KALINGA INSTITUTE OF INDUSTRIAL TECHNOLOGY (KIIT)

Deemed to be University U/S 3 of the UGC Act, 1956

School of Biotechnology

B.Tech.-M.Tech. Dual Degree in Biotechnology

Curriculum

(2022 admitted batch)

UNIVERSITY VISION:

- To create an advanced center of professional learning of international standing where the pursuit of knowledge and excellence shall reign supreme, unfettered by the barriers of nationality, language, cultural plurality and religion.

UNIVERSITY MISSION:

- Imparting quality value-based education of international standard and imbibing skills for solving real-life problems.
- Inculcating global perspective in attitude.
- Creating leadership qualities with a futuristic vision.
- Fostering the spirit of entrepreneurship and realization of societal responsibilities.
- Cultivating adaptation of ethics, morality and healthy practices in professional life.
- Instilling the habit of continual learning.
- Encouraging and supporting creative abilities and research temperament.
- Establishing and promoting close interaction with industries and other utility sectors and keep abreast with state-of-the-art technology.

SCHOOL VISION

- The school of Biotechnology has the vision to impart international standard quality education in the field of Biotechnology.

SCHOOL MISSION

- To have integrated academic and research programmes in biotechnology and allied areas
- Establish globally acceptable technical education in biotechnology and allied areas.
- To develop a skilled professional human resource in the field of biotechnology and microbiology
- Encouragement of bio-entrepreneurship among young innovators to contribute to socio-economic development
- Foster an all-round nurturing environment for the scientific growth of students imbibed with overall attitude, ethics, morals, leadership and life skills
- Promote collaboration with Academia, Industries and Research Organizations at the National and International levels to enhance the quality of education and research.
- Cultivate and encourage graduates for innovation and creativity in the field of Biotechnology with ethical, social, sustainable, and global perspectives.
- To create state-of-the-art infrastructure for Research and Training in Biotechnology.

PREAMBLE

Biotechnology focuses on technological applications of biological systems, living organisms, or their parts to develop different products for the benefit of humankind. It provides sustainable solutions to different problems in various sectors including drug development, food, agriculture, pollution control, etc. The B.Tech.- M.Tech. dual degree in Biotechnology offered by the School of Biotechnology integrates basic science and engineering to train students to become future biotech industry professionals or research scientists. This is a five-year program including 6 months of laboratory project/dissertation. The basic eligibility criteria of this program are higher secondary (10+2) qualification with physics, chemistry and biology. Students who did not have mathematics at their +2 level are required to take a bridge course in Mathematics offered by the school.

The program starts with basic science subjects in engineering courses as per the requirement of accreditation agencies. The course includes Introduction to biotechnology which is a foundation course to prime students in various branches of Biotechnology leading to future careers in research and industry. Yoga and Human Consciousness is offered as a compulsory humanities-based subject which maps very well with the development of universal human values. The program offers several core subjects like biochemistry, molecular biology, recombinant DNA technology, bioprocess engineering, immunology, animal and plant biotechnology and a variety of minor and open electives for the students to choose from. Throughout the program, students will be offered exhaustive hands-on training on different techniques of biotechnology using high-end equipment in state-of-the-art academic laboratories by the highly qualified faculty of the school. Students also take part in giving seminars, national-level symposia, mini and major projects and industrial visits.
The program intends to connect several interdisciplinary areas of sciences with biotechnology so that students can update their skills according to the requirements of industry and fuel their scientific temper by creating innovations, startups and providing solutions to benefit society. The program aims to develop cutting-edge research skills and scientific temper that will help the students to take up various biotech or pharmaceutical industry jobs or join for Ph.D. positions both in India and abroad. Moreover, student exchange programs during the course will give students a chance to visit laboratories of various national and international repute. The program will also help students to grow into independent intellectuals that will help them to be future entrepreneurs. Through social outreach programs, these students also get to learn about their responsibility towards society and train themselves for sustainable development. The alumni of the course can be found pursuing Ph.D. or postdoc in reputed research labs throughout the world including India. Moreover, the biotech dual degree alumni are making their presence felt in food technology, pharmaceuticals, diagnostics, healthcare and other industries.

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

The course aims to provide an advanced understanding of the core principles and topics of Biotechnology and their experimental basis and to enable students to acquire specialized

knowledge and understanding of selected aspects by means of lecture series and research seminars/projects.

Hence, the main objectives of the program are:

PEO1: To enable students to pursue careers in academia, industry/entrepreneurship in the field of biotechnology involving innovation, application of relevant tools and problem-solving at the national or international level.

PEO2: To undertake research careers within realistic economic, environmental, socio-political, health, safety & sustainability realms in biotechnology and allied areas

PEO3: To contribute to society by becoming a model citizen, who is good at communication, ethics, and professionalism

PEO4: To prepare students to be independent and enable them to enrich their knowledge and skills for lifelong learning throughout their career

PROGRAMME OUTCOMES (POs)

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

PO2: Problem analysis: Identify, formulate, solve, and analyze complex bioprocess engineering problems reaching substantiated conclusions using the principles of mathematics, natural sciences, and engineering sciences.

PO3: Design/development of solutions: Design solutions, analyze, optimize and simulate bioprocess operations and design system components or processes that meet the specified needs with appropriate consideration for public health and safety, and the cultural, societal, and environmental considerations.

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

PO5: Modern tool usage: Acquire skills to create, select, use and apply appropriate techniques, resources, modern analytical tools/software/equipment and solve problems in various courses in biotechnology

PO6: The bioengineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and execute their role in society for personal and professional growth responsibly as a biotechnology professional, employer, and employee.

PO7: Environment and sustainability: Understand the impact of 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 in the social context and norms of the biotechnology practice.

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

PO10: Communication: Critically evaluate and effectively communicate contributions to science reported in all forms of media and be able to identify valid approaches to scientific problem-solving and reporting on biotechnology activities with the existing community and the 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 biotechnology and allied areas and management principles to apply these to one's own work, as a member and leader in a team, to manage relevant projects in multidisciplinary environments.

PO12: Life-long learning: Recognize the need for developing skills, attitude, and self-directed independent and life-long learning in the broadest context of technological change.

PROGRAMME SPECIFIC OUTCOMES (PSOs)

After successfully completing this course, the students should be able to:

PSO1: Independently carry out research/investigation & development work to identify and solve a practical problem

PSO2: Acquire the ability to write & present a substantial technical report/scientific document

PSO3: Demonstrate a degree of mastery over the field of biotechnology as per the specialization of the program in pharmaceutical biotechnology, food technology, environmental technology and nanotechnology. The mastery should be at a level higher than the requirements in the appropriate bachelor's program

PSO5: Demonstrate the ability to employ relevant tools in biological and interdisciplinary areas of research, to design, conduct experiments and analyze data in the field of Biotechnology

PSO6: Pursue careers in academia and industry in the areas of bioscience, bioengineering, and biotechnology.

SEMESTER-WISE CREDIT DISTRIBUTION

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FIRST YEAR

Semester-I

Sl No.	Theory							
	Course Category	Course Code	Course	L	T	P	Total	Credit
1	BSC	MA 1003	Mathematics-I	3	1	0	4	4
2	BSC	PH 1007	Physics	3	1	0	4	4
3	BS	BT 1011	Introduction to Biotechnology	2	1	0	3	3
4	ESC	EE 1003	Basic Electrical Engineering	3	0	0	3	3
						Total Theory	**14**	**14**
Practical								
1	BSC	PH 1097	Physics Lab	0	0	3	3	1.5
2	BS	BT 1097	Biology Lab	0	0	2	2	1
3	ESC	EE 1093	Basic Electrical Engineering Lab	0	0	2	2	1
Sessional								
1	ESC	CE 1083	Engineering Graphics	0	1	2	3	2
2	AU	YG 1081	Yoga and Human Consciousness	1	0	1	2	1
						Total Practical & Sessional	**12**	**6.5**
						Semester Total	**26**	**20.5**

1		MA 0001	Mathematics Bridge course *					**P/NP

*Only for students having no mathematics in their 11^{th} and 12^{th} grade

** Pass/Not Pass

Semester-II

Sl No.	Theory							
	Course Category	Course Code	Course	L	T	P	Total	Credit
1	BSC	MA 1004	Mathematics-II	3	1	0	4	4
2	BSC	CH 1007	Chemistry	3	0	0	3	3
3	HS	HS 1005	Professional Communication	2	0	0	2	2
4	BSC	BT 1014	Environmental Science	2	0	0	2	2
5	BS	BT 1016	Macromolecular Structure	2	0	0	2	2
						Total Theory	**13**	**13**
Practical								
1	BSC	CH 1097	Chemistry Lab	0	0	3	3	1.5
2	ESC	CS 1093	Computer Programming	0	2	4	6	4
Sessional								
1	ESC	ME 1083	Basic Manufacturing system	0	1	2	3	2
2	HS	HS 1085	Language Lab	0	0	2	2	1
						Total Practical & Sessional	**14**	**8.5**
						Semester Total	**26**	**20.5**

SECOND YEAR

Semester-III

Sl No.	Theory							
	Course Category	**Course Code**	**Course**	**L**	**T**	**P**	**Total**	**Credit**
1	ESC	BT 2011	Engineering Principles	2	1	0	3	3
2	BS	BT 2013	Biochemistry	2	1	0	3	3
3	BS	BT 2015	Microbiology	2	1	0	3	3
4	BS	BT 2017	Cell Biology and Genetics	2	1	0	3	3
5	BS	BT 2019	Plant Physiology	2	0	0	2	2
6	HS	HS 2021	Principle of Economics	2	0	0	2	2
Total Theory							**16**	**16**
Practical								
1	BS	BT 2095	Biochemical Techniques	0	0	4	4	2
2	BS	BT 2097	Methods in Microbiology	0	0	6	6	3
Audit								
1	AU	BT 2083	Indian Constitution	1	0	0	1	P/NP
Total Practical & Sessional							**11**	**5**
Semester Total							**27**	**21**

Semester-IV

Sl No.	Theory							
	Course Category	**Course Code**	**Course**	**L**	**T**	**P**	**Total**	**Credit**
1	ESC	BT 2014	Transport Processes	2	1	0	3	3
2	BSC	BT 2016	Methods in Biostatistics	2	0	0	2	2
3	BS	BT 2018	Principles of Biophysics	2	0	0	2	2
4	BS	BT 2020	Molecular Biology	2	1	0	3	3
5	BS	BT 2022	Animal Physiology	2	0	0	2	2
6	HS	HS 2022	Principle of Management	2	0	0	2	2
Total Theory							**14**	**14**
Practical								
1	BS	BT 2096	Methods in Cell Biology	0	0	6	6	3
2	BS	BT 2098	Molecular Biology Techniques	0	0	6	6	3
Total Practical & Sessional							**12**	6
Semester Total							**26**	**20**

THIRD YEAR

Semester-V

Sl No.	**Theory**							
	Course Category	**Course Code**	**Course**	**L**	**T**	**P**	**Total**	**Credit**
1	PC	BT 3	Computational Biology	2	0	2	4	3
2	PC	BT 3	Bioreaction Engineering	2	0	0	2	2
3	PC	BT 3	Immunology	2	1	0	3	3
4	PC	BT 3	rDNA Technology	2	1	0	3	3
5	PE	BT 3	Professional Elective-I	3	0	0	3	3
Total Theory							**15**	**14**
Practical								
1	PC	BT 3	Immunology Lab	0	0	6	6	3
2	PC	BT 3	rDNA Technology Lab	0	0	6	6	3
Total Practical & Sessional							**12**	**6**
Semester Total							**27**	**20**

Semester-VI

Sl No.	**Theory**							
	Course Category	**Course Code**	**Course**	**L**	**T**	**P**	**Total**	**Credit**
1	PC	BT 3	Enzymology and Enzyme Technology	2	1	0	3	3
2	PC	BT 3	Bioprocess Engineering	2	1	0	3	3
3	PC	BT 3	Bioanalytical Techniques	2	0	0	2	2
4	PE	BT 3	Professional Elective-II	3	0	0	3	3
5	OS	BT 3	Open Subject-I	3	0	0	3	3
Total Theory							**14**	**14**
Practical								
1	PC	BT 3	Enzymology Lab	0	0	4	4	2
2	PS	BT 3	Bioreaction and Bioprocess Engineering Lab	0	1	6	7	4
Sessional								
1	PS	BT 3	Advanced QA and QC techniques	0	0	2	2	1
Total Practical & Sessional							**13**	**7**
Semester Total							**27**	**21**

FOURTH YEAR

Semester-VII

Sl No.	**Theory**							
	Course Category	**Course Code**	**Course**	**L**	**T**	**P**	**Total**	**Credit**
1	PC	BT 4	Bioseparation	2	1	0	3	3
2	PC	BT 4	Animal and Medical Biotechnology	2	0	0	2	2
3	PC	BT 4	Plant Biotechnology	2	0	0	2	2
4	HS	BT 4	Intellectual Property Rights (IPR) and Regulatory Practices	2	0	0	2	2
6	PE	BT 4	Professional Elective-III	3	0	0	3	3
6	OS	BT 4	Open Subject-II	3	0	0	3	3
Total Theory							**15**	**15**
Practical								
1	PC	BT 4	Animal and Plant Biotechnology Lab	0	0	6	6	3
2	PC	BT 4	Bioseparation Lab	0	0	4	4	2
Sessional								
1	PS	BT4	Seminar	1	0	0	1	1
Total Practical & Sessional							**11**	**6**
Semester Total							**26**	**21**

Semester-VIII

Sl No.	**Theory**							
	Course Category	**Course Code**	**Course**	**L**	**T**	**P**	**Total**	**Credit**
1	PC	BT 4	Genomics and Proteomics	2	1	0	3	3
2	PE	BT 5	Professional Elective-IV	3	0	0	3	3
3	PE	BT 4	Professional Elective-V	3	0	0	3	3
4	OS	BT 4	Open Subject-III	3	0	0	3	3
Total Theory							**12**	**12**
Practical								
1	PS	BT 4	Minor Project	0	2	8	10	6
Sessional								
1	HS	BT 4	Scientific Writing and Communication	2	0	0	2	2
2	PC	BT 4	Good Manufacturing and Lab Practices	1	0	0	1	1
Total Practical & Sessional							**13**	**9**
Semester Total							**25**	**21**

FIFTH YEAR

Semester-IX

Sl No.	**Theory**							
	Course Category	**Course Code**	**Course**	**L**	**T**	**P**	**Total**	**Credit**
1	ESC	BT 5	Biomedical Instrumentation	2	1	0	3	3
2	HS	BT 5	Bioentrepreneurship and Startup	2	0	0	2	2
3	PC	BT 5	Synthetic Biology	2	1	0	3	3
4	PE	BT 5	Professional Elective-VI	3	0	0	3	3
5	OS	BT 5	Open Subject-IV	3	0	0	3	3
Total Theory							**14**	**14**
Practical								
2	PC	BT5	Molecular Diagnostics Lab	0	0	4	4	2
1	PC	BT 5	Industrial Biotechnology Lab	0	0	6	6	3
Sessional								
1	PS	BT 5	Project Proposal Preparation and Presentation	1	0	0	1	1
2	PS	BT 5	Summer training seminar*				4	2
Total Practical & Sessional							**15**	**8**
Semester Total							**29**	**22**

***Summer training (at least 4 weeks)** at the end of $4^{th}/6^{th}/8^{th}$ semester- credit in 9^{th} semester*

Semester-X

Sl No.								
	Course Category	**Course Code**	**Course**	**L**	**T**	**P**	**Total**	**Credit**
1	PS	BT	Major Project	0	0	40	40	20
Total Practical								**20**
Semester Total								**20**

DETAILED SYLLABUS

SEMESTER-I

MA 1003 Mathematics-I

Course code	MA 1003
Course title	Mathematics-I
Number of credits	4 (L: 3, T: 1, P: 0)
Course category	BSC
Continuous Assessment (C.A.)	50
End Semester Assessment (E.S.A.)	50
Prerequisite	Mathematics in 11^{th} &12^{th} grade or Mathematics Bridge course (**MA 0001**)

Course Description:

This course is designed to familiarize prospective engineers with techniques in ordinary differential equations, multivariate calculus and solution for ODEs numerically. This course also focuses on Linear algebra that covers the system of linear equations and properties of matrices. The objective of the course is to equip the students with standard concepts and tools at an intermediate to advanced level that will serve them well towards tackling more advanced levels of mathematics and applications that they would find useful in their disciplines.

