HERITAGE INSTITUTE OF TECHNOLOGY

(An Autonomous Institution affiliated to MAKAUT, West Bengal)

DEPARTMENT

OF

BIOTECHNOLOGY

B.TECH. PROGRAMME

Curriculum and Detailed Syllabus

Release Version 1: JULY 2023

Release Version 2: June 2024

(Applicable from 2023 admitted batch)

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Preamble

The curriculum for the B. Tech. in Biotechnology programme has been modified as per the guidelines of AICTE and MAKAUT, and considering the new education policy (NEP) under Academic Regulation 2022 from the academic session 2023 - 2024. In addition, this outcome-based curriculum (OBC) is created with a choice-based credit system (CBCS), which enables students to develop professional competency through a multidisciplinary approach that satisfies the requirements of industry, academics and the different Accreditation bodies like NBA and NAAC. Courses such as Bioinformatics, Molecular Modeling & Drug Designing, Medical & Pharmaceutical Biotechnology, Bioprocess Technology, etc. are included in the syllabus keeping in mind the industry demand, as well as the suggestions given by the NBA experts from time to time. Laboratory courses like Bioreactor Design, Fermentation Technology, Biochemistry, Microbiology, Molecular Biology, Recombinant DNA Technology, Genetics and Immunology are included so that the students develop skills that enable them to learn latest developments in these domains and be more innovative. Students are being motivated to select and study MOOCS courses of their choice towards attaining the degree with Honors. Apart from this, the course code is now changed from 4 letters to 3 letters from the session 2023 – 2024 as per the suggestions came from the office of the controller of examinations. This will help to distinguish the new courses from the old ones. In accordance with this, the curriculum and syllabi are revised in a structured manner by implementing Feedback Mechanism on Curriculum from various stakeholders, including potential employers, alumni, and parents.

Institutional Vision & Mission

VISION:

To prepare dynamic and caring citizens to meet the challenges of global society while retaining their traditional values.

MISSION:

- To prepare students with strong foundation in their disciplines and other areas of learning.
- To provide an environment for critical and innovative thinking, and to encourage life-long learning.
- To develop entrepreneurial and professional skills.
- To promote research and developmental activities and interaction with industry.
- To inculcate leadership qualities for serving the society.

Departmental Vision & Mission

VISION:

To be a centre of excellence in technology education to create responsible citizens committed to development of the country and mankind

MISSION:

M1: To build a strong foundation of domain knowledge in the students through a comprehensive set of courses in biotechnology, engineering science and basic science.

M2: To impart understanding of the broader implications of the subject to fulfill societal needs, environmental concerns and economic constrains.

M3: To develop critical thinking, communication and professional skills in the students and to motivate them for lifelong learning

Program Educational Objectives (PEOs) of

B.Tech. in Biotechnology Programme

The graduate students with the B.Tech. degree in Biotechnology from Heritage Institute of Technology, Kolkata are expected to achieve the following qualities after a few years of getting this degree.

PEO1. Be engaged in a professional career in biotechnology or other related industries.

PEO2. Demonstrate adherence to the professional codes of conduct appropriate to his/her field of study and/or practice, as well as exhibit behavior consistent with accepted standards of responsibility, risk/benefit analysis and professional accountability.

PEO3. Work in a technically competent manner as a leader as well as a team member to address challenges in engineering or their chosen profession, considering the ethical matters and social concerns.

PEO4. Develop their technical knowledge and professional skills through self-directed lifelong learning.

Program Outcomes (POs)

Engineering Graduates will be able to:

PO1: Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2: Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3: Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4: Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5: Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO6: The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7: Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8: Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9: Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10: Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11: Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12: Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes (PSOs) of

B.Tech. in Biotechnology Programme

PSO1. An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

PSO2. Ability to demonstrate a better understanding of diagnosis and treatment of diseases through novel biotechnology approaches.

PSO3. Ability to provide a cost-effective environment-friendly and less-energy consuming solution to a problem.

Credit Summary for B Tech programme in BIOTECHNOLOGY with effect from 2023-24

Sl. No.	Course Type	Credit
1.	Humanities and Social Sciences including Management Courses	12
2.	Basic Science Courses	19
3.	Engineering Science Courses including Workshop, Drawing, Basics of Electrical / Mechanical / Computer, etc.	28.5
4.	Biological Science courses including Laboratory	16.5
5.	Professional Core Courses	43
6.	Professional Elective Courses relevant to chosen specialization / Branch	16
7.	Open Subjects – Electives from other Technical and/or Emerging Subjects	12
8.	Project Work, Seminar and Internship in industry or elsewhere	16
9.	Mandatory Courses (Non-credit) [Environmental Sciences, Induction Program, Indian Constitution, Essence of Indian Traditional Knowledge]	(NON-CREDIT)
	Total	**163**
10.	Honours Courses (MOOCS or otherwise)	20
	Grand Total	**183**

Definition of Credit (as per National Credit Framework 2022):

- Total notional learning hours = 1200 Hours/ Year
- Minimum credits to be earned = 40/ Year
- 1 Credit = 30 notional learning hours

Range of Credits (as per AICTE):

- A student will be eligible to get B Tech degree with Honours if he/she completes an additional 20 credit points.
- These could be acquired through MOOCs. For details kindly refer to APPENDIX – A.
- A student will be eligible to get B.Tech. degree certificate, if he/ she acquires 100 MAR points in 4 years of their study.
- Lateral entry students must acquire 75 MAR points in their 3 years of study.
- For details kindly refer to APPENDIX – B.

Curriculum

1st Year 1st Semester

A. Theory							
Sl.	Code	Subject	Contacts Periods/ Week				Credit Points
			L	T	P	Total	
1	CHM1001	Chemistry-I	3	0	0	3	3
2	MTH1101	Mathematics-I	3	1	0	4	4
3	CSE1001	Programming for Problem Solving	4	0	0	4	4
4	ELE1001	Basic Electrical Engineering	3	1	0	4	4
5	HUM1001	English for Technical Writing	2	0	0	2	2
Total Theory			**15**	**2**	**0**	**17**	**17**
B. Practical							
1	CHM1051	Chemistry-I Lab	0	0	2	2	1
2	CSE1051	Programming for Problem Solving Lab	0	0	3	3	1.5
3	ELE1051	Basic Electrical Engineering Lab	0	0	2	2	1
4	HUM1051	English for Technical Writing Lab	0	0	2	2	1
Total Practical			**0**	**0**	**9**	**9**	**4.5**
Total of Semester			**15**	**2**	**9**	**26**	**21.5**

1st Year 2nd Semester

A. Theory							
Sl.	**Code**	**Subject**	**Contacts Periods/ Week**				**Credit Points**
			L	**T**	**P**	**Total**	
1	PHY1001	Physics-I	3	0	0	3	3
2	MTH1201	Mathematics-II	3	1	0	4	4
3	ECE1001	Introduction to Electronics Devices & Circuits	3	0	0	3	3
4	HUM1002	Universal Human Values and Professional Ethics	2	1	0	3	3
Total Theory			**11**	**2**	**0**	**13**	**13**
B. Practical							
1	PHY1051	Physics-I Lab	0	0	2	2	1
2	ECE1051	Introduction to Electronics Devices & Circuits Lab	0	0	2	2	1
3	MEC1051	Workshop / Manufacturing Practice	1	0	3	4	2.5
4	MEC1052	Engineering Graphics and Design	1	0	3	4	2.5
Total Practical			**2**	**0**	**10**	**12**	**7**
Total of Semester			**13**	**2**	**10**	**25**	**20**

2nd Year 1st Semester

A. Theory							
Sl.	**Code**	**Subject**	**Contacts Periods/ Week**				**Credit Points**
			L	**T**	**P**	**Total**	
1	EVS2016	Environmental Sciences	2	0	0	2	0
2	BTC2101	Chemistry of Biomolecules	3	0	0	3	3
3	BTC2102	Thermodynamics & Kinetics	3	0	0	3	3
4	BTC2103	Biochemistry	3	0	0	3	3
5	BTC2104	Microbiology	3	0	0	3	3
6	CSE2005	Data Structure	3	0	0	3	3
Total Theory			**17**	**0**	**0**	**17**	**15**
B. Practical							
1	BTC2151	Biomolecular Chemistry Lab	0	0	2	2	1
2	BTC2153	Biochemistry Lab	0	0	2	2	1
3	BTC2154	Microbiology Lab	0	0	3	3	1.5
4	CSE2055	Data Structure Lab	0	0	2	2	1
5	BTC2155	Design Thinking and IDEA Lab (BT)	0	0	2	2	1
Total Practical			**0**	**0**	**11**	**11**	**5.5**
Total of Semester			**17**	**0**	**11**	**28**	**20.5**

2nd Year 2nd Semester

A. Theory							
Sl.	**Code**	**Subject**	**Contacts Periods/ Week**				**Credit Points**
			L	**T**	**P**	**Total**	
1	BTC2201	Transfer Operation-I	3	0	0	3	3
2	BTC2202	Industrial Microbiology & Enzyme Technology	3	0	0	3	3
3	BTC2203	Molecular Biology	3	0	0	3	3
4	BTC2231-BTC2240	Professional Elective – I	3	0	0	3	3
	BTC2231 BTC2232	Bioethics & IPR Industrial Stoichiometry					
5	CSE2207	RDBMS Concept and Computer Networking	3	0	0	3	3
6	MTH2204	Mathematical & Statistical Methods	3	0	0	3	3
Total Theory			**18**	**0**	**0**	**18**	**18**
B. Practical							
1	BTC2251	Transfer Operation-I Lab	0	0	2	2	1
2	BTC2252	Enzyme Technology & Fermentation Technology Lab	0	0	2	2	1
3	BTC2253	Molecular Biology Lab	0	0	2	2	1
4	CSE2257	RDBMS Concept lab	0	0	2	2	1
Total Practical			**0**	**0**	**8**	**8**	**4**
Total of Semester			**18**	**0**	**8**	**26**	**22**

3rd Year 1st Semester

A. Theory							
Sl.	Code	Subject	Contacts Periods/ Week				Credit Points
			L	T	P	Total	
1	INC3016	Indian Constitution and Civil Society	2	0	0	2	0
2	BTC3101	Genetics	3	0	0	3	3
3	BTC3102	Bioinformatics	3	0	0	3	3
4	BTC3103	Recombinant DNA Technology	3	0	0	3	3
5	BTC3104	Transfer Operations-II	3	0	0	3	3
6	BTC3131 – BTC3140	Professional Elective - II	3	0	0	3	3
	BTC3131 BTC3132 BTC3133	Food Biotechnology Environmental Biotechnology Bioprocess & Process Instrumentation					
7	****	Emerging Area / Open Elective-I *	3	0	0	3	3
	CHE3121 CHE3122 ECE3122 MEC3123	Water and Liquid Waste Management Industrial Safety and Hazards Introduction to Machine Learning Total Quality Management (TQM)					
Total Theory			**20**	**0**	**0**	**20**	**18**
B. Practical							
1	BTC3151	Genetics Lab	0	0	2	2	1
2	BTC3152	Bioinformatics Lab	0	0	2	2	1
3	BTC3153	Recombinant DNA Technology Lab	0	0	2	2	1
4	BTC3154	Transfer Operation-II lab	0	0	2	2	1
5	BTC3161-BTC3170	Professional Elective – II Lab	0	0	2	2	1
	BTC3161 BTC3162 BTC3163	Food Biotechnology Lab Environmental Biotechnology Lab Bioprocess & Process Instrumentation Lab					
Total Practical			**0**	**0**	**10**	**10**	**5**
Total of Semester			**20**	**0**	**10**	**30**	**23**

* To be offered by other departments

3rd Year 2nd Semester

A. Theory							
Sl.	**Code**	**Subject**	**Contacts Periods/ Week**				**Credit Points**
			L	**T**	**P**	**Total**	
1	HUM3201	Economics for Engineers	3	0	0	3	3
2	BTC3201	Immunology	3	0	0	3	3
3	BTC3202	Bioseparation Technology	3	0	0	3	3
4	BTC3203	Plant Biotechnology	3	0	0	3	3
5	BTC3231- BTC3240	Professional Elective – III	3	0	0	3	3
	BTC3231 BTC3232 BTC3233	Molecular Modelling and Drug Designing Biophysics of Macromolecules Biosensors and Diagnostics					
6	****	Emerging Area/ Open Elective-II	3	0	0	3	3
	BIOT3221 BIOT3222	Animal Cell Culture & Animal Biotechnology Basics of Nanotechnology					
7	INC3016	Indian Constitution and Civil Society	2	0	0	2	0
Total Theory			**20**	**0**	**0**	**18**	**18**
B. Practical							
1	BTC3251	Immunology lab	0	0	2	2	1
2	BTC3252	Bioseparation Technology Lab	0	0	2	2	1
3	BTC3253	Plant Tissue Culture Lab	0	0	2	2	1
Total Practical			**0**	**0**	**6**	**6**	**3**
C. Sessional							
1	BTC3293	Term Paper and Seminar	0	0	4	4	2
Total Sessional			**0**	**0**	**4**	**4**	**2**
Total of Semester			**20**	**0**	**10**	**28**	**23**

4th Year 1st Semester

Sl.	Code	Subject	Contacts Periods/ Week				Credit Points
			L	T	P	Total	
A. Theory							
1	HUM4101	Principles of Management	3	0	0	3	3
2	BTC4201	Bioreactor Design and Analysis	3	0	0	3	3
3	BTC4131-BTC4140	Professional Elective – IV	3	0	0	3	3
	BTC4131 BTC4132 BTC4133 BTC4134	Biomaterials Biofertilizers and Biopesticides Post-harvest Technology Medical & Pharmaceutical Biotechnology					
4	****	Emerging Area/ Open Elective-III	3	0	0	3	3
	BTC4121 BTC4122 BTC4123	Proteomics and Protein Engineering Human Genomics Biomedical Engineering					
5	****	Emerging Area/ Open Elective-IV*	3	0	0	3	3
6	BTC4141-BTC4140	Professional Elective – V	3	0	0	3	3
	BTC4141 BTC4142 BTC4143	Renewable Energy Technology Tissue Engineering Metabolic Engineering					
Total Theory			**18**	**0**	**0**	**18**	**18**
B. Practical							
1	BTC4251	Bioreactor Design lab	0	0	2	2	1
Total Practical			**0**	**0**	**2**	**2**	**1**
C. Sessional							
1	BTC4191	Industrial Training / Internship	4 to 6 weeks				2
2	BTC4195	Project-I	0	0	6	6	3
Total Sessional			**0**	**0**	6	6	**5**
Total of Semester			**18**	**0**	**8**	**26**	**24**

Training in a suitable industry, R&D Organization, Reputed Laboratory or Research Institute for 4 to 6 weeks to be arranged during summer vacation.

* To be offered by other departments

4th Year 2nd Semester

Sl.	Code	Subject	Contacts Periods/ Week				Credit Points
			L	T	P	Total	
1	BTC4295	Project-II	0	0	14	14	7
2	BTC4297	Comprehensive Viva-voce	-	-	-	-	2
Total Sessional			0	0	14	14	9
Total of Semester			**0**	**0**	**14**	**14**	**9**

Open Elective-II papers offered by the Department of Biotechnology

Sl.	Code	Subject	Contacts Periods/ Week				Credit Points
			L	T	P	Total	
1	BTC3223	Introduction to Biology	3	0	0	3	3
2	BTC3224	Biopolymer	3	0	0	3	3
3	BTC3225	Computational Biology	3	0	0	3	3
Total Theory			**3**	**0**	**0**	**3**	**3**

Open Elective-IV papers offered by the Department of Biotechnology

Sl.	Code	Subject	Contacts Periods/ Week				Credit Points
			L	T	P	Total	
1	BTC4126	Biology for Engineers	3	0	0	3	3
2	BTC4127	Biosensor	3	0	0	3	3
3	BTC4128	Bioenergy and other Non-conventional Energy	3	0	0	3	3
Total Theory			**3**	**0**	**0**	**3**	**3**

DETAILED SYLLABUS

1st Year

Course Title: Chemistry-I					
Course Code: CHM001					
Contact Hours per week	**L**	**T**	**P**	**Total**	**Credit Points**
	4	0	0	4	4

Course outcomes:

The subject code CHM-1001 corresponds to Chemistry Theory classes (**Chemistry I**) for the first year B. Tech students, offered as Chemistry for Engineering and is common to all Branches of Engineering Disciplines. The course provides basic knowledge of theory and applications in the subjects like Thermodynamics, Quantum mechanics, Electrochemistry, & Energy conversion, Structure and reactivity of molecules. Spectroscopic techniques and their applications, Synthesis & use of Drug molecules. The Course Outcomes for the subject code **CHM1001** are furnished below:

CHM1001.1: Knowledge acquisition of bulk properties of materials and understanding of reaction processes using thermodynamic considerations.
CHM1001.2: Conception of energy conversion and its importance in clean energy scenario, the operating principles for batteries, fuel cells and the materials and reactions involved there in, their applications as sustainable energy devices, particularly in automobiles sectors to reduce environmental pollution.
CHM1001.3: Analytic view of microscopic chemistry in terms of atomic structure, molecular orbital and intermolecular forces to reinforce strong background on materials science and engineering.
CHM1001.4: Rationalize periodic trends of elements to explain various physico - chemical properties.
CHM1001.5: Understanding of the spectrum of electromagnetic radiation used for exciting different molecular energy levels in various spectroscopic techniques.
CHM1001.6: Knowledge of stereochemistry and conception of the mechanism of major chemical reactions involved in synthesis of drug molecules.

MODULE I: [9L]

Thermodynamics

The 1st and 2nd laws of thermodynamics and thermodynamic functions like free energy, work function and entropy; Carnot cycle, Joule-Thomson effect, Gibbs-Helmholtz equation; Chemical Potential, Gibbs-Duhem Equation and Clausius-Clapeyron Equation.

5L

Electrochemical Cell

Generation of electromotive force in electrochemical cells and application of Nernst equation; Electrode potentials and the redox reactions; Cell configuration and half-cell reactions; Standard Hydrogen Electrode, Reference electrode, evaluation of thermodynamic functions; Electrochemical corrosion. Electrochemical Energy Conversion: Primary & Secondary batteries, Fuel Cells.

4L

MODULE II: [9L]

Molecular Structure

Molecular geometry, Hybridization, Ionic, dipolar and van Der Waals interactions; Molecular Orbital Theory and its application in diatomic molecule; Pi-molecular orbital of unsaturated system; Band structure of solids, intrinsic and extrinsic semiconductors and the role of doping on band structures.

5L

Periodic Properties

Effective nuclear charge, penetration of orbitals; variations of s, p, d and f orbital energies of atoms in the periodic table, electronic configurations, atomic and ionic sizes; ionization energies, electron affinity and electro-negativity, polarizability, oxidation states, coordination numbers and geometries; hard-soft acid base theory.

4L

MODULE III: [9L]

Atomic structure and Wave Mechanics

Brief outline of the atomic structure, wave particle duality, Heisenberg uncertainty principle; Introduction to quantum mechanics, Schrodinger wave equation for particle in one dimensional box.

5L

Spectroscopic Techniques & Applications

Electromagnetic spectrum: Interaction of EMR with matter; Principle and applications of Fluorescence & Phosphorescence, UV-Visible, Infrared and NMR spectroscopy

4L

MODULE IV: [9L]

Stereochemistry

Representations of 3-dimensional structures, structural isomers and stereo-isomers, configurations, symmetry and chirality; enantiomers, diastereomers, optical activity, absolute configurations and conformational analysis.

5L

Organic reactions and synthesis of drug molecules

Introduction to reaction mechanism: substitution, addition, elimination and oxidation, reduction reactions. Synthesis of commonly used drug molecules.

4L

Text Books:

1. Atkins' Physical Chemistry, P.W. Atkins (10^{th} Edition)
2. Organic Chemistry, I. L. Finar, Vol-1 (6^{th} Edition)
3. Engineering Chemistry, Jain & Jain,(16^{th} Edition)
4. Fundamental Concepts of Inorganic Chemistry, A. K. Das, (2^{nd} Edition)
5. Engineering Chemistry-I, Gourkrishna Dasmohapatra, (3^{rd} Edition)

Reference Books

1. General & Inorganic Chemistry, R. P. Sarkar
2. Physical Chemistry, P. C. Rakshit, (7^{th}Edition)
3. Organic Chemistry, Morrison & Boyd, (7^{th}Edition)
4. Fundamentals of Molecular Spectroscopy, C.N. Banwell, (4^{th}Edition)
5. Physical Chemistry, G. W. Castellan, (3^{rd}Edition)
6. Basic Stereo chemistry of Organic Molecules, Subrata Sen Gupta, (1^{st}Edition)

Course Title: Mathematics-I					
Course Code: MTH1101					
Contact Hours per week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	1	0	4	4

Course Outcomes:

After successfully completing this course the students will be able to:
MTH1101.1: Apply the concept of rank of matrices to find the solution of a system of linear simultaneous equations.
MTH1101.2: Develop the concept of eigen values and eigen vectors.
MTH1101.3: Combine the concepts of gradient, curl, divergence, directional derivatives, line integrals, surface integrals and volume integrals.
MTH1101.4: Analyze the nature of sequence and infinite series
MTH1101.5: Choose proper method for finding solution of a specific differential equation.
MTH1101.6: Describe the concept of differentiation and integration for functions of several variables with their applications in vector calculus.

Module I: [10L]
Matrix: Inverse and rank of a matrix; Elementary row and column operations over a matrix; System of linear equations and its consistency; Symmetric, skew symmetric and orthogonal matrices; Determinants; Eigen values and eigen vectors; Diagonalization of matrices; Cayley Hamilton theorem; Orthogonal transformation.

