultivate a computational mindset to confidently use artificial intelligence as a routine research tool to solve complex biotechnological problems.

SET OF EXPERIMENTS

1. DNA k-mer Counting (sequence composition) via Google Colab
2. Finding Promoter Regions using NCBI BLAST&MEME Suite
3. Analyzing and Validating Novel Protein Folds using AlphaFold2
4. Predicting Drug Likeness and Toxicity via SwissADME and ProTox-3.0
5. Network Analysis: Using tools like NetworkX or Cytoscape (Cytoscap Web) to map protein-protein interaction networks and identify disease modules.
6. Visualizing Gene Expressions and studying Disease associated Genes using Morpheus
7. Grouping of cell types using UCSC Cell Browser
8. Data Mining and Disease Classification: Tool: Orange Web / Orange CloudTask: Import a CSV file of breast cancer clinical data. Drag and drop a Random Forest or Decision Tree model to classify tumors as benign or malignant
9. Predicting Patient Outcomes: Tool: Kaggle Kernels
10. Task: Use an existing online notebook template to train a simple Logistic Regression model that predicts heart disease based on age, cholesterol, and blood pressure.
11. De Novo Drug Design: Virtual screening of phytochemicals against disease targets (e.g., specific viral proteins).
12. Clustering Analysis: Utilizing K-Means and Hierarchical Clustering algorithms for identifying cell types or gene co-expression networks or Microbiome data grouping via Tools like Morpheus (Broad Institute), Galaxy Project (UseGalaxy.org).
13. Image Analysis: Using Convolutional Neural Networks (CNNs) for tasks like automated detection in microscopy or histology image classification via BioImage.IO, Edge Impulse (Healthcare/Biology section).
14. Bioprocess Optimization: Predictive modeling of bioreactor yields using supervised learning using Orange Data Mining (Web/Cloud Component),BigML, Edge Impulse (Regression Mode).

Suggested Learning Resources: (Text Book/ Reference Book/ Manuals):

Text books:

1. Alok Kumar Srivastav, Priyanka Das, Babasaheb Ghodke. Artificial Intelligence in Biotechnology and Genomics (Emerging Technologies, Innovations and Applications) Namya Press, 2025.
2. Raschka, S., Liu, Y., & Mirjalili, V. Machine Learning with Python and Scikit-Learn, Keras, and TensorFlow, 4th Edition, Packt Publishing, 2025.
3. Pankaj Bhambri, Sandeep Kautish, Yogita Gupta , " From Genes to Algorithms: Navigating the Biotechnology Data Revolution ", Bentham Science Publishers. 2025.
4. Alpaydin, E. Introduction to Machine Learning, 5th Edition, MIT Press, 2020.
5. Zou, J., Huss, M., Abid, A., Mohammadi, P., Torkamani, A., and Telenti, A. A Primer on Deep Learning in Genomics, Nature Genetics.

Reference books / Manuals:

1. Charu C. Aggarwal Neural Networks and Deep Learning, Springer.
2. Pevsner, J. Bioinformatics and Functional Genomics, Wiley.
3. Jones, D., et al. Artificial Intelligence in Drug Discovery, Royal Society of Chemistry.
4. Kelleher, J., Mac Namee, B., and D'Arcy, A. Fundamentals of Machine Learning for Predictive Data Analytics, MIT Press.

Web links and Video Lectures (e-Resources):

1. Deep Learning for the Life Sciences by Ramsundar et al. – Specifically designed for applying deep learning to biological problems.
2. Machine Learning for Bioinformatics (UW-Madison) – Course materials covering ML applications in genomics and proteomics.
3. Molecular Machine Learning – Interactive textbook for applying ML to molecular and chemical data.
4. ML for Healthcare (MIT) – Focuses on clinical and health data applications.
5. https://www.coursera.org/specializations/machine-learning-introduction
6. https://www.embl.org/topics/ai-at-embl/

Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

1. Hands-on training using AI, machine learning, and bioinformatics software tools.
2. Flipped classroom with NPTEL/MOOC video lectures and pre-lab demonstrations.
3. Project-based learning using real biological and clinical datasets.
4. Inquiry-based learning through open-ended computational biology problems.
5. Case studies on AI applications in drug discovery, genomics, and precision medicine.
6. Interactive coding sessions using Google Colab, Python, and Jupyter Notebook.
7. Collaborative learning through group projects and peer-assisted problem solving.
8. Demonstration of cloud-based platforms such as Galaxy, Orange, Cytoscape, Morpheus, and AlphaFold.

Assessment Structure:

The assessment for each course is equally divided between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each component carrying **50% weightage** (i.e., 50 marks each).

The CIE marks awarded shall be based on the continuous evaluation of the laboratory report using a defined set of rubrics. Each experiment report can be evaluated for 30 marks. Total marks for the all report shall be scaled down to 30 marks. The laboratory test (duration 03 hours) at the end of the last week of the semester /after completion of all the experiments (whichever is early) shall be conducted for 50 marks and Marks scored shall be scaled down to 20 marks. Final average of marks for report and test shall be out of 50 marks.

Rubrics for CIE – Continuous assessment:

Performance Indicator (CO/PO Mapping)	Superior (5)	Good (4)	Fair (3)	Needs Improvement (2)	Unacceptable (1)
PI-1: Laboratory Preparation & Fundamental Knowledge (CO1/PO1)	Excellent understanding of theory and protocol	Good understanding	Satisfactory understanding	Limited understanding	Poor understanding
PI-2: Experimental Skills & Aseptic Techniques (CO2/PO2, PO5)	Performs accurately and independently	Minor guidance	Moderate guidance	Frequent errors	Unable to perform
PI-3: Data Recording, Analysis & Interpretation (CO3/PO4)	Accurate observations and analysis	Minor errors	Basic interpretation	Limited interpretation	No interpretation
PI-4: Laboratory Record & Documentation (CO1,	Complete and organized	Good	Satisfactory	Incomplete	Not submitted

CO4/PO10)					
PI-5: Scientific Communication & Teamwork (CO4/PO9, PO10)	Excellent	Good	Satisfactory	Poor	No participation

Rubrics for SEE / CIE Test:

Performance Indicator (CO/PO Mapping)	Superior (5)	Good (4)	Fair (3)	Needs Improvement (2)	Unacceptable (1)
PI-1: Understanding of Experimental Principle (CO1/PO1)	Excellent	Good	Satisfactory	Limited	Poor
PI-2: Experimental Execution (CO2/PO2, PO5)	Independent execution	Minor procedural errors	With guidance	Significant errors	Unable
PI-3: Observation, Result & Interpretation (CO3/PO4)	Accurate and scientific	Minor errors	Basic	Limited	Incorrect
PI-4: Open-ended Problem Solving (CO4/PO2, PO4)	Independent design	Good approach	Basic solution	Limited	Unable
PI-5: Viva Voce & Scientific Communication (CO1–CO4/PO10)	Excellent	Good	Satisfactory	Limited	Unable

- To qualify and become eligible to appear for SEE, in the **CIE component**, a student must secure **a minimum of 40% of 50 marks**, i.e., **20 marks**.
- To pass the **SEE component**, a student must secure **a minimum of 35% of 50 marks**, i.e., **18 marks**.
- A student is deemed to have **successfully completed the course** if the **combined total of CIE and SEE is at least 40 out of 100 marks**.