Course Outcomes:

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

CO1: understand the concept of modelling and formulation of differential equations of physical problems. Apply different methods to solve ODEs.
CO2: develop an ability to solve 2nd order ODEs.
CO3: get the concept of numerical solution of ODEs.
CO4: apply differential calculus in engineering problems.
CO5: use the essential tool of matrices and linear algebra in a comprehensive manner.
CO6: apply the knowledge of Eigen value and Eigen vector in the field of engineering.

Course contents:

Unit-1: Ordinary Differential Equations: Basic concepts and definitions of 1st order differential equations, solution of differential equations: variable separable, homogeneous, equations reducible to homogeneous form, exact differential equation, equations reducible to exact form, linear differential equation, equations reducible to linear form (Bernoulli's equation), Picard's iteration method to solve the 1st order ODE, applications of differential equations.

Unit-2: Linear Differential equations of 2ndorder: Second order linear homogeneous equations with constant coefficients; differential operators; solution of homogeneous equations; Euler-Cauchy equation; linear dependence and independence; Wronskian; Solution

of non-homogeneous equations: general solution, complementary function, particular integral; solution by variation of parameters; undetermined coefficients.

Unit-3: Differential Calculus and Numerics for ODEs: Taylor's Theorem (one and Two variables), Maxima and Minima (Two variables), Numerical solution of ODEs: Taylor's method, Euler's and Modified Euler's method.

Unit-4: Vector Space and system of linear equations: Linear system of equations; rank of matrix; consistency of linear systems; Solution of system of linear equations: Gauss elimination, Gauss Jacobi and Gauss-Seidel methods; inverse of a matrix by Gauss Jordan method, Vector Space, Sub-space, Basis and dimension, linear dependence and independence, Linear transformation.

Unit-5: Matrix-Eigen value problems: Eigen values, Eigen vectors, Cayley Hamilton theorem, basis, complex matrices; quadratic form; Hermitian, Skew-Hermitian forms; similar matrices; Diagonalization of matrices; transformation of forms to principal axis (conic section).

Textbook(s):

1. Advanced Engineering Mathematics by Erwin Kreyszig, Wiley, INC, (online) 10th Edition.
2. Differential Calculus, Shanti Narayan and P. K. Mittal, S. Chand, reprint 2009.

Reference Book(s):

1. Higher Engineering Mathematics, Grewal B.S., Khanna Publishers, 36th edition.
2. Introduction to engineering Mathematics, Dass H.K., S.Chand & Co Ltd, 11th edition.
3. Higher Engineering Mathematics, Ramana B.V., TMH, 2007.

PH 1007 Physics

Course code	PH 1007
Course title	Physics
Number of credits	4 (L: 3, T: 1, P: 0)
Course category	BSC
Continuous Assessment (C.A.)	50
End Semester Assessment (E.S.A.)	50
Prerequisite	Nil

Course Description:

This course includes the fundamentals of different types of oscillations and its applications; mathematical expression of waves and its physical interpretation; the concept of interference, diffraction and their applications; the principle, construction and working of different Lasers. The course also gives a flavour of Quantum mechanics, which is the founding stone to the state of the art in modern techniques and paves the way towards the world of nano devices. It covers the formulation of Maxwell's electromagnetic equations, and verification of different properties

of electromagnetic waves. Mechanical and magnetic properties of different materials and their applications are also covered in this course.

Course Outcomes:

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

CO1: utilize the concept of waves and intensity modulation in day to day life through various applications

CO2: apply the mechanism of LASER technology in different fields

CO3: formulate and solve engineering problems of electricity and magnetism using Maxwell's electromagnetic equations

CO4: apply the principles of quantum mechanics to related problems

CO5: apply the knowledge of magnetic materials in related applications

CO6: analyze the macroscopic behavior of solids and utilize them in future applications

Course contents:

Unit-1: Simple Harmonic Oscillation, Damped Harmonic Oscillation (under damped, over damped and critically damped), Energy decay, Relaxation time, Forced Oscillation (Steady state Motion of Forced Damped Oscillator), Resonance, Coupled Oscillation. Harmonic waves, Wave equation. Superposition of waves, Interference of light by wave front and amplitude splitting, Newton’s rings, applications. Diffraction by a single slit, Plane Diffraction Grating, Absent spectra, Resolving Power and Dispersive power. LASER, Spontaneous emission and stimulated emission, Meta-stable state, population inversion, Pumping, Ruby Laser, He-Ne Laser, applications.

Unit-2: Vector calculus: gradient, divergence and curl, Maxwell's equations in differential and integral form with necessary derivations. Derivation of electromagnetic wave equations, Transverse nature of EM waves, Scalar and vector potentials, Electromagnetic wave equations in terms of scalar and vector potentials, Poynting's theorem.

Unit-3: Inadequacy of classical mechanics, de Broglie hypothesis for matter waves, phase velocity and group velocity, Heisenberg’s uncertainty principle, wave function and its interpretation, Postulates of Quantum mechanics, basic concepts of operators, Schrodinger’s equations, particle in one dimensional box, potential barrier, tunnelling, applications.

Unit-4: Magnetic materials, Susceptibility, Permeability, Diamagnetic, Paramagnetic and Ferromagnetic materials, Langevin’s theory for Diamagnetic and Paramagnetic materials, Weiss theory for Ferromagnetic materials, Curie temperature.

Unit-5: Stress, strain, Hooke's law, stress-strain diagram, elastic constants and their relations, torsional pendulum, bending moment, cantilever.

Textbook (s):

1. Engineering Physics, B. K. Pandey and S. Chaturvedi, Cengage Publication, New Delhi

Reference Book(s):

1. Introduction to Electrodynamics, D J Griffiths, Pearson Education
2. Quantum Mechanics, L. I. Schiff, Tata McGraw-Hill Publications
3. Optics, A K Ghatak, Tata McGraw-Hill Publications
4. Concepts of Modern Physics, A. Beiser, Tata McGraw-Hill Publications
5. Engineering Physics, R K Gaur and S. L. Gupta, Dhanpat Rai Publications, New Delhi.

BT 1011 Introduction to Biotechnology

Course code	BT 1011
Course title	Introduction to Biotechnology
Number of credits	3 (L: 2, T: 1, P: 0)
Course category	BS
Continuous Assessment (C.A.)	50
End Semester Assessment (E.S.A.)	50
Prerequisite	Nil

Course Description:

This course is designed to give students both a theoretical background and a working knowledge of the instrumentation and techniques employed in a biotechnology laboratory. Emphasis will be placed on the introduction of foreign DNA into bacterial cells, as well as the analysis of nucleic acids (DNA and RNA) and proteins. Specifically, students will be made aware of the concepts of Cells and Organelles, Chromosome and DNA Replication, Biomolecules, Fundamentals of Biochemical Engineering, Genetic Engineering, Genomics, Proteomics, and Bioinformatics, Enzyme Biotechnology, Protein Structure and Engineering, Microbial Biotechnology, Plant Biotechnology, Animal Biotechnology, Environmental Biotechnology, Horizon of Biotechnology, Bioethics and Biosafety, Intellectual Property Rights and Bio patents

Course Outcomes:

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

CO1: Define, Identify, recognize, and recall the details of history and foundations of biotechnology and how it has shaped the current ecosystem, types of biotechnology, breakthrough techniques.

CO2: Understand, describe, discuss, and summarize the fundamental biological, chemical and genetic basis of life, the central dogma of molecular biology and its use in biotechnology in various aspects of DNA manipulation with restriction enzymes, RDT and genetic engineering, enzymes, model organisms, bioprocess, DNA finger printing, etc.

CO3: Apply, demonstrate, illustrate, and organize the role of enzymes and proteins in various fields of biotechnology, how bacteria are used for commercial purposes, usage of RDT in generating GMOs, environmental and for curing human diseases,

CO4: Analyse, compare, and contrast, investigate and outline role of bioinformatics in modern data analytics and omics-based research, ethical implications of biotechnology, role of IPR in set up of regulatory compliance

CO5: Evaluate, criticize, examine, and justify the importance of bioremediation, creation and use of GMOs and environmental causes, future, and scope of areas in biotechnology related to bioenergy, biosimilars, innovation, entrepreneurship, and R & D.

CO6: Develop, generate, and summarize seminars and reports on the status, scope and future of biotechnology, various topics related to biotechnology

Detailed Syllabus

Unit 1: **Introduction to Biotechnology**: History and foundations, modern biotechnology, types and disciplines, multidisciplinary science, challenges and future, Business, biotech industry and market.

Unit 2: Fundamentals of Biology and Biotechnology: Introduction to origin of life, RNA world, chemical basis of life (water, carbon, macromolecules), cell as fundamental basis of life, cellular organization, homeostasis, metabolism, inheritance, biological diversity, evolution, tree of life, domain classification. Basic introduction to microbes, microbiome and their usage in biotechnology. Fundamentals of central dogma, introduction to genes, genomes, genomics, manipulation of DNA with restriction enzymes, recombinant DNA technology and genetic engineering.

Unit 3: **Disciplines of Biotechnology**: Role of enzymes in biotechnology, Proteins as products, industrial biotechnology, microbial, plant and animal biotechnology; medical biotechnology and biomedical engineering, agricultural and food, aquatic and environmental biotechnology, case studies. **Topics**: model organisms used in research, GMOs, Bioremediation, biofilms, biosensors and diagnostics, vaccines, biosimilars, DNA fingerprinting and forensic analysis, bioenergy, synthetic biology, biostatistics, bioanalytics, QA/QC, bioreactor, cell culture, bioartificial organs, bioelectricity, bio design, biomimetics

Unit 4: **Current Biotechnology, status, future and scope:** Bioinformatics: history and role in biotechnology, Biosafety and bioethics, IPR, regulatory biotechnology, scope of biotechnology (bio innovation, technology development, commercialization, bio entrepreneurship, careers), biotechnology for economic development, Biotech R&D, status of biotechnology in world and Indian scenario, future prospects. **Topics**: patents, AI, ML, NN, IOT, Big Data, data analytics, omics driven biotechnology

Textbook (s):

1. Introduction to Biotechnology, Ashim K. Chakravarty, Oxford University Press; 1st edition

Reference Book(s):

1. A Textbook of Biotechnology, S Chand; Fifth edition
2. Biotechnology, U Satyanarayana Books & Allied Ltd
3. Textbook of Biotechnology by H.K. Das (Author) Wiley; Fifth edition
4. Introduction to biotechnology, William J Thieman and Micheal A, Palladino, 3rd edition, Pearson

EE 1003 Basic Electrical Engineering

Course code	EE 1003
Course title	Basic Electrical Engineering
Number of credits	3 (L: 3, T: 0, P: 0)
Course category	ESC
Continuous Assessment (C.A.)	50
End Semester Assessment (E.S.A.)	50
Prerequisite	Nil

Course description:

This course depicts on generating stations (Thermal, Hydro, Nuclear and Solar Photovoltaic Stations), transmission of powers (overhead transmission lines and underground cable); distribution system (AC and DC), types of wiring, types of batteries, safety measures, necessity of earthing and fuse. The basic concepts of DC and AC (Single Phase and Three Phase Circuits) network analysis, DC transients, AC networks (1-Phse and 3-Phase), AC series circuit resonance and magnetic circuits. This course will also cover single-phase transformers, three Phase Induction machines, measuring Instruments and illumination.

Course Outcomes:

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

CO1: explore the electric supply systems, safety measures and illumination
CO2: solve the different parameters in the DC circuits
CO3: solve the different quantities of 1-Phase and 3-Phase AC circuits
CO4: interpret the behavior of magnetic circuits
CO5: illustrate the application of transformer and induction motors
CO6: demonstrate electrical instruments for measurement

Course Contents:

Unit-1: Introduction to Electrical Energy: Electrical Energy Scenario in India, Power System Layout. Comparison: overhead transmission lines and underground cable; generating stations (Thermal, Hydro, Nuclear and Solar PV Stations), AC and DC distribution system. Safety measures in electrical system, Components of LT Switch gear: Switch Fuse Unit (SFU), MCB, ELCB, MCCB, Types of Wiring, Types of Batteries, necessity of earthing and fuse.

Unit-2: DC Circuits: Basic terminology- circuit, network, mesh, loop, node, junction, active element, passive element, lumped network, distributed network, bilateral element and unilateral element, linear and nonlinear network, Kirchhoff's law. Star-delta transformation, Mesh analysis, Nodal analysis, Superposition theorem, Thevenin's theorem, Norton's theorem, DC transients (RL series circuits), DC transients (RC series charging circuit), DC transients (RC series Discharging circuit) (with numerical problems).

Unit-3: AC Circuits: Basic Terminology: Amplitude, Time period, +Frequency, phase, Phase difference, average value, RMS Value, Form Factor, Peak Factor. Problems on Basic Terminology of AC Circuits. Phasor representation of alternating quantities, Phasor Algebra. Behavior of R, L, C in AC circuit, AC Series RL, RC circuit, AC Series RLC Circuit, Parallel AC Circuit (with numerical problems). Three phase AC circuits: voltage and current relationship star and delta connections along with phasor diagram. Problems on star and delta connection. Measurement of power and power factor by two watt meter method (with numerical problems).

Unit-4: Magnetic Circuits: Basic Terminology: Magnetic field, Magnetizing Force, Magnetic Flux density, Magnetic permeability, MMF, Reluctance, Permeance, Analogy between Electric Circuits and Magnetic Circuits. Faraday's laws of Electromagnetic Induction, Self and Mutual inductance Analysis of series magnetic Circuit, simple problems. B-H curve, hysteresis and eddy current loss.

Unit-5: Measuring Instruments and Illumination: Principle and Construction of Moving coil instruments(PMMC), Principle and Construction of Moving Iron Instruments (Attraction and Repulsion type). Extension of range of Ammeters and Voltmeters, simple problems. Dynamometer type wattmeter,1 phase Induction type energy meter, Basic Terminology: luminous flux, luminous intensity, lumen, candela power, brightness. Construction and working of Different lamps: Fluorescent Lamp, Compact Florescent Light (CFL), Light Emitting Diode (LED).

Textbook(s):

1. Basic Electrical Engineering by D.C. Kulshreshtha, Tata Mcgraw publication, 1st Edition 2011.
2. Basic Electrical Engineering, T.K. Nagasarkar and M.S. Sukhija, Oxford University press, 3rd Edition 2017.

Reference Book(s):

1. Basics Electrical Engineering Sanjeev Sharma, I.K.International, New Delhi (Third Reprint 2010).
2. Principles of Electrical Engineering and Electronics- V K Mehta, Rohit Mehta, S Chand and Company, New Delhi (Revised Edition 2013).

PH 1097 Physics Lab

Course code	PH 1097
Course title	Physics Lab
Number of credits	1.5 (L: 0, T: 0, P: 3)
Course category	BSC
Continuous Assessment (C.A.)	50
End Semester Assessment (E.S.A.)	50
Prerequisite	Nil

Course Description:

This lab course covers different measurement techniques of various parameters using the instruments i.e., interferometer, spectrometer, spherometer, Screw gauge, vernier calliper, microscope, and telescope. It includes the application of photoelectric effect and photovoltaic effect in photocell and solar cell respectively. Evaluation of the mechanical strength of materials by calculating elastic constants such as Young's modulus, rigidity modulus and Poisson's ratio are also included. This course provides hands on training for the usage of electrical, optical and mechanical systems for various measurements with precision and analysis of the experimental data by graphical interpretation and error calculation.