Module II: [10L]
Vector Calculus: Vector function of a scalar variable, Differentiation of a vector function, Scalar and vector point functions, Gradient of a scalar point function, divergence and curl of a vector point function, Directional derivative, Related problems on these topics.
Infinite Series: Convergence of sequence and series; Tests for convergence: Comparison test, Cauchy's Root test, D' Alembert's Ratio test(statements and related problems on these tests), Raabe's test; Alternating series; Leibnitz's Test (statement, definition); Absolute convergence and Conditional convergence.

Module III: [10L]
First order ordinary differential equations: Exact, linear and Bernoulli's equations, Euler's equations, Equations not of first degree: equations solvable for p, equations solvable for y, equations solvable for x and Clairaut's type.

Ordinary differential equations of higher orders: General linear ODE of order two with constant coefficients, C.F. & P.I., D-operator methods, Method of variation of parameters, Cauchy-Euler equations.

Module IV: [10L]

Calculus of functions of several variables: Introduction to functions of several variables with examples, Knowledge of limit and continuity, Determination of partial derivatives of higher orders with examples, Homogeneous functions and Euler's theorem and related problems up to three variables.

Multiple Integration: Concept of line integrals, Double and triple integrals. Green's Theorem, Stoke'sTheorem and Gauss Divergence Theorem.

References:

1. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 2000.
2. E. Kreyszig, Advanced Engineering Mathematics, John Wiley & Sons, 2006.
3. Veerarajan T., Engineering Mathematics for first year, Tata McGraw-Hill, New Delhi, 2008.
4. Ramana B.V., Higher Engineering Mathematics, Tata McGraw Hill New Delhi, 11th Reprint, 2010.
5. K. F. Riley, M. P. Hobson, S. J. Bence. Mathematical Methods for Physics and Engineering, Cambridge University Press, 23-Mar-2006.
6. S. L. Ross, Differential Equations", Wiley India, 1984.
7. G.F. Simmons and S.G. Krantz, Differential Equations, McGraw Hill, 2007.
8. Vector Analysis(Schaum's outline series): M. R. Spiegel, Seymour Lipschutz, Dennis Spellman (McGraw Hill Education)
9. Engineering Mathematics: S. S. Sastry (PHI)
10. Advanced Engineering Mathematics: M.C. Potter, J.L. Goldberg and E.F. Abonfadel (OUP),Indian Edition.
11. Linear Algebra (Schaum's outline series): Seymour Lipschutz, Marc Lipson (McGraw Hill Education)

Course Title: Programming for Problem Solving					
Course Code: CSE1001					
Contact Hours per week	**L**	**T**	**P**	**Total**	**Credit Points**
	4	0	0	4	4

Course Outcomes:

After completion of the course, students will be able to:

CSE1001.1: Remember and understand the functionalities of the different hardware and software components present in a computer system, the standard representations of various types of data in a computer system.

CSE1001.2: Illustrate how a computer system with one way of representation can be converted to one another equivalent representation.

CSE1001.3: Construct flow charts for any arithmetic or logical problems in hand.

CSE1001.4: Remember and understand the C programming development environment, writing, compiling, debugging, linking and executing a C program using that development environment, basic syntax and semantics of C programming language and interpret the outcome of any given C program.

CSE1001.5: Use loop constructs, conditional branching, iteration, recursion to solve simple engineering problems.

CSE1001.6: Apply pointers, arrays, structures, files to formulate simple engineering problems.

Module I: [12L] Fundamentals of Computer

History of Computers, Generations of Computers, Classification of Computers.

Basic Anatomy of Computer System, Primary & Secondary Memory, Processing Unit, Input & Output devices. Basic Concepts of Assembly language, High level language, Compiler and Assembler.

Binary & Allied number systems (decimal, octal and hexadecimal) with signed and unsigned numbers (using 1's and 2's complement) - their representation, conversion and arithmetic operations. Packed and unpacked BCD system, ASCII. IEEE-754 floating point representation (half- 16 bit, full- 32 bit, double- 64 bit).

Basic concepts of operating systems like MS WINDOWS, LINUX How to write algorithms & draw flow charts.

Module II: [12L] Basic Concepts of C

C Fundamentals:

The C character set identifiers and keywords, data type & sizes, variable names, declaration, statements. Operators & Expressions:

Arithmetic operators, relational and logical operators, type, conversion, increment and decrement operators, bit wise operators, assignment operators and expressions, precedence and order of evaluation. Standard input and output, formatted output -- printf, formatted input scanf.

Flow of Control:

Statement and blocks, if-else, switch-case, loops (while, for, do-while), break and continue, go to and labels.

Module III: [12L]

Program Structures in C

Basic of functions, function prototypes, functions returning values, functions not returning values. Storage classes - auto, external, static and register variables – comparison between them. Scope, longevity and visibility of variables. C preprocessor (macro, header files), command line arguments.

Arrays and Pointers:

One dimensional arrays, pointers and functions – call by value and call by reference, array of arrays. Dynamic memory usage– using malloc(), calloc(), free(), realloc(). Array pointer duality.

String and character arrays; C library string functions and their use.

Module IV: [12L]

Data Handling in C

User defined data types and files:

Basic of structures; structures and functions; arrays of structures.

Files – text files only, modes of operation. File related functions – fopen(), fclose(), fscanf(), fprintf(), fgets(), fputs(), fseek(), ftell();

Text Books

1. Schaum's outline of Programming with C – Byron Gottfried
2. Teach Yourself C- Herbert Schildt
3. Programming in ANSI C – E Balagurusamy

Reference Books

1. C: The Complete Reference – Herbert Schildt
2. The C Programming Language- D. M. Ritchie, B.W. Kernighan

Course Title: Basic Electrical Engineering					
Course Code: ELE1001					
Contact Hours per week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	1	0	4	4

Course Outcomes

After attending the course, the students will be able to

ELE1001.1: Analyze DC electrical circuits using KCL, KVL and network theorems like Superposition Theorem, Thevenin's Theorem, Norton's Theorem and Maximum Power Transfer Theorem.

ELE1001.2: Analyze DC Machines; Starters and speed control of DC motors.

ELE1001.3: Analyze magnetic circuits.

ELE1001.4: Analyze single and three phase AC circuits.

ELE1001.5: Analyze the operation of single phase transformers.

ELE1001.6: Analyze the operation of three phase induction motors.

Module I: [11L]

DC Network Theorem: Kirchhoff's laws, Nodal analysis, Mesh analysis, Superposition theorem, Thevenin's theorem, Norton's theorem, Maximum power transfer theorem, Star-Delta conversion. [6L]

Electromagnetism: Review of magnetic flux, Force on current carrying conductors, Magnetic circuit analysis, Self and Mutual inductance, B-H loop, Hysteresis and Eddy current loss, Lifting power of magnet. [5L]

Module II: [10L]

AC single phase system: Generation of alternating emf, Average value, RMS value, Form factor, Peak factor, representation of an alternating quantity by a phasor, phasor diagram, AC series, parallel and series-parallel circuits, Active power, Reactive power, Apparent power, power factor, Resonance in RLC series and parallel circuit.

Module III: [11L]

Three phase system: Generation of three-phase AC power, Balanced three phase system, delta and star connection, relationship between line and phase quantities, phasor diagrams, power measurement by two wattmeter method. [4L]

DC Machines: Construction, EMF equation, Principle of operation of DC generator, Open circuit characteristics, External characteristics, Principle of operation of DC motor, speed-torque characteristics of shunt and series machine, starting of DC motor, speed control of DC motor.[7L]

Module IV: [10L]

Transformer: Construction, EMF equation, no load and on load operation and their phasor diagrams, Equivalent circuit, Regulation, losses of a transformer, Open and Short circuit tests, Efficiency, Introduction to three phase transformer.[6L]

Three-phase induction motor: Concept of rotating magnetic field, Principle of operation, Construction, Equivalent circuit and phasor diagram, torque-speed/slip characteristics, Starting of Induction Motor.[4L]

Text Books:

1. Basic Electrical engineering, D.P Kothari & I.J Nagrath, TMH, Second Edition.
2. Basic Electrical Engineering, V.N Mittle&Arvind Mittal, TMH, Second Edition.
3. Basic Electrical Engineering, Hughes.
4. Electrical Technology, Vol-I,Vol-II,Surinder Pal Bali, Pearson Publication.
5. A Text Book of Electrical Technology, Vol. I & II, B.L. Theraja, A.K. Theraja, S.Chand& Company.

Reference Books:

1. Electrical Engineering Fundamentals, Vincent Del Toro, Prentice-Hall.
2. Advance Electrical Technology, H. Cotton, Reem Publication.
3. Basic Electrical Engineering, R.A. Natarajan, P.R. Babu, Sictech Publishers.
4. Basic Electrical Engineering, N.K. Mondal, DhanpatRai.
5. Basic Electrical Engineering, Nath & Chakraborti.
6. Fundamental of Electrical Engineering, Rajendra Prasad, PHI, Edition 2005.

Course Title: English for Technical Writing					
Course Code: HUM1001					
Contact Hours per week	**L**	**T**	**P**	**Total**	**Credit Points**
	2	0	0	2	2

Course Outcomes:
Students will be able to:
HUM1001.1: Communicate effectively in an official and formal environment.
HUM1001.2: Use language as a tool to build bridges and develop interpersonal relations in multi-cultural environment.
HUM1001.3: Use various techniques of communication for multiple requirements of globalized workplaces.
HUM1001.4: Learn to articulate opinions and views with clarity.
HUM1001.5: Write business letters and reports.
HUM1001.6: Apply various communication strategies to achieve specific communication goals.

Module I: [6L]
Introduction to Phonology and Morphology

- Phonetics- Vowel and Consonant Sounds (Identification & Articulation)
- Word- stress, stress in connected speech
- Intonation (Falling and Rising Tone)
- Vocabulary Building-The concept of Word Formation

Module II: [6L]
Communication Skills

- The Basics of Business Communication- Process, types, levels.
- Barriers to Communication Common obstacles to effective communication.
- Approaches and Communication techniques for multiple needs at workplace: persuading, convincing, responding, resolving conflict, delivering bad news, making positive connections
- Identify common audiences and design techniques for communicating with each audience.

Module III: [6L]
Organizational Communication

- Business Letters
- Organizational Communication: Agenda & minutes of a meeting, Notice, Memo, Circular.
- Organizing e-mail messages, E-mail etiquette.
- Techniques for writing precisely: Creating coherence, organizing principles –accuracy, clarity, brevity. Different styles of writing: descriptive, narrative, expository.

Module IV: [6L]

Principles, techniques and skills for professional writing

- Logic in writing, thinking and problem-solving; applying deductive and inductive reasoning; Use of infographics in writing.
- Report Writing: Importance and Purpose, Types of Reports, Report Formats, Structure of Formal Reports, Writing Strategies. Interpreting data and writing reports.
- Writing proposals and Statement of purpose.

Text Books:

1 Kumar,S. & Lata, P. Communication Skills, OUP, New Delhi2011

2 Rizvi, Ashraf, M. Effective Technical Communication, Mc Graw Hill Education(India) Pvt. Ltd..Chennai,2018

3 Raman, M. and Sharma, S., Technical Communication: Principles and Practice, 2nd Ed., 2011

Reference Books:

1. Professional Writing Skills, Chan, Janis Fisher and Diane Lutovich. San Anselmo, CA: Advanced Communication Designs.
2. Hauppauge, Geffner, Andrew P. Business English, New York: Barron's Educational Series.

Course Title: Chemistry-I Lab					
Course Code: CHM1051					
Contact Hours per week	**L**	**T**	**P**	**Total**	**Credit Points**
	0	0	2	2	1

Course outcomes:

The subject code CHM1051 corresponds to chemistry laboratory classes for the first year B. Tech students. This course enhances the students' experience regarding handling of various chemicals along with various laboratory equipments. Hands on experiments increase the depth of knowledge that is taught in the theory classes as well as it increases research aptitude in students because they can see the direct application of theoretical knowledge in practical field. The course outcomes of the subject are

CHM1051.1: Knowledge to estimate the hardness of water which is required to determine the usability of water used in industries.
CHM1051.2: Estimation of ions like Fe^{2+}, Cu^{2+} and Cl^{-} present in water sample to know the composition of industrial water.
CHM1051.3: Study of reaction dynamics to control the speed and yield of various manufactured goods produced in polymer, metallurgical and pharmaceutical industries.
CHM1051.4: Handling physicochemical instruments like viscometer, stalagmometer, pH-meter, potentiometer and conductometer.
CHM1051.5: Understanding the miscibility of solutes in various solvents required in paint, emulsion, biochemical and material industries.
CHM1051.6: Knowledge of sampling water can be employed for water treatment to prepare pollution free water.

Experiments

1. Estimation of iron using KMnO4 self indicator.
2. Iodometric estimation of Cu2+.
3. Determination of Viscosity.
4. Determination of surface tension.
5. Adsorption of acetic acid by charcoal.
6. Potentiometric determination of redox potentials.
7. Determination of total hardness and amount of calcium and magnesium separately in a given water sample.
8. Determination of the rate constant for acid catalyzed hydrolysis of ethyl acetate.

9. Heterogeneous equilibrium (determination of partition coefficient of acetic acid in n-butanol and water mixture).
10. Conductometric titration for the determination of strength of a given HCl solution against standard NaOH solution.
11. pH-metric titration for determination of strength of a given HCl solution against a standard NaOH solution.
12. Determination of chloride ion in a given water sample by Argentometric method (using chromate indicator solution)

Reference Books:

1. Vogel's Textbook of Quantitative Chemical Analysis-G. H. Jeffery, J. Bassett, J. Mendham, R. C. Denney.
2. Advanced Practical Chemistry- S. C. Das.
3. Practicals in Physical Chemistry- P. S. Sindhu.

Course Title : Programming for Problem Solving Lab					
Course Code : CSE1051					
Contact hrs per week:	**L**	**T**	**P**	**Total**	**Credit points**
	0	0	3	3	1.5

Course Outcomes:

After completion of this course the students should be able to:

CSE1051.1: Write simple programs relating to arithmetic and logical problems.
CSE1051.2: Interpret, understand and debug syntax errors reported by the compiler.
CSE1051.3: Implement conditional branching, iteration (loops) and recursion.
CSE1051.4: Decompose a problem into modules (functions) and amalgamating the modules to generate a complete program.
CSE1051.5: Use arrays, pointers and structures effectively in writing programs.
CSE1051.6: Create, read from and write into simple text files.

Software to be used: GNU C Compiler (GCC) with LINUX NB: Cygwin (Windows based) may be used in place of LINUX

Topic 1: LINUX commands and LINUX based editors

Topic 2: Basic Problem Solving

Topic 3: Control Statements (if, if-else, if-elseif-else, switch-case)

Topic 4: Loops - Part I (for, while, do-while)

Topic 5: Loops - Part II

Topic 6: One Dimensional Array

Topic 7: Array of Arrays

Topic 8: Character Arrays/ Strings Topic

Topic 9: Basics of C Functions

Topic 10: Recursive Functions

Topic 11: Pointers

Topic 12: Structures

Topic 13: File Handling

Text Books:

1. Schaum's outline of Programming with C – Byron Gottfried
2. Teach Yourself C- Herbert Schildt
3. Programming in ANSI C – E Balagurusamy

Course Title : Basic Electrical Engineering Lab					
Course Code : ELE1051					
Contact hrs per week:	**L**	**T**	**P**	**Total**	**Credit points**
	0	0	2	2	1

Course Outcomes:

The students are expected to:
ELE1051.1: Get an exposure to common electrical apparatus and their ratings.
ELE1051.2: Make electrical connections by wires of appropriate ratings.
ELE1051.3: Understand the application of common electrical measuring instruments.
ELE1051.4: Understand the basic characteristics of different electrical machines.

List of Experiments:

1. Characteristics of Fluorescent lamps
2. Characteristics of Tungsten and Carbon filament lamps
3. Verification of Thevenin's& Norton's theorem.
4. Verification of Superposition theorem
5. Verification of Maximum Power Transfer theorem
6. Calibration of ammeter and voltmeter.
7. Open circuit and Short circuit test of a single phase Transformer.
8. Study of R-L-C Series / Parallel circuit
9. Starting and reversing of speed of a D.C. shunt Motor
10. Speed control of DC shunt motor.
11. No load characteristics of D.C shunt Generators
12. Measurement of power in a three phase circuit by two wattmeter method.

Course Title : English for Technical Writing Lab					
Course Code : HUM1051					
Contact hrs per week:	**L**	**T**	**P**	**Total**	**Credit points**
	0	0	2	2	1

Course Outcome:

Students will be able to:

HUM1051.1: Communicate in an official and formal environment.
HUM1051.2: Effectively communicate in a group and engage in relevant discussion.
HUM1051.3: Engage in research and prepare presentations on selected topics.
HUM1051.4: Understand the dynamics of multicultural circumstances at workplace and act accordingly.
HUM1051.5: Organize content in an attempt to prepare official documents.
HUM1051.6: Appreciate the use of language to create beautiful expressions.

Detailed Syllabus

Module I (6hrs)
The Art of Speaking

- Techniques for Effective Speaking
- Voice Modulation: Developing correct tone
- Using correct stress patterns: word stress, primary stress, secondary stress. Rhythm in connected speech
- Encoding Meaning Using Nonverbal Symbols,
- How to Improve Body Language
- Eye Communication, Facial Expression, Dress and Appearance
- Posture and Movement, Gesture, Paralanguage
- Encoding meaning using Verbal symbols: How words work and how to use words
- Volume, Pace, Pitch and Pause
- Structuring content for delivery in accordance with time, platform, and audience.

Module II (6hrs)
Group Discussion

- Nature and purpose and characteristics of a successful Group Discussion
- Group discussion Strategies: Getting the GD started, contributing systematically, moving the discussion along, promoting optimal participation, Handling conflict, Effecting closure

Module- III (6hrs)

- Interviewing
  Types of Interviews, Format for Job Interviews: One-to-one and Panel Interviews, Telephonic Interviews, Interview through video conferencing.
- Cover Letter & CV
- Interview Preparation Techniques, Frequently Asked Questions, Answering Strategies, Dress Code, Etiquette, Questions for the Interviewer, Simulated Interviews.

Module IV (6 hrs)

Professional Presentation Skills

- Nature and Importance of Presentation skills
- Planning the Presentation: Define the purpose, analyze the Audience, Analyze the occasion and choose a suitable title.
- Preparing the Presentation: The central idea, main ideas, collecting support material, plan visual aids, design the slides
- Organizing the Presentation: Introduction-Getting audience attention, introduce the subject, establish credibility, preview the main ideas, Body-develop the main idea, present information sequentially and logically, Conclusion-summaries, re-emphasize, focus on the purpose, and provide closure.
- Improving Delivery: Choosing Delivery methods, handling stage fright
- Post-Presentation discussion: Handling Questions-opportunities and challenges.

References:

1. Carter, R. And Nunan, D. (Eds), The Cambridge guide to Teaching English to Speakers of Other Languages, CUP, 2001.
2. Edward P. Bailey, Writing and Speaking At Work: A Practical Guide for Business Communication, Prentice Hall, 3rd Ed., 2004.
3. Munter, M., Guide to Managerial Communication: Effective Business Writing and Speaking, Prentice Hall, 5th Ed., 1999.
4. R. Anand, Job Readiness For IT & ITES- A Placement and Career Companion, McGraw Hill Education.2015.
5. Malhotra, A., Campus Placements, McGraw Hill Education.2015.

Course Title : Physics-I					
Course Code : PHY1001					
Contact hrs per week:	**L**	**T**	**P**	**Total**	**Credit points**
	3	0	0	3	3

Course Outcome:

After successfully completing this course the students will be able to:

PHY1001.1: Understanding physical systems in terms of their modelling of time evolution.

PHY1001.2: Comprehending wave interpretation of natural phenomena and implications of allied observations.

PHY1001.3: Understanding theoretical backgrounds associated to some experiments based on wave phenomena.

PHY1001.4: Grasping an analytic view of micro and macroscopic world.

PHY1001.5: Accessing the knowledge of the behaviour of a particle under the influence of different potential.

PHY1001.6: Understanding conservative systems based on their particle and wave nature.

Module I: [10L]

Mechanics:

Plane-polar coordinate system-velocity and acceleration of a particle-trajectory under central force-conservation principle-Kepler's laws -Rotating frame of reference-Five point acceleration formula-Coriolis effect-deflection of a moving particle.

Module II: [10L]

Oscillation:

Constitutive equation of damping-nature of solutions for large, critical and weak damping-relaxation time, logarithmic decrement, energy decay (qualitative discussion) -Forced oscillation-transient and steady state-amplitude and velocity resonance---power transfer theorem-quality factor-series LCR circuit with AC source.

Module III: [10L]

Optics:

Plane Progressive Wave-phase/wave-length/frequency-qualitative description of light as an electromagnetic wave-Huygens principle-polarization (state of polarization, general equation of ellipse,

transformation of polarized lights)-interference (basic theory from superposition principle)-Division of wave front (Young's double slit experiment)-Division of amplitude (thin film, wedge, Newton's ring)-Diffraction (single slit, double slit, grating, Resolving Power).

Module IV: [10L]

Quantum Mechanics:

An informal discussion from Planck to de Broglie as the historical context of quantum mechanics-Quantum Mechanics of a particle-operator-eigenvalue problem- Unitary-Hermitian frame work-position and momentum operator-Canonical Commutation Relations (CCR)- Schrodinger equation-time dependent/time independent Schrodinger equation-wave function-stationary states-probability density-probability current density-normalization-expectation value-uncertainty-Bound state problem-particle in a one dimensional box- scattering state problem-potential step-reflection and transmission coefficients-tunnelling.