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Rubrics suggested for Practical continuous assessment				
Performance Indicators	**Excellent**	**Very Good**	**Good**	**Satisfactory**
Fundamental Knowledge (4) (PO1)	The student has well depth knowledge of the topics related to the course (4)	Student has good knowledge of some of the topics related to course (3)	Student is capable of narrating the answer but not capable to show in depth knowledge (2)	Student has not understood the concepts clearly (1)
Design Of Experiment (5) (PO2 & PO3)	Student is capable of discussing more than one design for his/her problem statement and capable of proving the best suitable design with proper reason (5)	Student is capable of discussing few designs for his/her problem statement but not capable of selecting best (4)	Student is capable of discussing single design with its merits and de-merits (3)	Student is capable of explaining the design (1-2)
Implementation (8) (PO3 & PO8)	Student is capable of implementing the design with best suitable algorithm considering optimal solution. (7-8)	Student is capable of implementing the design with best suitable algorithm and should be capable of explaining it (5-6)	Student is capable of implementing the design with proper explanation. (3-4)	Student is capable of implementing the design. (1-2)
Result &Analysis (5) (PO4)	Student is able to run the program on various cases and compare the result with proper analysis. (5)	Student will be able to run the program for all the cases. (4)	Student will be able to run the code for few cases and analyze the output. (3)	Student will be able to run the program but not able to analyze the output. (1-2)
Demonstration (8) (PO9)	The lab record is well-organized, with clear sections (e.g., Introduction, Method, Results, Conclusion). Transitions between sections are smooth. (7-8)	The lab record is organized, with clear sections, but some sections are not well-defined. (5-6)	The lab record lacks clear organization or structure. Some sections are unclear or incomplete. (3-4)	The lab record is poorly organized, with missing or unclear sections. (1-2)

Note: Can add Engineering & IT tool usage based on the nature of the course

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HERBAL EXTRACTION TECHNIQUES AND PHYTOCHEMICAL ANALYSIS LAB			
Course Code	**1BBTL406C**	Scheme	**2025**
Type of Course	**Ability Enhancement Course (Laboratory)**	Semester	**04**
Teaching Hours/Week (L:T:P)	**0:0:2**	CIE Marks	**50**
Total Hours of Pedagogy L:T:P:SLTW	**0:0:28:2**	SEE Marks	**50**
Credits	**01**	Total Marks	**100**
Examination type (SEE)	**Practical**	Exam Hours	**02**

Course outcome (Course Skill Set)

CO1:Upon successful completion of this course, students will be able to:

CO2: Demonstrate skills in medicinal plant identification, authentication, and raw material processing. Perform and optimize conventional and advanced herbal extraction techniques for bioactive compounds.

CO3: Apply analytical and quality control techniques for the standardization of herbal extracts and formulations.

CO4: Develop value-added herbal products by integrating formulation, stability, and packaging practices.

CO5: Prepare industrial documentation, SOPs, and quality records following GMP, GLP, and regulatory requirements.

CO6; Demonstrate entrepreneurial, process design, and commercialization skills for sustainable herbal product development.

SET OF EXPERIMENTS

1. Authentication, Pharmacognostic Evaluation, and Pre-processing of Medicinal Plants : Identification and authentication of medicinal plants. Organoleptic evaluation, moisture determination, drying, pulverization, sieving, and storage of herbal raw materials.
2. Extraction of Bioactive Compounds Using Conventional Techniques :Preparation of herbal extracts using maceration, decoction, Soxhlet, or reflux extraction. Comparison of extraction yield using different solvents.
3. Extraction of Essential Oils and Green Extraction Techniques :Isolation of essential oils by steam/hydrodistillation. Demonstration of Ultrasound-Assisted Extraction (UAE) or Microwave-Assisted Extraction (MAE) and comparison with conventional extraction.
4. Quality Evaluation and Phytochemical Analysis of Herbal Extracts :Determination of extractive value, moisture content, pH, and qualitative phytochemical screening. Estimation of total phenolic or flavonoid content using UV–Visible spectrophotometry.
5. Chromatographic Fingerprinting and Standardization of Herbal Extracts:Separation and characterization of phytochemicals using Thin Layer Chromatography (TLC)/HPTLC. Demonstration or interpretation of HPLC/GC-MS/FTIR data for herbal extract standardization.
6. Preparation of Herbal Products and Industrial Documentation :Preparation of a herbal formulation (powder, herbal tea, syrup, or capsule) using standardized extracts. Preparation of Standard Operating Procedure (SOP), Batch Manufacturing Record (BMR), Batch Packaging Record (BPR), and GMP documentation
7. Isolation and characterization of essential oils from different aromatic plants and comparison of yield and composition.
8. Comparative evaluation of antioxidant activity of herbal extracts using DPPH, FRAP, or ABTS assays. Preparation of herbal nanoparticles or nanoemulsions and evaluation of their stability
9. Design of a pilot-scale extraction unit using process simulation software and Development of a digital quality control dashboard for herbal extraction processes using Excel, Python, or AI-based analytics
10. Detection and estimation of adulterants in commercial herbal products using chromatographic techniques
11. Preparation and evaluation of functional foods or nutraceutical formulations enriched with herbal extracts.

Suggested Learning Resources: (Text Book/ Reference Book/ Manuals):

1. Trease and Evans' Pharmacognosy, 17th Edition, Elsevier, 2024.
2. Medicinal Natural Products: A Biosynthetic Approach, 3rd Edition, John Wiley & Sons, 2009 (standard reference).
3. Quality Control and Evaluation of Herbal Drugs, 2nd Edition, Elsevier, 2019.
4. Herbal Drug Technology, Latest Available Edition, Universities Press/Orient BlackSwan.
5. Handbook of Herbs and Spices, 3rd Edition, Woodhead Publishing–Elsevier, 2023.

Reference Books:

1. Handbook of Medicinal Herbs, 2nd Edition, CRC Press.
2. Herbal Medicine: Biomolecular and Clinical Aspects, 2nd Edition, CRC Press.
3. Natural Products Isolation, 4th Edition, Humana Press (Springer), 2021.
4. Plant Drug Analysis: A Thin Layer Chromatography Atlas, 2nd Edition, Springer.
5. Standardization of Botanicals, Latest Available Edition, Eastern Publishers.

Laboratory Manuals, Standards and Pharmacopoeias:

1. World Health Organization, Quality Control Methods for Herbal Materials, WHO, Geneva, Latest Edition/Updates.
2. Indian Pharmacopoeia Commission, Indian Pharmacopoeia, 2022 (9th Edition) and subsequent addenda.
3. Ayush Pharmacopoeia Commission, The Ayurvedic Pharmacopoeia of India (API), Latest Volumes and Addenda.
4. Food Safety and Standards Authority of India, Food Safety and Standards (Nutraceutical) Regulations, Latest Amendments.
5. OECD Principles of Good Laboratory Practice (GLP) and WHO Guidelines on Good Agricultural and Collection Practices (GACP), Latest Editions.