Course Outcomes:

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

CO1: calculate appropriate structural members using the fundamental concepts of the elastic behavior of materials

CO2: use the principles of interference and diffraction to find out the wavelength of an unknown monochromatic source of light

CO3: apply the concept of photoelectric emission to calculate the Planck's constant and analyze some aspects of electron-photon interaction through characteristic curves

CO4: explore the efficiency in terms of power output of a green energy source i.e. solar cell

CO5: calculate the acceleration due to gravity 'g' by using the concept of a compound pendulum

Laboratory Experiments:

1. Estimation of elastic constants such as Young's modulus, rigidity modulus and Poisson's ratio
2. Determination of wavelength of unknown source using Newton's rings and Michelson's interferometer
3. Precision length measurement up to the order of 6 A° (distance between sodium D-lines) using Michelson interferometer
4. Determination of grating element using a diffraction grating
5. Study of photo cell and solar cell by analyzing their characteristic curves
6. Determination of acceleration due to gravity using a bar pendulum

BT1097 Biology Lab

Course code	BT 1097
Course title	Biology Lab
Number of credits	1 (L: 0, T: 0, P: 2)
Course category	BS
Continuous Assessment (C.A.)	50
End Semester Assessment (E.S.A.)	50
Prerequisite	Nil

Course Description:

Laboratory course in biology is intended for undergraduates to expose them to the process of scientific methods, examination of cellular processes (eg. respiration, photosynthesis, mitosis, meiosis), operation of basic laboratory equipment, taxonomic classification, and investigations of structure and function of prokaryotes, protists, fungi, plants, and animals using drawing hypothesis, experimental design, observation, and data interpretation.

Course Outcomes:

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

CO1: Understand the basics of a biology lab including do's and don'ts, good lab practices and safety measures

CO2: Recognize the various equipment and their working principle and increase the knowledge on the ability to use basic techniques in several areas of biology.

CO3: Learn the preparation, formulation and mathematical calculations for the preparation of reagents, buffers and solutions for experimental use and standard curve analysis.

CO4: Demonstrate and distinguish an understanding of the organismal form, function and diversity of plants, animals and microbes.

CO5: Demonstrate the ability to perform appropriate qualitative and quantitative analysis of experimental data and draw valid conclusions from their analyses.

CO6: Identify and apply the scientific methods, drawing testable hypotheses from observations and interpreting data

Laboratory Experiments:

1. Good laboratory practices and safety.
2. Study the different parts and use of Microscopes, micropipettes and other laboratory instruments.
3. Calculation of molarity, normality, concentration and molality.
4. Study of plasmolysis using onion (*Allium cepa*) epidermal cells / *Rhoeo discolour* plant leaf / *Tradescantia discolour* plant leaf.
5. Preparation of buffers of desired strength and pH from the required acid and base components and measurement of the pH of the prepared buffer and measure pH of a cell extract or tissue extract.

6. Determination of the standard curve for protein and estimation of protein from plant/animal extract samples by Biuret method or Folin-phenol reagent.
7. Gram staining and its visualization under microscopes of gram-positive and gram-negative bacteria.
8. To stain fungal cells by using lactophenol cotton blue (LPCB)
9. To test the presence of cellulose in plant material by the chloro-zinc iodine test.
10. Identification of glucose/sucrose/starch present in the supplied samples.
11. Measurement of total hardness in supplied water samples by soda reagent method.
12. Measurement of water quality based on total suspended solids (TSS), total dissolved solids (TDS) and total solids (TS) of given water samples.
13. Study the plant diversity and evolution through slides and photographs: Algae, Bryophyta, Pteridophytes, Gymnosperms, etc.

EE 1093 Basic Electrical Engineering Lab

Course code	EE 1093
Course title	Basic Electrical Engineering Lab
Number of credits	1 (L: 0, T: 0, P: 2)
Course category	ESC
Continuous Assessment (C.A.)	50
End Semester Assessment (E.S.A.)	50
Prerequisite	Nil

Course Description:

Basic Electrical Engineering lab comprises of various equipment and loads i.e voltmeters, ammeters, wattmeters, single phase and three phase transformer, induction motors etc. It is a specialized practical oriented course which intends to develop and understand various principles like Ohm's law and Kirchoff's law. The course focused on learning methodical and logical idealization of various theorems which is highly essential for solving a network. The course intends to make the students familiar with various parts of DC machines and AC machines. The course intends to develop the ability of problem solving by analyzing RL and RLC series circuits. This lab helps the students to understand the principle of operation of a single phase transformer with its no load calculation.

Course Outcomes:

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

CO1: recall the safety practices in the laboratory and the associated work areas

CO2: comprehend the skills for working in a team with common objective

CO3: apply different theorems to find the parameters in DC and AC circuit

CO4: analyse the different parts of DC and AC machines to describe operational features thereof

CO5: apprise the experimental results in systematic manner

CO6: discuss about determination of resistance in incandescent lamp and power factor in

fluorescent lamp

Laboratory Experiments:

1. Measurement of resistance of tungsten filament lamp
2. Measurement of inductance of a choke coil
3. Study and use of megger
4. Study of different parts of dc machine and three phase induction motor
5. Layout of power system analysis
6. Determination of voltage ratio of a single phase transformer
7. Measurement of no load current and core loss of a single phase transformer
8. Verification of KCL and KVL
9. Verification of voltage and current ratio of star and delta connection
10. Study & determine the power factor of the RLC series circuit
11. Study, connection & determine the power factor of fluorescent tube
12. Verification of the superposition theorem
13. Transient analysis of series RL and RC circuit using matlab-simulink with dc excitation

Textbook(s):

1. Basic Electrical Engineering by D.C. Kulshreshtha, Tata Mcgraw publication, 1st Edition 2011.
2. Basic Electrical Engineering, T.K. Nagasarkar and M.S. Sukhija, Oxford University press, 2nd Edition 2011.

Reference Book(s):

1. Basics Electrical Engineering Sanjeev Sharma, I.K. International, New Delhi.(Third Reprint 2010).
2. Principles of Electrical Engineering and Electronics- V K Mehta, Rohit Mehta,S Chand and Company,New Delhi (Revised Edition 2013)
3. Basic Electrical Engineering Abhijit Chakrabarti,Sudip Nath,Chandan Kumar Chnada,Tata McGraw Hill Publishing Limited,New Delhi,2007

CE 1083 Engineering Graphics

Course code	CE 1083
Course title	Engineering Graphics
Number of credits	2 (L: 0, T: 1, P: 2)
Course category	ESC
Continuous Assessment (C.A.)	100
End Semester Assessment (E.S.A.)	0
Prerequisite	Nil

Course Description:

The course of Engineering Graphics comprises of basics of drafting, projection of points & lines, line inclined to both the planes, projection of planes, Computer Aided Drafting, projection of solids and development of surfaces.

Course Outcomes:

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

CO1: use common drafting tools properly

CO2: select, construct and interpret appropriate drawing scale as per the situation

CO3: draw orthographic projections of points, lines and planes

CO4: draw orthographic projection of solids like cylinders, cones, prisms and pyramids including sections

CO5: develop the sections of solids for practical situations

CO6: communicate ideas effectively using Computer Aided Drafting

Topics:

1. Introduction to Engineering graphics
2. Lettering
3. Projection of points & lines
4. Line inclined to both the planes
5. Projection of planes
6. Introduction to Computer Aided Drafting
7. Projection of solids
8. Section of solids
9. Development of surface

Textbook(s):

1. Engineering Drawing + AutoCAD by K. Venugopal, New Age Publishers, 1st edition, 2011

Reference Book(s):

1. Engineering Drawing with an Introduction to AutoCAD by S. N. Lal, Cengage India Private Limited, 1st edition, 2017

YG 1081 Yoga and Human Consciousness

Course code	YG 1081
Course title	Yoga and Human Consciousness
Number of credits	1 (L: 1, T: 0, P: 1)
Course category	AU
Continuous Assessment (C.A.)	100
End Semester Assessment (E.S.A.)	0
Prerequisite	Nil

Course content:

Unit-1: Concept and significance of consciousness , Mideron and ancient approach of consciousness, Types of consciousness viz., Jagrata, Svapna, susupti and. Turya, Turiyatita - beyond our consciousness and comprehension

Unit -2: Preparatory practices, Breathing practices, Suksma and Sthoola vyayma

Unit-3: Dharana practices, Principles and procedure of Antaranga & Bahranga trataka, Jatru trataka & Jyoti trataka Principles and practices of Ajappa japa, antarmouna, Chakra meditation, Cyclic meditation, Taichi and meditation

Unit-4: Concept and practice of dhyana, Concept of Jyoti and Bindu dhyana, principle and procedure of Vipassana meditation, Preksha meditation, Transcendental meditation, Brahma kumari Raja yoga meditation, Yoga nidra

This course is a Sessional in the Course structure namely YOGA AND HUMAN CONSCIOUSNESS. The course will have a separate evaluation pattern. It will consist of yogic practices and assignments with continuous Evaluation throughout the semester with no End semester examination.

MA 0001 Mathematics Bridge Course

Course code	MA 0001
Course title	Mathematics Bridge Course
Number of credits	0 (L: 1, T: 0, P: 0)
Course category	BSC
Continuous Assessment (C.A.)	P/NP
End Semester Assessment (E.S.A.)	0
Prerequisite	Nil

Course content:

Unit-1: Sets; Sets and their representation, Subset, Universal set, complement of set, Cardinality of a set, Set operations (union, intersections, difference), Cartesian product, relations, Functions, Types of function

Unit-2: Matrices and Determinants; Matrices, algebra of matrices, types of matrices, Evaluation of determinants, Adjoint and evaluation of inverse of a square matrix using determinants, Test of consistency and solution of simultaneous linear equations in two or three variables using determinants and matrices.

Unit-3: Permutations and combinations; Fundamental principle of counting, Permutation as an arrangement and combination as selection, Meaning of P (n, r) and C (n, r), Simple applications. Binomial Theorem

Unit-4: Co-ordinate Geometry; Cartesian system of rectangular co-ordinates in a plane, Distance formula, Section formula, Slope of a line, Parallel and perpendicular lines, Intercepts of a line on the coordinate axes, Locus and its equation, Straight lines, Circles.

Unit-5: Trigonometry; Trigonometric identities and standard trigonometric formulae, Inverse trigonometric functions and their properties,

Unit-6: Differentiability: Derivatives, its geometrical and physical meaning. Differentiation of the sum, difference, product and quotient of two functions, Differentiation of trigonometric, inverse trigonometric, logarithmic, exponential, parametric, composite and implicit functions; derivatives of order upto two

Unit-7: Integral Calculus; Integral as an anti-derivative, Fundamental integrals involving algebraic, trigonometric, exponential and logarithmic functions, Integration by substitution, by parts and by partial fractions, Evaluation of definite integrals

Unit-8: Vector; Vector and scalars, types of vectors, position vector of a point, addition of vectors, position vector of a point dividing a line segment in a given ratio. Scalar (dot) product of vectors, vector (cross) product of vectors, projection of a vector on a line, Scalar triple product.

Unit-9: 3-D; Co-ordinate axes and co-ordinate planes, Co-ordinate of a point, Distance between two points, Division formula, Direction cosine and direction ratios, Projection, plane, Equation of plane, Equation of line.

Reference Book(s):

1. A Textbook of Mathematics (For class-XI and class-XII) by Mahadevaiah, Seethalakshmi & Nagaraja, Published by Cengage Learning.
2. A Textbook of Mathematics (For class-XI and class-XII) by G.K. Ranganath, Published by Himalaya Publishing House.
3. S. Chand’s Mathematics (For class-XI and class-XII) by H. K. Das & R. Verma, Published by S. Chand.

Semester-II

MA 1004 Mathematics-II

Course code	MA 1004
Course title	Mathematics-II
Number of credits	4 (L: 3, T: 1, P: 0)
Course category	BSC
Continuous Assessment (C.A.)	50
End Semester Assessment (E.S.A.)	50
Prerequisite	Nil

Course Description:

The course is to familiarize the students with series solutions of ODEs, Laplace Transforms, Fourier series, vector calculus, and numerical integration. For the ODEs with variable coefficients, the situation is more complicated to get their solutions in elementary functions. Legendre and Bessel's equations are important ODEs of this kind and their solutions, the Legendre polynomials and Bessel functions play an important role in engineering applications. Laplace transforms can be used as a mathematical toolbox for engineers to solve linear ODEs and related initial value problems. The Fourier series and vector calculus play a very important role in many engineering areas such as solid mechanics, aerodynamics, fluid flow, heat flow, quantum physics. The applied mathematician, engineer, physicist, or scientist must become familiar with the essentials of numerics and its ideas, such as interpolation and numerical integration.

Course Outcomes:

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

CO1: Know the concept of power series and solution of ODEs by using power series method.

CO2: Use the knowledge of power series solutions to a special type of ODEs such as Legendre and Bessel's equations.

CO3: Apply the Laplace transform to solve IVPs.

CO4: Know the periodic and non-periodic functions and the concept of finding Fourier series.

CO5: Apply fundamental concepts of vector differential and integral calculus in real-life problems by the applications of Green's theorem, Gauss Divergence theorem & Stoke's theorem.

CO6: Use numerical techniques in interpolation and evaluation of the definite integral.

Course contents

Unit-1: Series Solution of Differential Equations: Power series method, Legendre's equations, Legendre's polynomial and its properties, Frobenious method, Special functions: Gamma function, Beta function; Bessel's equations, Bessel's function and its properties.

Unit-2: Laplace Transforms: Laplace Transform, Inverse Laplace Transform, Linearity, transform of derivatives and Integrals, Unit Step function, Dirac delta function, Second Shifting theorem, Differentiation and Integration of Transforms, Convolution, Solution of ODEs and Integral Equation by Laplace transform.

Unit-3: Fourier series: Periodic functions, Even and Odd functions, Fourier series, Half Range Expansion.

Unit-4: Vector Calculus: Gradient of a scalar field, Directional derivative, Divergence and Curl of a vector field, Line integral, Double Integral, Green's theorem, Surface Integral, Triple Integral, Divergence Theorem for Gauss, Stokes's Theorem.

Unit-5: Interpolation and Numerical integration: Lagrange Interpolation, Newton's divided difference interpolation, Numerical integration by Trapezoidal rule and Simpson's rule.

Textbook(s):

1. Advanced Engineering Mathematics by Erwin Kreyszig, Wiley, INC, 10^{th} Edition.

Reference Book(s):

1. Higher Engineering Mathematics, Grewal B.S., Khanna Publishers, 36th edition.
2. Introduction to engineering Mathematics, Dass H.K., S.Chand& Co Ltd, 11^{th}edition.
3. Higher Engineering Mathematics, Ramana B.V., TMH, 2007.
4. A course on ordinary & partial differential Equation, Sinha Roy and S Padhy, Kalyani Publication, 3rd edition.

CH 1007 Chemistry

Course code	CH 1007
Course title	Chemistry
Number of credits	3 (L: 3, T: 0, P: 0)
Course category	BSC
Continuous Assessment (C.A.)	50
End Semester Assessment (E.S.A.)	50
Prerequisite	Nil

Course Description:

The course is designed to enrich the students with basic concepts in Chemistry to strengthen their fundamentals which will support them for pursuing education and research in engineering. It will help them to develop the idea on feasibility and mechanism of different chemical processes, conceptualize alternative sources of energy, give an exposure for handling instrumental techniques to explore structure of organic molecules and an idea of different methods for synthesis of advanced materials.

Course Outcomes:

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

CO1: Rationalize bulk properties and processes using thermodynamic consideration and apply the knowledge to decide the feasibility of a given process

CO2: Analyze the kinetics of simple and multistep reactions as well as theories of reaction rates

CO3: Evaluate some properties such as pH, solubility product etc. by using electrochemical cell and understand the working of modern batteries

CO4: Able to understand the mechanism of corrosion and its different controlling measures

CO5: Distinguish the different electromagnetic radiations used for exciting different molecular energy levels in various spectroscopic techniques to evaluate the structure of molecules

CO6: Get an exposure to different methods used for synthesis of nanostructured materials

Course Contents:

Unit-1: Thermodynamics & Equilibrium: Internal energy, enthalpy, entropy and free energy, dependence of free energy on temperature and pressure, Gibb's-Helmholtz equation, conditions of spontaneity and equilibrium, free energy change and equilibrium constant, van't Hoff isotherm and isochore, Clapeyron-Clausius equation, partial molar properties, Chemical potential, Gibb's-Duhem equation.