BOOKS

1. Theoretical Mechanics : M R Spiegel (Schaum Series) McGrow-Hill Book Company
2. Classical Mechanics : N C Rana and P S Joag Tata- McGrow-Hill Publishing Company Limited.
3. Vibrations and Waves : A P French, W W Norton and Company,
4. The Physics of Waves and Oscillations : N K Bajaj, Tata- McGrow-Hill Publishing Company Limited.
5. Optics : A Ghatak, Tata McGraw-Hill Publishing Company Limited.
6. Optics : E. Hecht, Addison Wesley
7. Fundamentals of Optics : F A Jenkins and H E White, McGrow-Hill Higher Education.
8. Atomic Physics (Modern Physics): S N Ghosal, S. Chand and Company.
9. Practical Quantum Mechanics : S Flugge, Springer (Reprint of the 1994 Edition)
10. Concepts of Modern Physics : A Baiser, Tata McGraw-Hill Publishing Company Limited.
11. Refresher Course in B.Sc. Physics – Vol1 and Vol 2 – C.L.Arora.

Course Title : Mathematics-II					
Course Code : MTH1201					
Contact hrs per week:	**L**	**T**	**P**	**Total**	**Credit points**
	3	1	0	4	4

Course Outcomes:
After successfully completing this course the students will be able to:

MTH1201. 1: Demonstrate the knowledge of probabilistic approaches to solve wide range of engineering problem.
MTH1201. 2: Recognize probability distribution for discrete and continuous variables to quantify physical and engineering phenomenon.
MTH1201. 3: Develop numerical techniques to obtain approximate solutions to mathematical problems where analytical solutions are not possible to evaluate.
MTH1201. 4: Analyze certain physical problems that can be transformed in terms of graphs and trees and solving problems involving searching, sorting and such other algorithms.
MTH1201. 5: Apply techniques of Laplace Transform and its inverse in various advanced engineering problems.
MTH1201. 6: Interpret differential equations and reduce them to mere algebraic equations using Laplace Transform to solve easily.

Module I: [10L]
Basic Probability: Random experiment, Sample space and events, Classical and Axiomatic definition of probability, Addition and Multiplication law of probability, Conditional probability, Bayes' Theorem, Random variables, General discussion on discrete and continuous distributions, Expectation and Variance, Examples of special distribution: Binomial and Normal Distribution.

Module II: [10L]
Basic Numerical Methods: Solution of non-linear algebraic and transcendental equations: Bisection Method, Newton-Raphson Method, Regula-Falsi Method. Solution of linear system of equations: Gauss Elimination Method, Gauss-Seidel Method, LU Factorization Method, Matrix Inversion Method. Solution of Ordinary differential equations: Euler's Method, Modified Euler's Method, Runge-Kutta Method of 4th order.

Module III: [10L]
Basic Graph Theory: Graph, Digraph, Weighted graph, Connected and disconnected graphs, Complement of a graph, Regular graph, Complete graph, Sub-graph, Walk, Path, Circuit, Euler Graph,

Cut sets and cut vertices, Matrix representation of a graph, Adjacency and incidence matrices of a graph, Graph isomorphism, Bipartite graph, Dijkstra's Algorithm for shortest path problem. Definition and properties of a Tree, Binary tree and its properties, Spanning tree of a graph, Minimal spanning tree, Determination of spanning trees using BFS and DFS algorithms, Determination of minimal spanning tree using Kruskal's and Prim's algorithms.

Module IV: [10L]

Laplace Transformation: Basic ideas of improper integrals, working knowledge of Beta and Gamma functions (convergence to be assumed) and their interrelations. Introduction to integral transformation, Functions of exponential order, Definition and existence of Laplace Transform(LT) (statement of initial and final value theorem only), LT of elementary functions, Properties of Laplace Transformations , Evaluation of sine , cosine and exponential integrals using LT, LT of periodic and step functions, Definition and properties of inverse LT, Convolution Theorem (statement only) and its application to the evaluation of inverse LT, Solution of linear ODEs with constant coefficients (initial value problem) using LT

References:

1. Advanced Engineering Mathematics, E.Kreyszig, Wiley Publications.
2. Introduction to Probability and Statistics for Engineers and Scientists, S.Ross, Elsevier.
3. Introductory methods of Numerical Analysis, S.S. Sastry, PHI learning.
4. Introduction to Graph Theory, D. B. West, Prentice-Hall of India.
5. Engineering Mathematics, B.S. Grewal, S. Chand & Co.

Course Title : Introduction to Electronics Devices & Circuits					
Course Code : ECE1001					
Contact hrs per week:	**L**	**T**	**P**	**Total**	**Credit points**
	3	0	0	3	3

Course Outcomes:

After going through this course, the students will be able to:

ECE1001.1: Categorize different semiconductor materials based on their energy bands and analyze the change in characteristics of those materials due to different types of doping.

ECE1001.2: Describe energy band of P-N Junction devices and solve problems related to P-N Junction Diode.

ECE1001.3: Design different application specific circuits using diodes.

ECE1001.4: Analyze various biasing configurations of Bipolar Junction Transistor.

ECE1001.5: Categorize different field-effect transistors and analyze their behavior.

ECE1001.6: Design and implement various practical electronic circuits.

Module I: [10 L]

Basic Semiconductor Physics:

Crystalline materials, energy band theory, Conductors, Semiconductors and Insulators, Concept of Fermi energy level, intrinsic and extrinsic semiconductors, mass action law, drift and diffusion currents in semiconductor, Einsteinrelation.

Diodes and Diode Circuits:

Formation of p-n junction, energy band diagram, forward & reverse biased configurations, V-I characteristics, DC load line, breakdown mechanisms - Zener and avalanche breakdown, voltage regulation using Zener diode.

Rectifier circuits: half wave & full wave rectifiers: ripple factor, rectification efficiency, rectifier output without and with filters. Light emitting diode.

Module II: [8 L]

Bipolar Junction Transistors (BJT):

PNP & NPN BJT structures, different operating modes of BJT, current components in BJT, dc current gains in CE & CB configurations and their interrelation, input & output V-I characteristics of CE & CB configurations. Concept of Biasing: DC load line, Q-point, basic concept of amplification using BJT.

Module III: [9 L]

Field Effect Transistors (FET):

Classification of FET, basic structure and operation of Junction Field Effect Transistor (n-channel) along with its V-I characteristics.

Metal Oxide Semiconductor Field Effect Transistor (MOSFET): Enhancement & depletion type MOSFETs (for both n & p channel devices), drain & transfer characteristics.

Module IV: [9 L]

Feedback in amplifiers:

Concept of feedback, different feedback topologies using block diagram only, effects of negative feedback(qualitative), Barkhausen criteria for sustained oscillation.

Operational Amplifier:

Usefulness of differential amplifier over single ended amplifier, ideal OPAMP characteristics, transfer characteristics of OPAMP, CMRR, slew rate, offset error voltages and current, concept of virtual ground Basic circuits using OPAMP: Comparator, inverting and non-inverting amplifiers, voltage follower, adder, subtractor, integrator, differentiator.

References:

1. Boylestad & Nashelsky: Electronic Devices & Circuit Theory.
2. R.A Gayakwad: Op Amps and Linear IC's, PHI.
3. D. Chattopadhyay, P. C Rakshit: Electronics Fundamentals and Applications.
4. Adel S. Sedra, Kenneth Carless Smith: Microelectronics Engineering.
5. Millman & Halkias: Integrated Electronics.
6. Salivahanan: Electronics Devices & Circuits.
7. Albert Paul Malvino: Electronic Principle.

Course Title : Universal Human Values and Professional Ethics					
Course Code : HUM1002					
Contact hrs per week:	**L**	**T**	**P**	**Total**	**Credit points**
	2	1	0	3	3

Course Outcome:

Students will be able to:

HUM1002.1: Appreciate the essential complementarily between 'values and 'skills' to ensure sustained happiness and prosperity which are the core aspirations of all human beings.
HUM1002.2: Develop a Holistic perspective towards life and profession.
HUM1002.3: Develop a correct understanding of the Human reality and the rest of existence.
HUM1002.4: Appreciate the relationship of values in terms of ethical human conduct.
HUM1002.5: Understand the importance of trustful and mutually fulfilling human behaviour and mutually enriching interaction with Nature.
HUM1002.6: Differentiate between the characteristics and activities of different orders and study the mutual fulfilment among them.

Module 1: Introduction to Value Education [6 L]
Understanding Values: Historical perspective to the development of values and its importance for the integration and harmony of the self and body
Understanding Human being as the Co-existence of the Self and the Body
Exploring Harmony of Self with the Body
Distinguishing between the Needs of the Self and the Body
Understanding and appreciating basic human aspirations-Maslow's Hierarchy of Needs Theory
Strategies, Methods to Fulfill the Basic Human Aspirations
Continuous Happiness and Prosperity – the Basic Human Aspirations

Module II: Harmony in the Family and Society [10 L]
The self as a social being starting with the family as the smallest unit—the process of socialisation.
Development of the self in relation to the society – Cooley's and Mead's theories of socialization.
Self and Integrated personality-Morality, Courage and Integrity
Conflict of interest at home and society and its resolution through the implementation of the Human Values
Societal Values – Justice, Democracy and Rule of law
Establishing harmony in the society with the help of ethical conduct based on values- Ethics of Rights and Duties, Ethics of care, Ethics justice and Fairness, Work Ethics and quality of life at work.

Value crisis- disharmony in relationships, understanding harmony in the society
Solutions - contribution of the individual in establishing harmony in the society.
'Trust' and 'Respect'--the Foundational Values in Relationship
Exploring the Feeling of Trust and Respect

Module III: Implications of the Holistic Understanding – a Look at Professional Ethics [10 L]
Ethics and Ethical Values
Principles and theories of ethics--Consequential and non-consequential ethics, Utilitarianism, Kant's theory and other non-consequential perspectives
Professional Ethics- Right understanding of Professional Ethics
Canons of professional Ethics
Technology – various perspectives-its use, overuse and misuse
Privacy, data security and data protection, Artificial intelligence-harmony or disharmony, misinformation, deep fake, cyber-crime - a sociological perspective.
Code of Ethics, Violation of code of ethics, Whistle blowing, Institutionalizing Ethics
Vision for the Universal Human Order, Exploring Systems to fulfill Human Endeavours

Module IV: Harmony in the Nature/Existence [10 L]
Understanding Harmony in the Nature -Ecological Ethics
Sustainable development- Definition and Concept
Strategies for sustainable development- Small is beautiful, Slow is Beautiful
Sustainable Development--- The Modern Trends
Sustainable Development Goals- Case studies and Best practices
Exploring the Four Orders of Nature -Interconnectedness, self-regulation and Mutual Fulfillment among the Four Orders of Nature
The Holistic Perception of Harmony in Existence

Suggested Readings:

1. A Foundation Course in Human Values and Professional Ethics, R.R. Gaur, R. Asthana, G.P. Bagaria, Excel Books Pvt. Ltd. New Delhi.
2. Human Values, A.N. Tripathi, New Age Intl. Publishers, New Delhi, 2004.
3. The Story of Stuff (Book).
4. The Story of My Experiments with Truth - by Mohandas Karamchand Gandhi.
5. Small is Beautiful - E. F Schumacher.
6. Slow is Beautiful - Cecile Andrews

Course Title : Physics-I Lab					
Course Code : PHY1051					
Contact hrs per week:	**L**	**T**	**P**	**Total**	**Credit points**
	0	0	2	2	1

Course Outcome:

After successfully completing this course the students will be able to:

PHY1051.1: Applying practical knowledge using the experimental methods to correlate with the Physics theory.

PHY1051.2: Understanding the usage of electrical and optical systems for various measurements.

PHY1051.3: Applying the analytical techniques and graphical analysis to the experimental data.

PHY1051.4: Understanding measurement technology, usage of new instruments and real time applications in engineering studies.

PHY1051.5: Evaluating intellectual communication skills and discuss the basic principles of scientific concepts in a group.

MINIMUM OF SIX EXPERIMENTS TAKING AT LEAST ONE FROM EACH OF THE FOLLOWING FOUR GROUPS:

Group I: Experiments in Optics

1. Determination of dispersive power of the material of a prism
2. Determination of wavelength of a monochromatic light by Newton's ring
3. Determination of wavelength of the given laser source by diffraction method

Group II: Electricity & Magnetism experiments

1. Determination of specific charge (e/m) of electron by J.J. Thompson's method.
2. Determination of dielectric constant of a given dielectric material.
3. Determination of Hall coefficient of a semiconductor by four probe method.
4. To study current voltage characteristics, load response, areal characteristic and spectral response of a photovoltaic solar cell.
5. Determination of Magnetic Field Measurement for a current carrying coil.
6. Determination of unknown resistance using Carey Foster's bridge

Group III: Experiments in Quantum Physics

1. Determination of Stefan-Boltzmann constant.
2. Determination of Planck constant using photocell.
3. Determination of Lande-g factor using Electron spin resonance spectrometer.
4. Determination of Rydberg constant by studying Hydrogen spectrum.
5. Determination of Band gap of semiconductor.

Group IV: Miscellaneous experiments

1. Determination of Young's modulus of elasticity of the material of a bar by the method of flexure.
2. Determination of bending moment and shear force of a rectangular beam of uniform cross section.
3. Determination of modulus of rigidity of the material of a rod by static method.
4. Determination of rigidity modulus of the material of a wire by dynamic method.
5. To determine the moment of inertia of a body about an axis passing through its centre of gravity and to determine the modulus of rigidity of the material of the suspended wire.
6. Determination of coefficient of viscosity by Poiseulle's capillary flow method.

Course Title : Introduction to Electronics Devices & Circuits Lab					
Course Code : ECE1051					
Contact hrs per week:	**L**	**T**	**P**	**Total**	**Credit points**
	0	0	2	2	1

Course Outcomes:

After successfully completing this course the students will be able to:

ECE1051.1: The students will correlate theory with diode behavior.

ECE1051.2: They will design and check rectifier operation with regulation etc.

ECE1051.3: Students will design different modes with BJT and FET and check the operations.

ECE1051.4: They will design and study adder, integrator etc. with OP-AMPs.

List of Experiments

1. Familiarization with passive and active electronic components such as Resistors, Inductors, Capacitors, Diodes, Transistors (BJT) and electronic equipment like DC power supplies, multi-meters, etc.
2. Familiarization with measuring and testing equipment like CRO, Signal generators etc.
3. Study of I-V characteristics of Junction diodes.
4. Study of I-V characteristics of Zener diodes.
5. Study of Half and Full wave rectifiers with Regulation and Ripple factors.
6. Study of I-V characteristics of BJTs in CB mode
7. Study of I-V characteristics of BJTs in CE mode
8. Study of I-V characteristics of Field Effect Transistors.
9. Determination of input-offset voltage, input bias current and Slew rate of OPAMPs.
10. Determination of Common-mode Rejection ratio, Bandwidth and Off-set null of OPAMPs.
11. Study of OPAMP circuits: Inverting and Non-inverting amplifiers, Adders, Integrators and Differentiators.

Course Title : Workshop/ Manufacturing Practices					
Course Code : MEC1051					
Contact hrs per week:	**L**	**T**	**P**	**Total**	**Credit points**
	1	0	3	4	2.5

Course Outcomes:

On successful completion of the course, students will be able to

MEC1051.1: Follow the various safety practices in workshop and personal protective elements.

MEC1051.2: Identify tools, work material and measuring instruments useful for fitting, carpentry and sheet metal practices.

MEC1051.3: Operate machine tools, components and processes to prepare jobs of specific shape and size.

MEC1051.4: Acquire knowledge of foundry process and casting of a product.

MEC1051.5: Perform welding, brazing and soldering processes.

MEC1051.6: Assemble a simple product.

Syllabus:

(i) Lectures: (13 hours)

Detailed contents

1. Introduction on Workshop and familiarization with safety norms **(1 lecture)**
2. Carpentry and Fitting **(2 lectures)**
3. Sheet metal **(1 lecture)**
4. Metal casting **(1 lecture)**
5. Welding (arc welding & gas welding), brazing and soldering **(2 lectures)**
6. Manufacturing Methods- machining (Lathe, Shaping and Milling) **(4 lectures)**
7. Additive manufacturing **(1 lecture)**
8. Assembling of a product **(1 lecture)**

(ii) Workshop Practice:(39 hours)

1. Safety practices in workshop **(3 hours)**
2. Carpentry shop **(3 hours)**
3. Fitting shop **(6 hours)**
4. Foundry shop **(3 hours)**
5. Machine shop **(9 hours)**
6. Welding shop-Arc welding **(3 hours)**
7. Sheet metal shop and brazing **(6 hours)**
8. Soldering operation **(3 hours)**
9. Assembling of a product **(3 hours)**

Suggested Text/Reference Books:

1. Hajra Choudhury S.K., Hajra Choudhury A.K. and Nirjhar Roy S.K., "Elements of Workshop Technology", Vol. I 2008 and Vol. II 2010, Media promoters and publishers private limited, Mumbai.
2. Kalpakjian S. And Steven S. Schmid, "Manufacturing Engineering and Technology", 4th edition, Pearson Education India Edition, 2002.
3. Gowri P. Hariharan and A. Suresh Babu, "Manufacturing Technology – I" Pearson Education, 2008.
4. Roy A. Lindberg, "Processes and Materials of Manufacture", 4th edition, Prentice Hall India, 1998.
5. 5. Rao P.N., "Manufacturing Technology", Vol. I and Vol. II, Tata McGraw Hill House, 2017.

Course Title : Engineering Graphics & Design					
Course Code : MEC1052					
Contact hrs per week:	**L**	**T**	**P**	**Total**	**Credit points**
	1	0	3	4	2.5

Course Outcomes:
After going through the course, the students will be able to:

MEC1052.1: Visualize the basic concept of engineering drawing.
MEC1052.2: Use engineering drawing tools (conventional / modern tools).
MEC1052.3: Apply the various standards and symbols followed in engineering drawing.
MEC1052.4: Implement the concept of projections used in engineering graphics.
MEC1052.5: Relate the concept of sections to determine its true shape.
MEC1052.6: Execute the concept of isometric projections.

Lecture Plan (13 L)
1. Importance and principles of engineering drawing (1 L)
2. Lettering (1 L)
3. Concepts of Scale, dimensioning and Conic sections (3 L)
4. Introduction to concept of projection (Projections of points, lines and surfaces) (3 L)
5. Definitions of different solids and their projections (1 L)
6. Section of solids and sectional view (1 L)
7. Isometric projection (1 L)
8. Introduction to CAD (1 L)
9. Viva-voce (1L)

Detailed contents of Laboratory hours (39 hours)

Module 1: Introduction to Engineering Drawing (**3 hours**)
Principles of Engineering Graphics and their significance, usage of Drawing instruments, lines, lettering & dimensioning, Conic sections like Ellipse (General method only); Involute; Scales – Plain, Diagonal.

Module 2: Orthographic Projections (**9 hours**)
Principles of Orthographic Projections - Conventions - Projections of Points and lines inclined to both planes; Projections on Auxiliary Planes; Projection of lamina.

Module 3: Projections of Regular Solids (**6 hours**)
Those axes inclined to both the Planes- Auxiliary Views.

Module 4: Sections and Sectional Views of Right Angular Solids (**3 hours**)

Prism, Cylinder, Pyramid, Cone – Auxiliary Views; Development of surfaces of Right Regular Solids - Prism, Pyramid, Cylinder and Cone; Sectional orthographic views of geometrical solids.

Module 5: Isometric Projections (**6 hours**)

Principles of Isometric projection -Isometric Scale, Isometric Views, Conventions; Isometric Views of lines, Planes, Simple and compound Solids; Conversion of Isometric Views to Orthographic Views and Vice-versa, Conventions.

Module 6: Overview of Computer Graphics (**3 hours**)

Listing the computer technologies that impact on graphical communication, Demonstrating knowledge of the theory of CAD software [such as: The Menu System, Toolbars (Standard, Object Properties, Draw, Modify and Dimension), Drawing Area (Background, Crosshairs, Coordinate System), Dialog boxes and windows, Shortcut menus (Button Bars), The Command Line (where applicable), The Status Bar, Different methods of zoom as used in CAD, Select and erase objects.; Isometric Views of lines, Planes, Simple and compound Solids.

Module 7: Customization& CAD Drawing (**3 hours**)

Consisting of set up of the drawing page and the printer, including scale settings, setting up of units and drawing limits; ISO and ANSI standards for coordinate dimensioning and tolerancing; Orthographic constraints, Snap to objects manually and automatically; Producing drawings by using various coordinate input entry methods to draw straight lines, Applying various ways of drawing circles.

Module 8: Annotations, layering & other functions (**3 hours**)

Applying dimensions to objects, applying annotations to drawings; Setting up and use of Layers, layers to create drawings, Create, edit and use customized layers; Changing line lengths through modifying existing lines (extend/lengthen); Printing documents to paper using the print command; orthographic projection techniques; Drawing sectional views of composite right regular geometric solids and project the true shape of the sectioned surface; Drawing annotation.

Module 9: Demonstration of a simple team design project that illustrates (**3 hours**)

Geometry and topology of engineered components: creation of engineering models and their presentation in standard 2D blueprint form and as 3D wire-frame.

References:

1. Bhatt, N.D., Panchal V.M. & Ingle P.R., (2014) “Elementary Engineering Drawing”; Charotan Publishing House.
2. Narayana, K.L. and Kannaaiah P “Engineering Graphics”; TMH.
3. Lakshminarayanan, V. and Vaish Wanar, R.S “Engineering Graphics” Jain Brothers.
4. Shah, M.B. & Rana B.C. (2008), Engineering Drawing and Computer Graphics, Pearson Education.
5. Agarwal B. & Agarwal C. M. (2012), Engineering graphics, TMH Publications.