Web Resources:

1. World Health Organization – Herbal medicine guidelines and quality standards.
2. Ministry of AYUSH – Pharmacopoeias, regulatory guidelines, and medicinal plant resources.
3. Food Safety and Standards Authority of India – Nutraceutical and functional food regulations.
4. National Medicinal Plants Board – Cultivation, conservation, and commercialization of medicinal plants.
5. Indian Pharmacopoeia Commission – Official pharmacopoeial standards and monographs.

Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

1. Demonstration-based laboratory sessions on herbal extraction and phytochemical analysis.
2. Hands-on training using modern analytical instruments such as UV–Vis, HPTLC, HPLC, GC–MS, and FTIR.
3. Inquiry-based and problem-solving experiments for herbal formulation development.
4. Case studies on herbal drug standardization, quality control, and regulatory compliance.
5. Industry-oriented mini-projects on herbal product development and nutraceuticals.
6. ICT-enabled teaching using virtual laboratories, multimedia, and simulation tools.

Assessment Structure:

The assessment for each course is equally divided between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each component carrying **50% weightage** (i.e., 50 marks each).

The CIE marks awarded shall be based on the continuous evaluation of the laboratory report using a defined set of rubrics. Each experiment report can be evaluated for 30 marks. Total marks for the all report shall be scaled down to 30 marks. The laboratory test (duration 03 hours) at the end of the last week of the semester /after completion of all the experiments (whichever is early) shall be conducted for 50 marks and Marks scored shall be scaled down to 20 marks. Final average of marks for report and test shall be out of 50 marks.

Rubrics for CIE – Continuous assessment:

Performance Indicator (CO/PO Mapping)	Superior (5)	Good (4)	Fair (3)	Needs Improvement (2)	Unacceptable (1)
PI-1: Laboratory Preparation & Fundamental Knowledge	Excellent understanding of theory and protocol	Good understanding	Satisfactory understanding	Limited understanding	Poor understanding

(CO1/PO1)					
PI-2: Experimental Skills & Aseptic Techniques (CO2/PO2, PO5)	Performs accurately and independently	Minor guidance	Moderate guidance	Frequent errors	Unable to perform
PI-3: Data Recording, Analysis & Interpretation (CO3/PO4)	Accurate observations and analysis	Minor errors	Basic interpretation	Limited interpretation	No interpretation
PI-4: Laboratory Record & Documentation (CO1, CO4/PO10)	Complete and organized	Good	Satisfactory	Incomplete	Not submitted
PI-5: Scientific Communication & Teamwork (CO4/PO9, PO10)	Excellent	Good	Satisfactory	Poor	No participation

Rubrics for SEE / CIE Test:

Performance Indicator (CO/PO Mapping)	Superior (5)	Good (4)	Fair (3)	Needs Improvement (2)	Unacceptable (1)
PI-1: Understanding of Experimental Principle (CO1/PO1)	Excellent	Good	Satisfactory	Limited	Poor
PI-2: Experimental Execution (CO2/PO2, PO5)	Independent execution	Minor procedural errors	With guidance	Significant errors	Unable
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PI-4: Open-ended Problem Solving (CO4/PO2, PO4)	Independent design	Good approach	Basic solution	Limited	Unable
PI-5: Viva Voce & Scientific Communication (CO1–CO4/PO10)	Excellent	Good	Satisfactory	Limited	Unable

- To qualify and become eligible to appear for SEE, in the **CIE component**, a student must secure **a minimum of 40% of 50 marks**, i.e., **20 marks**.
- To pass the **SEE component**, a student must secure **a minimum of 35% of 50 marks**, i.e., **18 marks**.
- A student is deemed to have **successfully completed the course** if the **combined total of CIE and SEE is at least 40 out of 100 marks**.

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Rubrics suggested for Practical continuous assessment				
Performance Indicators	**Excellent**	**Very Good**	**Good**	**Satisfactory**
Fundamental Knowledge (4) (PO1)	The student has well depth knowledge of the topics related to the course (4)	Student has good knowledge of some of the topics related to course (3)	Student is capable of narrating the answer but not capable to show in depth knowledge (2)	Student has not understood the concepts clearly (1)
Design Of Experiment (5) (PO2 & PO3)	Student is capable of discussing more than one design for his/her problem statement and capable of proving the best suitable design with proper reason (5)	Student is capable of discussing few designs for his/her problem statement but not capable of selecting best (4)	Student is capable of discussing single design with its merits and de-merits (3)	Student is capable of explaining the design (1-2)
Implementation (8) (PO3 & PO8)	Student is capable of implementing the design with best suitable algorithm considering optimal solution. (7-8)	Student is capable of implementing the design with best suitable algorithm and should be capable of explaining it (5-6)	Student is capable of implementing the design with proper explanation. (3-4)	Student is capable of implementing the design. (1-2)
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Demonstration (8) (PO9)	The lab record is well-organized, with clear sections (e.g., Introduction, Method, Results, Conclusion). Transitions between sections are smooth. (7-8)	The lab record is organized, with clear sections, but some sections are not well-defined. (5-6)	The lab record lacks clear organization or structure. Some sections are unclear or incomplete. (3-4)	The lab record is poorly organized, with missing or unclear sections. (1-2)

Note: Can add Engineering & IT tool usage based on the nature of the course

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ANALYSIS OF DAIRY PRODUCTS LAB			
Course Code	**1BBTL406D**	Scheme	**2025**
Type of Course	**Ability Enhancement Course (Laboratory)**	Semester	**04**
Teaching Hours/Week (L:T:P)	**0:0:2**	CIE Marks	**50**
Total Hours of Pedagogy L:T:P:SL:TW	**0:0:28:2**	SEE Marks	**50**
Credits	**01**	Total Marks	**100**
Type of Examination	**Practical**	Exam Hours	**02**

Course outcome (Course Skill Set)

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

1. Analyze the physicochemical properties of milk using standard laboratory techniques and interpret their significance in quality assessment.
2. Evaluate the nutritional composition of milk (fat, protein, lactose) using quantitative methods
3. Assess microbial quality and safety of milk through tests like MBRT and correlate results with hygiene and storage conditions.
4. Evaluate milk adulteration and propose suitable detection strategies for ensuring product authenticity and safety.
5. Optimize dairy processing techniques (fermentation, butter making, pasteurization) and assess the quality of resulting products.

SET OF EXPERIMENTS

1. Determination of Specific Gravity of Milk
2. Estimation of Fat Content (Gerber Method)
3. Determination of Protein (Kjeldahl Method)
4. Estimation of Lactose (Benedict's Method)
5. Determination of pH and Acidity
6. Methylene Blue Reduction Test (MBRT)
7. Detection of Adulteration in Milk
8. Preparation of Curd (Fermentation Study)
9. Butter Making and Fat Estimation
10. Ice Cream Quality Analysis
11. Pasteurization Study
12. Cleaning and Sanitization Efficiency Test

Suggested Learning Resources: (Text Book/ Reference Book/ Manuals):

Text books:

1. A. K. Bandyopadhyay, P.K. Ghatak, P.R. Ray , Textbook on Analysis of Milk Products, 9789327258011, Kalyani Publishers,

Reference books / Manuals:

1. Bunkar, D. S. Master of Technology in Dairy Technology. Diss. BANARAS HINDU UNIVERSITY VARANASI, 2022.

Web links and Video Lectures (e-Resources):

1. NPTEL – Dairy and Food Process Engineering
   https://nptel.ac.in
2. NPTEL – Food Processing and Preservation
   https://onlinecourses.nptel.ac.in
3. National Dairy Development Board (NDDB) – Dairy processing, quality control, and milk testing resources.
   https://www.nddb.coop
4. Food Safety and Standards Authority of India (FSSAI) – Food safety standards, dairy regulations, and laboratory manuals.
   https://www.fssai.gov.in

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5. ICAR – National Dairy Research Institute (NDRI) – Training materials, dairy processing, and quality analysis.
   https://www.ndri.res.in

Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

1. Demonstration-based laboratory sessions on milk quality analysis and dairy product processing.
2. Hands-on training in physicochemical, microbiological, and compositional analysis of milk.
3. Inquiry-based laboratory experiments for quality control and adulteration detection.