Unit-2: Chemical Kinetics: Rate of reaction and rate laws of multi- step reactions (steady state approximation), parallel, opposing and consecutive reactions, theory of reaction rate: Collision theory, Lindemann's modification, Absolute reaction rate; Catalysis: types, theories, kinetics of enzyme catalysis (Michaelis-Menten mechanism).

Unit-3: Spectroscopy: UV-Vis spectroscopy: Beer Lambert's law, Types of transition, Concept of auxochrome and chromophore, factors affecting and Woodward-Fieser rules for calculation of in diene systems; IR spectroscopy: types of vibration, Hooke's law, detection of functional groups like C=C, -OH, $-NH_2$ and -C=O; NMR spectroscopy: Basics of NMR spectroscopy: Theory, Chemical shift, Shielding-deshielding effect, structural elucidation of simple compounds.

Unit-4: Electrochemistry: Transport number, determination by Hittorf's method; Types of electrodes, Electrode/Cell potential; Nernst equation and applications to: find electrode and cell potential, equilibrium constant, solubility product and pH; Frost and predominance diagram; Modern batteries: Fuel cells (AFCs, PEMFs, SOFCs, MCFCs), Zn-air battery, Li- ion battery, Ni-MH battery; Corrosion: Mechanism of dry and wet corrosion, types of wet corrosion, prevention.

Unit-5: Chemistry of Nanomaterials: Classification of nanostructured materials; Synthesis of nano-materials: CVD, wet chemical synthesis, GPC, CVC and PLD; Applications.

Textbook(s):

1. Engineering Chemistry: Fundamentals and Applications- Shikha Agarwal, Cambridge University Press, 2016

Reference Book(s):

1. Textbook of Engineering Chemistry: Sashi Chawala, Dhanpat Rai and Co, 2016
2. Principles of Physical Chemistry- B.R. Puri, L.R Sharma, M.S. Pathania; 42nd Edition, Vishal Publishing Co.
3. Spectrometric Identification of Organic compaunds ,7th Edition -Robert M. Silverstein, Fransis, Webster, Dravid j. Kiemle; Jhon Wiley& Sons, INC.
4. Nanostructures &Nanomaterials: Synthesis, Properties and Applications- G. Cao and Y. Wang, World Scientific Pvt. Ltd.; 2nd Edition

HS 1005 Professional Communication

Course code	HS 1005
Course title	Professional Communication
Number of credits	2 (L: 2, T: 0, P: 0)
Course category	HS
Continuous Assessment (C.A.)	50
End Semester Assessment (E.S.A.)	50
Prerequisite	Nil

Course Description:

Professional Communication is more emphasized on enhancing the four LSRW skills like Listening, Speaking, Reading, and Writing in order to improve students' professional communication. It is basically designed to enhance speaking skills through pronunciation, stress, and tone. This course is prepared to improve reading skills through reading, comprehending, and retaining information. This course is basically expected to provide the learner with an approach to communicate using all the four skills

Course Outcomes:

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

CO1: Understand the communication process and practical implementations in the workplace
CO2: Apply verbal and non-verbal modes of communication effectively in practical situations
CO3: Apply effective conflict management strategies
CO4: Use English grammar correctly and unambiguously in technical writing
CO5: Bridge the gap between the native language and the target language i.e., English
CO6: Retain a logical flow while drafting reports and other technical pieces of writing

Course Contents:

Unit-1: Meaning & Definition, difference between general and technical communication; process, diagram of the process; methods (verbal & non-verbal), verbal communication (Oral & Written)-types & differences, Non-verbal- types (Kinesics, proxemics, haptics, chronemics, oculesics, olfactics, gustorics, sign language); paralanguage; flow of communication (formal & informal), grapevine communication; levels; barriers.
Unit-2: Basics of Grammar: Time & Tense, Subject-Verb Agreement, Analogy, Active & Passive Voice, Error Detection in Sentences.

Unit-3: Writing Skills: Paragraph Writing-Techniques & Skills, Use of Punctuation, Business Letter- Enquiry, Claim/ Complaint, Order.

Unit-4: Basic Sounds of English: Hearing & Listening, Introduction to Basic Sounds of IPA, Problem Sounds & MTI

Textbook(s):

1. Technical Communication Principles & Practices. Meenakshi Raman and Sangeeta Sharma OUP. Second Edition-2011

Reference Book(s):

1. A Communicative English Grammar. Geoffrey Leech and Jan Svartvik. Third Edition. Routledge Publication.New York.2013.
2. Effective Technical Communication. MAshraf Rizvi TMH 2005
3. The Oxford Grammar (English) Sidney Greenbaum, Oxford University Press India. 1st Edition. 2005
4. Verbal Ability and Reading Comprehension for the CAT. Arun Sharma and Meenakshi Upadhyay, TMH,New Delhi,2007
5. Better English Pronunciation, Cambridge University Press, J D O'Connor, 2nd Edition (Paper Back) 2013

BT 1014 Environmental Sciences

Course code	BT 1014
Course title	Environmental Sciences
Number of credits	2 (L: 2, T: 0, P: 0)
Course category	BSC
Continuous Assessment (C.A.)	50
End Semester Assessment (E.S.A.)	50
Prerequisite	Nil

Course Description:

The course provides comprehensive knowledge of environmental science, environmental issues and management. The course is designed to make the students aware of different environmental components, ecosystems, resources, biodiversity and their composition. It will make the students understand different pollutants, their sources and their management. It will also help students to apply the principles of Green Chemistry and implement them in the synthesis of advanced materials required for engineering and biotechnological applications. It also outlines the basic steps for developing the EIA statements

Course Outcomes:

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

CO1: Understand the different components and composition of the environment, ecosystems

CO2: Identify, Summarize and distinguish knowledge with respect to biodiversity and its conservation and natural resources

CO3: Rationalize the different pollutants, their sources, effects and control measures

CO4: Apply the systematic environmental impact assessment (EIA) requirements before the setup of any project

CO5: Understand and implement the principles of solid waste management

CO6: Conceptualize the principles of green chemistry, sustainability and implement them in solving environmental issues, so as to reduce the pollution

Course Contents:

Unit-1: Environment and Ecosystem Definition; multidisciplinary nature of environmental science, scope and importance; components of environment: biotic, abiotic. Ecosystem definition; structure and function; energy flow, food chain and food web; ecological pyramids, biogeochemical cycles (Carbon, Nitrogen and Phosphorus)

Unit-2: Natural Resources Definition, Resource, types, perpetual and non perpetual, renewable and non renewable, Fuel and Energy Resources, Wildlife resources, their exploitation and impacts on environment, mineral resources and reserves, water, energy, soil, exploitation, recycling.

Unit-3: Biodiversity and Conservation Introduction to genetic, species and ecosystem diversity; Agro-biodiversity, land races and genetic resources. Valuation of biodiversity; Threats to biodiversity: habitat loss, poaching, over-utilisation, invasive species. Endemic and threatened species.

Unit-4: Pollution and waste management Definition of pollution and pollutants; types of pollution - Air, water, soil, noise, thermal, nuclear; causes of pollution, effects of pollution and control measures; Bioremediation; Impact Assessment (EIA): Objectives, Principles & Process; Management plans using Geographic Information System (GIS) and Remote Sensing (RS) tools.

Unit-5: Current Environmental issues Introduction to Soil, water and climate change; soil and water quality deterioration, eutrophication, Global warming and greenhouses gases – Carbon dioxide, methane, nitrous oxide, ozone, vehicle emissions, industry; agricultural practices, deforestation. Industrial effluents and release of heavy metals and emerging contaminants etc. Ozone layer depletion: causes, impacts.

Unit-6: Environmental protection and management Sustainable Development; Green Chemistry approaches; Role of UNFCC (United Nation Framework Convention on Climate Change) in monitoring greenhouse gas emissions. International treaties: Kyoto protocol.

Textbook(s):

1. Kurian Joseph & R. Nagendran, "Essential of Environmental Studies" "Pearson Education

Reference Book(s):

1. Environmental Chemistry- S. Chakroborty, D. Dave, S.S. Katewa, Cengage Publishers
2. Environment Science and Engineering, Aloka Debi. Second Edition ;Universities Press
3. Text Book of Environment studies for under graduate courses, Erach Bharucha : 2nd Edition, Universities Press
4. Fundamentals of Environment and Ecology, D. De, D. De; 2013, S. Chand Group
5. Engineering Chemistry, Jain and Jain, Dhanpat Rai Publishing Company

BT 1016 Macromolecular Structure

Course code	BT 1016
Course title	Macromolecular Structure
Number of credits	2 (L: 2, T: 0, P: 0)
Course category	BS
Continuous Assessment (C.A.)	50
End Semester Assessment (E.S.A.)	50
Prerequisite	Nil

Course Description:

This course provides an understanding of the basic biochemical properties of molecules that make life possible. It introduces various fundamental biological molecules such as carbohydrates, proteins, lipids and nucleic acids. Key themes within this course include the basic nomenclature, classification, structure, functional groups, stereochemistry and biological functions of the important macromolecules and their monomers that make life possible.

Course Outcomes:

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

CO1: Identify and define different types of molecules that make life possible.

CO2: Describe the structure and chemistry of carbohydrates, amino acids and lipids.

CO3: Illustrate the structure and functional aspects of glycoconjugates.
CO5: Describe the structure and chemistry of nucleotides and nucleic acids.
CO4: Evaluate the three-dimensional structure of proteins and biological membranes.
CO6: Develop an understanding of the structural aspects of the biomolecules and correlate them to their functional characteristics.

Course content:

Unit-1: Foundation: Living organisms, prokaryotes and eukaryotes, chemical elements, carbon, small molecules and macromolecules, stereoisomers, chiral compounds. Weak interactions: ionic interactions, hydrogen bond, hydrophobic interactions, van der Waals interactions, hydrophilic, hydrophobic and amphipathic compounds.

Unit-2: Carbohydrates: Monosaccharides: Structure and properties, D and L sugars, anomers, reducing properties. Disaccharides: Glycosidic bond, structure, non-reducing sugars. Polysaccharides: Starch, glycogen, cellulose, chitin, glycosaminoglycans, proteoglycans, glycoproteins, and glycolipids.

Unit-3: Amino acids and proteins: Amino acids: Structure, optical activity, acid-base properties, titration curve. Protein primary structure: peptide bond, properties, torsion angles, Ramachandran plot. Protein secondary structure: α Helix and β Conformation, turns and loops. Protein tertiary and quaternary structure: Globular proteins: motifs, domains, monomeric and oligomeric proteins, Fibrous proteins - α Keratin, collagen and silk fibroin. Protein denaturation and renaturation.

Unit-4: Lipids: Fatty acids, nomenclature, saturated and unsaturated fatty acids, triacylglycerols, glycerophospholipids, sphingolipids and sterols. Biological membranes: membrane lipids, fluid mosaic model, membrane fluidity, factors affecting membrane fluidity, membrane proteins, membrane asymmetry. Water- and fat-soluble vitamins.

Unit-5: Nucleotides and nucleic acids: Purine and pyrimidine bases, nucleosides, nucleotides, phosphodiester bond. DNA: History, Chargaff rule, Watson–Crick Structure, ssDNA and dsDNA as genetic material, mutations and their significance. RNA: Types and structure, RNA as genetic material. Denaturation, hyperchromicity, renaturation.

Textbook(s):

1. Lehninger Principles of Biochemistry, eighth edition. Authors: Nelson DL and Cox MM. W. H. Freeman and company, 2021.
2. Biochemistry – The Molecular Basis of Life, sixth edition. Authors: McKee T and McKee JR. Oxford University Press, 2017.

Reference Book(s):

1. Biochemistry, fourth edition. Authors: Voet G & Voet JG, John Wiley and Sons, Inc. 2011.

2. Biochemistry, nineth edition. Authors: Berg JM, Tymoczko J, Gatto G, Stryer L. W. H. Freeman and Company, 2019.
3. Harper's Illustrated Biochemistry, thirty-first edition. Authors: Rodwell V, Bender D,Botham KM, Kennelly PJ, Weil PA. McGraw Hill Education - Lange Series, 2018.

CH 1097 Chemistry Lab

Course code	CH 1097
Course title	Chemistry Lab
Number of credits	1.5 (L: 0, T: 0, P: 3)
Course category	BS
Continuous Assessment (C.A.)	50
End Semester Assessment (E.S.A.)	50
Prerequisite	Nil

Course Description:

The Chemistry laboratory course is designed to develop basic concepts of quantitative analysis by using volumetric as well as instrumental methods. It includes classical titrations to estimate hardness, alkalinity, dissolved oxygen, ferrous ion content, chloride content in water/solution samples. It also gives hands-on training to use advanced titration techniques such as potentiometric, pH metric and conductometric titrations which can be used with turbid and coloured solutions in incredibly low concentrations. The course also gives exposure to the extensive use of UV-Vis spectroscopy for the estimation of different ions in the solution phase.

Course Outcomes:

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

CO1: Understand the significance of quantitative chemical analysis
CO2: Prepare solutions of different concentrations and do their standardization
CO3: Get exposure to different instrumental techniques such as Conductometry, pH-metre, Potentiometry and Colorimetry
CO4: Evaluate the rate constant of pseudo-first-order reactions
CO5: Analyse basic water quality parameters like hardness, dissolved oxygen, alkalinity, ferrous iron contents
CO6: Rationalize chemical handling and chemical safety in an advanced modern laboratory

Laboratory Experiments:

1. Estimation of dissolved oxygen in the water sample
2. Estimation of chloride in the water sample
3. Estimation of alkalinity/calcium in the water sample
4. To study the kinetics of ester hydrolysis
5. To study the solubility product of sparingly soluble salt
6. Estimation of hardness of water sample

7. (a) Standardisation of KMnO4, (b) Estimation of Iron (Fe2+)
8. Verification of Beer Lambert's Law
9. pH metric Titration
10. Conductometric Titration

CS 1093 Computer Programming Lab

Course code	CS 1093
Course title	Computer Programming Lab
Number of credits	4 (L: 0, T: 2, P: 4)
Course category	ESC
Continuous Assessment (C.A.)	50
End Semester Assessment (E.S.A.)	50
Prerequisite	Nil

Course Description:
The course aims to provide exposure to problem-solving through programming. It aims to train the student to the basic concepts of the C-programming language. This course involves lab component which is designed to give the student hands-on experience with the concepts.

Course Outcomes:
At the end of the course, the students will be able to:
CO1: have a fundamental knowledge of the basics of computers hardware and number systems with the concept on basics commands in Linux
CO2: write, compile and debug programs in C language
CO3: design programs involving decision structures, loops, and functions
CO4: understand the dynamics of memory by the use of pointers
CO5: use different data structures and create/update basic data files

Topics:

1. **Basic Linux commands:** Introduction to Linux, Directory Structure of Linux, and Basic Linux Commands
2. **Operators and Expressions:** Uses of operators for manipulating data and variables in mathematical or logical expressions, Arithmetic Operators, Relational Operators, Logical Operators, Assignment Operators, Increment and Decrement Operators, Conditional Operator, Bitwise Operators, Special Operators.
3. **Branching statements (if-else, switch):** Programs using C conditional statements such as if statement, if-else statement, Nested if-else statement, else if-statement, switch statement.
4. **Control statements (looping - for, while, do-while):** What is a loop? Solving Problems using different types of loops such as for loops, while loops, do-while loops
5. **Arrays:** Defining an array, initializing an array, Pictorial Representation of Array, Accessing Array Elements.

