TECHNO INDIA UNIVERSITY

WEST BENGAL

DEPARTMENT OF MICROBIOLOGY

SYLLABUS STRUCTURE AND COURSE DETAILS

w.e.f 2024-25

SEMESTER 3

MACHINE LEARNING

Program: B. Sc. in Microbiology	**Year, Semester:** 2nd Yr., 3rd Sem.
Course Title: Machine Learning	**Subject Code:** TIU-UCS-MD-T2101
Contact Hours/Week: 2–1–0 (L–T–P)	**Credit:** 3

COURSE OBJECTIVE :

Enable the student to:

1. introduce the fundamental concepts, types, and applications of Machine Learning, enabling students to understand its role in real-world problem-solving.
2. develop skills in data preprocessing, feature engineering, and implementing Machine Learning models, including regression, classification, clustering, and neural networks.
3. equip students with the knowledge of model evaluation, optimization, and deployment techniques, preparing them for practical applications in various domains.

COURSE OUTCOME :

The student will be able to:

CO-1	Understand the fundamental concepts and applications of Machine Learning.	K2
CO-2	Identify and preprocess data for effective Machine Learning model training.	K3
CO-3	Implement regression and classification algorithms for predictive modeling.	K3
CO-4	Analyze clustering and dimensionality reduction techniques for pattern recognition.	K4
CO-5	Explain the working principles of neural networks and reinforcement learning.	K2
CO-6	Apply Machine Learning techniques to real-world case studies and deployment scenarios.	K3

COURSE CONTENT :

MODULE 1:	**INTRODUCTION TO MACHINE LEARNING**	**6 Hours**
Basics of ML, Real-world Applications, ML vs AI vs Data Science, Types of ML (Supervised, Unsupervised, Reinforcement), ML Workflow (Data Collection, Model Training, Evaluation)		
MODULE 2:	**DATA HANDLING & PREPROCESSING**	**6 Hours**
Data Cleaning (Handling Missing Values, Duplicates), Feature Scaling (Normalization, Standardization), Encoding Categorical Data, Train-Test Split, Data Visualization using Matplotlib & Seaborn		
MODULE 3:	**SUPERVISED LEARNING**	**6 Hours**
Regression: Linear Regression, Polynomial Regression, Evaluation Metrics (MSE, RMSE, R^2 Score) Classification: Logistic Regression, Decision Trees, Support Vector Machines (SVM), k-Nearest Neighbors (k-NN), Confusion Matrix, Precision, Recall, F1 Score		
MODULE 4:	**UNSUPERVISED LEARNING & NEURAL NETWORKS**	**6 Hours**
Clustering: K-Means, Hierarchical, DBSCAN Dimensionality Reduction: Principal Component Analysis (PCA) Neural Networks: Basics of Perceptron, Activation Functions, Introduction to Deep Learning		
MODULE 5:	**ADVANCED TOPICS & APPLICATIONS**	**6 Hours**
Reinforcement Learning: Basics, Markov Decision Process, Q-Learning Model Deployment: Using Flask/Streamlit, Cloud ML Platforms (AWS, GCP) Applications: ML in Healthcare, Finance, Autonomous Systems, Chatbots		
TOTAL LECTURE		**30 Hours**

Books:

1. P. Flach, "Machine Learning: The art and science of algorithms that make sense of data", Cambridge University Press, 2012, ISBN-10: 1107422221, ISBN-13: 978-1107422223.
2. Trevor Hastie, Robert Tibshirani, Jerome Friedman, "The Elements of Statistical Learning: Data Mining, Inference, and Prediction", Second Edition (Springer Series in Statistics), 2016, ISBN-10: 0387848576, ISBN-13: 978-0387848570.

3. Christopher Bishop, "Pattern Recognition and Machine Learning (Information Science and Statistics)", Springer, 2007.
4. Kevin Murphy, "Machine Learning: A Probabilistic Perspective", MIT Press, 2012, ISBN-10: 0262018020, ISBN-13: 978-0262018029
5. Y. S. Abu-Mostafa, M. Magdon-Ismail, and H.-T. Lin, "Learning from Data", AMLBook Publishers, 2012 ISBN 13: 978-1600490064.
6. Tom Mitchell, "Machine Learning", McGraw-Hill, 1997, ISBN-10: 0071154671, ISBN-13: 978-0071154673.
7. Jiawei Han, Micheline Kamber, "Data Mining Concepts and Techniques", Chris Ullman, Morgan Kaufmann Publishers,Third Edition, 2011, ISBN 0123814790, ISBN-13 9780123814791.