Assessment Structure:

The assessment for each course is equally divided between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each component carrying **50% weightage** (i.e., 50 marks each).

The CIE marks awarded shall be based on the continuous evaluation of the laboratory report using a defined set of rubrics. Each experiment report can be evaluated for 30 marks. Total marks for the all report shall be scaled down to 30 marks. The laboratory test (duration 03 hours) at the end of the last week of the semester /after completion of all the experiments (whichever is early) shall be conducted for 50 marks and Marks scored shall be scaled down to 20 marks. Final average of marks for report and test shall be out of 50 marks.

Rubrics for CIE – Continuous assessment:

Performance Indicator (CO/PO Mapping)	Superior (5)	Good (4)	Fair (3)	Needs Improvement (2)	Unacceptable (1)
PI-1: Laboratory Preparation & Fundamental Knowledge (CO1/PO1)	Excellent understanding of theory and protocol	Good understanding	Satisfactory understanding	Limited understanding	Poor understanding
PI-2: Experimental Skills & Aseptic Techniques (CO2/PO2, PO5)	Performs accurately and independently	Minor guidance	Moderate guidance	Frequent errors	Unable to perform
PI-3: Data Recording, Analysis & Interpretation (CO3/PO4)	Accurate observations and analysis	Minor errors	Basic interpretation	Limited interpretation	No interpretation
PI-4: Laboratory Record & Documentation (CO1, CO4/PO10)	Complete and organized	Good	Satisfactory	Incomplete	Not submitted
PI-5: Scientific Communication & Teamwork (CO4/PO9, PO10)	Excellent	Good	Satisfactory	Poor	No participation

Rubrics for SEE / CIE Test:

Performance Indicator (CO/PO Mapping)	Superior (5)	Good (4)	Fair (3)	Needs Improvement (2)	Unacceptable (1)
PI-1: Understanding of Experimental Principle (CO1/PO1)	Excellent	Good	Satisfactory	Limited	Poor

PI-2: Experimental Execution (CO2/PO2, PO5)	Independent execution	Minor procedural errors	With guidance	Significant errors	Unable
PI-3: Observation, Result & Interpretation (CO3/PO4)	Accurate and scientific	Minor errors	Basic	Limited	Incorrect
PI-4: Open-ended Problem Solving (CO4/PO2, PO4)	Independent design	Good approach	Basic solution	Limited	Unable
PI-5: Viva Voce & Scientific Communication (CO1–CO4/PO10)	Excellent	Good	Satisfactory	Limited	Unable

- To qualify and become eligible to appear for SEE, in the **CIE component**, a student must secure **a minimum of 40% of 50 marks**, i.e., **20 marks**.
- To pass the **SEE component**, a student must secure **a minimum of 35% of 50 marks**, i.e., **18 marks**.
- A student is deemed to have **successfully completed the course** if the **combined total of CIE and SEE is at least 40 out of 100 markS**

Rubrics suggested for Practical continuous assessment				
Performance Indicators	**Excellent**	**Very Good**	**Good**	**Satisfactory**
Fundamental Knowledge (4) (PO1)	The student has well depth knowledge of the topics related to the course (4)	Student has good knowledge of some of the topics related to course (3)	Student is capable of narrating the answer but not capable to show in depth knowledge (2)	Student has not understood the concepts clearly (1)
Design Of Experiment (5) (PO2 & PO3)	Student is capable of discussing more than one design for his/her problem statement and capable of proving the best suitable design with proper reason (5)	Student is capable of discussing few designs for his/her problem statement but not capable of selecting best (4)	Student is capable of discussing single design with its merits and de-merits (3)	Student is capable of explaining the design (1-2)
Implementation (8) (PO3 & PO8)	Student is capable of implementing the design with best suitable algorithm considering optimal solution. (7-8)	Student is capable of implementing the design with best suitable algorithm and should be capable of explaining it (5-6)	Student is capable of implementing the design with proper explanation. (3-4)	Student is capable of implementing the design. (1-2)

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Result &Analysis (5) (PO4)	Student is able to run the program on various cases and compare the result with proper analysis. (5)	Student will be able to run the program for all the cases. (4)	Student will be able to run the code for few cases and analyze the output. (3)	Student will be able to run the program but not able to analyze the output. (1-2)
Demonstration (8) (PO9)	The lab record is well-organized, with clear sections (e.g., Introduction, Method, Results, Conclusion). Transitions between sections are smooth. (7-8)	The lab record is organized, with clear sections, but some sections are not well-defined. (5-6)	The lab record lacks clear organization or structure. Some sections are unclear or incomplete. (3-4)	The lab record is poorly organized, with missing or unclear sections. (1-2)

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AI & ML in Biotechnology			
Course Code	**1BBT407**	Scheme	**2025**
Type of Course	**BSC**	Semester	**04**
Teaching Hours/Week (L:T:P)	**3: 0 : 0**	CIE Marks	**50**
Total Hours of Pedagogy per semester L /T/P/SL&TW:	**42:0:0:48**	SEE Marks	**50**
Credits	**03**	Total Marks	**100**
Examination type (SEE)	**Theory**	Exam Hours	**03**

Course outcome (Course Skill Set)

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

CO1: Understand the basic definition, scope, and history of AI in BT.

CO2: Illustrate the importance of AI for analyzing biological data and improving research workflows.

CO3: Comprehend the integration of AI in enhancing experimental precision and reducing human error.

CO4: Differentiate between major AI methodologies (ML, DL, NLP, CV) for various/specific BT domains.

CO5:Discuss the ethical considerations and responsible use of AI in biological research.

Module-1

Fundamentals of AI and Biological Data:

Introduction to Artificial Intelligence (AI), Machine Learning (ML), Deep Learning (DL), and Generative AI. Role and applications of AI in biotechnology, healthcare, agriculture, and environmental sciences. Types of biological data (Genomics, Proteomics, Transcriptomics, Phenomics, Metagenomics, Phenotypic, Epidemiology, Biomedical and Clinical). Data collection, preprocessing, cleaning, normalization, feature selection, and data visualization. Case studies related to disease prediction using healthcare and Agri data.

Number of Hours: 8 hrs

Module-2

Python and AI Tools for Biotechnology:

Introduction to Python programming for biological data analysis. Scientific libraries: NumPy, Pandas, Matplotlib, Scikit-Learn, TensorFlow, and Keras. AI platforms and tools including Google Colab, Jupyter Notebook, KNIME, and Orange. Loading, visualizing, and analyzing biological datasets. Development of simple AI workflows for specific biotech applications.