6. **Character Arrays (strings):** String declaration, String Initialization, Memory representation of String
7. **Functions:** Benefits of using the function, Types of functions (Built-in library functions and User Defined Functions), Parts of Function, Function Prototype, Function Definition, Calling a function, Programs using User Defined Functions
8. **Pointers and Dynamic Memory Allocation:** Pointer Definition, Benefits of using Pointer, How to Use Pointers, Programs using Dynamic memory allocation functions such as malloc function, calloc function, realloc function, free function
9. **Structures and Unions:** Defining a Structure, Accessing Structure Members, Defining a Union, Accessing Union Members
10. **File Handling:** File Operations, Steps for Processing a File, Handling files using file input/output functions

ME 1083 Basic Manufacturing Systems

Course code	ME 1083
Course title	Basic Manufacturing Systems
Number of credits	2 (L: 0, T: 1, P: 2)
Course category	ESC
Continuous Assessment (C.A.)	100
End Semester Assessment (E.S.A.)	0
Prerequisite	Nil

Course Description:
This laboratory practice is designed to impart students the basic knowledge on manufacturing or developing a given object irrespective of their branch of engineering. While furnishing the given object, students will familiar with various mechanical operations and the respective tools or machines. This course involves four different sections namely Fitting, Welding, Turning and Sheet metal which covers both conventional and advanced tools to provide students with updated manufacturing experience. Students are also advised with various safety precautions to be followed during a specific manufacturing practice. At the end, students will also gain knowledge on different advanced machines such as CNC and 3D printing.

Course Outcomes:
At the end of the course, the students will be able to:
CO1: practice different operations related to the fitting shop
CO2: use different welding tools to prepare a given type of joint
CO3: demonstrate various turning operations including taper turning and knurling using a conventional lathe machine
CO4: design a tray and prepare it using sheet metal equipment involving soldering
CO5: appraise different operations using a CNC machine
CO6: interpret different advanced machines such as 3D printing/additive manufacturing

Topics:

- Turning operations
- Sheet metal operations
- Fitting
- Welding

HS 1085 Language Lab

Course code	HS 1085
Course title	Language Lab
Number of credits	1 (L: 0, T: 0, P: 2)
Course category	HS
Continuous Assessment (C.A.)	100
End Semester Assessment (E.S.A.)	0
Prerequisite	Nil

Course Description:

Language Lab is more practical oriented which is designed with an objective to make the learner practice the skills which he/she has learnt in the theory i.e., Listening, Speaking, Reading, and Writing to improve their communication skills. It is basically designed to engage the students to learn to perform group activity or an individual activity. This course is prepared to improve listening reading, speaking, and writing skills. It is expected to orient the students with vocabulary, analogy, sentence completion and sentence correction.

Course Outcomes:

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

CO1: Use English grammar correctly and unambiguously in technical writing

CO2: Apply verbal and non-verbal modes of communication effectively in practical situations

CO3: Have a basic understanding of the communication process and to know the practical implementations in the workplace

CO4: Retain a logical flow while drafting reports and other technical pieces of writing

CO5: Develop competence in reading and comprehension

CO6: Be familiar with English pronunciation and use neutral accent successfully

Topics:

- Reading & Comprehension
- Skit/ Role-Play Practice
- Listening Comprehension
- Time & Tense
- Business Letter
- Business Report
- Subject-Verb Agreement

- Visual Elements in Writing:
- Gadget-Supported Textual Formatting
- Attendance + Lab Record Checking
- Viva Voce

Text books:

1. Technical Communication Principles & Practices.Meenakshi Raman and Sangeeta Sharma OUP. Second Edition-2011

Reference Book(s):

1. A Communicative English Grammar. Geoffrey Leech and Jan Svartvik. Third Edition. Routledge Publication. New York.2013.
2. Effective Technical Communication. M. Ashraf Rizvi TMH 2005
3. The Oxford Grammar (English) Sidney Greenbaum, Oxford University Press India. 1st Edition. 2005.
4. Verbal Ability and Reading Comprehension for the CAT. Arun Sharma and Meenakshi Upadhyay, TMH, New Delhi, 2007.

SEMESTER-III

BT 2011 Engineering Principles

Course code	BT 2011
Course title	Engineering Principles
Number of credits	3 (L: 2, T: 1, P: 0)
Course category	ESC
Continuous Assessment (C.A.)	50
End Semester Assessment (E.S.A.)	50
Prerequisite	MA 1003, PH 1007, MA 1004, CH 1007

Course Description:

The primary goal of this course is to provide bioprocess engineering ideas in a way that biotechnology graduates can understand. It aims to familiarise them with engineering principles and thinking styles. The course is organized around major engineering subdisciplines such as dimensional analysis, mass and energy balances, and physical and chemical system thermodynamics. Numerical problems demonstrate how the same fundamental engineering approach may be applied to a range of bioprocess industries.

Course Outcomes:

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

CO1: Define the unit and dimension analysis through some basic chemical/biochemical analysis. Define the basic stoichiometry analysis through some equations/reactions involved in chemical/biochemical processes.

CO2: Define and illustrate thermodynamic equilibrium state system, ideal and non-ideal relations.

CO3: Relate properties such as a change in enthalpy, entropy, free energy, heat and work requirement for any batch and flow process that happens in chemical industries.

CO4: Make use of thermodynamic relations to interpret the partial molar properties of pure gases and liquids and their mixtures.

CO5: Estimate the feasibilities of any reaction and determine the equilibrium rate constant for chemical reactions.

CO6: Able to relate the thermodynamics principles to examples in real problems.

Course Contents:

Unit-1: Introduction to Engineering Calculations: Concept of dimensions and system of units; Fundamental quantities, Derived units, Basic chemical calculations with unit analysis: Concept of mole, atomic weight and molecular weight; Concept of materials balance and energy balance

Unit-2: The chemical equation & stoichiometry, concept of limiting & excess reactants, conversion, degree of conversion, yield etc, Ideal gas laws, equation of state.

Unit-3: Definition and Basic Concepts - classical and statistical thermodynamics - Volumetric properties of pure fluids: PVT Relations - Ideal gas- Real gas- Law of corresponding states, First law of thermodynamics.

Unit-4: Second law of thermodynamics - change in internal energy - enthalpy - entropy calculation for process, Gibbs free energy- Helmholtz free energy- Maxwell's relations and applications, fugacity - activity of pure substances determination of fugacity of pure gases, solids and liquids, Mixture of pure fluids - Ideal solutions - Lewis Randal rule - Raoult's law - Henry's law; Gibbs- Duhem equation.

Textbook:

1. Textbook of Chemical Engineering Thermodynamics, second edition. Author: Narayanan KV. Prentice Hall India, New Delhi, 2012.

Reference Books:

1. Chemical Engineering Thermodynamics, second edition. Author: Ahuja P. PHI Learning Pvt. Ltd, New Delhi, 2012.
2. Bioprocess. Engineering, second edition. Author: Pauline MD. Elsevier, 2012.
3. Introduction to Chemical Engineering Thermodynamics. Author: Smith JM, Van Ness HC, Abbott MM. McGraw-Hill New York, 2018.

BT 2013 Biochemistry

Course code	BT 2013
Course title	Biochemistry
Number of credits	3 (L: 2, T: 1, P: 0)
Course category	BS
Continuous Assessment (C.A.)	50
End Semester Assessment (E.S.A.)	50
Prerequisite	BT 1016

Course Description:

Biochemistry involves the study of the structure and functions of biomolecules and the vital processes that occur in living organisms. The structure and functions of major biomolecules are covered in BT1016. This course primarily focuses on the major integrated pathways of intermediary metabolism by which the cells synthesize and degrade carbohydrates, lipids, amino acids and nucleotides. This course describes the reactions that constitute these pathways along with the processes by which the organisms derive energy from the oxidation of nutrients and utilize the energy to build up the cellular components. This course also covers the regulation and integration of metabolic pathways as well as the major inborn errors of metabolism.

Course Outcome:

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

CO1: Identify the major catabolic and anabolic pathways of carbohydrates, lipids, amino acids and nucleotides.
CO2: Describe the basic mechanism, kinetics and regulation of enzymes.
CO3: Relate the energetic relationships and the mechanism of ATP synthesis with the catabolism.
CO4: Analyse the key regulatory points including the hormonal signalling in metabolic pathways.
CO5: Analyse the biochemical basis of major inborn errors of metabolism.
CO6: Evaluate the key metabolic interrelationships among the brain, adipose tissue, muscle, liver, and kidney.

Course Contents:

Unit-1: Foundation: Bioenergetics and metabolism: Redox reactions, phosphate compounds and phosphoryl-transfer reactions, ATP and its turnover, phosphocreatine. Enzymes: structure, cofactors, active site, specificity, kinetics of chemical and enzyme-catalyzed reaction, Michaelis-Menten equations, K_m, turnover number, Lineweaver-Burk plot, allosteric enzymes, metabolic regulation, and control by allosteric and covalent modification.

Unit-2: Carbohydrate metabolism: Dietary carbohydrates, glycolysis and its regulation, ethanol and lactic acid fermentation, glycogen synthesis, breakdown and its regulation, glycogen storage diseases, gluconeogenesis and its regulation, Cori cycle, citric acid cycle, it's regulation and anaplerotic reactions, pentose-phosphate pathway, glucose-6-phosphate dehydrogenase deficiency.

Unit-3: Oxidative phosphorylation: Mitochondrial transport systems, malate-aspartate and glycerophosphate shuttle, electron transport chain, chemiosmotic hypothesis, mechanism of ATP synthesis, inhibitors of oxidative phosphorylation, P/O ratio, uncouplers and non-shivering thermogenesis.

Unit-4: Lipid metabolism: Dietary lipids, lipoproteins, mobilization of stored triacylglycerols, carnitine shuttle, mitochondrial β-oxidation of saturated and unsaturated fatty acids, Acyl-CoA dehydrogenase deficiency, peroxisomal β-oxidation, ketone bodies and their over-production, biosynthesis of fatty acids, elongation and desaturation of fatty acids, regulation of fatty acid metabolism.

Unit-5: Amino acid metabolism: Dietary proteins, transamination, glucose-alanine cycle, oxidative deamination, urea cycle and its regulation, hyperammonaemia, breakdown of amino acids, glucogenic and ketogenic amino acids, Phenylketonuria, maple syrup urine disease, nitrogen cycle and nitrogen fixation, biosynthesis of non-essential amino acids.

Unit-6: Nucleotide metabolism: *De novo* synthesis of purine and pyrimidine ribonucleotides, synthesis of NTPs, salvage reactions, Lesch–Nyhan syndrome, orotic aciduria, synthesis of dNTPs and TTP, nucleotide biosynthesis as a target for cancer therapy, catabolism of purine

and pyrimidine nucleotides, gout. Prospects in biotechnology: metabolic engineering and manipulation of metabolic pathways in synthetic biology.

Textbook:

1. Lehninger Principles of Biochemistry, eighth edition. Authors: Nelson DL and Cox MM. W. H. Freeman and company, 2021.
2. Biochemistry – The Molecular Basis of Life, sixth edition. Authors: McKee T and McKee JR. Oxford University Press, 2019.

Reference Books:

1. Biochemistry, fourth edition. Authors: Voet G & Voet JG, John Wiley and Sons, Inc. 2011.
2. Biochemistry, ninth edition. Authors: Berg JM, Tymoczko J, Gatto G, Stryer L. W. H. Freeman and Company, 2019.
3. Harper's Illustrated Biochemistry, thirty-first edition. Authors: Rodwell V, Bender D, Botham KM, Kennelly PJ, Weil PA. McGraw Hill Education - Lange Series, 2018.

BT 2015 Microbiology

Course code	BT 2015
Course title	Microbiology
Number of credits	3 (L: 2, T: 1, P: 0)
Course category	BS
Continuous Assessment (C.A.)	50
End Semester Assessment (E.S.A.)	50
Prerequisite	Nil

Course Description:

It is intended to impart basic undergraduate-level knowledge in the area of general microbiology. The course will give detailed insights into five major themes: Structure and function of microbes (cellular structures, metabolism, and growth); microbial molecular genetics, microbial ecology, microbial diversity (prokaryotes, eukaryotes, viruses) and interactions, clinical microbiology (epidemiology, control of microbes, and diseases) and applications in Food and Industrial Microbiology.

Course Outcomes:

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

CO1: Understand and explain about microbial origin, evolution, taxonomy and identify, recognize and distinguish the diversity and types of microbes in the environment.

CO2: Understand and describe various tools/methods to classify and to study the growth physiology, and distinguish between nutritional and metabolic types of microorganisms.

CO3: Learn and understand microbial genetics and comprehend the differences at the molecular level.

CO4: Remember, understand and describe the role of microbes in natural environments and their influence in our daily lives as part of the food, soil, and air environment.

CO5: Understand and explain varied inter or intra-community microbial interactions and their contribution to disease development

CO6: Develop and Apply basic concepts about control of pathogenic microbes using antimicrobial and chemotherapeutic agents, antibiotic sensitivity and resistance and biofilms to applications in food and industrial microbiology.

Course Contents:

Unit-1: Introduction to Microbiology (History and Scope- Role of Microbes in agriculture, public health, medicine and industry). Organization of Prokaryotic and Eukaryotic Cell Structure and Function. Diversity of the Microbial World- (Microbial Evolution, Taxonomy, Diversity). Bacteria, Archaea, Algae, Fungi and Viruses (bacteriophages, lytic and lysogenic)

Unit-2: Microbial Nutrition and Growth (Types of growth media, growth phases, culture methods, mathematical expression of growth (generation time, growth rate), measurement of microbial growth). Microbial Metabolism (Aerobic & anaerobic respiration, fermentation, Entner Doudoroff pathway, chemolithotrophy, photosynthesis).

Unit-3: Microbial genome, microbial genetics, transformation, conjugation and transduction. Microbial Ecology (Microbes from Marine, Freshwater and Terrestrial Environments), Microbial Interactions (Symbiotic, non-symbiotic, positive, negative and neutral).

Unit-4: Micro-organisms and disease: Pathogenic Microbes (bacteria, fungi and viruses). Control of microbial growth – (Effect of heat, Sterilization, disinfectants, Chemotherapeutic agents): features, determination and efficacy of antimicrobial activity, anti-microbial sensitivity and resistance, drug-resistance mechanisms. Biofilms (Quorum sensing).

Unit-5: Applications in Food and Industrial Microbiology: Importance, industrial fermentation, enzymes, fermented foods, biopolymers, SCP, biomass, bioenergy, vitamins, probiotics, antibiotics, vaccines, biofertilizers and biopesticides, waste treatment.

Textbook:

1. Prescott's microbiology, eleventh edition, Authors: Willey J, Sherwood K and Woolverton D. McGraw-Hill Education, 2012.

Reference Books:

1. Brock biology of microorganisms, 14th edition, Authors: Madigan MT, Martinko JM, Stahl KS, Buckley DA. Pearson Education, 2017.
2. Environmental Microbiology, third edition, Authors: Pepper I L, Gerba CP and Gentry TJ. Elsevier, 2014.
3. Brock biology of microorganisms, microbiology, Fourteenth edition. Authors: Madigan MT, Martinko JM, Bender KS, Buckley DH, Stahl DA. Pearson Education, 2017.

BT 2017 Cell Biology and Genetics

Course code	BT 2017
Course title	Cell Biology and Genetics
Number of credits	3 (L: 2, T: 1, P: 0)
Course category	BS
Continuous Assessment (C.A.)	50
End Semester Assessment (E.S.A.)	50
Prerequisite	Nil

Course Description:

The focus of Cell Biology is the study of the structure and function of cells while Genetics focuses on understanding inheritance and genetic disorders. In this course, we will focus on prokaryotic and eukaryotic cell biology and will cover topics such as cell organelles, membrane structure and composition, transport, and trafficking; the cytoskeleton and cell-to-cell communication. We will also cover important cellular processes such as cell division and cell cycle. The course is also aimed to teach the fundamentals of genes and their inheritance and it will also relate to various genetic disorders.

Course Outcome:

Upon completion of this course, the student will be able to:

CO1: Describe the fundamental principles of genetics and the organization of eukaryotic and prokaryotic cells.