BIOMOLECULES AND BIOENERGETICS (Theory)

Program: B. Sc. in Microbiology	**Year, Semester:** 2nd Yr., 3rd Sem
Course Title: BIOMOLECULES AND BIOENERGETICS (Theory)	**Subject Code:** TIU-UMB-MJ-T21201
Contact Hours/Week: 2–1–0 (L–T–P)	**Credit:** 3

COURSE OBJECTIVE :

Enable the student to:

1. To understand the fundamental principles of thermodynamics and their relevance in biological systems.
2. To classify monosaccharides based on their functional groups and carbon number.
3. To classify lipids and understand their structural and functional roles in biological systems and biomolecules

COURSE OUTCOME :

On completion of the course, the student will be able to:

CO-1:	Be able to outline structure and function of monosaccharide, disaccharide and polysaccharide	K1
CO-2:	Be able to know about structure, properties and functions of essential fatty acids, Triacylglycerols, lipid	K2
CO-3:	Be able to apply different functions of proteins in different fields	K3
CO-4:	Able to arrange different levels of organization of proteins, primary, secondary (alpha helix and beta pleated sheet), tertiary and quaternary Forces holding the polypeptide together.	K4
CO-5:	Be able to explain the Enzyme kinetics, significance of hyperbolic, double reciprocal plots of enzyme activity and Km.	K2
CO-6:	Be able to explain functions of proteins, carbohydrates and enzyme kinetics	K2

COURSE CONTENT :

MODULE 1:	**BIOENERGETICS**	**6 Hours**
First and second laws of Thermodynamics. Definitions of Gibb's Free Energy, enthalpy, and Entropy and mathematical relationship among them, Standard free energy change and equilibrium constant Coupled reactions and additive nature of standard free energy change, Energy rich compounds: Phosphoenolpyruvate, 1,3- Bisphosphoglycerate, Thioesters, ATP		
MODULE 2:	**CARBOHYDRATES**	**7 Hours**
Families of monosaccharides: aldoses and ketoses, trioses, tetroses, pentoses, and hexoses.Stereo isomerism of monosaccharides, epimers, Mutarotation and anomers of glucose. Furanoseand pyranose forms of glucose and fructose, Haworth projection formulae for glucose; chair and boat forms of glucose, Sugar derivatives, glucosamine, galactosamine, muramic acid, N- acetyl neuraminic acid, Disaccharides; concept of reducing and non-reducing sugars, occurrence and Haworth projections of maltose, lactose, and sucrose, Polysaccharides, storage polysaccharides, starch and glycogen. Structural Polysaccharides, cellulose, peptidoglycan and chitin		
MODULE 3:	**LIPIDS**	**7 Hours**
Definition and major classes of storage and structural lipids. Storage lipids. Fatty acids structure and functions. Essential fatty acids. Triacyl glycerols structure, functions and properties,Saponification Structural lipids. Phosphoglycerides: Building blocks, General structure, functions and properties. Structure of phosphatidylethanolamine and phosphatidylcholine, Sphingolipids:building blocks, structure of sphingosine, ceramide. Special mention of sphingomyelins,cerebrosides and gangliosides Lipid functions: cell signals, cofactors, prostaglandins, Introduction of lipid micelles, monolayers, bilayers		
MODULE 4:	**AMINO ACIDS & PROTEINS**	**7 Hours**
Functions of proteins, Primary structures of proteins: Amino acids, the building blocks of proteins. General formula of amino acid and concept of zwitterion. Titration curve of amino acid and its Significance, Classification, biochemical structure and notation of standard protein amino acids Ninhydrin reaction.Natural modifications of amino acids in proteins hydrolysine, cystine and hydroxyproline, Non protein amino acids: Gramicidin,		