Number of Hours: 8 hrs

Module-3

Machine Learning and Deep Learning Techniques:

Supervised learning: Linear Regression, Logistic Regression, Decision Trees, Random Forests, and Support Vector Machines. Unsupervised learning: K-Means Clustering and Hierarchical Clustering. Dimensionality reduction using PCA. Fundamentals of Neural Networks, CNNs, and model evaluation metrics. Applications in biological data classification and prediction.

Number of Hours: 8 hrs

Module-4

AI in Genomics, Drug Discovery, and Healthcare:

Applications of AI in genomics, transcriptomics, and metagenomics. Genome analysis, variant identification, and gene expression analysis. AI-assisted drug discovery, virtual screening, protein structure prediction (AlphaFold), and prediction of drug-target interaction. Precision medicine, biomarker discovery, medical imaging, and clinical decision support systems.

Number of Hours: 8 hrs

Module-5

AI in Agricultural, Industrial and Environmental Biotechnology:

AI applications in crop improvement, precision agriculture, food quality assessment, fermentation optimization, metabolic engineering, wastewater treatment, and bioremediation. Introduction to synthetic biology and digital biotechnology. Ethical, legal, and regulatory considerations, including data privacy, explainable AI, and responsible use of AI in biotechnology. Emerging trends and future prospects.

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Number of Hours: 8 hrs

Suggested Learning Resources: (Text Book/ Reference Book/ Manuals):

Text books:

1. Alok Kumar Srivastav, Priyanka Das, Babasaheb Ghodke. Artificial Intelligence in Biotechnology and Genomics (Emerging Technologies, Innovations and Applications) Namya Press, 2025.
2. Raschka, S., Liu, Y., & Mirjalili, V. Machine Learning with Python and Scikit-Learn, Keras, and TensorFlow, 4th Edition, Packt Publishing, 2025.
3. Pankaj Bhambri, Sandeep Kautish, Yogita Gupta , " From Genes to Algorithms: Navigating the Biotechnology Data Revolution ", Bentham Science Publishers. 2025.
4. Alpaydin, E. Introduction to Machine Learning, 5th Edition, MIT Press, 2020.
5. Zou, J., Huss, M., Abid, A., Mohammadi, P., Torkamani, A., and Telenti, A. A Primer on Deep Learning in Genomics, Nature Genetics.

Reference books / Manuals:

1. Charu C. Aggarwal Neural Networks and Deep Learning, Springer.
2. Pevsner, J. Bioinformatics and Functional Genomics, Wiley.
3. Jones, D., et al. Artificial Intelligence in Drug Discovery, Royal Society of Chemistry.
4. Kelleher, J., Mac Namee, B., and D'Arcy, A. Fundamentals of Machine Learning for Predictive Data Analytics, MIT Press.

Web links and Video Lectures (e-Resources):

1. Deep Learning for the Life Sciences by Ramsundar et al. – Specifically designed for applying deep learning to biological problems.
2. Machine Learning for Bioinformatics (UW-Madison) – Course materials covering ML applications in genomics and proteomics.
3. Molecular Machine Learning – Interactive textbook for applying ML to molecular and chemical data.
4. ML for Healthcare (MIT) – Focuses on clinical and health data applications.
5. https://www.coursera.org/specializations/machine-learning-introduction
6. https://www.embl.org/topics/ai-at-embl/

Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

Suggested Practical/Skill Components

1. Biological data preprocessing using Python.
2. Dataset analysis using Pandas and Scikit-Learn.
3. PCA-based analysis of omics data.
4. Neural network implementation using TensorFlow/Keras.
5. Gene expression data analysis.

Assessment Structure:

The assessment in each course is divided equally between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each carrying 50% weightage.

- To qualify and become eligible to appear for SEE, in the **CIE**, a student must score at least **40% of 50 marks**, i.e., **20 marks**.
- To pass the **SEE**, a student must score at least **35% of 50 marks**, i.e., **18 marks**.
- Notwithstanding the above, a student is considered to have **passed the course,** provided the combined total of **CIE and SEE** is at least **40 out of 100 marks**.

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Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal EvaluationCIE [25+25=50 marks]
A minimum of two Internal Assessment Tests(IA)shall be conducted, carrying a total of 25 marks. In addition, Continuous Comprehensive Assessment (CCA) shall be conducted for a total of 25 marks.
It is recommended to include a maximum of two learning activities as part of the CCA to foster the holistic development of students. These activities shall be:

Sl. No.	Name of the Learning activity	Maximum Marks
1	Assignment	10
2	Quiz/Seminar/Case study/Project based learning	15

Rubrics for Learning Activity (Based on the nature of learning activity, design the rubrics for each activity):

Assignment (10 Marks)

Performance Indicator (CO/PO Mapping)	Superior (5)	Good (4)	Fair (3)	Needs Improvement (2)	Unacceptable (1)
PI-1: Conceptual Understanding (CO1, CO2 / PO1)	Excellent understanding with accurate explanations	Good understanding with minor errors	Satisfactory understanding	Limited understanding	Poor understanding
PI-2: Problem Solving & Presentation (CO3, CO4, CO5 / PO2, PO10)	Accurate calculations, logical presentation and timely submission	Minor errors	Satisfactory work	Incomplete or poorly presented	Not submitted

Quiz / Seminar / Case Study / Project-Based Learning (15 Marks)

Performance Indicator (CO/PO Mapping)	Superior (5)	Good (4)	Fair (3)	Needs Improvement (2)	Unacceptable (1)
PI-1: Technical Knowledge (CO1–CO5 / PO1)	Excellent conceptual knowledge	Good knowledge	Satisfactory knowledge	Limited knowledge	Poor knowledge
PI-2: Analytical & Problem-Solving Skills (CO3, CO4 / PO2, PO4)	Excellent analysis and application	Good analysis	Basic analysis	Limited analysis	Unable to analyze

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Suggested Learning Activities may include (but are not limited to):

- Course Project
- Case Study Presentation
- Programming Assignment
- Tool/Software Exploration
- Literature Review
- Open Book Test (preferably at RBL4 and RBL5 levels)
- GATE-based Aptitude Test
- Assignment (at RBL3, RBL4, or RBL5 levels)
- Any other relevant and innovative academic activity
- Use of MOOCs and Online Platforms

Suggested Innovative Delivery Methods may include (but are not limited to):

- Flipped Classroom
- Problem-Based Learning (PBL)
- Case-Based Teaching
- Simulation and Virtual Labs
- Partial Delivery of course by Industry expert/ industrial visits
- ICT-Enabled Teaching
- Role Play

Term Work (TW) and Self Learning (SL) components in Number of Hours per semester

Term work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)

Sl. No.	Term Work (TW) Activity	Number of Hours / Semester
1	Assignments, seminars, micro projects, industrial visits, any other student activities etc.	24

SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.