CO2: Develop a deeper understanding of the cell-cell signaling mechanisms and the transport of molecules across the membranes.

CO3: Understand the molecular mechanisms of fundamental cellular processes such as cell division, apoptosis, autophagy and necrosis.

CO4: Demonstrate the principles of chromosomes, heredity, population genetics and connect these to inherited disorders.

CO5: Apply cell biology and genetics principles to current biological questions related to the deregulation of biological processes.

CO6: Evaluate and innovate strategy to study cell biology- and genetics-related questions, analyze the related data, records, reports, etc.

Course Contents:

Unit-1: Basics of cell structure & function: Structure & function of different cell components: Cell membrane, intracellular organelles Cilia & Flagella. Cytoskeletal elements: structure & functions of microtubules, microfilaments, intermediate filaments.

Unit-2: Transport processes and cell-to-cell communication: Membrane Transport: Active and Passive transport: Simple Diffusion. Osmosis. Facilitated Diffusion, Transporters and channels (ATPase, ABC transporters, Na^+, K^+ Pump), Nucleo-cytoplasmic shuttle, Transport into mitochondria and chloroplast, Vesicular transport. Cell signaling and signal transduction: Cell-surface receptors (G-protein coupled receptor, ion-channel receptors, Tyrosine kinase linked receptors, Receptors with intrinsic enzyme activity (RTK), Second messengers and their role in signal transduction (Cyclic-AMP, Phosphatidyl inositol derived second messenger, IP3 and Calcium)

Unit-3: Cell Cycle, Cell Division, Cell Death, Cell Renewal: Cell cycle and its regulation, Cell cycle check points, G_0-G_1 transition, Mitosis and Meiosis. Apoptosis, Necrosis Autophagy, Stem cells.

Unit-4: Heredity & Genetics: Mendelian Laws of inheritance, monohybrid and dihybrid inheritance, law of segregation & independent assortment, Gene interactions, supplementary genes - Comb patterns in fowls, Complementary genes - Flower color in sweet peas, Epistasis-Inhibitory and coloured genes in fowls, simple problems. Multiple alleles and groups antigens. Numerical based on concepts.

Unit-5: Chromosomes & Population Genetics: Chromosome, Centrosome, telomere, Polytene and lamp-brush chromosomes, human chromosomes, karyotypes. Gene frequency, and equilibrium estimation, changes in gene frequency, Hardy Weinberg Law; Numericals. Linkage, Linkage maps, crossing over.

Unit-6: Sex-linked inheritance & inherited disorders: Sex determination in plants, animals XX-XY, XX-XO, ZW-ZZ, ZO-ZZ types in animals. Chromosomal disorders: Sex-linked diseases, haemoglobinopathies. Disorders of coagulation, Colour blindness.

Textbook:

1. Cell Biology Genetics Molecular Biology Evolution and Ecology, First edition. Authors: Verma PS, Agarwal VK. S.Chand Publication, 2022.
2. Karp's Cell Biology, seventh edition. Authors: by Karp G, Iwasa J and Marshall W. Wiley, 2018.
3. Principles of Genetics, eighth edition. Authors: Gardner EJ, Simmons MJ and Snustad DP. Wiley, 2016.

Reference Books:

1. Molecular cell biology, ninth edition. Authors: Lodish, Berk, Kaiser, Krieger, Bretscher, Ploegh, Amon and Martin. W H Freeman & Co, 2021.
2. Molecular biology of the cell, sixth edition. Authors: Alberts B, Johnson AD, Lewis J, Morgan D, Raff M, Roberts K, Walter P. W.W. Norton, 2014.
3. Genetics, third edition. Author: Strickberger MW. Pearson education India, 2015.
4. iGenetics A molecular approach, Third edition. Author: Russell PJ. Pearson education India, 2016.

5. Genetics essentials: concepts and connections, fifth edition. Author: Pierce BA. W H Freeman and Company, 2021.
6. Principles of genetics, 7th Edition. Authors: Snustad DP, Simmons MJ. Wiley, 2015.

BT 2019 Plant Physiology

Course code	BT 2019
Course title	Plant Physiology
Number of credits	2 (L: 2, T: 0, P: 0)
Course category	BS
Continuous Assessment (C.A.)	50
End Semester Assessment (E.S.A.)	50
Prerequisite	Nil

Course Description:

The goal of this course is to enhance the knowledge of students' understanding of basic concepts of the cellular function of plants. This course includes the basics of cellular content and organization of plant cells and tissues, water relations in whole plants and tissues, transport processes and photosynthetic mechanisms in plants. It will also demonstrate the role of different growth regulators and hormones in controlling various plant physiological processes. As a whole, this course will impart a basic understanding of the physiology and developmental biology of plants to the student, which will help them to understand plant biotechnology in their higher semester in a better way.

Course Outcome:

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

CO1: Explain the basic concept of plant cell structure and function.
CO2: Describe the physiological and molecular mechanisms of the transport of water and nutrients in plants.
CO3: Acquire and comprehend the basic concepts, principles, and biochemistry of different photosynthetic pathways.
CO4: Integrate the knowledge of nutrients and phytohormones in designing plant tissue culture experiments.
CO5: Analyse, evaluate and debate the importance of energy metabolism in plants.
CO6: Gain deeper insight into the plant physiological processes which will be used for the generation of improved varieties of plants using plant biotechnology tools and techniques.

Course Contents:

Unit-1: Plant cells, tissues, and organs; cell organelles and their physiological functions; Structure and physiological functions of cell walls; Growth and development in plants.

Unit-2: Transport in plants: Movement of water, gases and nutrients; Cell to cell transport- Diffusion, facilitated diffusion, active transport; Plant – water relations – Imbibition, water potential, osmosis, plasmolysis, Diffusion pressure deficit or suction pressure; Long-distance transport of water – Absorption, apoplast, symplast, transpiration pull, root pressure and guttation; Transpiration - Opening and closing of stomata, transpiration mechanism; Uptake and translocation of mineral nutrients, Transport of food.

Unit-3: Mineral nutrition: Essential minerals, macro and micronutrients and their role; Mineral deficiency and their symptoms; Mineral toxicity; Elementary idea of Hydroponics as a method to study mineral nutrition.

Unit-4: Energy processes: Photosynthesis and photosynthetic apparatus, photosynthetic pigments, Quantasomes, mechanism of photosynthesis and electron transport systems, Calvin cycle (C_3-Cycle), C_4-Dicarboxylic acid pathway, Crassulacean acid metabolism (CAM), Factors affecting photosynthesis.

Unit-5: Role of growth regulators in plants-auxin, gibberellin, cytokinin, ethylene, ABA; Seed dormancy and physiology of seed germination; Vernalization; Phytochromes- mode of action; photoperiodism- short day, long-day and day-neutral plants; photoperiodic induction; photoperiod and plant flowering.

Textbook:

1. Plant Physiology, fourth edition. Authors: by Taiz L, and Zeiger E. Sinauer Associates Inc.,U.S., 2006.

References:

1. Fundamentals of Plant Physiology, Author: Jain VK. S. Chand Publishing, 2017.
2. Plant Physiology, third edition. Authors: Salisbury F and Ross C. CBS Publishers, 2006.
3. A Textbook of Plant Physiology, Biochemistry, and Biotechnology. Authors: Varma SK and Varma M. S. Chand Publishing, 2017.

HS 2021 Principle of Economics

Course code	HS 2021
Course title	Principles of Economics
Number of credits	2 (L: 2, T: 0, P: 0)
Course category	HS
Continuous Assessment (C.A.)	50
End Semester Assessment (E.S.A.)	50
Prerequisite	Nil

Course Description:

This course aims at providing the student with advanced concepts of engineering economic analysis and its role in engineering decision-making. Additionally, the course also covers topics

such as depreciation, after-tax analysis, replacement analysis, uncertainty, inflation, deflation, and estimation of future events.

Course Outcome:

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

CO1: Describe the role of economics in the decision-making process and perform calculations in regard to interest formulas.
CO2: Estimate the Present, annual and future worth comparisons for cash flows.
CO3: Calculate the rate of return, depreciation charges and income taxes.
CO4: Enumerate different cost entities in estimation and costing.
CO5: Explain the importance of finance functions, financial ratios and solve related problems.
CO6: Explain the elements of budgeting and benchmarking

Course Contents:

Unit-1: Introduction: Definition – Nature – Scope and Significance of Economics for Engineers. Demand and Supply: Demand – Types – Determinants – Law of Demand – Elasticity of Demand – Types – Significance – Supply – Market price determination – Case Study in Demand Forecasting –- Meaning – Methods – Consumer Survey – Trend Projections – Moving average.

Unit-2: Cost and Revenue: Concepts – Classifications – Short run and long run cost curves – Revenue – Concepts – Measurement of Profit (Case Study). Market Structure: Perfect Competition – Characteristics – Price and output determination in short run and long run – Monopoly – Price Discrimination – Monopolistic Competition – Product Differentiation – Oligopoly and Duopoly.

Unit-3: Market Failure: Causes – Type of Goods – Rivalrous and Non-rivalrous goods – Excludable and Non-excludable goods – Solutions – Government Intervention. Money and Banking: Money – Functions – Quantity theory of money – Banking – Commercial Banks – Functions – Central Bank (RBI) – Functions – Role of Banks in
Economic Development.

Unit-4: Foreign Exchange: Balance of Payments – Exchange rate determination – Methods of foreign payments – International Institutions – IMF, IBRD. Business Cycle and National Income: Meaning –Phases of business cycle - Inflation – Causes – Control measures - Deflation - National Income – Concepts – Methods of calculating national income – Problems in calculating national income.

Textbook:

1. Sociology & Economics for Engineers, first edition. Author: Kapoor P. Khanna Publishing House, 2018.

References:

1. Modern Economic Theory, 24th edition. Authors: Dewett KK, Navalur MH. S. Chand and Company Ltd, New Delhi, 2014.
2. Economics, thirteenth edition. Lipsey R and ChrystalA. Oxford University Press, 2010.

BT 2095 Biochemical Techniques

Course code	BT 2095
Course title	Biochemical Techniques
Number of credits	2 (L: 0, T: 0, P: 4)
Course category	BS
Continuous Assessment (C.A.)	50
End Semester Assessment (E.S.A.)	50
Prerequisite	Nil

Course Description:
This course is aimed to give students an overview of how to conduct experiments in a biochemistry laboratory. Biochemical concepts and tools are at the core of recent developments in the life sciences and biotechnology. The main goals of this course are for students to become acquainted with the instruments and biochemical methods used in biochemistry laboratories, learn to collect, record and analyze the data, present the experimental results, relate the results and skills to the area of interest and perform the experiments in a collaborative environment.

Course Outcome:
At the end of the course, the students will be able to have concepts regarding:
CO1: Understand the general laboratory practices and safety guidelines including chemical safety.
CO2: Prepare the common solutions, reagents and buffers used in the biochemistry laboratory and measure the buffer capacity and isoelectric pH.
CO3: Understand and apply the colorimetric/spectrophotometric methods to quantify the biochemical compounds from biological samples.
CO4: Analyse the biochemical characteristics of lipids and their application to their self-life and quality.
CO5: Analyze and present the results in graphic, tabular, and written formats.
CO6: Apply the experimental skills to execute the routine biochemistry experiments.

Laboratory:

1. Basic biochemical calculations and preparation of solutions.
2. Preparation of buffers and measurement of their buffering capacity.
3. Determination of isoelectric pH of amino acids by the titration curve.
4. Estimation of total carbohydrates using anthrone reagent.
5. Estimation of reducing sugars using 3,5-dinitrosalicylic acid.

6. Estimation of proteins using Bradford reagent or biuret method or bicinchoninic acid method.
7. Estimation of amino acids using ninhydrin reagent.
8. Estimation of saponification number of oil/fat samples.
9. Estimation of the unsaturation of oil/fat samples.
10. Measurement of the acid number of oil/fat samples.
11. Separation of amino acids by paper chromatography.

Reference books:

1. Biochemical Calculations, second edition. Segel IH, Publisher: Wiley India Pvt. Ltd., 2010
2. Wilson Walker's Principles and Techniques of Biochemistry and Molecular Biology, eighth edition. Editors: Hofmann A, Clokie S. Cambridge University Press, 2018.
3. Practical Biochemistry, fifth edition. Authors: Gupta RC Bhargava S. CBS publishers and distributers Pvt Ltd. 2018.

BT 2097 Methods in Microbiology

Course code	BT 2097
Course title	Methods in Microbiology
Number of credits	3 (L: 0, T: 0, P: 6)
Course category	BS
Continuous Assessment (C.A.)	50
End Semester Assessment (E.S.A.)	50
Prerequisite	Nil

Course Description:

It is intended to impart basic undergraduate-level knowledge in the area of general Microbiology. The goals for the laboratory portion of this course are to teach microbiological techniques and to show students the impact of microbes on our daily lives and their central roles in nature. Laboratory sessions are focused on pure culture techniques, methods of staining and the microscopic, colonial and biochemical identification of microorganisms. They would also be able to assimilate recent research findings, advancements and developments in the relevant subject. The objectives of the course are to (1) Become proficient at laboratory skills and safety procedures; (2) Learn to follow experimental procedures; (3) Develop skills to formulate answerable questions/hypotheses and predict expected results; (4) Learn how to make careful observations, collect and analyze data, and draw appropriate conclusions; (5) Utilize active learning opportunities in the laboratories; (5) Demonstrate good lab citizenry and the ability to work with others.

Course Outcomes:

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

CO1: Understand the general laboratory practices and biosafety rules in a working laboratory.

CO2: Gain insights into the theories, applications and working principles of different

equipment.

CO3: Understand and apply concepts in culture-based methods to organize/classify the microorganisms, types of culture media/techniques, microbial preservation/storage and characterization of different types of microorganisms, to study these in the laboratory.

CO4: Observe, recognize and distinguish the different types of microorganisms using staining, biochemical assay and microscopy techniques.

CO5: Evaluate and analyze bacterial growth curve and factors affecting growth and metabolism by experimentation. Develop the concept of use and application of antimicrobial agents including antibiotics and their mode of action through antibiotic sensitivity test and Minimum inhibitory concentration

CO6: Apply scientific methods to collect, interpret, and present scientific data in microbiology.

Laboratory:

1. Demonstration of lab instruments and introduction to working with microorganisms and Biosafety protocols
2. Calculations for making solutions and microbiological media: Preparation of nutrient agar slants, plates and nutrient broth and their sterilization (Autoclave)
3. Techniques in Microbiology:
    a. Use of microscope: setting microscope at10X, 40X, 100X (oil immersion) magnification
    b. Types of media (general-purpose, selective, differential, minimal)
    c. Pure culture techniques: streak plate, pour plate, spread and drop plate method
    d. Serial dilution technique for counting micro-organisms
    e. Isolation of Micro-organisms from soil, water, food, etc
    f. Preservation of micro-organisms (Subculturing, stab culture, glycerol)
5. Diagnostic Microbiology:
    A. Microscopic Identification of micro-organisms by Staining methods:
        1) Simple staining (Fungal staining by lactophenol cotton blue)
        2) Differential staining (Gram staining and acid-fast staining)
        3) Selective staining (Endospore staining, Flagellar staining and crystal protein Staining)
    B. Study of biochemical features of micro-organisms by culturing methods
6. Microbial Physiology: (UV spectrophotometer, colorimeter, colony counter)
    a. Study the Bacterial growth curve and determination of generation time and growth rate
    b. Study the effect of pH/temperature/osmotic pressure on the growth of micro-organisms
7. Control of Microbial Growth:
    a. Estimation of Minimum inhibitory concentration (MIC) for an antimicrobial agent (Antibiotic)/ disinfectant/natural products.
    b. Test for antibiotic sensitivity of microbes against different antimicrobial agents (disc and strip test)

c. To test the antibacterial effect of lysozyme from human tears and egg albumin

8. Dairy Microbiology:
   a. To test the quality of Milk by Methylene blue reduction/Resazurin test
   b. Qualitative and quantitative estimation of fat content, Calcium and Phosphorus in milk
   c. Preparation of yogurt by lactic acid fermentation and estimation of quality

Text/Reference books:

1. Practical Microbiology, third edition. Authors: Dubey RC and Maheshwari DK. S. Chand and company limited, 2012.
2. Experiments in Microbiology, plant pathology and Biotechnology, fourth edition, Author: Aneja KR. New Age International Publishers, 2017.
3. Lab Manual in microbiology, second edition. Author: Gunasekaran P. New Age Internetional Publishers, 2009.