DETAILED SYLLABUS

2nd Year

Course Title: Environmental Sciences					
Course Code: EVS2016					
Contact Hours per week	**L**	**T**	**P**	**Total**	**Credit Points**
	2	0	0	2	0

Course outcomes:

The subject code EVS2016 corresponds to basic environmental chemistry for the 2nd year B.Tech students, which is offered as Environmental Sciences and is mandatory for all branches of engineering. The course provides basic knowledge of various environmental pollutions as well as its impact and ways to curb it. The course outcomes of the subject are:

ENV2016.1: Understand the natural environment and its relationships with human activities.
ENV2016.2: Characterize and analyze human impacts on the environment.
ENV2016.3: Integrate facts, concepts, and methods from multiple disciplines and apply to environmental problems.
ENV2016.4: Educate engineers who can work in a multi-disciplinary environment to anticipate and address evolving challenges of the 21st century.
ENV2016.5: Understand and implement scientific research strategies, including collection, management, evaluation, and interpretation of environmental data.
ENV2016.6: Design and evaluate strategies, technologies, and methods for sustainable management of environmental systems and for the remediation or restoration of degraded environments.

Module I: Socio Environmental Impact [6L]
Basic ideas of environment and its component
Population growth: exponential and logistic; resources; sustainable development. 3L
Concept of green chemistry, green catalyst, green solvents
Environmental disaster and social issue, environmental impact assessment, environmental audit, environmental laws and protection act of India. 3L

Module II: Air Pollution [6L]
Structures of the atmosphere, global temperature models
Greenhouse effect, global warming; acid rain: causes, effects and control.3L

Lapse rate and atmospheric stability; pollutants and contaminants; smog; depletion of ozone layer; standards and control measures of air pollution. 3L

Module II: Water Pollution [6L]

Hydrosphere; pollutants of water: origin and effects; oxygen demanding waste; thermal pollution; pesticides; salts.

Biochemical effects of heavy metals; eutrophication: source, effect and control. 2L

Water quality parameters: DO, BOD, COD.

Water treatment: surface water and waste water. 4L

Module II: [6L]

Land Pollution

Land pollution: sources and control; solid waste: classification, recovery, recycling, treatment and disposal. 3L

Noise Pollution

Noise: definition and classification; noise frequency, noise pressure, noise intensity, loudness of noise, noise threshold limit value; noise pollution effects and control. 3L

Text/Books:

1. GourKrishna Das Mahapatra, Basic Environmental Engineering and Elementary Biology, Vikas Publishing House P. Ltd.
2. A. K. De, "Environmental Chemistry", New Age International.
3. A. K. Das, Environmental Chemistry with Green Chemistry, Books and Allied P. Ltd.

Reference Books:

1. S. C. Santra, Environmental Science, New Central Book Agency P. Ltd.
2. D. De, D. De, Fundamentals of Environment & Ecology, S. Chand & Company Ltd.

Course Title: Chemistry of Biomolecules					
Course Code: BTC2101					
Contact Hours per week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	0	0	3	3

Course Outcomes:

After completion of this course, the students will be able to:

BTC2101.1: Calculate the pH of a buffer system, identify different stereoisomer's of carbohydrate and lipids and understood the chemistry of carbohydrate and lipids.
BTC2101.2: Explain the different structural components and physiochemical properties of amino acids, proteins.
BTC2101.3: Analyses and explain the different structural components and physiochemical properties of DNA and RNA.
BTC2101.4: Select and apply suitable spectroscopic techniques for estimation biomolecules.
BTC2101.5: Select and apply suitable techniques for and structure determination of biomolecules.
BTC2101.6: Able to solve mathematical problems related to estimation and structural features of biomolecules.

Module I: Introduction and Chemistry of Carbohydrates and lipids [9L]
Introduction: Structure of water molecules, weak inter-molecular interactions in biomacromolecules, concepts of pKa, pH, buffer**.** Chemistry of Carbohydrates: Definition, classification, structure and chemical properties of: monosaccharides, disaccharides and polysaccharides. Chemistry of Lipids: Definition, classification. structure, reactions and characterization of: lipids, phospholipids, glycolipids, cholesterol, steroids and carotenoids. Stereochemistry of carbohydrates and lipids: configuration, conformation, nomenclature of optical isomers of carbohydrates and geometrical isomers lipids.

Module II: Chemistry of Amino Acids and Proteins [9L]
Chemistry of amino acids: Classification, structure, pH titration curve and important chemical reactions of amino acids. Chemistry of proteins: Peptide bond, four levels of structures (primary, secondary, tertiary and quaternary structure with example of: RNaseA, keratins, collagen, lectins, myoglobin, and haemoglobin) and conformation (Ramachandran plot, domains, motif and folds), of proteins. Identification and separation methods of proteins based on structure and chemical properties. Stability of protein, denaturation and renaturation of proteins.

Module III: Chemistry of Nucleotides and Nucleic Acids [9L]
Chemistry of nucleoside and nucleotides: Classification, structure, nomenclature of nucleoside, nucleotides. Chemistry of nucleic acids: Four levels structures of nucleic acids (primary,

secondary, tertiary and quaternary structure), conformations (A-, B-, Z-,DNA), t-RNA, micro-RNA. Nucleotide sequence composition of DNA and RNA. Supercoiled structure of DNA, stability of nucleic acids, denaturation and renaturation kinetics of DNA. Identification, isolation, separation and analysis of nucleic acids.

Module IV: Techniques for analysis and structure determination of biomolecules [9L]

Principles and types of spectroscopy, Lambert–Beer law. Basic concepts and principles of analytical techniques: Centrifugation - high speed and ultra; spectroscopy- UV, visible, fluorescence, Raman spectroscopy, infrared (IR), FT-IR, circular dichroism, optical rotatory dispersion, electron spin resonance. Molecular analysis: light scattering, and surface plasma resonance. Structure determination techniques: Nuclear Magnetic resonance spectroscopy, X-ray diffraction crystallography; Microscopy: atomic force (AFM), Electron microscopy (SEM, STM, cryoelectron). Radioisotopic techniques.

Textbooks:

1. Lehninger Principles of Biochemistry (8th Edn. 2021) by Nelson and Cox, McMillan publishers.
2. Van Holde, Principles of Physical Biochemistry, Pearson.
3. Voet's Principles of Biochemistry (5th Edn. 2018) Voet, D., Voet, JG, and Pratt, CW (Wiley)
4. Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology 8thedn. (2018) by Andreas Hofmann, Samuel Clokie.
5. Biochemical Calculations (2nd Edn. 2010) by Irwin H. Segel, John Wiley & Sons.

Course Title: Thermodynamics and Kinetics					
Course Code: BTC2102					
Contact Hours per week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	0	0	3	3

Course Outcomes:

After completion of this course, the students will be able to:
BTC2102.1: Comprehend the thermodynamic properties and functions of different systems and processes.
BTC2102.2: Apply the thermodynamic laws in practical problems.
BTC2102.3: Relate the thermodynamic properties and functions to biological systems.
BTC2102.4: Explain effect of temperature on rate of reaction.
BTC2102.5: Determine the order of a reaction using different suitable analytical methods.
BTC2102.6: Understand the kinetic mechanism of enzyme-substrate reactions with/without the presence of inhibitor and solve related problems.

Module I: Concepts and Laws of Thermodynamics [9L]
Review of basic concepts - systems, surroundings, processes, properties (extensive/intensive), components (single/multi); Zeroth, first, second laws and their consequences; Application of 1st law of thermodynamics for flow process; Refrigeration process; Thermodynamic functions and free energy concept, chemical potential, Maxwell's relations.

Module II: Thermodynamics and Bioenergetics [9L]
Review of ideal gas, non-ideal gas, PVT behaviour, virial and cubic equations of state, residual properties. Importance of thermodynamic laws and free energy in Biological system; Partial molar properties, fugacity, ideal and non-ideal solutions, activity coefficient, Phase rule, criteria for phase equilibrium, VLE for pure component, Equilibrium criteria for homogeneous chemical reactions; evaluation of equilibrium constant; effect of temperature on equilibrium constant; Transport across membrane.

Module III: Kinetics [9L]
Rate of chemical reaction; Effect of Temperature on Rate Constant, Arrehnius equation, Collision Theory, Transition State Theory, Order and Molecularity of a Chemical reaction, Elementary Reactions, First, Second and Third order reactions, Non Elementary Reactions, Pseudo-first order reaction, Determination of rate constant and order of reaction, Half life method, Fractional order reactions.

Module IV: Applications of Kinetics [10L]

Interpretation of batch reactor data for simple and complex reactions. Kinetics of Enzyme catalyzed reactions for free and immobilized enzymes–derivation of Michaelis-Menten equation, Briggs-Haldane relationship, the determination and significance of kinetic constants, Lineweaver-Burk, Hanes–Woolf plot and Eadie-Hofstee plot, Principles of enzyme inhibition: competitive, noncompetitive and uncompetitive.

Textbooks:

1. Smith &Vanness, Thermodynamics for Chemical Engineers, McGraw Hill & Co.
2. Levenspiel. O. Chemical Reaction Engineering, Wiley Eastern Ltd.

Reference books:

1. Richardson, J.F., Peacock, D.G. Coulson & Richardson's Chemical Engineering, Volume 3rd ed., First Indian ed. Asian Books Pvt. Ltd. 1998.
2. Bailey & Olis, Biochemical Eng. Fundamentals, McGraw Hill & Co., 1990.
3. Gordon G. Hammes, Thermodynamics and Kinetics for the Biological Sciences; John Wiley & Sons, Inc., Publication; 2000.
4. Michael L. Shuler, Filkert Kargi, Bioprocess engineering: 2nd edition, Prentice Hall India.

Course Title: Biochemistry					
Course Code: BTC2103					
Contact Hours per week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	0	0	3	3

Course Outcomes:

After completion of this course, the students will be able to:

BTC2103.1: Explain the basic concepts of enzymes.

BTC2103.2: Understand the basic concept of metabolism and bioenergetics.

BTC2103.3: Understand and grasp knowledge about catabolic and anabolic pathways of carbohydrate metabolism.

BTC2103.4: Explain the basis behind lipid synthesis, cholesterol biosynthesis and lipid β oxidation pathways.

BTC2103.5: Gain knowledge about N-metabolism: amino acid and nucleic acid synthesis and degradation.

BTC2103.6: Know the basis of intracellular signalling network.

Module I: Introduction to Enzyme & Carbohydrate Metabolism [10L]

Enzymes: Basic concept of enzyme-substrate reaction, Classification and nomenclature, active site, allosteric regulation. Metabolism of carbohydrates and their regulation: glycolysis, TCA cycle, pentose phosphate pathway, Glyoxalate cycle, Cori cycle, glucuronate pathway, glycogenolysis, gluconeogenesis glycogenesis. Oxidative phosphorylation: electron transport chain, ATP synthesis and its regulation. Photosynthesis: Photophosphorylation, Calvin cycle. Disorder/ diseases of carbohydrate metabolism.

Module II: Metabolism of lipids and vitamins [10L]

Oxidation of Fatty acid and its regulation: Beta oxidation, Alpha oxidation and omega oxidation of fatty acids - saturated and unsaturated fatty acids - even and odd numbered. Catabolism of phospholipids. Biosynthesis of fatty acids, phospholipids, cholesterol, steroids and ketone bodies and their regulation. Disorder/ diseases of lipid metabolism. Vitamins and hormones: classification, Structure and Function; Micronutrients.

Module III: Metabolism of Amino acid and nucleic acid [10L]

Oxidation of amino acids: Transamination, oxidative deamination. Urea cycle and its regulation. Overview of amino acid degradation. Biosynthesis of amino acids and its regulation; Protein turnover. Disorder/ diseases of amino acids metabolism.

Nucleic acid metabolism: nucleotide metabolism, Overview of purine and pyrimidine biosynthesis and degradation, De Novo and Salvage Pathways. Disorder of purine and pyrimidine metabolism.

Module IV: Cell Signaling [10L]

Cell signaling and signal transduction pathways: Ligands and their receptors, cell surface receptor, signaling through G-protein coupled receptors, Receptor tyrosine kinase (RTKS), hormone receptors, second messengers, regulation of signaling pathways, general principles of cell communication, extracellular matrix.

Textbook:

1. Lehninger's Principles of Biochemistry (8^{th} Edn. 2021) by Nelson & Cox, Pub: Freeman

Reference books:

1. Molecular Biology of the Cell (7th ed 2022) by Bruce Alberts et. al, Pub: Norton & Co.
2. Biochemistry (10^{th} Edn. 2023) by Berg, J., Stryer, L., et. al, Pub: Freeman & Co.
3. Voet & Voet, Fundamentals of Biochemistry, John Willey & Sons.
4. Harper's Illustrated Biochemistry – (32th Edn. 2022) Botham, K. et. al. (McGraw Hill).
5. Outline of Biochemistry - Conn & Stump (John Willey & Sons).

Course Title: Microbiology					
Course Code: BTC2104					
Contact Hours per week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	0	0	3	3

Course Outcomes:

After completing this course, students will be able to:

BTC2014.1: Describe different cell structures with subcellular functional organelles.

BTC2014.2: Describe the working principles of different types of microscopes.

BTC2014.3: Isolate pure culture from different environmental sources.

BTC2014.4: Preserve and maintain pure culture.

BTC2014.5: Understand various microbial identification processes.

BTC2014.6: Apply their knowledge of microbes in different environmental aspects.

Module I: Introduction to Microbiology [9L]

Development of microbiology: Historical aspect.

Cell structure with subcellular functional organelles. Bacteria, Yeast, Fungi, Algae and Virus: General morphology and subcellular structure, growth and reproduction.

Biochemical & Molecular Taxonomical identification of microorganisms.

Module II: Basic principles and methods in microbiology [9L]

Microscopy: Optical microscope with special utility (phase contrast, fluorescence and inverted microscope), Electron microscope (TEM & SEM).

Cultivation of microbes – General media for the growth of bacteria, yeast and fungi, Types of growth media (synthetic, complex, enriched, selective- definition with example), pure culture methods (streak plate, spread plate, pour plate, stab culture, slant culture). Anaerobic (thioglycolate, anaerobic chamber, Robertson's media, microaerophilic), liquid shake culture of aerobic bacteria. Control of microbes: Sterilization, tyndallisation, pasteurization; Physical agents: dry heat, moist heat, UV light, ionizing radiation, filtration, HEPA filter; Chemical agents: antibiotics and antiseptics, disinfectants.

Module III: Microbial Growth and Metabolism [9L]

Growth of bacteria- Definition, growth phases, kinetics of growth, direct and indirect measurement of growth, The mathematical nature and expression of growth, growth principles of nutrition, influence of environmental factors-pH, temperature, oxygen, Heavy metals and Other compounds. Bacterial growth, fermentation and putrification, Aerobic and anaerobic respiration (definition, examples), fermentation (alcoholic, mixed acid, acetic acid, lactic acid), EntnerDuodruffs

pathway, bacterial photosynthesis (green and purple bacteria), biochemical nitrogen fixation – non-symbiotic, symbiotic (definition and examples), basic concept of nif-genes. Nod genes, nitrogenase complex, leghaemoglobin.

Module IV: Environmental microbiology [9L]

Air microbiology- Microorganisms in the air, sampling techniques, air borne pathogens. Microbiology of fresh water and wastewater (sewage), water borne diseases (name of pathogen, pathogenicity and preventive measures). Outlines of method for determination of microbial safety of drinking water (presumptive, confirmatory and completed tests). Soil microbiology: soil microbes, different kinds of associations, importance of soil microbes in agriculture.

Textbooks:

1. R.C Dubey and D. K Maheshwari -A Text Book of Microbiology, 3rd ed, S. Chand and Company.
2. C.B Powar and H.F Daginawala- General Microbiology (Vol I & II) 3rd ed, Himalaya Publishing House.

Reference books:

1. Prescott"s Microbiology (12th Edn. 2023) by Wood, D., Willey, J., Sandman, K. Pub: McGraw-Hill
2. Brock Biology of Microorganisms, (16th Edn. 2021) by Madigan, M., Jennifer Aiyer, Buckley, D., Sattley, W., and David Stahl, D. Pub: Pearson
3. Stanier R. –General Microbiology, 5th Edn, Macmilan Press Ltd.
4. M. Pelczar, E.Chan, N.Kreig, Microbiology, 5thed, MGH
5. Salle. A. J- Fundamental Principles of Bacteriology, Tata Mcgraw Hill.
6. Hans G. Schlegel, General Microbiology, 7thed, Cambridge Low Price Edition.
7. A.H. Rose, Chemical Microbiology, 3rded, Butterworth World Student Reprints.

Course Title: Data Structure					
Course Code: CSE2005					
Contact Hours per week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	0	0	3	3

Course Outcomes:
Upon successful completion of this course students should be able to:

CSE2005.1: Identify and select appropriate data structures as applied to specified problem definition.
CSE2005.2: Implement operations like searching, insertion, deletion, traversal etc. on linear data structures like array, stack and queue.
CSE2005.3: Implement operations like searching, insertion, deletion, traversal etc. on nonlinear data structures like tree and graph.
CSE2005.4: Apply appropriate sorting/searching technique for given problem.
CSE2005.5: Analyze and compare the different sorting algorithms.
CSE2005.6: Design advanced data structure using Nonlinear data structures.

Module I: Linear Data Structure I [8L]
Introduction (2L):
Concepts of data structures (Data, data structure, Abstract Data Type), Need of data structure, Basic idea of pseudo-code, algorithm analysis and order notations.
Array (2L):
Different representations – row major, column major. Sparse matrix - its implementation and usage. Array representation of polynomials.
Linked List (4L):
Singly linked list, Circular linked list, Doubly linked list (Creation, insertion at different positions, deletion from different positions of the list), Linked list representation of polynomial and applications.

Module II: Linear Data Structure II [6L]
Stack and Queue (4L):
Stack and its implementations (using array and linked list), applications.
Queue, circular queue, deque. Implementation of queue- both linear and circular (using array and linked list).
Recursion (2L):
Principles of recursion – Design of recursive algorithms, differences between recursion and iteration, merits and demerits of recursion, Tail recursion.

Module III: Nonlinear Data structures [12L]
Trees (9L):

Basic terminologies, tree representation (using array and linked list).
Binary trees - binary tree traversal (pre-order, in- order, post- order), threaded binary tree.
Binary search tree and its operations (creation, insertion, deletion, searching).
Height balanced binary tree – AVL tree and its operations (insertion, deletion with examples only).
B- Trees and its operations (insertion, deletion with examples only).
Graphs (3L):
Basic terminologies, Graph representations/storage implementations (using adjacency matrix and adjacency list)
Graph traversal and connectivity – Depth-first search (DFS), Breadth-first search (BFS).

Module IV: Searching, Sorting, Hashing [10L]
Sorting Algorithms (6L):
Bubble sort, Insertion sort, Selection sort, Merge sort, Quick sort, Heap sort and their comparisons.
Searching (1L):
Linear search, binary search and their comparisons.
Hashing (3L):
Basic terminologies, Different hashing functions, Collision resolution techniques (Open addressing and Chaining).

Recommended books:

1. "Data Structures and Program Design In C", 2/E by Robert L. Kruse, Bruce P. Leung.
2. "Fundamentals of Data Structures of C" by Ellis Horowitz, SartajSahni, Susan Andersonfreed.
3. "Classic Data Structures" by D.Samanta.
4. "Data Structures in C" by Aaron M. Tanenbaum.
5. "Data Structures" by S. Lipschutz.

Course Title: Biomolecular Chemistry Lab					
Course Code: BTC2151					
Contact Hours per week	**L**	**T**	**P**	**Total**	**Credit Points**
	0	0	2	2	1

Course Outcomes:

After completion of this course, the students will be able to:

BTC2151.1: Determine the presence of carbohydrates, proteins and lipids in a solution.
BTC2151.2: Develop a concept of different types of buffer and pH.
BTC2151.3: Develop the basic principles of spectrophotometric analysis.
BTC2151.4: Quantify the concentration of an unknown solution by spectrophotometry.
BTC2151.5: Estimate DNA, RNA and reducing sugars.
BTC2151.6: Determine saponification number and iodine number of lipids.

List of experiments (minimum six):

1. Buffer & pH: Calibration of pH meter, Preparation of buffer (Tris-HCl or Acetate or Phosphate buffer system) and pH titration of amino acids and validation of the Henderson-Hasselbach equation.
2. Spectroscopy: Verification of Lambert-Beer's law and determination of molar extinction coefficient.
3. Qualitative tests For Carbohydrates, Amino acids, Proteins and Lipids.
4. Estimation of Reducing Sugars (DNSA method).
5. Estimation of DNA /RNA by chemical method (DNA by diphenylamine reagent and RNA by orcinol reagent)
6. Determination of Saponification number of lipid.
7. Determination of Iodine Number of lipid.
8. Salting out of proteins with Ammonium sulfate.

Reference Books:

1. Principles and techniques of Practical Biochemistry: K. Wilson and J. Walker (1994), CUP, Cambridge University Press.
2. Introductory practical Biochemistry by S.K. Sawhney and Randhir Singh (2000), Narosa Publishing House.
3. An introduction to Practical Biochemistry by David T. Plummer (1988), McGraw- Hill Book Company.

Course Title: Biochemistry Lab					
Course Code: BTC2153					
Contact Hours per week	**L**	**T**	**P**	**Total**	**Credit Points**
	0	0	2	2	1

Course Outcomes:

After completion of this course, the students will be able to:

BTC2153.1: Estimate sugars by enzymatic method.
BTC2153.2: Develop the concept of enzyme kinetics
BTC2153.3: Determine the activity and specific activity of enzymes.
BTC2153.4: Determine the nature of enzyme inhibition.
BTC2153.5: Estimate the unknown concentration of a protein, cholesterol, vitamin C and liver enzymes.
BTC2153.6: Separate lipids and proteins by chromatographic techniques.