Sl. No.	Self-Learning (SL) Activity	Number of Hours / Semester
1	NPTEL,MIT,MOOCs, spoken tutorials, online educational resources etc.	24

Continuous Internal Evaluation (CIE)

1. The CIE marks shall be decided based on internal tests and other outcome-based activities. The continuous internal evaluation shall be carried out by the teacher handling the course.
2. Out of 50 marks earmarked for CIE, 25 marks shall be assigned for internal tests. The first test shall be conducted after completing two modules of the syllabus and the second one after completing the remaining three modules.
3. The remaining 25 marks shall be assigned for Continuous Course Assessment (CCA), conducted as per the rubrics listed in the assessment section of the respective syllabus.
4. A student shall obtain a minimum of 40% marks or 20 out of 50 marks allotted to CIE to become eligible to appear for the SEE.

Passing requirement in SEE

1. For a pass in the Semester End Examination (SEE), a student shall secure a minimum of 35 marks out of 100.
2. For the declaration of a pass grade, the sum of the Continuous Internal Evaluation (CIE) marks (out of 50) marks and the SEE marks scaled down to 50 shall be greater than or equal to 40 marks.
3. If the total (CIE + SEE) is less than 40 marks, the student shall be awarded the grade 'F' (Fail).

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ENVIRONMENTAL SCIENCE PROJECT			
Course Code	**1BEP408**	Scheme	**2025**
Type of Course	Societal Development Course(SDC)	Semester	04
Teaching Hours/Week(L:T:P)	30(0:0:0)	CIE Marks	50
Total Hours of Pedagogy per Semester CI(L/T):LI(P):TW&SL	30(0:0:0:30)	SEE Marks	50
Credits	**1**	Total Marks	100
Examination type (SEE)	**Theory**	Exam Hours	03

Course Objectives:

The Environmental Science Project is a practical, applied-learning course that builds students' environmental awareness and responsibility. It focuses on real issues such as climate change, pollution, biodiversity, resource use, soil erosion, and thermal comfort, using field surveys, case studies, data collection, audits, and analysis to develop feasible and sustainable solutions. Students may work individually or in groups of up to four, including interdisciplinary topics, and assessment is based on the prescribed rubrics.

Courseoutcome (CourseSkillSet):

Attheendofthecourse,thestudentwillbeableto:

1. **CO1 (L2 – Understand):** Identify and analyse environmental problems through field interaction and technical assessment.
2. **CO2 (L3 – Apply):** Develop skills in project planning, field survey, data collection, implementation, documentation and reporting.
3. **CO3 (L4 – Analyze):** Formulate feasible environmental problem statements and solutions considering practical constraints and sustainability aspects.
4. **CO4 (L3 – Apply):** Apply principles of environmental responsibility, ethics and societal welfare in engineering practice through community-oriented interventions.
5. **CO5 (L4 – Analyze):** Exhibit multidisciplinary learning and problem-solving ability based on collected data, user feedback and baseline conditions.
6. **CO6 (L5 – Evaluate):** Demonstrate teamwork and communication skills while interacting with technical and non-technical stakeholders and reflect on project impact on society.

Restrictionsandprofessionaconduct:

Environmental Science Projects should be academic, socially responsible, technically focused, and politically neutral. Students and faculty must maintain professionalism, ethical conduct, and respect while working with communities and stakeholders, and avoid any political, ideological, commercial, or disruptive activities. Projects should also consider practical constraints such as cost, resources, safety, environmental impact, and stakeholder cooperation.

SET OF PROJECT ACTIVITIES (TW/SL = 30 HOURS)

Methods for project identification:

Students may identify the project topic using one or more of the following methods: interaction with local rural or urban stakeholders such as local leaders, corporation/municipality personnel, NGOs, panchayat representatives, etc.; review of issues highlighted in print and electronic media, and social networks; and, after selecting a broad topic, collect data, conduct a feasibility survey, estimate timelines and resources, approximate expenditure, and define the problem statement and objectives clearly.

List of Project Topics and Engineering Outcomes:

The following structured sequence of activities is to be carried out during the semester:

Sl. No.	Project title	Measurable engineering outcome	Mapped POs	SDGs
1	Rural and urban water conservation and management systems	Prepare a site-specific water-saving plan, estimate water demand–supply gap, and propose a feasible conservation intervention with quantified savings.	PO1, PO2, PO3, PO4, PO10, PO11	SDG 6, SDG 11, SDG 12
2	Waste management	Conduct waste audit, classify waste	PO2, PO3,	SDG 11,

	and recycling	streams, and design a segregation/recycling workflow with measurable reduction in mixed waste.	PO4, PO6, PO8, PO10	SDG 12, SDG 13
3	Afforestation	Identify a degraded area, prepare plantation layout, and demonstrate survival-rate tracking and maintenance schedule for saplings.	PO2, PO3, PO4, PO6, PO7, PO11	SDG 11, SDG 13, SDG 15
4	Biogas generation and power generation	Estimate organic waste availability, size a small biogas system, and document expected gas output or energy yield.	PO1, PO2, PO3, PO4, PO5, PO10	SDG 7, SDG 11, SDG 12
5	DPR for solar power rural plant	Prepare a DPR with load assessment, panel sizing, cost estimate, and projected energy generation and payback.	PO1, PO2, PO3, PO4, PO5, PO10	SDG 7, SDG 9, SDG 11
6	DPR for electrification of village/tribal community	Map unserved/underserved households, propose electrification layout, and estimate coverage, losses, and implementation cost.	PO1, PO2, PO3, PO4, PO10, PO11	SDG 7, SDG 9, SDG 10
7	DPR for rural drainage system	Survey drainage bottlenecks, develop a drainage layout, and estimate runoff handling capacity and flood-risk reduction.	PO1, PO2, PO3, PO4, PO6, PO10	SDG 6, SDG 9, SDG 11
8	Sustainability and environmental health projects	Assess local environmental health issues and propose interventions with measurable improvement in hygiene, safety, or resource use.	PO2, PO3, PO4, PO6, PO7, PO8	SDG 3, SDG 6, SDG 11, SDG 12
9	Plastic free campaigns	Measure plastic usage before and after awareness intervention and report percentage reduction or behavioural change.	PO2, PO3, PO6, PO7, PO8, PO10	SDG 11, SDG 12, SDG 13
10	Health and nutrition awareness	Conduct baseline and post-program awareness survey and daocument improvement in awareness score or adoption of healthier practices.	PO2, PO6, PO7, PO8, PO9, PO10	SDG 2, SDG 3, SDG 11
11	Societal projects involving health wellness	Identify a community health need and develop an awareness/service module with measurable participation and feedback outcomes.	PO2, PO3, PO6, PO8, PO9, PO10	SDG 3, SDG 11, SDG 17
12	Air quality monitoring system	Collect air-quality data, compare with reference limits, and present trends along with possible mitigation suggestions.	PO2, PO3, PO4, PO5, PO6, PO10	SDG 3, SDG 11, SDG 13
13	Plastic waste reduction campaign	Track collection, segregation, and replacement actions, and quantify reduction in plastic waste generation or littering.	PO2, PO3, PO6, PO7, PO8, PO10	SDG 11, SDG 12, SDG 13