beta-alanine, D-alanine and Dglutamic acid Oligopeptides: Structure and functions of naturally occurring glutathione and insulin and synthetic aspartame, Secondary structure of proteins: Peptide unit and its salient features. Biologically important peptides like glutathione, oxytocin-important functions. The alpha helix, the beta pleated sheet and their occurrence in proteins, Tertiary and quaternary, structures of proteins, Forces holding the polypeptide together, Human haemoglobin structure, Quaternary structures of proteins		
MODULE 5:	**ENZYMES**	**6 Hours**
General properties, Nomenclature and classification Structure of enzyme: Apoenzyme and cofactors (prosthetic group-TPP, coenzyme NAD, metal cofactors) Mechanism of action of enzymes: active site, transition state complex and activation energy. Lock and key hypothesis, and Induced Fit hypothesis.		
MODULE 6:	**NUCLEIC ACIDS**	**7 Hours**
Miescher to Watson and Crick- historic perspective Purine, pyrimidine - definition and structure. Nucleoside, nucleotide: definition and structure. DNA & RNA: Chargaff's rule, Double helical structure. A-DNA, B-DNA & Z-DNA (structure and differences). Chemical Properties of DNA & RNA: Hydrolysis (acid, alkali), enzymatic hydrolysis		
MODULE 7:	**Vitamins**	**5 Hours**
Classification and characteristics with suitable examples, sources and importance		
TOTAL LECTURES		**45 Hours****

Books:

1. Campbell, MK (2012) Biochemistry, 7th ed., Published by Cengage Learning
2. Campbell, PN and Smith AD (2011) Biochemistry Illustrated, 4th ed., Published by Churchill Livingstone
3. Tymoczko JL, Berg JM and Stryer L (2012) Biochemistry: A short course, 2nd ed., W.H.Freeman
4. Berg JM, Tymoczko JL and Stryer L (2011) Biochemistry, W.H.Freeman and Company
5. Nelson DL and Cox MM (2008) Lehninger Principles of Biochemistry, 5th Edition., W.H. Freeman and Company,
6. Willey MJ, Sherwood, LM & Woolverton C J (2013) Prescott, Harley and Klein's Microbiology by. 9th Ed., McGrawHill
7. Voet,D. and Voet J.G (2004) Biochemistry 3rd edition, John Wiley and Sons

BIOMOLECULES AND BIOENERGETICS (Practical)

Program: B. Sc. in Microbiology	**Year, Semester:** 2nd Yr., 3rd Sem
Course Title: BIOMOLECULES AND BIOENERGETICS (Practical)	**Subject Code:** TIU-UMB-MJ-L21201
Contact Hours/Week: 0–0–1 (L–T–P)	**Credit:** 1

COURSE OBJECTIVE :

Enable the student to:

1. To understand the unique properties of water and their significance in biological systems
2. To differentiate between reducing and non-reducing sugars using biochemical tests
3. To identify lipids using solubility tests, Salkowski reaction, and Sudan III/IV tests.
4. To understand the different levels of protein structure (α-helix, β-sheet, tertiary conformation).
5. To differentiate between various DNA conformations (A-DNA, B-DNA, Z-DNA).

COURSE OUTCOME :

On completion of the course, the student will be able to:

CO-1:	Able to analyse and prepare pH, buffer, and their derivatives	K4
CO-2:	Able to analyse free energy	K4
CO-3:	Able to perform experiments of carbohydrates	K3
CO-4:	Able to perform experiments of lipids and proteins	K3
CO-5:	Able to analyse different protein structures	K4
CO-6:	Able to analyse DNA structures	K4

COURSE CONTENT :

MODULE 1:	QUANTIFICATION AND ESTIMATION OF BIOMOLECULES	15 Hours
1. Properties of water, Concept of pH and buffers, preparation of buffers and Numerical problems to explain the concepts 2. Numerical problems on calculations of Standard Free Energy Change and Equilibrium constant 4. Qualitative/Quantitative tests for carbohydrates, reducing sugars, non-reducing sugars 5. Qualitative/Quantitative tests for lipids and proteins 6. Study of protein secondary and tertiary structures with the help of models 7. Study of different types of DNA with the help of models		
TOTAL LECTURES		**15 Hours****

MICROBIAL PHYSIOLOGY AND METABOLISM (Theory)

Program: B. Sc. in Microbiology	**Year, Semester:** 2nd Yr., 3rd Sem
Course Title: MICROBIAL PHYSIOLOGY AND METABOLISM (Theory)	**Subject Code:** TIU-UMB-MJ-T21202
Contact Hours/Week: 2–1–0 (L–T–P)	**Credit:** 3

COURSE OBJECTIVE :

Enable the student to:

1. To understand the fundamental concepts of microbial growth, including different phases and growth kinetics.
2. To explore different mechanisms of nutrient transport, including passive diffusion, facilitated diffusion, and active transport.
3. To understand the principles of aerobic respiration, anaerobic respiration, and fermentation.
4. To introduce the concept of chemolithotrophy and Chemoheterotrophy and their significance in microbial ecology.