List of experiments (minimum six):

1. Estimation of glucose by enzymatic method (GOD –POD method).
2. Determination of activity & specific activity of enzyme: K_m and $V_{max.}$
3. Determination of optimum temperature & pH optima of an enzyme.
4. Enzyme inhibition and determining the nature of inhibition.
5. Determination of SGPT, SGOT by colorimetric end point method in blood.
6. Estimation of starch.
7. Estimation of proteins.
8. Estimation of cholesterol.
9. Separation of amino acids by Paper Chromatography.
10. Separation of lipids/ sugars by Thin layer Chromatography (TLC).

Reference Books:

1. Principles and techniques of Practical Biochemistry: K. Wilson and J. Walker (1994), CUP, Cambridge University Press.
2. Introductory practical Biochemistry by S.K. Sawhney and Randhir Singh (2000), Narosa Publishing House.
3. An introduction to Practical Biochemistry by David T. Plummer (1988), McGraw-Hill, Book Company.

Course Title: Microbiology Lab					
Course Code: BTC2154					
Contact Hours per week	**L**	**T**	**P**	**Total**	**Credit Points**
	0	0	3	3	1.5

Course Outcomes:

After completion of this course, the students will be able to:

BTC2154.1: Prepare different microbial media and plating.

BTC2154.2: Isolate pure culture by streak, spread and pour plate method.

BTC2154.3: Handle different types of microscopes

BTC2154.4: Determine bacterial growth kinetics

BTC2154.5: Perform the assay of antibiotic by zone inhibition method.

BTC2154.6: Study the biochemical activity of microorganism by some standard tests: IMViC test, hydrolysis of starch, casein etc.

List of experiments (minimum six):

1. General laboratory procedure; microbial safety and precaution; study of methods of sterilization
2. Preparation of microbial media and plating.
3. Isolation of pure culture by streak, spread and pour plate method.
4. Microscope and microscopy and identification of bacterial sample by differential staining.
5. Determination of microbial load in air, soil and water.
6. Determination of bacterial growth kinetics.
7. Assay of antibiotic by zone inhibition method.
8. Study of biochemical activity of microorganism by some standard tests: IMViC test, hydrolysis of starch, casein etc.
9. Isolation and morphological characterization of fungi.
10. Endospore staining.

Reference Books:

1. Practical Microbiology, (4th Edn., 2023) by Dr. R.C. Dubey (Author), D K Maheshwari, Pub: S Chand
2. Basic Practical Microbiology by Microbiology Society, UK
3. Microbiology: A Laboratory Manual, (11th Edn., 2023) by James G. Cappuccino, Chad Welsh, Pub: Pearson

Course Title: Data Structure Lab					
Course Code: CSE2055					
Contact Hours per week	**L**	**T**	**P**	**Total**	**Credit Points**
	0	0	2	2	1

Course Outcomes:
Upon successful completion of this course students should be able to:

CSE2005.1: Identify the appropriate data structure for given problem.
CSE2005.2: Understand the concept of Dynamic memory management, data types, algorithms etc.
CSE2005.3: Understand and implement basic data structures such as arrays, linked lists, stacks and queues.
CSE2005.4: Implement various applications involving array, stack, queue and linked lists.
CSE2005.5: Solve problem involving graphs and trees.
CSE2005.6: Apply algorithm for solving problems like sorting and searching.

List of experiments:

1. Implementation of array operations.
2. Stacks and Queues: adding, deleting elements, Circular Queue: Adding & deleting elements.
3. Evaluation of expressions operations on stacks.
4. Implementation of linked lists: inserting, deleting, and inverting a linked list.
5. Implementation of stacks & queues using linked lists
6. Polynomial addition.
7. Addition of Sparse matrices.
8. Traversal of Trees.
9. DFS and BFS implementation.
10. Sorting and searching algorithms.

Course Title: Design Thinking and IDEA Lab					
Course Code: BTC2155					
Contact Hours per week	**L**	**T**	**P**	**Total**	**Credit Points**
	0	0	2	2	1

Course Outcomes:
Upon successful completion of this course students should be able to:

BTC2155.1: Students will be able to identify an Opportunity from a Problem.
BTC2155.2: Students will be able to frame a Biotechnological Product/Service Idea.
BTC2155.3: Students will be able to empathize with the customers.
BTC2155.4: Students will be able to design and develop a Prototype.
BTC2155.5: Students will be able to pitch their idea.

Unit 1: Process of Product Design
Process of Engineering Product Design, Design Thinking Approach, Stages of Product Design, Examples of best product designs and functions, Assignment – Engineering Product Design.

Unit 2: Prototyping & Testing
What is Prototype? Why Prototype? Rapid Prototype Development process, Testing, Sample Example, Test Group Marketing.

Unit 3: Celebrating the Difference
Understanding Individual differences & Uniqueness, Group Discussion and Activities to encourage the understanding, acceptance and appreciation of Individual differences.

Unit 4: Design Thinking & Customer Centricity
Practical Examples of Customer Challenges, Use of Design Thinking to Enhance Customer Experience, Parameters of Product experience, Alignment of Customer Expectations with Product Design.

Unit 5: Feedback, Re-Design & Re-Create
Feedback loop, Focus on User Experience, Address "ergonomic challenges, User focused design, rapid prototyping & testing, final product, Final Presentation – "Solving Practical Engineering Problem through Innovative Product Design & Creative Solution".

Course Title: Transfer Operations-I					
Course Code: BTC2201					
Contact Hours per week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	0	0	3	3

Course Outcomes:

After completion of this course, the students will be able to:
BTC2201.1: Understand thy physical properties of fluid, flow behaviour and their consequence on fluid flow.
BTC2201.2: Apply the basic laws and equations to analyze fluid dynamics and solve numerical problems related to them.
BTC2201.3: Understand the importance of fluid flow measurement by various devices in industries.
BTC2201.4: Analyze and calculate various parameters involved in heat transfer by conduction, convection and thermal radiation.
BTC2201.5: Develop and design various equipments associated with heat transfer and evaluate heat exchanger performance.
BTC2201.6: Develop the knowledge of principles of communition, mechanical separation aspects, working of equipments used in mechanical operation and calculate various parameters for energy requirement related to size reduction of solid.

Module I: Basic concepts of Fluid Mechanics [9L]

Fluid – rheological properties – compressible, incompressible fluids. Newtonian and non Newtonian fluids. Basic equations of fluid flow, fluid flow phenomena – through pipes and other devices – pressure drop calculations. Fluid friction- friction in flow through packed beds. Fundamentals of fluidization and inverse fluidization, gravity settling, terminal settling velocity. Basic concept of multiphase flow-flow regime, pressure drop measurement.

Module II: Flow measurements and machineries [9L]

Flow measuring devices- orifice and venturi meters, pitot tube, weirs, rotameters and other types of meters. Pipe fittings and valves. Pumps – classification, centrifugal and positive displacement type, peristaltic pump. Principle of compressor and blower.

Module III: Heat transfer [9L]

Classification of heat flow processes- conduction, convection, radiation. Conduction- Steady state and unsteady state heat conduction. Heat flow in fluids by convection (natural and forced). Heat exchanger- double pipe and shell and tube heat exchanger. Basic concept of radiation.

Module IV: Mechanical Operations [9L]

Principles of comminution, types of comminuting equipment, energy and power requirement. Crushing, grinding, mixing and agitation, power consumption in mixing. Mechanical separation-screening, filtration (constant pressure and constant rate), centrifugation.

Textbooks:

1. Unit Operations of Chemical Engineering: McCabe, Smith &Harriot, TMH, 5th edition.

Reference books:

1. Geankopolis, Transport Processes & Unit operations: 3rd edition, PHI.
2. Coulson & Richardson, Chemical Engineering, Vol-I & II:, Butterworth Heinemann.
3. D.Q. Kern, Heat Transfer, MGH.
4. Badger, W.L., Banchero, J.T., Introduction to Chemical Engineering, MGH.
5. Foust, A.S., Wenzel, L.A, et.al. Principles of Unit Operations, 2nd edition, JWS.

Course Title: Industrial Microbiology & Enzyme Technology					
Course Code: BTC2202					
Contact Hours per week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	0	0	3	3

Course Outcomes:

After completing this course, students will be able to:

BTC2202.1: Describe different methods for immobilization of enzymes.
BTC2202.2: Apply enzymes in various industries that can benefit human life
BTC2202.3: Produce different useful secondary metabolites by microbes.
BTC2202.4: Modify the enzymes for better stability.
BTC2202.5: Design different biosensors for applications in biotechnology.
BTC2202.6: Develop the fermentation techniques and downstream processes.

Module I: Fermentation process and strain improvement [9L]
Definition and scope, Basic idea on fermentation process, submerged and solid– with their merits and demerits, Microbial Culture systems; Media for Industrial fermentations; Media optimization; Sterilization of Industrial Media, Cellular control regulating production of microbial metabolites – Primary and Secondary metabolite – Induced mutation technique – Analogue resistant mutant – Catabolic derepressed mutants – Genetically engineered strain – Protoplast fusion technique.

Module II: Production by fermentation [9L]
Microbial production: Production of organic acids and solvents, microbial polysaccharides, amino acids, enzymes, vitamins, growth factors and hormones, antibiotics and vaccines, alcoholic beverages and other microbial food products. Downstream processing and fermentation economics.

Module III: Enzyme Technology [9L]
Enzyme: brief overview, general characteristics, Units of enzyme activity, physical and chemical factors affecting enzyme activity, outlines of extraction and purification of commercial enzymes from plant, animal and microbial sources, formulation and stabilization of commercial enzymes. Stable enzymes: selection of extremophilic producer, chemical modification of enzymes for better stability. Enzyme immobilization: Physical and chemical methods for enzyme immobilization. Adsorption, matrix entrapment, covalent binding, cross linking – advantages and disadvantages of different immobilization techniques. Immobilized enzyme kinetics.

Module IV: Industrial applications of enzymes [9L]

Commercial enzymes: Industrial applications of food processing enzymes; Analytical, diagnostic and medicinal applications of enzymes.

Enzyme electrode and application as biosensor in biotechnology and environmental monitoring. Different bioreactors for processes using immobilized enzymes.

Text books:

1. L.E. Cassida.Jr, Industrial Microbiology, New Age International Publishers.
2. W. Crueger, Annelise Crueger, Biotechnology: A Textbook of Industrial Microbiology, Sinauer Assoc. Inc.
3. Fundamentals of Enzymology by Nicolas C. price and Lewis Stevens. Oxford University Press.
4. Enzymes by Trevor Palmer, East west Press.
5. Enzyme Technology by Messing.

Reference Books:

1. Prescott's and Dunn's, A. Industrial Microbiology, 4th edition. CBS Publishers, New Delhi, India, 1987.
2. Atkinson.B and Marituna.F, Biochemical Engineering and Biotechnology Handbook, The Nature Press, Macmillan Publ. Ltd.
3. Enzymes: Dixon and Webb. (IRL Press) Enzyme technology by Chaplin and Bucke. Cambridge University Press.
4. Biochemical engineering fundamentals, second edition. James E Bailey, David F., Ollis, McGraw Hill Intl. Edition.

Course Title: Molecular Biology					
Course Code: BTC2203					
Contact Hours per week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	0	0	3	3

Course Outcomes:

After completion of this course, the students will be able to:

BTC2203.1: Identify and analyze the different components and mechanism of replication.
BTC2203.2: Describe different types of DNA damage and repair systems and recombination process.
BTC2203.3: Comment on various components and detailed process of transcription.
BTC2203.4: Comment on various components and mechanism of translation.
BTC2203.5: Understand the rational of genetic code.
BTC2203.6: Comprehend on models of gene regulation and apply the knowledge of gene regulation as genetic switch.

Module I: Replication, repair and Recombination in Prokaryotes & Eukaryotes [9L]
The biochemical basis of inheritance, DNA as the genetic material, central dogma of molecular biology. organization of genome. DNA Replication: mechanism, models; initiation, elongation & termination; enzymes and accessory proteins. Inhibitors of DNA replication; extrachromosomal replicons, replication in DNA and RNA virus. DNA damage and mechanisms of different types of DNA repairs, SOS repair. Repair defects and human diseases. Recombination: mechanism of general and site specific recombination. Techniques of isolation, quantitation and separation of DNA, RNA and proteins.

Module II: Transcription in Prokaryotes & Eukaryotes [9L]
Structure of and function of different types of RNA, promoter, RNA polymerases: structure and assembly; RNA polymerase I, II, III, transcription factors, terminators. Process of transcription: initiation, elongation & termination of transcription. Post transcriptional modifications: Processing of hnRNA, 5'-Cap formation; 3'-end processing and polyadenylation; Splicing (different types); RNA editing; RNA transport. Inhibitors of transcription; reverse transcription.

Module III: Genetic Code & Translation in Prokaryotes & Eukaryotes [9L]
Concept of genetic code: universal genetic code; degeneracy of codons; termination codons; isoaccepting-tRNA; wobble hypothesis. Components translation: structure and function of ORF, tRNA, rRNA, ribosomes, RBS, aminoacylsynthetases. Process of Translation: initiation,

elongation, termination, proof-reading, translational inhibitors. Post translational modifications of protein, protein folding, protein trafficking, protein transport and degradation.

Module IV: Regulation of Gene Expressions in Prokaryotes & Eukaryotes [9L]

Organization of genes and its nomenclature. Principle of gene regulation: negative and positive regulation. Regulatory elements: Promoter, operator, inducer, repressor, activators, silencers, insulators, enhancers. Gene regulation in prokaryote: concept of operon model (*lac, gal, trp* and *ara* operon), attenuation; antitermination in lambda virus. Gene regulation in Eukaryotes: DNA looping model, hormonal control of gene expression (steroid and non-steroid), role of chromatin remodelling, gene silencing and epigenetic regulation. Regulations at level of translation, riboswitch, ribozyme. Structure and function of gene regulatory proteins.

Text books:

1. Molecular Biology of the Gene, (7th Edn., 2017) by J.D. Watson, Baker TA, Bell SP, Gann Alexander, Levine M, Losick R., Pub: Pearson Education.
2. Lewin's GENES XII (2017) by J. E. Krebs (Author), E. S. Goldstein (Author), S. T. Kilpatrick, Pub: Jones and Bartlett.
3. Freifelder's Essentials of molecular Biology, (2015) by Malacinski and Pub: Jones and Bartlett.

Reference books:

1. Molecular Biology of the Cell, (7^{th}edn. 2022) by Bruce Alberts, A D. Johnson, J Lewis, D Morgan, M Raff, K. Roberts, Pub: W. W. Norton & Company.
2. Molecular Cell Biology (8^{th}edn. 2016) by H. Lodish, A. Berk , C.A. Kaiser, , A. Amon , H. Ploegh, A. Bretscher , M. Krieger, K C. Martin, pub: WH Freeman.
3. Cell and molecular Biology, Concepts and experiments by Gerald Karp, John Wiley & Sons.
4. Molecular and Cellular Biology- by Stefen Wolfe, Wordsworth Publishing Co.
5. Genomes, by T. A. Brown, John Wiley and Sons PTE Ltd.
6. The Cell - A molecular approach, by G. M. Cooper, ASM Press.
7. Cell and Molecular Biology **(**8th ed, 2017**)** Robertis, EDP De & Robertis, EDP De.

Course Title: Bioethics & IPR					
Course Code: BTC2231					
Contact Hours per week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	0	0	3	3

Course Outcomes:

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

BTC2231.1: Interpret basics of biosafety and bioethics and its impact on all the biotechnology and the quality of human life.
BTC2231.2: Understand and analyze the different ethical, legal and social issues aspects related to biological, biomedical, health care, biotechnology and biotechnology research.
BTC2231.3: Understand the historical background, importance and levels of biosafety at laboratory and industrial scale and explain the biosafety-regulatory framework in India & international Level.
BTC2231.4: Gain an understanding of the basic concepts of patents, trademarks, copy rights, geographical indications and patent data base and their protection in biotechnology.
BTC2231.5: Gain entrepreneurial skills to apply the different objectives and fundamentals of entrepreneurship in biotechnology.
BTC2231.6: Identify scope for entrepreneurship in biotechnology.

Module I: Bioethics [9L]
Introduction to ethics and bioethics, roots of honours and integrity in science; the responsible conducts of biotechnological research; research with human beings (Nuremberg code, declaration of Helsinki, Belmont report and others); societal obligation of a biotechnologist. Ethical legal social issues (ELSI) in biotechnology: Health care / biomedicine: patient confidentiality, informed consent, euthanasia, artificial reproductive technologies, prenatal diagnosis, genetic screening, human gene therapy, organ transplantation. ELSI in Biotechnology research: genetic engineering, cloning and stem cell research, Human and animal experimentation, animal rights/welfare, biomedical science, Human genome project, patenting human genes, Agricultural biotechnology - Genetically engineered food and organism, environmental risk, labeling and public opinion. Sharing benefits and protecting future generations - Protection of environment and biodiversity – biopiracy. Case studies.

Module II: Biosafety [9L]
Introduction to Biosafety. The legal and socioeconomic impact of biotechnology, public education of the process of biotechnology involved in generating new forms of life for informed decision making, r-DNA guidelines, experimental protocol approvals, different levels of: containment for biohazards, biosafety and risk groups. Risk analysis, good laboratory practice (GLP) and good manufacturing practice (GMP). Biosafety regulation, national and international guidelines of:

DBT (India), different regulatory bodies in India and WHO. Convention of Biological Diversity (CBD): Cartagena Protocol, Kyoto protocol, Nagoya protocol and others; Case studies.

Module III: Intellectual Property Rights (IPR), Patents and protection [9L]
Concept of intellectual property and property rights. History and different forms of IPR: duties, Patents (history, criteria and patentability, compulsory licensing), industrial designs, trade secret, confidential information, trademarks, geographical indications, copyrights, traditional knowledge (TK); Distinctions among the various forms of IPR, infringement, Indian patent act and rules, traditional knowledge digital library (TKDL). International framework for the protection of IP: GATT, WTO, WIPO and TRIPS, Biodiversity, and farmer rights, Budapest treaty, Patent Cooperation Treaty (PCT). Case studies on IPR.

Module IV: Bioentrepreneurship [9L]
Concept of entrepreneurship, role of bioentrepreneur; fundamentals of marketing and selling of biotechnological products and services; technical aspects; entrepreneurship skill: vision, product idea, risk taking, problem solving, team building and organizational abilities. Business plan: products/ services; financial and human resources: the art of negotiation, workable marketing and the strength of distribution; opportunities in international marketing and lessons to be learned; steps involved in commercialization of a biotechnological product; case studies.

Text Books:

1. Bioethics and biosafety in biotechnology (2007) by V. Shree Krishna, Pub: New Age Int. Ltd.
2. IPR, Biosafety and Bioethics – (2013) D. Goel, S. Parashar, Pub: Pearson
3. Biotechnology Entrepreneurship: Starting, Managing, and Leading Biotech Companies (2014) by Craig Shimasaki
4. An Introduction to Ethical, Safety and Intellectual Property Rights Issues in Biotechnology (2017) by P Nambisan, Pub: Accademic press
5. Effective Entrepreneurial Management: Strategy, Planning, Risk Management, and Organization (2017) by R. D. Hisrich, and V. Ramadani, Pub: Springer.
6. Intellectual Property Law (2018) by L. Bently, B. Sherman, D. Gangjee, P. Johnson Pub: OUP.

Reference books:

1. Building Biotechnology: Biotechnology Business, Regulations, Patents, Law, Policy and Science (2013) by Yali Friedman.
2. Intellectual Property Rights and Bio-Technology (Biosafety and Bioethics) (2011) by N. P. House.
3. Regulatory Framework for GMOs in India (2006) Ministry of Environment and Forest, Govt. of India,
4. Cartagena Protocol on Biosafety (2006) Ministry of Environment and Forest, Govt. of India.

5. Patent Strategy For Researches & Research Manegers- Knight, Wiley Publications.
6. Agriculture & Intellectual & Property Rights, V. Santaniello& R.E. Evenson, University Press.
7. Bioethics Principles, Issues, and Cases (2016) by Lewis Vaughn, Pub:OUP.

Course Title: Industrial Stoichiometry					
Course Code: BTC2232					
Contact Hours per week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	0	0	3	3

Course Outcomes:

After completion of this course, the students will be able to:
BTC2232.1: Solve problems related to units and conversions and fit the given data using the methodologies.
BTC2232.2: Able to make *material balances* on unit operations and processes.
BTC2232.3: Understand stoichiometry of microbial growth and product formation.
BTC2232.4: Solve problems related to energy balance for steady state processes.
BTC2232.5: Determine the heat of reaction for processes with biomass and secondary metabolite production.
BTC2232.6: Design simultaneous material and energy balances in biochemical processes.

Module 1: Basic Chemical Calculations [9L]
Dimension – Systems of units, engineering FPS, Engineering MKS & SI systems –Conversion from one system to the other – composition of mixtures and solutions - mass fraction, mole fraction, mass ratios, molarity, molality, normality, ppm, composition by density. Ideal and actual gas equations, application to pure gas & gas mixtures – partial pressures, partial volumes. Use of log-log and semi-log graph paper, graphical differentiation and graphical, integration, treatment and interpretation of data by least square analysis.

Module II: Material balance [9L]
Introductory Concepts- simplification of the general mass balance equation for steady and unsteady state processes, procedure for material balance calculations, material balance without chemical reactions: application of humidification, distillation column. Material balance with chemical reaction: combustion.
Stoichiometry of growth and product formation- growth stoichiometry and elemental balances. Material Balance with recycle, bypass and purge streams in bioprocess.

Module-III: Energy Balance [9L]
General energy balance equation for steady state processes - without and with chemical reaction. Enthalpy calculation procedures: enthalpy change due to reaction, heat of combustion, heat of reaction for chemical processes.

Energy-balance equation for cell culture -heat of reaction for processes with biomass and secondary metabolites production in fermentation processes.

Module IV: Combined material and energy balance in bioprocesses [9L]
Simultaneous material and energy balances in biochemical processes: growth associated, non-growth associated and mixed growth associated product production process.