14	Urban greening projects	Prepare greening plan, identify planting locations, and assess environmental benefits such as shade, aesthetics, or heat mitigation.	PO2, PO3, PO4, PO6, PO7, PO11	SDG 11, SDG 13, SDG 15
15	Smart agriculture solution	Design a low-cost monitoring or irrigation support solution and estimate improvement in water use efficiency or crop support.	PO1, PO2, PO3, PO4, PO5, PO10	SDG 2, SDG 6, SDG 9
16	Smart irrigation system	Estimate crop water requirement, propose control logic, and quantify water savings compared with conventional irrigation.	PO1, PO2, PO3, PO4, PO5, PO10	SDG 2, SDG 6, SDG 12
17	Food security initiatives / cold storage system	Estimate storage need, design a simple cold-chain concept, and document reduction in spoilage or wastage.	PO1, PO2, PO3, PO4, PO5, PO10	SDG 2, SDG 9, SDG 12

Suggested Learning Resources

Particulars	Titles and Publishers
Textbooks	1. Phadke, N. D., *Community Engagement and Social Innovation*, Oxford University Press, New Delhi. 2. Garg, N. R., *Project-Based Learning in Engineering Education*, Pearson India Education Services, Noida. 3. Gupta, A. and P. Singh, *Service Learning and Community Projects*, McGraw-Hill Education (India), New Delhi. 4. Wilson, G., *Practical Guide to Community Development Projects*, Routledge, London.
Reference books	1. NPTEL courses on Project-Based Learning and Social Innovation. 2. SWAYAM courses on community engagement and sustainability. 3. UN Sustainable Development Goals portal. 4. MyGov India and local civic body portals for community initiatives. 5. YouTube resources on design thinking, social innovation, and community service learning. 6. NGO and government field-action case studies related to sanitation, water, health, education, and environment.
Web links and Video Lectures (e-Resources)	1. NPTEL courses on Engineering Geology. 2. NPTEL courses on Soil Mechanics and Foundation Engineering. 3. Virtual Labs – Geotechnical Engineering Virtual Lab. 4. Geological Survey of India. 5. YouTube channels on civil engineering experiments. 6. American Society of Civil Engineers (ASCE) – Geotechnical resources and standards.

Teaching Learning Process:

The suggested TLP for Community / Societal Project is as follows;

Week / Phase	Teaching–Learning Activity	Faculty Role	Student Activity	Output / Evidence

1	Course introduction, objectives, ethics, conduct, and assessment briefing	Explain course scope, rules, rubrics, and expected deliverables	Understand course requirements and form teams	Team list, course plan
2	Community problem identification and topic selection	Guide topic framing and feasibility	Identify local issues through discussion and observation	Shortlisted project topic
3	Stakeholder interaction and preliminary survey	Demonstrate survey methods and stakeholder engagement	Collect initial data from community/users	Survey notes, interview record
4	Problem statement and objective formulation	Review and refine problem statement	Prepare problem statement, scope, and objectives	Approved problem statement
5	Literature/case study review and baseline analysis	Suggest relevant references and examples	Study existing solutions and compare approaches	Baseline analysis summary
6	Project planning and role assignment	Help teams organize tasks, timeline, and responsibilities	Plan activities, divide roles, and prepare schedule	Work plan / Gantt chart
7	Feasibility analysis and solution brainstorming	Check technical feasibility and practicality	Generate possible engineering solutions	Solution alternatives sheet
8	Selection of final solution and design approach	Review final concept and design logic	Finalize concept, methods, and expected outcome	Concept note / design outline
9	Data processing / calculations / sizing / mapping	Support computations and technical review	Analyze data, perform calculations, prepare maps/charts	Technical analysis sheet
10	Prototype / model / audit / DPR / app development	Monitor progress and correct technical issues	Develop the selected output	Working model / draft DPR / map / app
11	Testing, refinement, and implementation planning	Evaluate technical correctness and improvements	Test prototype or validate proposal with users	Test results / revised output
12	Field implementation / demonstration / awareness activity	Facilitate community interaction and documentation	Conduct implementation or demonstration	Photos, attendance, implementation record
13	Documentation of outcomes, feedback, and impact	Review report structure and completeness	Compile findings, stakeholder feedback, and observations	Draft report
14	Presentation	Conduct mock	Prepare slides/poster	Presentation deck

	preparation and viva practice	presentation and feedback	and rehearse	
15	Final presentation, submission, and reflection	Evaluate performance using rubrics	Present project, submit report, reflect on learning	Final report, presentation, viva

Assessment structure:

A. Continuous Internal Evaluation (CIE) – 50 marks

- Students, in batches of 3–4, shall undertake at least one project (or a combination of two related activities) aiming, as far as possible, at a logical implemented or implementable outcome.
- CIE will be conducted by a departmental committee (HoD/nominee, guide and one senior faculty) using the following rubrics totalling 50 marks:

CIE pass requirement:

A student shall secure a minimum of 20 marks out of 50 in CIE to become eligible to appear for SEE.

- Students who fail to earn the required CIE marks may be given additional opportunities before closure of the semester; no re-doing of CIE is permitted after the end of the semester.

B. Semester End Examination (SEE) – 100 marks (scaled to 50)

- Examination duration: 2 hours.
- Maximum examination marks: 100 (entered as 100 in the VTU portal; the ITI-SMU module automatically scales 100 → 50 for result processing).
- The SEE shall be conducted batch-wise by a committee of three faculty: project guide, one faculty from the same department and one from a different department.

SEE pass requirement and overall passing rule:

- For a pass in SEE, a student shall secure minimum 35 marks out of 100.
- For declaration of a pass grade, the sum of CIE marks (out of 50) and scaled SEE marks (out of 50) shall be ≥ 40; otherwise, the student is awarded grade F (Fail).

CIE Rubric — Continuous Internal Evaluation (Total 50 marks):

Criterion	Weight (marks)	Excellent (Full marks)	Good	Fair	Needs Improvement
Problem identification & relevance to society/environment	8	Problem clearly identified with strong evidence of relevance and well-defined scope.	Relevant problem with clear scope and adequate evidence.	Problem defined but justification is weak.	Problem unclear or not relevant.
Formation of problem statement; engineering approach, innovation & feasibility	10	Precise statement; sound, innovative, feasible approach.	Adequate statement; feasible with minor gaps.	Partial statement; marginal feasibility.	Missing or infeasible.
Interaction with stakeholders; data collection, analysis & interpretation	8	Thorough engagement; comprehensive data and well-interpreted analysis.	Good engagement; adequate data and analysis.	Limited engagement; incomplete data and superficial analysis.	Little or no stakeholder contact; no data/analysis.
Project documentation;	10	Complete, well-organized,	Complete and clear with	Basic with omissions;	Missing/poorly organized; no

clarity, organization & problem-solving demonstrated		analytical, and strong problem-solving.	some analytical content.	problem-solving limited.	clear problem-solving.
Communication & presentation skills	6	Confident, structured, and answers queries fully; visuals effective.	Clear and satisfactory; responds to most queries.	Acceptable but lacks clarity or confidence; weak responses.	Poor or absent; unable to respond.
Contribution & benefit to society (impact, sustainability)	8	Clear, demonstrable societal benefit and realistic sustainability path.	Benefit plausible; sustainability considered with minor gaps.	Limited or unclear benefit; sustainability weak.	No evident benefit or sustainability.

Notes for CIE rubric:

- Minimum CIE pass requirement: 20/50 to be eligible for SEE. [Use departmental committee (HoD/guide + senior faculty) to apply the rubric and record marks.]