COURSE OUTCOME :

On completion of the course, the student will be able to:

CO-1:	Define and explain the concept of microbial growth, including the different phases of a typical growth curve.	K2
CO-2:	Explain the mechanisms of transport systems, including uniport, symport, and antiport systems.	K2

CO-3:	Recall and describe the key metabolic pathways involved in aerobic respiration (EMP, ED, Pentose phosphate pathway, TCA cycle).	K4
CO-4:	Illustrate the Chemoheterotrophic Metabolism - Anaerobic Respiration and Fermentation	K3
CO-5:	Explain different Chemolithotrophic and Phototrophic Metabolism	K3
CO-6:	Illustrate Nitrogen Metabolism and what will be application on agriculture	K3

COURSE CONTENT :

MODULE 1:	**MICROBIAL GROWTH AND EFFECT OF ENVIRONMENT ON MICROBIAL GROWTH**	**10 Hours**
Definitions of growth, measurement of microbial growth, Batch culture, Continuous culture, generation time and specific growth rate, synchronous growth, diauxic growth curve Microbial growth in response to environment -Temperature (psychrophiles, mesophiles, thermophiles, extremophiles, thermodurics, psychrotrophs), pH (acidophiles, alkaliphiles), solute and water activity (halophiles, xerophiles, osmophilic), Oxygen (aerobic, anaerobic, microaerophilic, facultative aerobe, facultative anaerobe),barophilic. Microbial growth in response to nutrition and energy – Autotroph/Phototroph, heterotrophy, Chemolithoautotroph, Chemolithoheterotroph, Chemoheterotroph, Chemolithotroph, photolithoautotroph, Photoorganoheterotroph, Peptidoglycan biosynthesis pathway		
MODULE 2:	**NUTRIENT UPTAKE AND TRANSPORT**	**7 Hours**
Passive and facilitated diffusion Primary and secondary active transport, concept of uniport, symport and antiport Group translocation Iron uptake		
MODULE 3:	**CHEMOHETEROTROPHIC METABOLISM - AEROBIC RESPIRATION**	**8 Hours**
Concept of aerobic respiration, anaerobic respiration and fermentation Sugar degradation pathways i.e. EMP, ED, Pentose phosphate pathway TCA cycle Electron transport chain: components of respiratory chain, comparison of mitochondrial and bacterial ETC, electron transport phosphorylation, uncouplers and inhibitors		
MODULE 4:	**CHEMOHETEROTROPHIC METABOLISM-**	**7 Hours**

	ANAEROBIC RESPIRATION AND FERMENTATION	
Anaerobic respiration with special reference to dissimilatory nitrate reduction (Denitrification; nitrate /nitrite and nitrate/ammonia respiration; fermentative nitrate reduction) Fermentation - Alcohol fermentation and Pasteur effect; Lactate fermentation (homofermentative and heterofermentative pathways), concept of linear and branched fermentation pathways		
MODULE 5:	**CHEMOLITHOTROPHIC AND PHOTOTROPHIC METABOLISM**	**8 Hours**
Introduction to aerobic and anaerobic chemolithotrophy with an example each. Hydrogen oxidation (definition and reaction) and methanogenesis (definition and reaction) Introduction to phototrophic metabolism - groups of phototrophic microorganisms, anoxygenic vs. oxygenic photosynthesis with reference to photosynthesis in green bacteria, purple bacteria and cyanobacteria		
MODULE 6:	**NITROGEN METABOLISM - AN OVERVIEW**	**7 Hours**
Introduction to biological nitrogen fixation, nitrogenase-mode of action and regulation, ammonia assimilation, assimilatory nitrate reduction, dissimilatory nitrate reduction, denitrification.		
TOTAL LECTURES		**45 Hours****

Books:

1. Madigan MT, and Martinko JM (2014). Brock Biology of Microorganisms. 14th edition.Prentice Hall International Inc.
2. Moat AG and Foster JW. (2002). Microbial Physiology. 4th edition. John Wiley & Sons
3. Reddy SR and Reddy SM. (2005). Microbial Physiology. Scientific Publishers India
4. Gottschalk G. (1986). Bacterial Metabolism. 2nd edition. Springer Verlag
5. Stanier RY, Ingrahm JI, Wheelis ML and Painter PR. (1987). General Microbiology. 5thedition, McMillan Press.
6. Willey JM, Sherwood LM, and Woolverton CJ. (2013). Prescott's Microbiology. 9th edition.McGraw Hill Higher Education

MICROBIAL PHYSIOLOGY AND METABOLISM (Practical)

Program: B. Sc. in Microbiology	**Year, Semester:** 2nd Yr., 3rd Sem
Course Title: MICROBIAL PHYSIOLOGY AND METABOLISM (Practical)	**Subject Code:** TIU-UMB-MJ-L21202
Contact Hours/Week: 0–0–1 (L–T–P)	**Credit:** 1

COURSE OBJECTIVE :

Enable the student to:

1. To understand different methods of measuring bacterial growth.
2. To calculate the generation time and specific growth rate from experimental data.
3. To study how environmental factors influences microbial metabolism and growth.
4. To learn techniques for isolating phototrophic bacteria from environmental samples

COURSE OUTCOME :

On completion of the course, the student will be able to:

CO-1:	Study and plot the growth curve of *E. coli* by turbidometric and standard plate count methods.	K3
CO-2:	Calculations of generation time and specific growth rate of bacteria from the graph plotted with the given data	K3
CO-3:	Understand the effect of temperature and pH on growth of *E. coli*	K4
CO-4:	Evaluate the presence of carbon, nitrogen and salt sources on growth of *E.coli*	K3
CO-5:	Demonstration of alcoholic fermentation	K4
CO-6:	Demonstration of the thermal death time and decimal reduction time of *E. coli*.	K4

COURSE CONTENT :

MODULE 1:	**STUDY OF ENVIRONMENTAL FACTORS AFFECTING GROWTH OF MICROBES**	**15 Hours**

Study and plot the growth curve of *E. coli* by turbidometric and standard plate count methods. 2. Calculations of generation time and specific growth rate of bacteria from the graph plotted with the given data 3. Effect of temperature on growth of *E. coli* 4. Effect of carbon and nitrogen sources on growth of *E.coli* 5. Effect of salt on growth of *E. coli* 6. Enrichment of phototrophic bacteria from natural sources	
TOTAL LECTURES	**15 Hours****

MICROBIAL QUALITY CONTROL IN FOOD & PHARMACEUTICAL INDUSTRIES (Theory)

Program: B. Sc. in Microbiology	**Year, Semester:** 2nd Yr., 3rd Sem
Course Title: MICROBIAL QUALITY CONTROL IN FOOD & PHARMACEUTICAL INDUSTRIES (Theory)	**Subject Code:** TIU-UMB-SEC-T2101
Contact Hours/Week: 2–1–0 (L–T–P)	**Credit:** 3

COURSE OBJECTIVE :

Enable the student to:

1. To understand Good Laboratory Practices (GLP) and Good Microbiological Practices (GMP) for safe handling of microorganisms.
2. To learn different methods for detecting and quantifying microbes in food and pharmaceutical products.
3. To understand the principles and applications of Hazard Analysis and Critical Control Points (HACCP) for food safety.
4. To study the enrichment culture techniques for isolating food- and waterborne pathogens.

COURSE OUTCOME :

On completion of the course, the student will be able to:

CO-1:	Recall key microbial quality control terminology, safety rules, and standard laboratory techniques.	K2
CO-2:	Explain the role of microbial testing methods and laboratory safety protocols in ensuring product quality.	K4
CO-3:	Demonstrate the ability to apply microbial testing techniques and safety rules in laboratory and industrial settings.	K3

CO-4:	Analyze microbial test results and assess the quality of food and pharmaceutical products.	K3
CO-5:	Evaluate the suitability of different microbial testing methods and laboratory protocols for various products.	K5
CO-6:	Design and implement a microbial quality control program for food or pharmaceutical products.	K6

COURSE CONTENT :