Textbook:

1. Bhatt & Vora, Stoichiometry, 4th Ed., Tata McGraw Hill.

Reference books:

1. Hougen and Watson, Chemical Process Principles (Part one): 2nd ed, John Wiley.
2. Basic Principles and Calculations in Chemical Engineering: Himmelblau, 6th Ed. Prentice Hall India.
3. Bioprocess Engineering: 2nd edition, Michael L. Shuler, FilkertKargi. Prentice Hall India.

Course Title: RDBMS Concept and Computer Networking					
Course Code: CSE2207					
Contact Hours per week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	0	0	3	3

Course Outcomes:
After completing the course, the students will be able to:
CSE2201.1: Identify the characteristics of a database and describe the architecture and languages of relational Database Management System.
CSE2201.2: Understand & analyze design principles for logical design of databases, including the E-R model and apply the concepts of normalization to design an optimal database.
CSE2201.3: Apply relational database theory, and be able to write relational algebra expressions for queries and apply the concepts to manage a database using SQL.
CSE2201.4: Understand the concept of database transaction, its properties and the concept called serializability.
CSE2201.5: Understand the topology, transmission mode of computer networks and explains key networking protocols in the context of a conceptual model, such as the OSI and TCP/IP framework.
CSE2201.6: Understand the basic workings of Inter networking, WWW, search engine and e-mail in the context of data communication.

Module I: [8L]
Introduction to Database Concepts, File Processing System and Database Management System, DBMS Architecture and Data Independence.
Data Model: Basic Concepts, Entity-Relationship Diagram, Keys, Cardinality, Weak Entity Set. Introduction to relational algebra & SQL: Operators like select, project, rename, Cartesian product, join, union, intersect, minus, DDL, DML.

Module II: [11L]
Relational Database Design: Functional Dependencies, Normalization: Different anomalies in database designing, 1NF, 2NF, 3NF and BCNF, Lossless-Join Decomposition and Dependency Preservation.
Introduction to Transaction Processing Concepts: ACID properties, Serializability and Recoverability.

Module III: [11L]
Computer Networking: Introduction, topology, transmission mode, LAN/MAN/WAN, Communication Techniques, OSI 7 layer Model: Basic functions of the different layers, TCP/IP reference model: basic functions of the different layers, Comparison between OSI and TCP/IP models.

Module IV: [6L]

Basic concepts of Inter-Networking, WWW, URLs, Search engines, Electronic mails, Basic concepts of Distributed Database System.

Text books:

1. Henry F. Korth and Silberschatz Abraham, "Database System Concepts, 4th Ed., McGraw Hill, Computer Science Series.
2. Behrouz A. Forouzan, Data Communications and Networking, 4th Ed., McGraw Hill.

Reference books:

1. Elmasri Ramez and Novathe Shamkant, "Fundamentals of Database Systems", Pearson.
2. Ramakrishnan: Database Management System, McGraw-Hill.
3. Gray Jim and Reuter Address, "Transaction Processing: Concepts and Techniques", Moragan Kauffman Publishers.
4. Jain: Advanced Database Management System, Cyber Tech.
5. Date C. J., "Introduction to Database Management", Vol. I, II, III Pearson.
6. Ullman J. D., "Principles of Database Systems", Galgottia Publication.
7. James Martin, "Principles of Database Management Systems", 1985, Prentice Hall of India, New Delhi.
8. Ramez Elmasri, Shamkant B. Navathe "Fundamentals of Database Systems", Pearson.
9. Andrew S. Tanenbaum: Computer Networks, Pearson Education, fourth edition.
10. William Stallings: Data and Computer Communication, Prentice hall, Seventh edition.
11. William Stallings: High speed Networks and Internets, Pearson education, second edition.
12. Arun K. Majumdar, Pritimay Bhattacharya, "Database Management Systems", Tata McGraw Hill.

Course Title: Mathematical & Statistical Methods					
Course Code: MTH2204					
Contact Hours per week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	0	0	3	3

Course Outcomes: After completion of this course, students will be able to:

MTH2204.1: Apply numerical methods to obtain approximate solutions to mathematical problems where analytic solutions are not possible.
MTH2204.2: Implement appropriate numerical methods for solving advanced engineering problems dealing with interpolation and integration.
MTH2204.3: Design stochastic models to predict the outcomes of events.
MTH2204.4: Recognize the significance of the expansion of a function in Fourier Series.
MTH2204.5: Provide deterministic mathematical solutions to physical problems through partial differential equations.
MTH2204.6: Employ statistical methods to make inferences on results obtained from an experiment.

Module I: [10L]

Partial Differential Equations: Introduction to Partial Differential equations and its Formation. Lagrange's method and Charpit's method of solution. Second order partial differential equations with constant coefficients. Method of separation of variables and its application to the solution of one-dimensional wave equation.

Module II: [10L]

Numerical Methods for Interpolation and Integration: Finite difference operator**s** and their relations. Interpolation: Newton's Forward and Backward Interpolation, Lagrange's Interpolation. Newton's Divided Difference Interpolation. Numerical Integration: Trapezoidal and Simpson's 1/3rd rule, Weddle's rule.

Module III: [10L]

Fourier Series: Definite Integral, Orthogonality of Trigonometric Functions, Power Series and its convergence. Periodic Functions, Even and Odd Functions, Dirichlet's Conditions. Euler Formulae for Fourier coefficients. Fourier series representation of a function, e.g. Periodic square wave, Half wave rectifier, Unit step function. Half Range series: Sine and Cosine, Parseval's Identity.

Module IV: [10L]

Probability Distributions and Statistics: Special Distributions: Hypergeometric, Poisson, Uniform, Exponential, Gamma and Normal approximation to binomial distribution. Measures of Central Tendency and Dispersion: Mean, Median, Mode and Standard Deviation for grouped and ungrouped frequency distribution. Moments: Skewness and Kurtosis. Simple Correlation and Regression, Rank correlation coefficient.

References:

Text Books:

1. Advanced Engineering Mathematics, Kreyszig, Wiley Publications.
2. Statistical Methods by N. G. Das, Mc Graw Hill (combined edition Vol-I &Vol-II).
3. Introduction to Probability Models by Sheldon M. Ross, Academic Press.
4. An Introduction to Differential Equation, R. K. Ghosh and K. C. Maity, New central Book Agency (P) Ltd.
5. Ordinary and Partial Differential Equation, M D Raisinghania, S Chand Publication.

Reference Books:

1. Numerical Methods (Problems and Solution) Jain, Iyengar & Jain, New Age International Publishers.
2. Fundamentals of Mathematical Statistics, S.C. Gupta and V.K. Kapoor Sultan Chand & Sons.
3. Mathematical Probability, A. Banerjee, S. K. De and S. Sen, U. N. Dhur and sons (P) Ltd.
4. Higher Engineering Mathematics, B. V. Ramana Tata McGraw-Hill.

Course Title: Transfer Operations-I Lab					
Course Code: BTC2251					
Contact Hours per week	**L**	**T**	**P**	**Total**	**Credit Points**
	0	0	2	2	1

Course Outcomes:

After completion of this course, the students will be able to:

BTC2251.1: Design and conduct experiments on flow measurement by venturimeter.
BTC2251.2: Compare the energy loss that occurring in flow measuring devices like venturimeter and orificemeter.
BTC2251.3: Calibrate flow measuring device like rotameter.
BTC2251.4: Conduct experiment, analyze and interpret the data of packed bed reactor operation.
BTC2251.5: Evaluate the performance and calculate the heat transfer coefficient of a double pipe heat exchanger.
BTC2251.6: Understand the operation of comminution equipments like ball mill, jaw crusher and find the energy consumption in operation of those equipments.

List of experiments (minimum six):

1. Experiments on Reynold's Apparatus-Determination of flow regime and plot of friction factor against NRe.
2. Experiments on flow measuring device—in closed conduit using Venturi meter.
3. Experiments on flow measuring device—in closed conduit using Orifice meter.
4. Experiments on flow measuring device—in closed conduit using Rotameter.
5. Determination of Pressure drop for flow through packed bed & verification of Ergun Equation, Kozeny-Karman equation, Blake-Plummer Equation.
6. Determination of pressure drop in flow through fluidized bed.
7. Study of working characteristics of a Jaw Crusher, calculation of the energy consumption as a function of size reduction and compare it with the actual energy requirements.
8. Study of working characteristics of a Ball Mill, calculate the energy consumption as a function of size reduction and determine the critical speed.
9. Determination of the Overall heat transfer coefficient of a double pipe heat exchanger.
10. Determination of thermal conductivity of metal rod or powder.

Course Title: Enzyme Technology & Fermentation Technology Lab					
Course Code: BTC2252					
Contact Hours per week	**L**	**T**	**P**	**Total**	**Credit Points**
	0	0	2	2	1

Course Outcomes :

After completion of the course, students will be able to:
BTC2252.1: Draw different types of Bioreactors and different components of Bioreactors.
BTC2252.2: Study acid hydrolysis of sucrose in CSTR at different temperature.
BTC2252.3: Carry out immobilization of enzyme by entrapment method.
BTC2252.4: Study Batch Fermentation and assay of Antibiotics (like Penicillin / Streptomycin).
BTC2252.5: Design the steps of production and recovery of Alcohol.
Produce different metabolites by Solid State Fermentation technique/process.

List of experiments (minimum six):

1. Basic Drawing of different types of Bioreactors [Air Lift Reactor (ALR), Bubble column, Continuous Stirred Tanked Reactor (CSTR)] and different components of Bioreactors.
2. Familiarization of different types of analytical instruments including Air Compressor and Autoclave (to know the operation with real sample).
3. Acid hydrolysis of sucrose in CSTR at different temperature.
4. Enzymatic hydrolysis of starch in ALR.
5. Immobilization of enzyme by entrapment method.
6. Operation of immobilized enzyme reactor using a Packed Bed Reactor.
7. Batch Fermentation and Assay of Antibiotics (like Penicillin / Streptomycin).
8. Production of Alcohol (Fermentation and Recovery).
9. Batch Fermentation of Organic Acid.
10. Solid State Fermentation.

Course Title: Molecular Biology Lab					
Course Code: BTC2253					
Contact Hours per week	**L**	**T**	**P**	**Total**	**Credit Points**
	0	0	2	2	1

Course Outcomes:

After completion of this course, the students will be able to:

BTC2253.1: Separate and visualize mixtures of DNA or mixtures of RNA or mixtures of protein.
BTC2253.2: Explain the mechanism of visualization of DNA, RNA and protein.
BTC2253.3: Determine the molecular size of unknown protein and DNA.
BTC2253.4: Estimate the amount of DNA, RNA and protein from unknown solution by spectrophotometer.
BTC2253.5: Understand the basics of electrophoresis.
BTC2253.6: Design experiment to study gene regulation

List of experiments (minimum six):
1. Agarose Gel Electrophoresis (AGE): Principles and separation of DNA
2. Isolation of Genomic DNA from blood or plant cell or bacterial cell and analysis by AGE.
3. Isolation of Plasmids DNA and analysis by AGE.
4. Determination of molecular size of DNA using AGE.
5. Estimation of DNA, RNA and Protein by spectroscopic method.
6. Isolation of total RNA from bacteria and separation by Formaldehyde Agarose gel electrophoresis.
7. Isolation and purification of proteins from bacterial cells and separation by SDS-PAGE.
8. Induced mutation by: (a) Chemical (b) Ultraviolet light.
9. Study of gene regulation in bacteria using lac operon.
10. Study gene regulation in bacterial growth in different carbon source and bacteriophage titration.

Text Book:

1. Molecular Cloning – A laboratory manual: 4th Edition (2013) Vol. 1-3.by Michael R Green, Sambrook J, CSHL Press, New York.

Reference books:

1. Biochemical calculation 2nd edn (2010) by I. Segel, Pub: Wiley.
2. Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology (8th edn. 2018) by A. Hofmann, S. Clokie, Pub: Cambridge University Press.
3. Biochemical Methods (3rd edn. 2018) by S. Sadasivam. Publishers New Age Intern. Pvt. Ltd.

Course Title: RDBMS Concept and Networking Lab					
Course Code: CSE2257					
Contact Hours per week	**L**	**T**	**P**	**Total**	**Credit Points**
	0	0	2	2	1

Course Outcomes:

After completing this course, students should be able to:

CSE2257.1: Create tables with different integrity constraints using DDL and DML commands in SQL.

CSE2257.2: Understand how to populate and manage the database using DDL and DML commands in SQL.

CSE2257.3: Understand how to query the database by writing simple to complex SQL queries to retrieve information.

CSE2257.4: Understand the basics of PL/SQL programming using cursor, trigger.

CSE2257.5: Understand how and when to use the basic networking commands.

DBMS Lab:

Experiments on Database on RDBMS Platform (Oracle):

DDL Commands: Creating Tables along with constraints like: Primary Key, Foreign Key, unique, Not Null, Check. Altering Table Structure like adding and modifying constraints, adding column, modifying column data types, etc.

DML: Inserting rows, Updating rows, Deleting rows

SQL Query: Cartesian Product, Join, Union, Intersect, Minus, Single Row functions, multiple row functions using GROUP BY clause, HAVING clause, ORDER BY Clause, Nested Sub-Queries

Computer Networking Lab:

Basic Networking Command

DETAILED SYLLABUS

3rd Year

Course Title: Indian Constitution and Civil Society					
Course Code: INC3016					
Contact Hours per week	**L**	**T**	**P**	**Total**	**Credit Points**
	2	0	0	2	0

Course Outcomes

The learner will be able to-

INC3016.1: Analyze the historical, political and philosophical context behind the Indian Constitution-making process.
INC3016.2: Appreciate the important principles characterizing the Indian Constitution and institute comparisons with other constitutions.
INC3016.3: Understand the contemporaneity and application of the Indian Constitution in present times.
INC3016.4: Critique the contexts for constitutional amendments in consonance with changing times and society.
INC3016.5: Establish the relationship between the Indian Constitution and civil society at the collective as well as the individual levels.
INC3016.6: Consciously exercise the rights and the duties emanating from the Indian Constitution to one's own life and work.

Module 1:[6L]
Introduction to the Constitution of India-Historical Background
Making of Indian Constitution -the process of framing the constitution, the constituent assembly

Module II: [6L]
Salient Features of the Indian constitution
Comparison with the constitutions of other countries

Module III: [6L]
Relevance of the Constitution of India
Constitution and Governance
Constitution and Judiciary
Constitution and Parliament-Constitutional amendments

Module IV: [6L]

Constitution and Society- democracy, secularism, justice
Constitution and the individual citizen- Fundamental Rights, Directive Principles of state policy and Fundamental Duties.

Reference Books:

1. C. M. Elliot, (ed.), Civil Society and Democracy, OUP, Oxford, 2012.
2. David Held et.al (ed), The Idea of the Modern State, Open Univ. Press, Bristol, 1993.
3. Neera Chandoke, State and Civil Society, Sage, Delhi, 1995.

Course Title: Genetics					
Course Code: BTC3101					
Contact Hours per week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	0	0	3	3

Course Outcomes:

After completing the course, the students will be able to:

BTC3101.1: Understand the basic principles of Mendelian mode of inheritance and also analyze the reasons behind the exceptions to this phenomenon.
BTC3101.2: Interpret the different modes of linkage, sex determination patterns and chromosomal abnormalities.
BTC3101.3: Identify and analyze the genetic network of carcinogenesis to reach out for novel therapeutic strategies.
BTC3101.4: Comprehend the mechanism of action of microbial genetics and genetic patterns of embryonic development.
BTC3101.5: Apply the mathematical and biostatistical models in biological systems for testing of hypotheses, estimation of group differences and case-control studies.
BTC3101.6: Use the Hardy-Weinberg model to quantify the allele frequency in a population for better understanding of evolutionary changes and gene flow.

Module I: Classical Genetics and its deviations [9L]
Principles of Mendelian inheritance, multiple alleles, pseudoallele, Codominance, incomplete dominance, gene interactions, pleiotropy, genomic imprinting, penetrance and expressivity, phenocopy, linkage and chromosome mapping, sex linkage, sex limited and sex influenced characters; sex determination in human, plants and Drosophila; extra-nuclear inheritance, special types of chromosomes; structural and numerical chromosomal abnormalities and their genetic implications; pedigree analysis, lod score for linkage testing, linkage disequilibrium.

Module II: Mutation and Cancer Genetics [9L]
Gene Mutation: Induced and spontaneous mutation**,** mutation types, causes and detection, mutant types. Molecular basis of genetic disorders, karyotypes, inborn errors of metabolism. Cancer Genetics: genetic rearrangements in progenitor cells, oncogenes, proto-oncogenes, tumour suppressor genes – p53, RB and others, virus-induced cancer; cell cycle check points and cancer.

Module III: Microbial and Developmental Genetics [9L]

Methods of genetic transfers: transformation, conjugation, transduction and sex-duction; Gene mapping methods: interrupted mating, recombination and complementation analysis; Genetics of animal virus; Developmental genetics in Drosophila model: egg-polarity genes and formation of body axes; molecular control of segmentation: gap genes, pair-rule genes, segment polarity genes; homeotic genes, Wnt and cadherin pathways; cellular ageing & senescence.

Module IV: Biostatistics and Population Genetics [9L]

Biostatistics: Mean, median, mode, standard deviation, variance, discrete and continuous probability distributions, Poisson, normal and binomial distributions; T test, chi-square analysis, ANOVA. Population genetics: Hardy-Weinberg equilibrium, allele frequency and genotype frequency. Extensions of H-W equilibrium: mutation, selection, continuous variation, genetic drift, migration.

Textbooks:

1. Concepts of Genetics, 7th edition. M.R. Cummings, A.W. Klug. Pub: Pearson Education.
2. Genetics, 3rd edition. M.W. Strickberger. Pub: Pearson Education.

Reference Books:

1. Introduction to Genetic Analysis, 8th edition, Anthony J. F. Griffiths, Jeffrey H. Miller, David T. Suzuki, Richard C. Lewontin, and William M. Gelbart. Pub: W.H. Freeman & Co.
2. Principles of Genetics, 5th edition. D. Peter Snustad, Arthur J. Simmons. Pub: John Wiley & Sons.
3. iGenetics: a Conceptual Approach, 3rd edition. Peter J. Russell. Pub: WH Freeman & Co.
4. Microbial Genetics, 2nd edition. Stanley R. Maloy, John E. Cronan, David Freifelder. Pub: Jones and Bartlett Publisher Inc.
5. Genetics: analysis of genes and genomes, 6th edition. D.L. Hartl & E.W. Jones. Pub: Jones and Bartlett Publishers.
6. An introduction to Human Molecular Genetics: Mechanism of Inherited Diseases. 2nd edition. J. Pasternak. Pub: Fitzgerald Science Press.
7. Developmental Biology, 10thedition.S.F. Gilbert. Pub: Sinauer Associates.
8. Introduction to Biostatistics, 2nd edition, Pranab Kumar Banerjee. Pub: S. Chand & Co.
9. Problems on Genetics, Molecular Genetics and Evolutionary Genetics. Pranab Kumar Banerjee. New Central Book Agency Pvt. Ltd.
10. Statistics in Biology and Psychology, 4th edition. Debajyoti Das, Arati Das. Academic Publishers.

Course Title: Bioinformatics					
Course Code: BTC3102					
Contact Hours per week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	0	0	3	3

Course Outcomes:

After completing the course, the students will be able to:

BTC3102.1: Gain and analyze knowledge about genes and proteins obtained through primary, secondary and specialized databases (e.g. NCBI, PDB).
BTC3102.2: Learn and apply principles and methodologies of pairwise and multiple sequence alignment towards biological problems (e.g., Smith Waterman, Needleman and Wunsch, CLUSTAL algorithm).
BTC3102.3: Learn and apply principles of gene prediction algorithms.
BTC3102.4: Learn and apply PERL and PYTHON for bioinformatics data interpretation (e.g. sequence analysis, protein to DNA translation).
BTC3102.5: Learn and apply principles and algorithms for secondary and tertiary structure prediction of globular and fibrous proteins (e.g. homology modeling, fold recognition methodologies).
BTC3102.6: Use introductory applications of bioinformatics procedures and protein structure prediction techniques to molecular modeling, molecular docking and virtual screening using representative examples.

Module I: Introduction to Bioinformatics and its Applications; Resources and Databases in bioinformatics [9L]

Definition of bioinformatics as a subject; applications of bioinformatics to biological research/biology; introduction to databases/portals; sequence submission methods and tools (Sequin, Sakura, Bankit); primary, secondary (e.g., NCBI and its sub-databases; PDB, EMBL-EBI) some idea on Derived Databases (Prosite, Pfam), Metabolic Pathway DB (KEGG); Introduction to AI/ML in biological data analysis.

Module II: Sequence analysis of proteins and nucleic acids [9L]

Introduction to sequence analysis; Basic concepts of sequence homology, similarity and identity; orthology and paralogy of sequences; pairwise sequence alignment using global and local alignment procedures; Needleman-Wunsch and Smith-Waterman algorithms; Use of

substitution matrices (PAM and BLOSUM); Multiple sequence alignment using progressive alignment (e.g., Clustal W); Brief introduction to gene prediction; Signal sites Predictions (Promoter, Splice, UTR, CpG-islands.

Module III: Scripting languages in Bioinformatics (e.g PERL, Python) [9L]

Difference between traditional programming languages and scripting languages in bioinformatics; role of interpreted languages; PERL: regular expressions; sequences and strings: Variables, Arrays, files, string operators; subroutines; Introduction to Python: introduction data, expressions, statements, control flow, loops, functions and arrays. Applications of Python programming in biotechnology.