BT 2083 Indian Constitution

Course code	BT 2083
Course title	Indian Constitution
Number of credits	0 (L: 1, T: 0, P: 0)
Course category	AU
Continuous Assessment (C.A.)	P/NP
End Semester Assessment (E.S.A.)	0
Prerequisite	Nil

Course Description:

To realize the significance of the constitution of India to students from all walks of life and help them to understand the basic concepts of the Indian constitution. Identification of the importance of fundamental rights as well as fundamental duties. Understanding the functioning of Union, State and Local Governments in the Indian federal system. Learning procedure and effects of emergency, composition and activities of the election commission and amendment procedure.

Course Outcomes:

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

CO1: Understand the meaning and importance of the Constitution
CO2: Explain about making of Indian Constitution
CO3: Describe the Salient features of the Indian Constitution.
CO4: Describe the importance of the Preamble of the Indian Constitution and its significance.
CO5: Understand the components of the Indian federal system.
CO6: Understand the electoral system and regulations

Course Content

Unit-1: The Constitution – Introduction, The History of the Making of the Indian Constitution, Preamble and the Basic Structure, and its interpretation, Fundamental Rights and Duties and their interpretation, State Policy Principles.

Unit-2: Union Government, Structure of the Indian Union, President – Role and Power, Prime Minister and Council of Ministers, Lok Sabha and Rajya Sabha.

Unit-3: State Government, Governor – Role and Power, Chief Minister and Council of Ministers, State Secretariat.

Unit-4: Local Administration, District Administration, Municipal Corporation, Zila Panchayat.

Unit-5: Election Commission: Role and Functioning, Chief Election Commissioner, State Election Commission.

Textbooks:

1. Politics and ethics of the Indian constitution. Editor: Bhargava R. Oxford University Press, New Delhi, 2009.

References:

1. The Constitution of India. Authors: Fadia BL, Fadia K. Sahitya Bhawan, 2017.
2. Introduction to the Constitution of India, 23rd edition. Author: Basu DD. Lexis Nexis; 2018.

Suggested Software/Learning Websites:

1. https://www.constitution.org/cons/india/const.html
2. http://www.legislative.gov.in/constitution-of-india
3. https://www.sci.gov.in/constitution
4. https://www.toppr.com/guides/civics/the-indian-constitution/the-constitution-of-india/

SEMESTER-IV

BT 2014 Transport Processes

Course code	BT 2014
Course title	Transport Processes
Number of credits	3 (L:2, T: 1, P:0)
Course category	ESC
Continuous Assessment (C.A.)	50
End Semester Assessment (E.S.A.)	50
Prerequisite	BT 2011

Course Description:

It is intended to make students capable of designing protocols for industrial operations. Students can develop a better understanding and perform more efficiently in commercial as well as research areas associated with food processing, pharmaceutical development and waste management.

Course Outcome:

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

CO1: Write the basic mass transfer equations

CO2: Understand and solve problems in fluid dynamics

CO3: Understand and solve problems on heat transfer equations

CO4: Understand basic principles of mass and heat conservation to analyze bioreactor systems, identify the major engineering parameters that characterize the performance of bioreactors and techniques to parameters

CO5: Apply the knowledge of engineering fundamentals to the solution of complex engineering aspects of Bioprocess engineering and Food processing.

CO6: Apply the knowledge of transport processes to related areas of biotechnology.

Course Contents:

Unit-1: Fluid mechanics: Newtonian and non-Newtonian fluids, fluid flow-laminar and turbulent; Mixing in bioreactors, mixing time.

Unit-2: Mass transfer principles, Molecular diffusion and film theory; Oxygen transfer and uptake in reactor; kLa determination Agitation and aeration-gas-liquid mass transfers.

Unit-3: Heat Transfer; Conductive and connective heat transfer, Log and arithmetic mean Temperature differences, Overall heat transfer coefficients, Operation of Heat exchangers, design equations and its application in reactor operations.

Text Books:

4. Principles of Mass transfer and separation processes, eight printing. Author: Dutta BK. PHI Learning Pvt. Ltd, 2016.

Reference Books:

7. Mass Transfer Operations, third edition: Author: Treybal RE. McGraw Hill Education; 3rd edition, 2017.
2. Transport Processes and Unit Operations, third edition. Author: Geankopolis CK. Prentice Hall India, 1993.

BT 2016 Methods in Biostatistics

Course code	BT 2016
Course title	Methods in Biostatistics
Number of credits	2 (L: 2, T: 0, P: 0)
Course category	BSC
Continuous Assessment (C.A.)	50
End Semester Assessment (E.S.A.)	50
Prerequisite	Nil

Course description:

Biostatistics is the application of statistical science to research in health-related fields including medicine, biology, public health, nursing, and pharmacy. The objective of Biostatistics is to advance statistical science and its application to problems of human health and disease, with the goal of advancing statistics. The role of biostatisticians is an important one, especially when it comes to designing studies and analyzing data from research problems. Biostatisticians help in formulating the scientific questions to be answered, determine appropriate sampling techniques, coordinate data collection procedures, and conduct statistical analyses to answer those scientific questions. Biostatisticians also play a vital role in the preparation of research material for publication.

Course outcomes

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

CO1: Get the idea about data collection, tabulation and graphical representation of such data.
CO2: Know the nature of the data by means of central values and measure of Dispersion.
CO3: Apply the statistical tools to know whether the data is symmetrical or skewed.
CO4: Use the probability and Probability Distribution in biological sciences.
CO5: Evaluate the significant difference between the populations by using different types of tests such as ANOVA, Chi-Square test, etc.
CO6: Develop the linear relationship between the variables by using statistical tools and predict an unknown value from the set of known values.

Course Content

Unit-1: Primary and secondary data, methods of collecting primary data, sources of secondary data**.** Simple frequency distribution, grouped frequency distribution, two way frequency distribution. Bar diagram, Histogram, Frequency polygon, Pie Chart and Ogives.

Unit-2: Measures of central tendency- Arithmetic Mean, median and mode, computation of quartiles, computation of deciles. Range, Mean deviation, Quartile deviation, Variance, Standard deviation, Coefficient of variation and Skewness.

Unit-3: Concept of Probability theory, sample space, Events, Trials, Mutually exclusive events, favourable events, exhaustive events, Addition theorem, Conditional Probability, Multiplication theorem, Bayesian theorem of Probability. Probability distributions: Discrete – Binomial and Poisson; Continuous-Normal, analysis of biological data.

Unit-4: Census and sample method, theoretical basis of sampling, methods of sampling, size of sample, merits and limitations of sampling, sampling errors. Null & Alternative hypothesis, level of significance, Chi square test & its applications, Large Sample Tests- Z-test of Means & Proportions, T-test for Means, Paired T-test, F-test and Analysis of variance.

Unit-5: Correlation and Regression analysis: Correlations and regressions-: Relation between two variables, scatter diagram, definition of correlations, Two regression lines, Karl Pearson's coefficient of correlation, Rank correlation.

Textbook:

1. Biostatistics, 2018 edition. Authors: Arora PN and Malhan PK. Himalaya publishing house, 2018.

Reference Books:

1. Biostatistics, second edition: Authors: Forthofer RN, Lee ES, Hernandez M. Academic Press, 2016.
2. Biostatistics: How it works, first edition. Author: Selvin S. Peterson Education, 2003.
3. Statistical Methods, first edition. Author: Gupta SP Sultan Chand and Sons, 2019.
4. Introduction to Biostatistics, first edition. Author: Banerjee PK. S Chand & Company, 2010.

BT 2018 Principles of Biophysics

Course code	BT 2018
Course title	Principles of Biophysics
Number of credits	2 (L: 2, T: 0, P: 0)
Course category	BS
Continuous Assessment (C.A.)	50
End Semester Assessment (E.S.A.)	50
Prerequisite	BT 1016, PH 1007

Course Description:

The basic biophysics course provides a fundamental understanding of physical processes that occur in different biological systems such as proteins, DNA, RNA, etc. The students would be able to understand the molecular and mechanistic basis of cellular functions and organism physiology.

Course Outcome:

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

CO1: Explain the basics of entropy, free energy, chemical forces and other physical concepts with respect to biology.

CO2: Summarize the physical principles responsible for maintaining the basic cellular function.

CO3: Understand the physical aspects of protein stability and folding.

CO4: Understand the membrane-associated electrophysiological phenomenon.

CO5: Correlate the mechanism of molecular motors to their mechanical work in cells and its significance in health.

CO6: Evaluate the core concepts of biophysics and its interconnection with biology, chemistry and physics.

Course Contents:

Unit 1: Concept of **e**ntropy, temperature, free energy, chemical forces and self-assembly, Physical properties of DNA, RNA, Protein, torsional angles in proteins and nucleic acids, free energy landscapes.

Unit 2: Protein structure, stability, and folding, Ramachandran plot Thermodynamics and kinetics of bimolecular structures, Functional Design of Proteins.

Unit 3: Membrane proteins, Channels and Transporters in Biological system, Functional Properties of Voltage-Gated Ion Channels, Ion pumping and action potential, Electrical Phenomena in Excitable Cells, Electrical Signals of Nerve Cells. Rhodopsins and their functions.

Unit 4: Concept of molecular motors. Cilia and Flagella: Structure and Movement, Kinesin, Dynein and Myosin, and intracellular movement, significance in human health.

Textbook:

1. Essentials of Biophysics, 2nd edition. Author: Narayanan P. New age international publisher, 2000.

Reference Books:

1. Biological Physics: Energy, Information, Life, 1st edition. Authors: Nelson P. W. H. Freeman, 2007.
2. Biophysics for Beginners, 2nd edition. Author: Schiessel H. Jenny Stanford Publisher, 2021.
3. Molecular Cell Biology, 6th Edition. Authors: Lodish H, Berk A, Kaiser CA, Krieger M, Scott MP, Bretscher A, Ploegh H, Matsudaira P. W. H. Freeman and company, 2008.

BT 2020 Molecular Biology

Course code	BT 2020
Course title	Molecular Biology
Number of credits	3 (L: 2, T: 1, P: 0)
Course category	BS
Continuous Assessment (C.A.)	50
End Semester Assessment (E.S.A.)	50
Prerequisite	BT1016, BT 2013

Course Description

This course focuses on DNA, RNA and protein synthesis in cells and introduces the students to the classical and modern concepts of molecular biology. The topics include structure and genome organization of prokaryotes and eukaryotes, replication of DNA and its regulation molecular mechanisms of DNA recombination, mutations, and DNA repair. At the end of the course, the student will be able to understand the concepts of gene expression and its regulation.

Course outcomes

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

CO1: Explain the basic concepts, structure and functions of DNA and RNA, and the general principles of genome organization.
CO2: Describe the molecular mechanisms of replication and expression of genes in both prokaryotic and eukaryotic organisms.
CO3: Comprehend the principle of central dogma in understanding cellular function.
CO4: Gain insight into the consequences of recombination, mutations, and DNA repair mechanisms.
CO5: Design and integrate the knowledge of molecular biology in understanding advanced courses like genetic engineering, genomics and proteomics etc.
CO6: Acquire a comprehensive understanding of the essential aspects of molecular biology and develop professional skills to apply the knowledge in the related field both in academia and industries.

Course Contents:

Unit-1: Genome structure: Central dogma, DNA structure and topology, linking numbers, supercoiling, topoisomerases, denaturation and renaturation kinetics, repetitive DNA

sequences in the genome, C-value paradox, Protein-DNA complexes in prokaryotes and eukaryotes, chromatin structure, nucleosomes, nucleoproteins, and their functions.

Unit-2: DNA replication: Chemistry of DNA synthesis, DNA polymerase, replication fork, initiation, elongation and termination of prokaryotic and eukaryotic replication and its regulation, fidelity, nucleosome modification and remodeling during replication.

Unit-3: Recombination, transposition, and mutation: Homologous recombination, double-strand break– repair model, gene conversion, site-specific recombination - mechanism and biological roles. Transposition: mechanism and biological roles. Mutation: chemical and biochemical basis of mutations, types of mutations, replication errors and mutations, DNA repair.

Unit-4: Transcription: Structure and types of RNA, genetic code, transcription of DNA in prokaryotes and eukaryotes, structure and function of RNA polymerases, initiation, elongation and termination, promoter structure and function, regulatory elements.

Unit-5: Post-transcriptional modifications: Processing of prokaryotic RNAs, intron-exon structure of eukaryotic RNAs, splicing mechanisms, mRNA capping, poly-adenylation, alternative splicing and its significance, RNA editing and exon shuffling, mechanism of regulatory RNAs.

Unit-6: Translation and post-translational modifications: Ribosome structure and functions, tRNAs, prokaryotic and eukaryotic translation mechanisms: initiation, elongation and termination, regulation, post-translational modifications, and its significance.

Textbook:

1. Molecular Biology of the Gene, Seventh edition. Authors: Watson JD, Gann A, Baker TA, Levine M, Bell SP, Losick R. Pearson, 2014.

Reference books

1. Lewin's Genes XII, Twelfth edition, Authors: Krebs JE, Goldstein ES, Kilpatrick ST. Jones and Bartlett Publishers, Inc, 2017.
2. Molecular Biology; Genes to protein, fourth edition. Authors: Tropp BE. Jones and Bartlett Publishers, Inc, 2011.

BT 2022 Animal Physiology

Course code	BT 2022
Course title	Animal Physiology
Number of credits	2 (L: 2, T: 0, P: 0)
Course category	BS
Continuous Assessment (C.A.)	50
End Semester Assessment (E.S.A.)	50

Prerequisite	Nil

Course Description:
The course is designed for undergraduate students of biotechnology with the aim that they will gain insight into human physiology and anatomy, including respiration, digestion, circulation, nerve and muscle function, hormones, and reproduction. The course aims to develop critical thinking skills, apply physiological concepts and principles at the basic and applied levels, develop a working knowledge of the major physiological systems, and associate anatomical areas with their specific function.

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

CO1: Recognize, distinguish and classify principal tissue structures of extracellular matrix, blood and different tissue organs and compare and contrast the properties and function of various tissues
CO2: Develop an understanding of the fundamental concepts of physiology, regulation and interactions between digestive, cardiac system, respiratory system and excretory system function
CO3: Develop a basic understanding of the fundamental concepts of physiology of digestion, and metabolic systems along with responses to challenges such as exercise, fasting and state of homeostasis
CO4: Develop a basic understanding of the nervous and endocrine system, and its interactions with other systems like the reproductive system. Functioning of skeletal muscle and mechanism of contraction
CO5: Apply knowledge of physiology to evaluate how separate systems interact to yield integrated physiological responses and how their imbalance leads to various disorders and diseases
CO6: Analyze, Compare, and contrast the properties and function of different systems to integrate them with the subject matter and case studies from research papers

Course Contents:

Unit-1: Tissues: Types of tissue (structure and distribution): Epithelial, Connective, Nervous and Muscular. Elementary details of Extra Cellular Matrix (ECM) components. Blood - Composition (RBC, WBCs and platelets) and functions of blood, Haematopoiesis, Blood groups (ABO and Rh), Blood coagulation

Unit-2: Cardiovascular and Respiratory System: Myogenic heart, specialized tissue of conduction, Membrane potential and generation of action potential. ECG and cardiac cycle, cardiac output, blood pressure measurement, neural and chemical regulation. Respiratory system – Cardiac-pulmonary circuit, pulmonary ventilation (lung volumes and lung capacities),

Role of hemoglobin in oxygen transport, Oxygen dissociation curves and their physiological significance, Transport of CO_2, Bohr and Haldane effect, Chloride shift.