MODULE 1:	**MICROBIOLOGICAL LABORATORY AND SAFE PRACTICES**	**10 Hours**
Good laboratory practices - Good laboratory practices, Good microbiological practices Biosafety cabinets –Working of biosafety cabinets, using protective clothing, specification for BSL-1, BSL-2, BSL-3. Discarding biohazardous waste – Methodology of Disinfection, Autoclaving & Incineration.		
MODULE 2:	**DETERMINING MICROBES IN FOOD / PHARMACEUTICAL SAMPLES**	**10 Hours**
Culture and microscopic methods - Standard plate count, Most probable numbers, Direct microscopic counts, Biochemical and immunological methods: Limulus lysate test for endotoxin, gel diffusion, sterility testing for pharmaceutical products Molecular methods - Nucleic acid probes, PCR based detection, biosensors.		
MODULE 3:	**PATHOGENIC MICROORGANISMS OF IMPORTANCE IN FOOD & WATER**	**15 Hours**
Enrichment culture technique, Detection of specific microorganisms - on XLD agar, Salmonella Shigella Agar, Manitol salt agar, EMB agar, McConkey Agar, Saboraud Agar Ascertaining microbial quality of milk by MBRT, Rapid detection methods of microbiological quality of milk at milk collection centres (COB, 10 min Resazurin assay)		

MODULE 4:	HACCP FOR FOOD SAFETY AND MICROBIAL STANDARDS	10 Hours
Hazard analysis of critical control point (HACCP) - Principles, flow diagrams, limitations Microbial Standards for Different Foods and Water – BIS standards for common foods and drinking water		
TOTAL LECTURES		**45 Hours****

Books:

1. Harrigan WF (1998) Laboratory Methods in Food Microbiology, 3rd ed. Academic Press
Garg N, Garg KL and Mukerji KG (2010) Laboratory Manual of Food Microbiology I K International Publishing House Pvt. Ltd.
Jay JM, Loessner MJ, Golden DA (2005) Modern Food Microbiology, 7th edition. Springer
Baird RM, Hodges NA and Denyer SP (2005) Handbook of Microbiological Quality control in Pharmaceutical and Medical Devices, Taylor and Francis Inc.

MARINE BIOTECHNOLOGY (Theory)

Program: B. Sc. in Microbiology	**Year, Semester:** 2nd Yr., 3rd Sem
Course Title: MARINE BIOTECHNOLOGY (Theory)	**Subject Code:** TIU-UBT-MI-T21202
Contact Hours/Week: 2–1–0 (L–T–P)	**Credit:** 3

COURSE OBJECTIVE :

Enable the student to:

1. Understand the diversity and role of microorganisms in marine ecosystems.
2. Study the physiological and metabolic adaptations of marine microorganisms.
3. Learn about microbial interactions in marine environments.
4. Explore the techniques used in marine microbiology research.
5. Investigate the ecological and biogeochemical processes mediated by marine Microorganisms

.COURSEOUTCOME :

On completion of the course, the student will be able to:

CO-1:	Students will be able to explain the fundamental characteristics of diverse marine microbial communities and their distribution across various marine environments	K2

CO-2:	Students will be able to apply principles of microbial physiology and ecology to describe how marine microorganisms adapt to extreme conditions and contribute to key biogeochemical cycles within marine food webs.	K3
CO-3:	Students will be able to analyze the intricate interactions between marine viruses and their hosts, critically assessing their impact on marine microbial population dynamics and nutrient cycling.	K4
CO-4:	Students will be able to utilize knowledge of marine biotechnology to identify potential bioprospecting opportunities for novel compounds and evaluate the environmental and industrial applications of marine microorganisms.	K3
CO-5:	Students will be able to evaluate the role of marine microorganisms in significant oceanographic processes, including ocean productivity, climate regulation, and the microbial loop, by integrating ecological and oceanographic concepts.	K4
CO-6:	Students will be able to critically assess the ecological and public health implications of marine pathogens, pollutio , and climate change on marine microbial communities and associated ecosystems.	K5

COURSE CONTENT :

MODULE 1:	**INTRODUCTION TO MARINE MICROBIOLOGY AND MICROBIAL DIVERSITY**	**5 Hours**
Overview of marine environments Importance of marine microbiology History and scope of marine microbiology Pelagic and benthic zones Hydrothermal vents, cold seeps, and coral reefs Diversity of marine microorganisms: Bacteria, Archaea, Viruses, Fungi, and Protists		
MODULE 2:	**MARINE MICROBIAL PHYSIOLOGY AND ECOLOGY**	**7 Hours**
Adaptations to marine conditions: salinity, pressure, temperature Microbial food webs Microbial interactions: symbiosis, competition, predation		