Module IV: Protein structure prediction and drug design applications [9L]

SCOP and CATH classification databases; Secondary structure prediction of proteins using generation based algorithms (e.g GORIV, SSPro); Neural Network and Hidden Markov Model algorithms and applications; Tertiary structure prediction: homology modeling, fold recognition (threading) and *ab initio* methods, Structural comparison & alignment methods, VAST & DALI, Drug design applications: Receptor-ligand binding sites and interactions, molecular docking, Virtual screening; Structure and Ligand based drug design; concepts of QSAR and ADMET.

Textbooks:

1. Essential Bioinformatics by Jin Xiong, (2006) Cambridge University Press
2. Introduction to Bioinformatics, by Arthur M. Lesk, International Fourth Edition, (2014), Oxford University Press
3. Bioinformatics –Principles and Applications – Z.Ghosh and R.Mallick (2012), Oxford University Press
4. Beginning PERL for Bioinformatics –James Tisdall, SPD Publishers

Reference books:

1. Introduction to Bioinformatics, C. Atwood, Pearson Education.
2. A practical Guide to the Analysis of Genes and Proteins-A.D. Baxevanis.
3. Molecular Modelling and Drug Design –K. Anand Solomon-1st edition (2011) –MJP Publishers.
4. Molecular Modelling-Principles and Applications-by Andrew Leach, Pearson Education.

Course Title: Recombinant DNA Technology					
Course Code: BTC3103					
Contact Hours per week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	0	0	3	3

Course Outcomes:

After completion of this course, student will be able to

BTC3103.1: Understand mechanism of action and the use of the different DNA modifying enzymes, vectors and host in recombinant DNA technology and solve and analyze the problems of restriction mapping.

BTC3103.2: Explain and demonstrate the different techniques of recombinant DNA technology like labelling of probe, DNA, RNA and protein sequencing, blotting and hybridization, microarray; ELISA; separate and identify nucleic acid and protein by electrophoresis and chromatography, and apply the knowledge to solve and analyse problem related to these techniques.

BTC3103.3: Demonstrate the mechanism of standard, quantitative and different modified polymerase chain reactions (PCR), use of PCR in DNA cloning and solve and analyse problems related to PCR.

BTC3103.4: Apply the different types of cloning and expression methods of gene in biotechnology and screen, identify, modify and analyse the cloned gene; explain the creation and screening of genomic and cDNA library in different vectors.

BTC3103.5: Understand and demonstrate the applications of recombinant DNA technology in different filed of biotechnology like gene therapy, human genome project, production of recombinant vaccine, explain the creation of transgenic animals and plants, construct recombinant biopharmaceutical, analyze and use of molecular biomarkers in disease diagnostics, forensic science with analysis of gene expression.

BTC3103.6: Analyze and solve problems related to rDNA technology.

Module-I: Tools of Recombinant DNA Technology [9L]

DNA & RNA manipulating enzymes and other tools used in Recombinant DNA technology: Restriction endonuclease; DNA polymerases (DNA Pol I, T4, T7, Taq), reversetranscriptases, DNA ligases; alkaline phosphatases; polynucleotidekinase; terminal deoxy-nucleotidetransferase; topoisomerases; DNase; RNase and others; linker and adapter. Physical map, specific host and features of Vectors: Plasmids, bacteriophage vectors, cosmids, phagemids, PAC, BAC, YAC, and MAC, Expression vectors (pET vectors, Baculovirus vectors and others).

Module-II: Techniques of Recombinant DNA Technology: [9L]

DNA and RNA labeling (radioactive and nonradioactive methods); Restriction mapping; DNA sequencing (Maxum& Gilbert, Sanger, pyro-sequencing, and others methods); Protein and RNA sequencing; Polymerase chain reactions (PCR), different modified PCR and Real time PCR; Techniques of separation of nucleic acid and protein (electrophoresis, chromatography and others);

Southern, northern, and western blotting & hybridization; In-situ hybridization; ELISA, Chip assay, Sitedirected mutagenesis; DNA and protein based microarray.

Module-III: Gene Cloning Methods: [9L]

Isolation and preparation of DNA fragments from prokaryotic and eukaryotic source; Different types of cloning and expression methods of gene in prokaryotic and eukaryotic host cell system using different vectors (by restriction enzyme, PCR product cloning and other methods); Transfer of recombinant DNA into host; Screening & Expression of cloned gene; Gene isolation; Subcloning strategies; Generation of genomic and cDNA libraries in plasmid, phage, cosmid, BAC and YAC vectors and their screening.

Module-IV: Application of Recombinant DNA technology [9L]

Genetically engineered vaccine; DNA vaccine; recombinant biopharmaceuticals (insulin, human growth factor and others); Gene therapy (gene transfer technologies, antisense, SiRNA, miRNA, and ribozyme technology, CRISPR-Cas); Molecular marker in disease diagnostics and forensic science (RFLP, RAPD, AFLP SNP, EST and others), DNA fingerprinting; Human genome project (strategies for genome sequencing and its application); Genetically modified organism (microbes, plant and animal); Large scale gene expression analysis; Biosafety.

Textbooks:

1. Genetic Engineering (2009) by S. Rastogi and N. Pathak, Pub: Oxford Univ. Press.
2. Principles of Gene Manipulation & Genomics, (7th Edn., 2006) Old and Primrose, Pub: Blackwell.
3. Wilson and Walker's principles and techniques of biochemistry and molecular biology (8^{th}edn. 2018) by Hofmann and Clokie.
4. Molecular Cloning: A Laboratory Manual (3-volume set 4th Edn.: 2012) by Green, M.R., Joseph Sambrook, J.,Pub: CSHL press.
5. Molecular Biotechnology: Principles and Applications of Recombinant DNA, (6th Edn. 2022) by Glick, and Patten. Pub: ASM press

Reference books:

1. Recombinant DNA: Genes and Genomes - A Short Course, 3rd Edn. (2007) by James D. Watson, Richard M. Meyers, Amy A. Caudy, Jan A. Witkowski. Pub: CSHL.
2. H.K. Das, Text Book of Biotechnology, 4th ed, 2010, Wiley Publishers.
3. Gene cloning, (8th Ed. 2020) by Brown, T.A., pub: Wiley.
4. Genomes 4, (4^{th} ed 2017) by Brown TA, Pub: Garland Science.
5. Human Molecular Genetics, (5th Ed. 2018) by Tom Strachan, Andrew Read, Pub: Garland Science.

Course Title: Transfer Operations-II					
Course Code: BTC3104					
Contact Hours per week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	0	0	3	3

Course Outcomes:

After completing the course, the students will be able to:

BTC3104.1: Understand the concept of diffusion and diffusivity and identify the type of diffusion in a given problem and solve it.
BTC3104.2: Determine gas-liquid mass transfer coefficient in a wetted wall column or packed bed absorption column and calculate the number of stages required for the unit operation.
BTC3104.3: Apply McCabe-Thiele Method and Rayleigh's equation as required in a distillation process.
BTC3104.4: Comprehend different other unit operations like adsorption, liquid-liquid extraction and crystallization explicitly.
BTC3104.5: Draw the drying characteristic curve under a given constant drying condition.
BTC3104.6: Study and apply the principle and operation of different advanced separation processes like dialysis, ultrafiltration, reverse osmosis, pervaporation and electrodialysis in the field of biotechnology.

Module I: Introduction to Mass Transfer [9L]
Introduction to Mass Transfer: Molecular diffusion in fluids. Diffusivity, Mass Transfer Coefficients, Interphase Mass Transfer, Gas Absorption, co-current and counter-current multistage operation, Packed Tower, Drying, adsorption and Leaching principles

Module II: Distillation [9L]
Distillation: Vapor-liquid equilibrium, Rayleigh's Equation, Flash and Differential distillation, McCabe-Thiele Method to determine stages

Module III: Miscellaneous Mass Transfer Operations [9L]
Liquid–liquid equilibrium. Liquid extraction, Stagewise contact; Adsorption Equilibria: batch and fixed bed adsorption, Batch drying and mechanism of batch drying. Freeze drying, Basic idea of crystallization

Module IV: Advanced Separation Processes [9L]
Advanced Separation Processes: Dialysis, Ultrafiltration, Reverse osmosis, Pervaporation, Electrodialysis and Membrane separation- Principle and operation

Textbook:

1. Unit Operations of Chemical Engineering: McCabe, Smith & Harriot, TMH, 5th edition.

Reference books:

1. Transport Processes & Unit operations: Geankopolis, PHI, 3rd edition.
2. Chemical Engineering, Vol-I & II: Coulson & Richardson, Butterworth Heinemann.
3. Treybal, R.E., Mass-Transfer Operations, MGH 4. Perry, Chilton & Green, Chemical Engineers' Handbook, MGH.

Course Title: Food Biotechnology					
Course Code: BTC3131					
Contact Hours per week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	0	0	3	3

Course Outcomes:
After completing this course, students will be able to:

BTC3131.1: Apply different food preservation techniques.
BTC3131.2: Know different food processing techniques.
BTC3131.3: Analyze different processed food.
BTC3131.4: Application of enzymes in food industry.
BTC3131.5: Detect adulteration and toxic components of food.
BTC3131.6: Gain knowledge on different functional food and GMO

Module I: Food Preservation Technology [9L]
Spoilage of food: fruits, vegetables, meat, milk and milk products, fats and oils.
Food poisoning: Botulism, Staphylococcal intoxication and fungal toxins: disease manifestation and mechanism of action of toxins: Food preservation techniques: physical methods: canning, heating, refrigeration, irradiation, dehydration.

Module II: Food Production Technology [9L]
Fermented and semi fermented food products: Fermentation of fruits and vegetables (e.g., sauerkraut, Dill pickle), dairy products; Production of single cell protein, Mushroom cultivation; Genetically modified crop: production technology and safety aspects

Module III: Enzymes in Food Industry [9L]
Enzymes in bakery and cereal products, Enzymes in fruit juice production, Enzymes in fat/oil production, Enzymes in cheese making and beverage production

Module IV: Food Additives, Packaging and Safety Regulations [9L]
Food preservative: natural and synthetic, Other additives: Food colour, food flavor enhancers, nutritional supplements, Probiotics, Chemical safety measurement: heavy metals, fungal toxins, bacterial toxins, herbicide, pesticide, antibiotics, adulterant, introduction to FSSAI; different food packaging techniques and materials.

Textbooks:

1. Jay, Modern Food Microbiology, CBS Publishers, 1987.
2. Frazier, Food Microbiology, Tata McGraw Hill, 2004.

Reference books:

1. Meyer, Food Chemistry, CBS Publishers, 2004.
2. Shakuntala Manay, Foods: Facts and Principles, New Age Publication, 2005.

Course Title: Environmental Biotechnology					
Course Code: BTC3132					
Contact Hours per week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	0	0	3	3

Course Outcomes:
After completing this course, students will be able to:

BTC3132.1: Describe different methods of sampling and controlling air pollutants.
BTC3132.2: Analyze the characteristics of wastewater and understand the principles of physical and chemical treatment of it.
BTC3132.3: Design different processes for biological treatment of wastewater and solve numerical problems related to them.
BTC3132.4: Explain the processes of solid waste management and apply the knowledge in waste to energy conversion.
BTC3132.5: Understand the principle of biodegradation and bioconversion of natural and xenobiotic compounds.
BTC3132.6: Apply the knowledge of bioremediation for controlling and removal of heavy metals in contaminated wastewater.

Module I: Air Pollution: Control Methods and Equipments [9L]
Primary and secondary air pollutants, effects of air pollutants on health, basic ideas of air pollution control equipments- bag filter, electrostatic precipitators, cyclone separators, wet-scrubbers, bio-scrubbers.

Module II: Water Pollution: Control Methods and Equipments [9L]
Sources -- municipal and industrial wastewater. Characterization of wastewater. Treatment principles: primary, secondary, tertiary. Activated sludge process, extended aeration, trickling filter, mechanically aerated lagoons, waste stabilization ponds, upflow anaerobic sludge blanket (UASB) reactor. Common effluent treatment plant- fundamental and case studies. Membrane based treatment processes – fundamental and case studies. Numerical problems on parameters and their determination methods.

Module III: Solid Waste Management [9L]
Sources and types; Treatment: Landfilling, Composting and Vermiculture, Biopiling, Incineration; Energy production from solid waste.

Module IV: Bioremediation [9L]
Preliminary ideas of Bioremediation—in-situ and ex-situ, Biodegradation of xenobiotics, polycyclic aromatic hydrocarbons, Persistent Organic Pollutants (POP), pesticides. Factors affecting the degradation of organics and removal of heavy metals (Mercury, Chromium, Arsenic etc.) by microbes.

Textbooks:

1. Rao, C.S., Environmental Pollution Control Engineering, New Age International, 1999.
2. S. P. Mahajan, Pollution Control in Industries, TMG.

Reference books:

1. Omasa, Air pollution & Plant Biotechnology, Springer.
2. Metcalf & Eddy, Wastewater Engineering – Treatment, Disposal and Reuse, 4th ed., TMG.
3. Arceiwala, S.J., Wastewater treatment for pollution control, 2nd Ed. TMH.
4. Introduction to Environmental Engineering and Sciences by Gilbert M.TAL

Course Title: Bioprocess & Process Instrumentation					
Course Code: BTC3133					
Contact Hours per week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	0	0	3	3

Course outcomes:

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

BTC3133.1: Understand the mechanism of enzyme action on a substrate explicitly.
BTC3133.2: Apply the above concepts to solve problems in the enzyme technology field.
BTC3133.3: Comprehend and solve any problem regarding sterilization of the medium used in fermentation.
BTC3133.4: Compare between a batch process and a continuous process regarding microbial growth.
BTC3133.5: Classify a microbial product and determine its productivity.
BTC3133.6: Appreciate the operation of different process instruments used for measuring various operating parameters of a bioprocess.

Module I: Principles of enzyme catalysis [9L]
Introduction to enzymes, mechanistic models for simple enzyme kinetics, rate parameters, models for allosteric enzyme kinetics, effect of pH and temperature, methods of immobilization, diffusional limitations in immobilized enzyme systems.

Module II: Fundamentals of sterilization [9L]
Media for industrial fermentation, medium formulation, medium optimization, Sterilization, design of batch and continuous sterilization process. Effect of operating variables of sterilization on nutrient quality in media. Air sterilization.

Module III: Mixed Culture kinetics [9L]
Microbial growth kinetics in batch and continuous culture. Product productivity. Mixed Culture: classification, kinetics and application.

Module IV: Fundamental of measuring instruments [9L]

Basic principles and operations of measuring instruments for measurement of temperature, flow pressure, DO level.

Text books:

1. Michael Shuler and Fikret Kargi, Bioprocess Engineering: Basic Concepts, 2nd Edition, Prentice Hall, Englewood Cliffs, NJ, 2002.
2. P.F. Stanbury, A. Whitaker, S.J. Hall, Principles of Fermentation Technology. Butterworth-Heinemann, 1995.

Reference Books:

1. Pauline M. Doran. Bioprocess Engineering Principles. Academic Press. 1995.
2. James E. Bailey and David F. Ollis, Biochemical Engineering Fundamentals. Mc-Graw Hill Education. 2nd edition, 1996.
3. Shuichi Aiba, Arthur E. Humphrey & Nancy F. Millis. Biochemical Engineering. Academic Press. 1965.

Open Elective - I

Course Name: Water and Liquid Waste Management					
Course Code: CHE3121					
Contact Hours Per Week	**L**	**T**	**P**	**TOTAL**	**CREDIT POINT**
	3	**0**	**0**	**3**	**3**

Course Outcomes:

The objective of this course is to provide approaches of Domestic/ Industrial Water and Liquid Waste Management for interdisciplinary B Tech students. After completion of the course students will be able to:

CHE 3121.1 Identify the importance of Legislative orders prevalent in India concerning Water and Liquid Waste Management.

CHE 3121.2 Develop the methodology of Establishing and Operating Water and Liquid Waste intensive processes.

CHE 3121.3 Develop the knowledge base on various water conservation technologies.

CHE 3121.4 Understand the suitable parameters for wastewater treatment and their computation methodologies.

CHE 3121.5 Design the Drinking Water and Wastewater Treatment plants following the standard code of practice.

CHE 3121.6 Design the Liquid Waste Management Plan for selected process Industries.

Module I: [10L]

Introduction to Water Quality and its Storage. Methodology of Water flow measurement; Classification and various Water and Wastewater Standards prevalent in India. Legislative aspects including Water Act. 1974 and its revisions; Consent to Establish and Consent to Operatewater intensive industries; Water conservation methodologies in 1) Process industry, 2) Construction industry and 3) Service industry; Rainwater Harvesting and various recharge techniques. Principles of Water Audit.

Module II: [10L]Water pollution:

Sources, sampling and classification of water pollutants, determination of basic parameters and computations associated with BOD, COD, TS, TDS, SS; Waste water treatment: primary, secondary, tertiary and advanced; aerobic treatment with special reference to activated sludge, trickling filter, RBDC and RBRC, EA;

Non-conventional:

WSP, anaerobic treatment with special reference to AFFR, UASB, numerical problems associated with all topics sited here.

Module III: [10L]

Preliminaries of Water treatment processes;

Basic design consideration:

Pre-design, Raw water intake, Screening and aeration, Water conveyance, Coagulation, Flocculation and Precipitation, Sedimentation, filtration, colour, taste and odor control, Disinfections and fluoridation,

Water quality:

Physico Chemical and Bacteriological quality. Water Treatment Plant with design criteria: Slow sand bed and Rapid sand bed filter, layout, Process control, Non-conventional water treatment processes and its design, numerical problems associated with all topics sited here.

Module IV: [10L]

Liquid Waste Management in selected process industries:

Fertilizer, refineries and petrochemical units, pulp and paper industries, Tanneries, Sugar industries, Dairy, Alcohol industries, electroplating and metal finishing industries, Root Zone and Reed Bed Treatment for Effluents of small scale industries, Ranking of wastewater treatment alternatives. Case Studies.

Text Books:

1. Wendell P. Ela, Gilbert M. Masters, Introduction to Environmental Engineering and Science, PHI, Ed 3rd Edition.
2. Metcalf & Eddy, Wastewater Engineering, Tata Mc-Graw Hill – 2002.
3. Arceivala S.J., Wastewater treatment for pollution control, TMH, 2nd Edition.
4. Montogomery, J.M., Water Treatment Principles and Design, John Willey and Sons.

Books of reference:

1. Mahajan, S.P., Pollution Control in Process Industries, Tata Mc Graw Hill, 2008.
2. Davis M., Cornwell, D, Introduction to Environmental Engineering, Tata Mc GrawHill, 2012.
3. Standard Methods for Examination of Water and Wastewater, APHA / AWWA, 20th Edition.
4. Manual of Water Supply and Treatment: CPHEEO, Ministry of Urban Development, Govt. of India, 1999.
5. Water Treatment Plant Design, 5th Edition: ASCE and AWWA, 1912.
6. Design of Water treatment Plant - Part I, A G Bhole, Indian Water Works Association.

Open Elective - I

Course Name: Industrial Safety and Hazards					
Course Code: CHE3122					
Contact Hours Per Week	**L**	**T**	**P**	**TOTAL**	**CREDIT POINT**
	3	**0**	**0**	**3**	**3**

Course Outcomes:
After completion of the course students will be able to:
CHE 3122.1: Use important technical fundamentals of chemical process safety and to impart basic knowledge that allows the students to evaluate occupational safety and health hazards in the workplace.
CHE 3122.2: Analyze the effects of work place exposures, injuries and illnesses, fatalities.
CHE 3122.3: Use safety programs to prevent or mitigate damage or losses and to develop preventative measure to avoid accident.
CHE 3122.4: Use logic based quantitative risk analysis.
CHE 3122.5: Carry out HAZOP analyses.
CHE 3122.6: Use knowledge of safety and hazards in chemical plant layout.

Module I [10L]
Fundamental Concepts: Introduction to Process Safety:
Definition of safety, Concepts of Hazard and Risk, Safety program, Engineering ethics,
Inherent Safety:
Safety regulations, OSHA, FAR, Process safety management,
Introduction to Hazards:
Hazards due to fire, explosions and toxic chemicals,
Fire and Explosion:
Distinction between fire and explosion, Upper Flammability limit and Lower Flammability Limit, Fire Triangle, BLEVE, Runaway reaction.

Module II [10L]
Tools for Hazards Identification and Analysis:
Concepts of HAZOP, HAZOP Analysis
Logic Tree in Safety Analysis:
Concepts of Fault Tree and its analysis, Concepts of Event Tree and its analysis, Combination of frequencies, Duration of coincidence of events, Advantage of ETA, Comparison of FTA and ETA, Bath Tub Curve
Failure Mode and Effect Analysis:
Methodology of FMEA, Dow Fire and Explosion Index, Mond Index. Fire and Explosion Index

Module III [10L]

Risk Analysis Concept and Methodology:

Risk concept and measure of risk,

Risk Acceptance Criteria:

Quantitative risk analysis, Probit number. Fractional dead time

Module IV [10L]

Control of Chemical Plant Hazards:

Intensification and attenuation of hazardous materials, Industrial plant layout,

Industrial Ventilation:

Reasons for ventilation, Positive pressure ventilation, Dilution ventilation, TLV, TWA

Personal Protection:

Fire prevention, Personnel protection devices, Laboratory safety, Emergency safety, Safety systems.

Disaster Management:

Definition, Types of disaster, Complex Emergencies, Pandemic Emergencies, Preparedness, Disaster Response, Disaster Recovery

Case Studies:

Flixborough (England), Bhopal (India),Seveso (Italy),Pasadona (Texas)

Text Book:

1. Crowl D.A. and .Louvar J.F. Chemical Process Safety: Fundamentals with Applications: Prentice Hall, 1990.

Books of reference:

1. Kharbanda O.P. and Stall worthy E. Safety in Chemical Process Industries: Heinmann. Professional Publishing LTD.1988.
2. Wentz C.A. Hazardous Waste management: Mc-Graw Hill,
3. Cutter S.L. Environmental Risks & Hazards, Prentice Hall, 1994.
4. Trevor A. Kletz, What went wrong? Case Histories of Process Plant Disasters and How They Could Have Been Avoided, 5th, Edition, Butterworth-Heinemann/IChemE .