SEE Rubric — Semester End Examination (Enter marks out of 100; scaled to 50 later):

Criterion	Weight (marks)	Excellent (Full marks)	Good	Fair	Needs Improvement
Problem identification & relevance to society/environment	16	Clearly articulated with strong evidence and context.	Clear with reasonable evidence.	Problem stated but evidence/context weak.	Poorly defined or irrelevant.
Formation of problem statement; engineering approach, innovation & feasibility	20	Precise; demonstrates engineering depth, novelty and feasibility.	Technically sound and feasible with minor limitations.	Basic; limited technical depth or feasibility concerns.	No viable engineering approach or infeasible plan.
Interaction with stakeholders; data collection, analysis & interpretation	16	Excellent engagement; rigorous data collection and insightful analysis.	Good engagement and acceptable analysis.	Superficial data collection and limited analysis.	Inadequate or no data; poor analysis.
Project documentation; clarity, technical rigor & problem-solving demonstrated	20	Comprehensive, technically rigorous, and systematic.	Complete and technically correct with minor gaps.	Lacks technical depth or has notable omissions.	Missing key elements or technically incorrect.

Communication, presentation & viva-voce responses	12	Presents expertly, defends work persuasively and answers all queries correctly.	Good presentation and satisfactory answers to most queries.	Adequate but fails to answer some technical questions.	Poor presentation and unable to defend work.
Contribution & benefit to society; impact assessment & sustainability	16	Clear, evidence-based impact assessment with scaling recommendations.	Reasonable impact discussion and sustainability considerations.	Limited evaluation of impact or sustainability.	No coherent assessment of impact or sustainability.

SEE pass rule:

- Student must secure at least 35/100 in SEE itself to be eligible for pass consideration.
- Final passing is based on CIE (out of 50) + SEE (scaled to 50) >= 40. Otherwise, grade F (Fail) is awarded.

Suggested implementation notes (for BoS / exam committees):

- Use numerical scores from the rubric and keep brief evaluator comments for each criterion.
- For team projects: record individual contribution within the documentation and adjust individual marks using a peer-evaluation sheet or guide's assessment.
- Maintain evidence (field notes, photos, questionnaires, DPRs, reports) as annexures for SEE moderation.
- Use standardized score sheet (spreadsheet) mapping rubric items to columns for easy aggregation and archival.

- Awareness Campaign on Single-Use Plastic and E-Waste Management

SuggestedLearningResources:

TextBooks:

1. BennyJoseph,*EnvironmentalStudies*,TataMcGraw-Hill,2ndEdition.
2. R.Rajagopalan,*EnvironmentalStudies:FromCrisistoCure*,OxfordUniversityPress,2005.
3. ErachBharucha,*TextbookofEnvironmentalStudies*,UniversityPress,latesteditionasavailablein library.
4. M.P.PooniaandS.C.Sharma,*EnvironmentalStudies*,VikasPublishingHouse,latesteditionasavailable

ReferenceBooks:

1. R.Sivakumar,PrinciplesofEnvironmentalScienceandEngineering,CengageLearning,2ndEdition.
2. G.TylerMillerJr.,EnvironmentalScience:WorkingwiththeEarth,ThomsonBrooks/Cole,11thEdition.
3. PratibhaSingh,AnoopSingh,andPiyushMalaviya,TextBookofEnvironmentalandEcology,AcmeLearnin 1stEdition.
4. S.M.Prakash,EnvironmentalStudies,ElitePublishingHouse,Mangalore,3rdEdition,2018.

WeblinksandVideoLectures(e-Resources):

1. VTUe-LearningCentre:http://elearning.vtu.ac.in
2. VTUe-Resources/e-Content:http://elearning.vtu.ac.in/e-Res.php
3. VTUe-ShikshanaLectureVideos:http://elearning.vtu.ac.in/esk3.php
4. VTUConsortiumDigitalResources:https://access.vtuconsortium.com/msec
5. VTUe-LearningCentre:http://elearning.vtu.ac.in
6. VTUe-Resources/e-Content:http://elearning.vtu.ac.in/e-Res.php
7. VTUe-ShikshanaLectureVideos:http://elearning.vtu.ac.in/esk3.php
8. VTUConsortiumDigitalResources:https://access.vtuconsortium.com/msec

AssessmentStructure:

ContinuousInternalEvaluation(CIE)shallbeconductedbytheDepartmentalProjectReviewCommitteeconsisting of a Senior Professor, the Project Guide, and one additional faculty member nominated by the Head of the Department.SemesterEndEvaluation(SEE)shallbeconductedbyuniversity-appointedexaminers.Theevaluation shall be basedonrubrics designedtoassess the attainmentofNBA-defined graduate attributes,includingproblem analysis, investigation, design of solutions, communication, teamwork, and professionalism**.**

TheweightageofmarksforCIEandSEEis50% each.

Pass Criteria:A candidate shall secure a minimum of 40% of the total marks prescribed for Project Work, subject to the required minimum in Continuous Internal Evaluation and Semester End Evaluation as per VTU regulations.

Sample Rubrics for Campus water-quality and development of a water-conservation plan.

Criterion	**Weight (%)**	**4 - Excellent**	**3 - Good**	**2 - Satisfactory**	**1 - Needs improvement**
Problem definition and campus context	10	Clearly defines campus water issue, boundaries, water sources, and purpose.	Defines issue and context with minor gaps.	Basic problem stated, but scope is incomplete.	Vague or incorrect problem definition.
Water-quality data collection	15	Uses appropriate sampling points, methods, and frequency; data are well documented.	Methods are mostly appropriate with minor omissions.	Limited methods or incomplete documentation.	Weak or unclear data collection.
Water-quality parameters and analysis	20	Correctly analyzes key physical, chemical, and microbiological parameters and	Analyzes most parameters correctly with minor	Some parameters analyzed, but interpretation is weak.	Minimal or incorrect analysis.

Criterion	Weight (%)	4 - Excellent	3 - Good	2 - Satisfactory	1 - Needs improvement
		interprets results.	interpretation gaps.		
Evidence and standards comparison	15	Compares results against relevant standards/guidelines and draws valid conclusions.	Compares most results with reasonable conclusions.	Comparison is partial or uneven.	No meaningful comparison with standards.
Diagnosis of issues and causes	10	Identifies likely causes of poor quality or water loss using evidence.	Identifies main causes with some support.	Causes are mentioned, but weakly supported.	Causes are speculative or absent.
Conservation plan objectives and measures	15	Plan includes clear goals, realistic measures, prioritization, and campus suitability.	Plan is relevant and mostly realistic.	Plan has some useful measures but limited prioritization.	Plan is generic or impractical.
Feasibility and implementation	10	Addresses resources, responsibilities, timeline, and implementation steps clearly.	Covers most implementation aspects.	Implementation is partial or underdeveloped.	Little or no implementation planning.
Cost, savings, and sustainability	5	Provides reasonable cost-benefit thinking and expected savings.	Includes some cost or savings discussion.	Limited financial/savings analysis.	No cost or savings consideration.
Presentation and documentation	0–10	Clear structure, tables/figures, references, and professional report quality.	Well organized with minor issues.	Acceptable but uneven formatting or writing.	Poorly organized and difficult to follow.