Role of microorganisms in nutrient cycles: carbon, nitrogen, sulfur, phosphorus		
MODULE 3:	**MARINE VIRUSES AND VIRAL ECOLOGY**	**8 Hours**
Diversity of marine viruses Virus-host interactions Impact of viruses on marine microbial communities		
MODULE 4:	**MARINE BIOTECHNOLOGY**	**5 Hours**
Marine microorganisms in biotechnology Bioprospecting for novel compounds: enzymes, antibiotics, biofuels Environmental and industrial applications		
MODULE 5:	**MICROBIAL OCEANOGRAPHY**	**5 Hours**
Oceanographic processes influencing microbial distribution Role of microorganisms in ocean productivity and climate regulation Marine microbial loops		
MODULE 6:	**MICROBIAL SYMBIOSES IN THE MARINE ENVIRONMENT**	**5 Hours**
Symbiotic relationships: coral reefs, hydrothermal vent communities, marine sponges Molecular basis of symbiosis Ecological impact of symbiotic associations		
MODULE 7:	**MARINE PATHOGENS AND PUBLIC HEALTH**	**5 Hours**
Pathogenic marine microorganisms Diseases in marine organisms: corals, fish, marine mammals Marine microorganisms and human health: harmful algal blooms, marine toxins		

MODULE 8:	**ENVIRONMENTAL IMPACT AND MARINE MICROBIOLOGY**	**5 Hours**
Pollution and its effects on marine microbial communities Oil spills, plastic pollution, and microbial degradation Climate change and its impact on marine microbiology		
TOTAL LECTURES		**45 Hours****

Books:

1. "Marine Microbiology: Ecology & Applications" by Colin Munn
2. "The Microbiology of Sea Water" by Uwe B. Riebesell
3. "Marine Biotechnology: Applications in Food, Pharmaceuticals, and Bioenergy" edited by SeKwon Kim
4. Relevant research articles and reviews from journals like Marine Microbiology, Aquatic
5. Microbial Ecology, and Environmental Microbiology

MARINE BIOTECHNOLOGY (Practical)

Program: B. Sc. in Microbiology	**Year, Semester:** 2nd Yr., 3rd Sem
Course Title: MARINE BIOTECHNOLOGY (Practical)	**Subject Code:** TIU-UBT-MI-L21202
Contact Hours/Week: 0–0–1 (L–T–P)	**Credit:** 1

COURSE OBJECTIVE :

Enable the student to:

1. To gain practical proficiency in collecting and preparing marine water samples for microbiological analysis, ensuring aseptic techniques and sample integrity.
2. To develop skills in enumerating marine microbial populations using standard quantitative methods like the Most Probable Number (MPN) technique.
3. To acquire the ability to characterize marine microbial isolates through morphological and biochemical identification tests, and to assess their growth responses to varying environmental conditions (salinity, temperature).
4. To learn techniques for screening marine microorganisms for commercially valuable enzyme production and to quantitatively determine their antimicrobial potential.

COURSE OUTCOME :

On completion of the course, the student will be able to:

CO-1:	Students will be able to correctly perform the collection of water samples from diverse marine environments using appropriate sterile techniques to ensure sample integrity for microbial analysis	K3
CO-2:	Students will be able to analyze the Most Probable Number (MPN) data to quantitatively estimate the microbial population density in different marine water samples and interpret the variations observed.	K4
CO-3:	Students will be able to design and execute experiments to assess the growth characteristics of marine microorganisms under varying salinity and temperature conditions, demonstrating an understanding of environmental adaptations.	K3
CO-4:	Students will be able to interpret the results from morphological and biochemical tests to accurately identify isolated marine microorganisms to at least the genus level.	K4
CO-5:	Students will be able to evaluate the enzyme production capabilities of isolated marine microorganisms through qualitative screening methods, assessing their potential for biotechnological applications.	K5
CO-6:	Students will be able to synthesize the experimental data from isolation, identification, and physiological characterization to propose potential ecological roles or biotechnological uses for novel marine microbial isolates.	K6

COURSE CONTENT :

MODULE 1:	**STUDY OF ENVIRONMENTAL FACTORS AFFECTING GROWTH OF MICROBES**	**15 Hours**

Collection of water sample from different Marine environment MPN count for Marine microbial population Assessing microbial growth under varying salinity and temperature condition Morphological and biochemical identification of isolated Marine microorganisms Screening Marine microorganisms for enzyme production	
TOTAL LECTURES	**15 Hours****