Open Elective - I

Course Name : Introduction to Machine Learning					
Course Code: ECE3122					
Contact Hours per week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	0	0	0	3

Course outcomes:
After completing the course the student will be able to:

ECE3122.1: Apply fundamental engineering knowledge for analyzing data in a given feature space.

ECE3122.2: Explain the fundamental concepts of different Machine learning models and can evaluate a machine learning problem.

ECE3122.3: Apply machine learning techniques for classification and regression approaches in real-world applications.

ECE3122.4: Distinguish between supervised and unsupervised learning and able to apply machine learning tools for clustering approaches.

ECE3122.5: Analyze a machine learning problem with ensemble and reinforcement learning techniques.

ECE3122.6: Understand different techniques to create application using deep learning algorithms.

Module I: [9L]
Introduction: Foundations for ML: What is Machine Learning, Examples of Various Learning Paradigms, Perspectives and Issues, Version Spaces and Candidate Elimination Algorithm, Data Normalization, Feature Reduction/Dimensionality reduction, Validation Techniques (Cross-Validations), Bias-Variance Trade-off.
Feature Selection and Dimensionality Reduction: Principal Components Analysis (PCA), Independent Component Analysis (ICA), and Linear Discriminate Analysis (LDA).

Module II: [11L]
Supervised Learning:
Classification: Learning from Examples, Linear, Non-linear, Multi-class and Multi-label classification, Regression and Classification Trees, Decision tree, Naïve Bayes, k-Nearest Neighbor. Support vector machines: Linear and Non-Linear, Kernel Functions. Artificial neural networks: Introduction, Introduction, Perceptron, Multilayer Perceptron, Backpropagation algorithm
Regression: Ordinary Least Squares, Linear Regression, Multiple Linear Regression: Ridge

Regression, Lasso Regression, Non-Linear Regression: Logistic Regression.

Module III: [7L]

Unsupervised Learning:

Introduction to clustering, A Categorization of Major Clustering Methods, Partitioning Methods, Density-Based Methods, Grid-Based Methods, Model-Based Clustering Methods, Hierarchical: AGNES, DIANA, Partitional: K-means clustering, Self-Organizing Map, Expectation Maximization, Gaussian Mixture Models.

Module IV: [8L]

Ensemble Learning: Ensemble Learning Model Combination Schemes, Voting, Error-Correcting Output Codes, Bagging: Random Forest Trees, Boosting: Adaboost.

Reinforcement Learning:

Introduction to reinforcement learning, Learning Framework and Markov Decision Process with some examples.

Deep Learning: Autoencoder, Convolutional Neural Networks, Recurrent Neural Networks- with some real life examples.

Text Books:

1 .Ethem Alpaydin, 'Introduction to Machine Learning", MIT Press, Prentice Hall of India.
2. R.O. Duda, P.E. Hart, and D.G. Stork, "Pattern Classification", John Wiley.
3. M. Bishop, "Pattern Recognition and Machine Learning", Springer.
4. "The Elements of Statistical Learning" by Jerome H. Friedman, Robert Tibshirani, and Trevor Hastie.
5. Andreas C.Mueller ,Sarah Guido , "Introduction to Machine Learning with Python: A Guide for Data Scientists" O'Reilly.
6. Sebastian Raschka, "Python Machine Learning".

References:

1) T. M. Mitchell, "Machine Learning", McGraw Hill Education.
2) Murphy, Kevin, "Machine learning: a probabilistic perspective", MIT press.
3) Stuart Russell, and Peter Norvig, "Artificial intelligence: a modern approach", Prentice Hall.
4) "Deep Learning" by Ian Goodfellow, Yoshua Bengio, Aaron Courville.
5) Richard S. Sutton and Andrew G. Barto, "Reinforcement learning: An introduction", SecondEdition, MIT Press.

Open Elective - I

Course Name : Total Quality Management (TQM)					
Course Code: MEC3123					
Contact Hours	**L**	**T**	**P**	**Total**	**Credit points**
per week:	3	0	0	3	3

Course Outcomes:

After completion of the course, students will be able to:

MEC3123.1: Explain the concepts of Total Quality Management and Total Quality Education, Report Quality Costmeasure, Customer Satisfaction Index

MEC3123.2: Identify the problems in Quality Improvement Process, Use various QC tools, appreciate the benefits of implementing 5-S Techniques

MEC3123.3: Apply various Quality Function Deployment (QFD) Techniques

MEC3123.4: Analyze Statistical Process Control (SPC) data to improve processes, Design experiments for arrivingat optimal solutions

MEC3123.5: Appreciate the incorporation of ISO System standard and its benefits, Address issues relating to closure of NCR'S

MEC3123.6: Propose how business leaders might plan and execute quality management in an organization,struggles to gain and sustain competitive advantage in today's global business arena

Module I: [9L] Introduction

Definition of quality ; Quality control vs. Quality Assurance ; TQM- Components of TQM; TQM vs. TPM; Quality Gurus ; Quality Planning and Quality costs; Collection and reporting of quality cost information; Leadership role in TQM; Role of senior management in TQM; Implementation and Barriers to TQM ; Customer Satisfaction- Customer perception of quality-customer complaints- customer feedback- customer retention; Employee involvement.

Module II: [11L] QMS (ISO 9000):

Evolution of QMS- ISO 9000 series of standards- Quality manual – ISO 9001 requirements; Different clauses of ISO 9001 system and their applicability in various business processes; Registration of ISO 9001 : 2000 ; ISO 9001: 2000

Certification: Steps involved in ISO 9001: 2000 Certification: benefits/limitations of ISO 9001:2000; Internal Audits and Implementation of ISO 9001:2000.

EMS (ISO 14000):

Concepts of ISO 14001; Requirements of ISO 14001; Benefits of ISO 14001

Module III: [9L] Continuous Improvement in Quality
PLAN-DO-CHECK-ACT (PDCA); 7 QC tools and their use for quality improvement; Quality Function Deployment; QFD team; Benefits of QFD; QFD Process KAIZEN; 5 – S Principle; Concept of quality circles.

Module IV: [10L] Statistical Process Control
Basic statistical concepts; control charts for variables; Group control charts; Control charts for attributes; Acceptance Sampling - OC Curve; Process capability; Sampling Plans; Six Sigma and its applications; Design of experiments and Taguchi Methodology

Text Books

1. Total Quality Management – J.D. Juran, MHE.
2. Total Quality Management - Besterfield, Pearson Education.

Reference Books

Statistical Quality Control –M. Mahajan, Dhanpat Rai &Co. (Pvt.) Ltd.

Course Title: Genetics Lab					
Course Code: BTC3151					
Contact Hours per week	**L**	**T**	**P**	**Total**	**Credit Points**
	0	0	2	2	1

Course Outcomes:

After completing the course, the students will be able to:

BTC3151.1: Estimate the mean, median, mode and standard deviation using basic concepts of biometry in a biological data series.
BTC3151.2: Identify the different patterns of inheritance by studying family pedigrees.
BTC3151.3: Prepare a microscopic slide from human tissue and identify the Barr body.
BTC3151.4: Prepare and identify different stages of mitosis and meiosis from animal and plant cells.
BTC3151.5: Analyze human karyotype patterns and identify chromosomal abnormalities.
BTC3151.6: Estimate the viability of cells upon exposure to chemical mutagens.

List of Experiments (minimum six):

1. Computation of Descriptive Statistics
2. Introduction to Statistical Computing.
3. Pedigree analysis of human genetic disorders.
4. Preparation and identification of different stages of Mitosis and Meiosis.
5. Estimation of mitotix index.
6. Barr body preparation from peripheral blood cells.
7. Cell viability assay.
8. Karyotyping analysis and identification of human chromosomal disorders.
9. Study of chromosomal aberrations in animal and plant cells.

Reference books:

1. A Practical manual on fundamentals of Genetics by Dr. Mamata Behera, Dr. Rinny Swain, Dr. Aditya Pratap Singh. Bigfoot Publications, New Delhi, 2024.

Course Title: Bioinformatics Lab					
Course Code: BTC3151					
Contact Hours per week	**L**	**T**	**P**	**Total**	**Credit Points**
	0	0	2	2	1

Course outcomes:

Upon completion of this practical course students should be able to:

BTC3152.1: Learn and utilize public domain biological/bioinformatics databases (NCBI, EMBL-EBI, PDB) *for routine research driven applications.*
BTC3152.2: Learn and utilize public domain bioinformatics tools for sequence analysis of genes and proteins (combining both pairwise and multiple sequence alignment).
BTC3152.3: Learn and utilize public domain bioinformatics tools (including use of HMM) for annotation and structure prediction of prokaryotic genes.
BTC3152.4: Learn and utilize public domain bioinformatics tools (Homology modeling and threading based) for secondary and tertiary structure prediction of globular and fibrous proteins and subsequent structural analysis.
BTC3152.5: Learn and compile simple bioinformatics tasks using PERL (Practical Extraction and Reporting Language) commands.

List of Experiments (minimum six):

1. Basic understanding of biological databases.
2. Pair wise sequence alignment (LOCAL and GLOBAL Alignment).
3. Multiple sequence alignment.
4. Gene Prediction.
5. RNA structure prediction.
6. Compute the hydrophobicity scales from protein sequence.
7. Prediction of secondary structure of globular and membrane proteins.
8. Structure viewer and analysis; protein 3D structure prediction.
9. Basics of protein-ligand docking.
10. Introduction to PERL and PYTHON Programming in Bioinformatics.

Course Title: Recombinant DNA Technology Lab					
Course Code: BTC3153					
Contact Hours per week	**L**	**T**	**P**	**Total**	**Credit Points**
	0	0	2	2	1

Course Outcomes:

After completion of this lab, student will be able to:
BTC3153.1: Clone DNA fragment using restriction enzyme and DNA ligase.
BTC3153.2: Select of recombinant DNA clone by restriction analysis and blue-white selection.
BTC3153.3: Identify the clone either by southern blotting or western blotting.
BTC3153.4: Design PCR primer and amplification of DNA by PCR.
BTC3153.5: Over-express the cloned gene at protein level and analysis by SDS-PAGE.
BTC3153.6: Purify protein by one chromatography technique.

List of Experiments (minimum six):

1. Restriction enzyme digestion of DNA and construction of Restriction map.
2. Agarose gel electrophoresis and extraction of DNA from agarose gel.
3. Ligation of DNA fragments with cloning vector pUC18 or pBR322.
4. Preparation of competent cells and transformation into *E.coli* with recombinant vector.
5. Isolation of recombinants and confirmation of insert DNA in recombinant vector.
6. Primer design for standard PCR and amplification of DNA by standard PCR and RT-PCR.
7. Expression of cloned gene.
8. Southern/Western/Northern blotting.
9. Protein purification by affinity chromatography (any one type).
10. Reporter enzyme assay (β-gal etc.)

Reference books:

1. Wilson and Walkers principles and techniques of biochemistry and molecular biology (8^{th}edn. 2018) by Hofmann and Clokie.
2. Molecular Cloning: A Laboratory Manual (3-volume set 4th Edn.): (2012) by Michael R. Green, Joseph Sambrook, Pub: CSHL press.

Course Title: Transfer Operations-II Lab					
Course Code: BTC3154					
Contact Hours per week	**L**	**T**	**P**	**Total**	**Credit Points**
	0	0	2	2	1

Course Outcomes:

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

BTC3154.1: Verify Rayleigh's equation in batch distillation process.
BTC3154.2: Determine gas-liquid mass transfer coefficient in a wetted wall column or packed bed absorption column.
BTC3154.3: Study the drying characteristic curves under constant drying condition in tray dyer.
BTC3154.4: Determine Distribution Coefficient in liquid- liquid extraction operation.
BTC3154.5: Measure adsorption efficiency and draw the adsorption isotherm using activated carbon as an adsorbent in a batch reactor
BTC3154.6: Calculate diffusivity of a volatile liquid.

List of Experiments (minimum six):

1. Batch Distillation to verify Rayleigh's equation.
2. Drawing the vapour-liquid equilibrium diagram from Othmer Still.
3. Study of performance of a Rectification Column.
4. Determination of gas-liquid mass transfer coefficient (Wetted Wall column or packed bed).
5. Study of drying characteristic curves under constant drying condition in tray dyer.
6. Determination of Distribution Coefficient in liquid- liquid extraction operation
7. Study of adsorption efficiency and adsorption isotherm using activated carbon as an adsorbent in a batch reactor.
8. Calculation of diffusivity of a volatile liquid

Course Title: Food Biotechnology Lab					
Course Code: BTC3161					
Contact Hours per week	**L**	**T**	**P**	**Total**	**Credit Points**
	0	0	2	2	1

Course Outcomes:

After performing this lab, students will be able to:

BTC3161.1: Detect microbial spoilage of food.
BTC3161.2: Apply standard techniques quality testing.
BTC3161.3: Measure the efficiency of Pasteurization.
BTC3161.4: Isolation and identification of microbes from different food sample.
BTC3161.5: Estimate different food ingredients.
BTC3161.6: Gain knowledge on food preservation techniques.

List of Experiments (minimum six):

1. Detection of microbial load of milk by standard plate count method.
2. Detection of microbial load of milk by MBRT method.
3. Determination of effectiveness of pasteurization by alkaline phosphatase assay.
4. Identification and characterization of food fermenting organism from idly batter.
5. Determination of lactose content of milk.
6. Determination of ascorbic acid content of fruit juice.
7. Determination of polyphenol and tannin in tea samples.
8. Detection of food colour/ adulterant/ microbial contamination.

Course Title: Environmental Biotechnology Lab					
Course Code: BTC3162					
Contact Hours per week	**L**	**T**	**P**	**Total**	**Credit Points**
	0	0	2	2	1

Course Outcomes:

After performing this lab, students will be able to:

BTC3162.1: Estimate basic environmental parameters in water and soil samples.
BTC3162.2: Estimate organic pollutants in a water sample
BTC3162.3: Demonstrate toxic effects of pollutants.
BTC3162.4: Apply regular methods for removal of organic / inorganic pollutants.
BTC3162.5: Apply microorganisms for degradation of organic pollutants

List of Experiments (minimum six):

1. Determination of Total Suspended Solid in water.
2. Determination of Hardness of water.
3. Determination of Chloride content of surface water.
4. Determination of BOD of waste water.
5. Determination of COD of waste water.
6. Determination of sulphate/ nitrate/ nitrite/ iron in surface water.
7. Estimation of persistant organic pollutant (phenol) in waste water.
8. Adsorptive removal of Heavy metals from waste water.

Course Title: Bioprocess & Process Instrumentation Lab					
Course Code: BTC3163					
Contact Hours per week	**L**	**T**	**P**	**Total**	**Credit Points**
	0	0	2	2	1

Course Outcomes:

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

BTC3163.1: Determine the specific growth rate and doubling time for cell (pure/mixed) growth.
BTC3163.1: Calculate Arrhenius constant and activation energy for cellular growth.
BTC3163.1: Determine kinetic constants in free and immobilized enzyme systems/cellular systems.
BTC3163.1: Determine optimum pH for an enzyme reaction.
BTC3163.1: Determine optimum temperature for an enzyme reaction.
BTC3163.1: Study the performance of continuous flow bioreactors (Packed-bed and Plug-flow).

List of Experiments (minimum six):

1. Determination of specific growth rate and doubling time from cell (pure/mixed) growth kinetics profile.
2. Determination of Arrhenius constant and activation energy for cellular growth from growth kinetics data.
3. Determination of kinetic constants in free and immobilized enzyme systems.
4. Determination of kinetic constants in free and immobilized cellular systems.
5. Study of effect of pH on enzyme reaction.
6. Study of effect of temperature on enzyme reaction.
7. Performance study of continuous flow bioreactors (Packed-bed and Plug-flow).

APPENDIX – A

Point Description for Mandatory Additional Requirement (MAR)

Sl. No.	Name of the Activity	Points	Maximum Points allowed
1	MOOCS (SWAYAM/NPTEL/Spoken Tutorial) (per course)	20	40
2	Tech Fest / Teachers Day / Freshers Welcome		
	(i) Organizer	05	10
	(ii) Participants	03	06
3	Rural Reporting	05	10
4	Tree Plantation (per tree)	01	10
5	Participation in Relief Camps	20	40
6	Participation in Debate/Group Discussion/ Tech quiz	10	20
7	Publication of Wall magazine at Institutional level (magazine/article/internet)	10	20
8	Publication in News paper, Magazine & Blogs	10	20
9	Research Publication (per publication)	15	30
10	Innovative Projects (other than course curriculum)	30	60
11	Blood donation camp		
	(i) Donor	08	16
	(ii) Camp Organizer	10	20
12	Participation in Sports/Games		
	(i) College Level	05	10
	(ii) University Level	10	20
	(iii) District Level	12	24
	(iv) State Level	15	30
	(v) National / International Level	20	40
13	Cultural programme (Dance, Drama, Elocution, Music etc.)	10	20
14	Member of Professional Society	10	20
15	Student Chapter Activities / Seminars		
	(i) Participant	05	20
	(ii) Presentation	10	20
	(iii) Organizer	10	20
16	Relevant industry visit & report	10	20
17	Activities in different clubs at HIT (Photography Club, Cine Club etc.)	05	10
18	Participation in Yoga Camp	05	10
19	Self-Entrepreneurship programme	20	20
20	Adventure sports	10	20
21	Training to under privileged / Physically challenged	15	30
22	Community Service & Allied Activities	10	20
23	Hackathon (State / National Level)		
	(i) Participation in Hackathon	10	20
	(ii) Qualifier for final round (not prize winner) in Hackathon	20	40
	(iii) Prize Winners of Hackathon	30	60

Format for Report Submission

Name :

Department :

Year/Semester :

Title of the Activity :

Date :

Name of the organization :

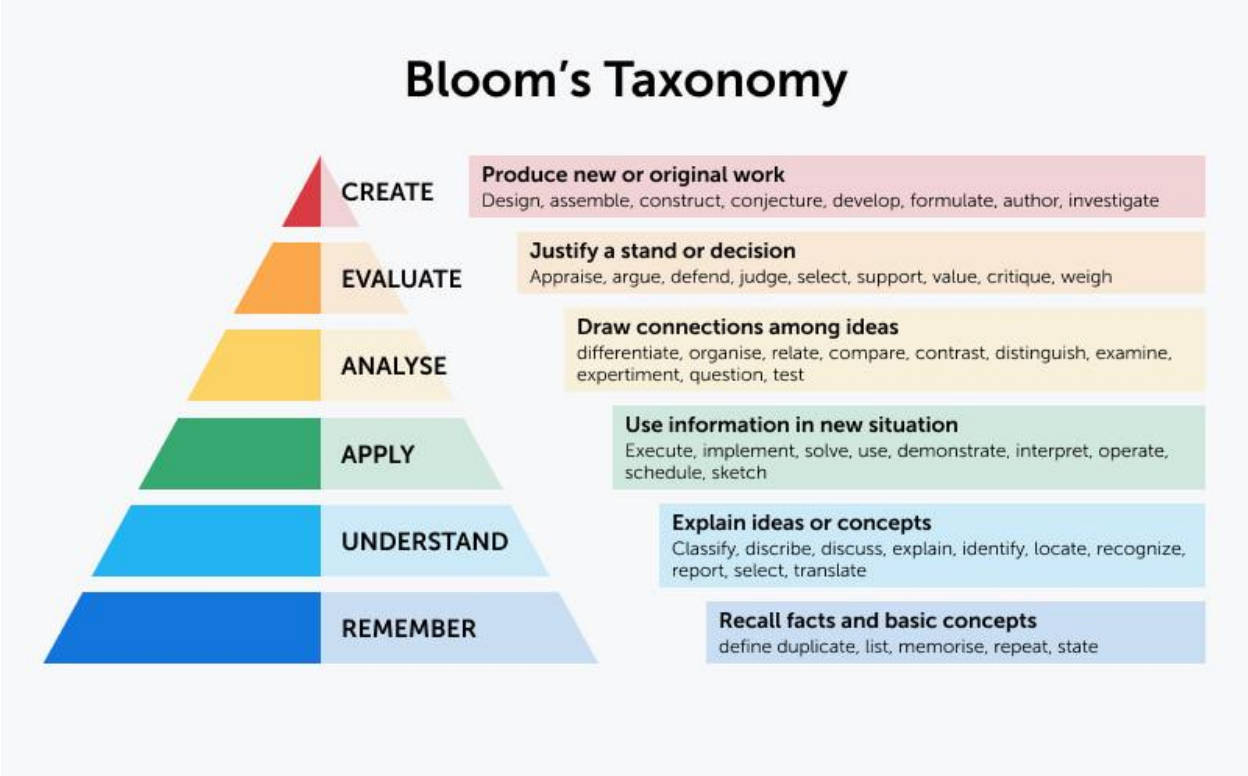
Report :

Signature
(Coordinator / Competent Authority)

Points earned:

Signature of the Mentor

APPENDIX – B


Bloom's Taxonomy
CREATE
Produce new or original work
Design, assemble, construct, conjecture, develop, formulate, author, investigate
EVALUATE
Justify a stand or decision
Appraise, argue, defend, judge, select, support, value, critique, weigh
ANALYSE
Draw connections among ideas
differentiate, organise, relate, compare, contrast, distinguish, examine, expertiment, question, test
APPLY
Use information in new situation
Execute, implement, solve, use, demonstrate, interpret, operate, schedule, sketch
UNDERSTAND
Explain ideas or concepts
Classify, discribe, discuss, explain, identify, locate, recognize, report, select, translate
REMEMBER
Recall facts and basic concepts
define duplicate, list, memorise, repeat, state