MODERN INDIAN LANGUAGE – BENGALI

Program:	Year, semester: 2nd yr, 3rd semester
Course Title: MODERN INDIAN LANGUAGE- BENGALI	**Subject Code:** TIU-UEN-AEC-S2191B
Contact Hours/Week: 2-0-0 (L-T-P)	**Credit: 0**2

COURSE OBJECTIVE :

Enable the student to:

1. Develop Bengali proficiency for clear, precise, and confident workplace communication.
2. Enhance practical skills in vocabulary, grammar, pronunciation, speaking, and writing.
3. Apply communication theories to improve professional and interpersonal interactions.

COURSE OUTCOME :

On completion of the course, the student will be able to:

CO-1:	Explain fundamental communication principles and their relevance in workplace interactions.	K2
CO-2:	Apply grammar and language skills to construct precise and coherent spoken and written communication.	K3
CO-3:	Demonstrate fluency in spoken Bengali through pronunciation drills, vocabulary building, and interactive conversations.	K4
CO-4:	Construct well-organized sentences, paragraphs, and linked paragraphs to enhance professional writing	K3

CO-5:	Develop and revise written communication by employing strategies for drafting, editing, and proofreading.	K3
CO-6:	Assess and refine communication skills to ensure clarity, precision, and confidence in workplace interactions.	K4

COURSE CONTENT:

MODULE 1:	**INTRODUCTION TO COMMUNICATION**	**10Hours**
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MODULE 2:	**LANGUAGE AND GRAMMAR SKILLS**	**10 Hours**
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MODULE 3:	**SPEAKING SKILLS**	**10 Hours**
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TOTAL LECTURES		**30 Hours**

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MODERN INDIAN LANGUAGE – HINDI

Program:	**Year, Semester: 2ND Year, 3rd Sem**
Course Title:MODERN INDIAN LANGUAGE - HINDI	**Subject Code:** TIU-UEN-AEC-S2191A
Contact Hours/Week: 2-0-0 (L-T-P)	**Credit:** 2

COURSE OBJECTIVE :

Enable the student to:

1. To develop foundational knowledge of Hindi grammar and vocabulary, enabling students to construct simple sentences and engage in basic reading and writing tasks.
2. To enhance listening and speaking skills through interactive classroom activities, dialogues, and pronunciation practice, focusing on everyday conversational Hindi.
3. To introduce students to literary appreciation through two short stories and one poem in Hindi, fostering comprehension, discussion, and cultural understanding.

COURSE OUTCOME :

On completion of the course, the student will be able to:

CO-1:	Recognize and reproduce the Devanagari script accurately while reading and writing basic Hindi words and sentences.	K1
CO-2:	Apply basic Hindi grammar rules and vocabulary to construct simple, grammatically correct sentences.	K3
CO-3:	Demonstrate the ability to engage in short conversations using appropriate expressions, pronunciation, and sentence structures	K3
CO-4:	Interpret and explain the central ideas and themes of two selected short stories and one poem in Hindi.	K2
CO-5:	Analyze the use of language and cultural elements present in the literary texts to deepen appreciation of Hindi literature.	K4
CO-6:	Improve comprehension by responding to questions based on audio inputs and classroom discussions in Hindi.	K2

COURSE CONTENT :

MODULE 1:	[illegible] ([illegible]): [illegible]	**5 Hours**
[illegible] [illegible], [illegible], [illegible]		
MODULE 2:	[illegible] ([illegible]) :[illegible]	**5 Hours**
[illegible]		
MODULE 3:	[illegible] ([illegible]) :[illegible]	**5 Hours**
[illegible] [illegible], [illegible], [illegible]		
MODULE 4:	[illegible] ([illegible]) :[illegible]	**5 Hours**
[illegible] । [illegible], [illegible]		

MODULE 5:	[illegible]	**5 Hours**
[illegible]		
MODULE 6:	[illegible]	**5 Hours**
[illegible] । [illegible]		
TOTAL LECTURES		**30 Hours**

Books:

1. Srivastava, Harimohan. Hindi Bhasha aur Vyakaran. Vani Prakashan, New Delhi, 2017.
2. Bahri, Hardev. Vyavaharik Hindi Vyakaran, Anuvadtatha Rachna. Lokbharati Prakashan, Allahabad, 2016.