Unit-3: Digestive and Excretory system: Energy homeostasis and Basal Metabolic Rate (BMR). Digestion and absorption of carbohydrates, lipids, proteins and nucleic acids. Regulation of gastrointestinal tract digestion and secretions. Structure and functions of kidney, Mechanism of urine formation, regulation of water and electrolyte balance. Blood pressure and its regulation through Renin-Angiotensin-Aldosterone-System (RAAS).

Unit-4: Neuromuscular system and Endocrinology: Generation and conduction of nerve impulse, neuromuscular junction and neurotransmitters. Events in contraction of muscle. Structure of the brain and spinal cord, central and peripheral nervous system. Endocrine glands, Mechanism of hormone action, anterior and posterior pituitary hormones and diseases, physiology of reproductive processes, neuroendocrine regulation (menstrual cycle).

Textbook:

1. Biology, 10th edition. Authors: Raven PH, Johnson GB, Mason KA, Losos JB and Singer SR. McGraw Hill Education, 2013.
2. Vander's Human Physiology, 16th edition. Authors: Widmaier E and Raff Hand Strang KT. Mc Graw Hill Education, 2022.

Reference Books:

1. Guyton and Hall Textbook of Medical Physiology, Twelfth edition, Authors: Vaz M, Kurpad A, Raj T. Elsevier, 2016.
2. Molecular Cell Biology, ninth edition. Authors: Lodish, Berk, Kaiser, Krieger, Bretscher, Ploegh, Amon and Martin. W H Freeman & Co, 2021.
3. Harper's Illustrated Biochemistry. 28th edition. Authors: Murray et al. McGraw Hill 2011.
4. Molecular Biology of the cell, sixth edition. Authors: Alberts et al. W.W. Norton, 2014.

HS 2022 Principle of Management

Course code	HS 2022
Course title	Principle of Management
Number of credits	2 (L: 2, T: 0, P: 0)
Course category	HS
Continuous Assessment (C.A.)	50
End Semester Assessment (E.S.A.)	50
Prerequisite	Nil

Course Description:

This course investigates the way that managers get things done in an organization relying on the dynamic processes of strategic planning, business development, budgeting, and operations to move their organizations forward and achieve results.

Course outcomes:

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

CO1: Recognize the role of a manager and how it relates to the organization's mission.
CO2: Define management, its four basic functions and skills.
CO3: Know critical management theories and philosophies and how to apply them.
CO4: Recognize the concept of social responsiveness and its benefits.
CO5: Identify the strategic management and its benefits
CO6: Understand the current trends in management

Course Content

Unit-1: Nature of Management: Meaning, Definition, it's nature purpose, importance & Functions, Management as Art, Science & Profession- Management as social System Concepts of management-Administration-Organization

Unit-2: Evolution of Management Thought: Contribution of F.W.Taylor, Henri Fayol ,Elton Mayo , Chester Barhard & Peter Drucker to the management thought. Various approaches to management (i.e. Schools of management thought) Indian Management Thought

Unit-3: Functions of Management: Planning - Meaning - Need & Importance, types levels - advantages & limitations. Forecasting - Need & Techniques Decision making - Types - Process of rational decision making & techniques of decision-making Organizing - Elements of organizing & processes: Types of organizations, Delegation of authority - Need, difficulties in delegation - Decentralization Staffing - Meaning & Importance Direction - Nature - Principles Communication - Types & Importance Motivation - Importance - theories Leadership - Meaning - styles, qualities & functions of leaders

Unit-4: Functions of Management: Controlling - Need, Nature, importance, Process & Techniques Coordination - Need – Importance

Unit-5: Strategic Management: Definition, Classes of Decisions, Levels of Decision, Strategy, Role of different Strategist, Relevance of Strategic Management and its Benefits, Strategic Management in India

Unit-6: Recent Trends in Management: Social Responsibility of Management – environment friendly management Management of Change Management of Crisis Total Quality Management Stress Management International Management

Textbook:

Essentials of management: an international, innovation and leadership perspective, eleventh edition. Authors: Koontz H, Weihrich H. McGraw Hill, 2020.

Reference Books:

1. Management theory and practice, first edition. Author: Chandan, JS. Vikas Publishing House, 2018.
2. Essentials of business environment, fifteenth edition. Author: Aswathapa K. Himalaya Publishing House Pvt Ltd, 2022.
3. Principles and practice of management. Author: Prasad LM. SULTAN CHAND & SONS, 2019.
4. Fundamentals of business organisation and management. Author: Bhushan YK. Sultan Chand and sons, 2016.
5. Management: concept and strategies. Author: Chandan JS. Vikas Publishing, 1997.
6. Principles of management, seventh edition. Author: Tripathi PC, Reddy PN. Mc Graw Hill, 2021.

BT 2096 Methods in Cell Biology

Course code	BT 2096
Course title	Methods in Cell Biology
Number of credits	3 (L: 0, T: 0, P: 6)
Course category	BS
Continuous Assessment (C.A.)	50
End Semester Assessment (E.S.A.)	50
Prerequisite	Nil

Course Description:

The cell biology laboratory course consists of experiments illustrating the principles of types of cells and cellular responses relevant to the study of science and engineering. The students will learn to explore the structure and function of cells using different aspects of biological sciences. The course includes an understanding of how cells behave in vitro under different environmental conditions, how cell diversity arises, and how cells communicate and co-operate. The students will also understand the processes used to extract the cells to analyze their response to stimuli.

Laboratory Outcomes:

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

CO 1: Use different techniques and model systems to explore mechanisms of cellular biology.
CO 2: Learn to design experiments and use methods of data collection and analysis followed by interpretation of results.
CO 3: Develop skills to interpret and write observations scientifically.
CO 4: Understand how disease states affect cellular functions.
CO 5: Develop and maintain a notebook of laboratory records.

CO 6: Utilize laboratory skills to enhance understanding of cell structure and function while participating in a group environment.

Laboratory Experiments: Choice of 8-9 experiments from the following:

1. Introduction of microscopy for cell visualization and visualization of different cells of human blood using Giemsa stain.
2. Isolation and visualization of different cells in human blood using the RBC lysis method.
3. Preparation of slides and study the cell organelles and inclusions of eukaryotic plant or animal cells.
4. Isolation of Lymphocytes from peripheral blood using Ficol density gradient.
5. Live cell count by staining with trypan blue followed by using Haemocytometer.
6. Visualization of stages of mitosis during cell proliferation.
7. In vitro activation and visualization of phenotypic changes post activation of cells.
8. In vitro activation of cells to visualize and measure the process of apoptosis.
9. Preparation of temporary stained squash of onion [Allium cepa L.] root tip or grasshopper testis chromosomes and study of various stages of mitotic cell division.
10. Preparation of temporary stained squash of onion [Allium cepa L.] flower bud chromosomes and study of various stages of meiotic cell division.
11. Identification of plant/animal metaphase chromosomes and karyotyping.
12. Animal tissue block preparation by paraffin embedding.
13. Tissue sectioning using microtome from PE blocks and adherence to slides.
14. Hematoxylin and eosin staining and preparation of permanent slides of the animal tissue section.
15. Microscopic imaging and anatomical interpretation of HE stained tissue slides.

Reference Books:

1. Practical laboratory manual - cell biology, first edition. Authors: Gupta A, Sati, BK. Lap Lambert Academic Publishing, 2019.
2. Cell Biology: Practical Manual, first edition. Authors: Gupta R, Makhija S, Toteja R. Prestige Publishers, 2018.

BT 2098 Molecular Biology Techniques

Course code	BT 2098
Course title	Molecular Biology Techniques
Number of credits	3 (L: 0, T: 0, P: 6)
Course category	BS
Continuous Assessment (C.A.)	50
End Semester Assessment (E.S.A.)	50
Prerequisite	Nil

Course Description:

The molecular biology Lab course intends to provide the basic concepts of DNA, RNA, plasmid and protein extraction, quantitation and separation procedures using electrophoresis and spectrophotometric techniques. In addition, the students will be exposed to advanced techniques such as PCR and SDS-PAGE. The knowledge and skills of this course will enable the students to design and conduct experiments in genetic engineering in the future.

Laboratory Outcomes

The Molecular Biology Lab course will help the students to

CO1: Learn the preparation and uses of different reagents frequently used in Molecular Biology Practical.

CO2: Learn the techniques of extraction of nucleic acids (DNA, RNA and plasmids) and proteins from different cells.

CO3: Comprehend the theory, principle and techniques of nucleic acids and protein isolation and analysis of data of gel electrophoresis and spectrophotometer.

CO4: Design and select the appropriate method for the analysis of proteins and nucleic acids extracted from biological samples.

CO5: Analyze the data from different experiments and present them in a scientifically accepted format.

CO6: Develop the knowledge of the application of molecular biology techniques, designing and evaluating strategies for their application in genetic engineering.

Laboratory Experiments

1. Extraction of DNA from bacteria, plant and animal tissues.
2. Extraction of plasmid DNA from a bacterial culture.
3. Isolation of RNA from animal/plant tissue
4. Quantitation of DNA and RNA by spectrophotometry or gel quantitation.
5. Separation of DNA, RNA and plasmids by agarose gel electrophoresis
6. Isolation of total protein from bacterial and animal cells.
7. Separation of proteins using SDS- PAGE, visualization of gel by silver and CBB staining and determination of molecular weight.
8. Separation of proteins by gel filtration column chromatography.

Reference Books:

1. Molecular cloning: A laboratory manual, fourth edition. Authors: Sambrook JF and Russell DW, Cold Spring Harbor Laboratory Press, 2001.
2. Principles and techniques of biochemistry and molecular biology, eighth edition. Authors: Wilson K and Walker J. Cambridge University Press, 2018.

SEMESTER-V

BT XXXX Computational Biology

Course code	BT XXXX
Course title	Computational Biology
Number of credits	3(L: 2, T: 0, P: 2)
Course category	PC
Continuous Assessment (C.A.)	50
End Semester Assessment (E.S.A.)	50
Prerequisite	Nil

Course Description:

In this course, students will understand the fundamentals of the development and application of computational methods such as data analysis, mathematical modeling and simulation to analyze large collections of biological data, such as genetic sequences, cell populations or protein samples, to make new predictions or discover new biology. This course includes the different databases of biological information such as sequences and structures of DNA, RNA, and protein, and provides computational studies on genome assembly, microarray data analysis, RNA sequence data analyses, gene prediction and system biology.

Course Outcomes:

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

CO1: Learn the basic concepts, overview and application of bioinformatics.

CO2: Understand different biological databases, including the sequences and structures of DNA, RNA, and protein.

CO3: Analyze the sequence alignment, genome sequencing, gene prediction methods, phylogenetic tree construction, and protein secondary structure prediction methods.

CO4: Evaluate the use of bioinformatics in application-oriented studies such as computer-aided drug design and systems biology.

CO5: Design and integrate the knowledge of bioinformatics and systems biology in understanding advanced courses like genomics and proteomics.

CO6: Acquire a comprehensive understanding of the essential aspects of bioinformatics and develop professional skills to apply the knowledge in the related fields both in academia and industries.

Course Contents:

Unit-1: Biological Databases: NCBI and Pubmed, Uniprot, organism-specific databases (Ecocyc, SGD, HPRD, PlasmoDB, etc.), Drugbank, Genome browsers

Unit-2: Pair-wise sequence similarity: Alignment score and substitution matrices, gap penalty, dot plots, the Needleman-Wunsch algorithm and the Smith-Waterman algorithm, Global and

Local Alignment, types of homology, database search for sequence similarity (BLAST algorithm, significance of a hit). Multiple Sequence Alignment: Utility, progressive and iterative algorithms, scoring schemes, domain search: Position-specific scoring matrix, hidden Markov models, PSI-BLAST, InterproScan.

Unit-3: Genome assembly: de novo assembly (de Bruijn graphs and mate-pair reads) and reference-based methods, microarray data analyses: normalization, background correction, differential gene expression, multiple testing, functional enrichment, hierarchical clustering, RNA-Seq data analyses: Read mapping, read normalization, differential gene expression. Gene prediction: Prokaryotic and eukaryotic gene prediction, expression-based and de novo gene prediction, HMM-based prediction.

Unit-4: Phylogenetic analysis: Uses, selection of types of sequences, distance-based (UPGMA, Fitch-Margoliash, and neighbour joining algorithms), maximum parsimony and maximum likelihood method, determining the quality of phylogenetic trees.

Unit-5: Secondary structure prediction, neural networks, signal peptide prediction. Tertiary structure prediction: Homology modeling, quality parameters, PDB file format, Swiss PDB viewer. Structure-based drug design: Scoring functions and molecular docking.

Unit-6: Cellular networks like protein-protein, protein-DNA and gene-gene network visualization and analyses.

Textbook:

1. Bioinformatics: Sequence and Genome Analysis, Second edition. Authors: David M. CSHL press, 2004.

Reference books:

1. Introduction to bioinformatics, Fifth edition. Author: Lesk A. Oxford university press, 2019.
2. Bioinformatics: A practical guide to the analysis of genes and proteins, Third edition. Authors: Baxevanis AD, Ouellette BFF. Wiley-Interscience, 2004.

BT XXXX Bioreaction Engineering

Course code	BT XXXX
Course title	Bioreaction Engineering
Number of credits	2 (L: 2, T: 0, P: 0)
Course category	PC
Continuous Assessment (C.A.)	50
End Semester Assessment (E.S.A.)	50
Prerequisite	Nil

Course Description:

This course provides an overview of biochemical reaction engineering and reactor design. The aims are to apply knowledge from calculus, differential equations, thermodynamics, general chemistry, and material and energy balances to solve reactor design problems, to examine reaction rate data to determine rate laws, to use them to design biochemical reactors and to simulate several types of reactors in order to choose the most appropriate reactor for a given need.

Course Outcomes:

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

CO1: Understand the basic concepts of chemical reactions and factors affecting their rate
CO2: Study the classification of reactor systems and their respective designs
CO3: Calculate the reaction kinetics and its respective performance equation
CO4: Examine the kinetics of the reaction in presence of accelerators ad moderator
CO5: Justify the reaction equations for the biochemical processes
CO6: Co-relate the basic principles with relevant industrial problems

Course Contents:

Unit-1: Homogeneous reactions in ideal reactors: Kinetics of homogeneous reactions: Concentration-dependent term of a rate equation, temperature-dependent term of a rate equation, searching for a mechanism, predictability of reaction rate from theory, interpretation of batch reactor data: Constant-volume batch reactor, varying-volume batch reactor, temperature and reaction rate, the search for a rate equation.

Unit-2: Introduction to Reactor Design: Ideal batch reactors, steady-state mixed flow reactors, steady-state plug flow reactors.

Unit-3: Heterogeneous Reactions: Solid catalyzed reactions, the rate equation for surface kinetics, pore diffusion resistance combined with surface kinetics, porous catalyst particles, heat effects during reaction, performance equations for reactors containing porous catalyst particles.

Unit-4: Biochemical Reaction Systems: Enzyme fermentation: Michaelis-Menten kinetics, inhibition by a foreign substance-competitive and noncompetitive inhibition, microbial fermentation.

Textbook:

1. Chemical reaction engineering, third edition, (An Indian Adaptation). Author: Levenspiel, Wiley India Pvt Ltd., 2021.
2. Bioprocess engineering principles, Second edition. Author: Doran PM. Academic Press, 2012.

Reference Books:

1. Elements of chemical reaction engineering, Fifth edition. Author: Fogler HS. Prentice Hall, 2016.
2. Principle of fermentation technology, Second edition. Authors: Stanbury P, Whitaker A, Hall SJ. Butterworth-Heinemann, 2016.

BT XXXX Immunology

Course code	BT XXXX
Course title	Immunology
Number of credits	3 (L: 2, T: 1, P: 0)
Course category	PC
Continuous Assessment (C.A.)	50
End Semester Assessment (E.S.A.)	50
Prerequisite	Nil

Course Description:

Immunology is the study of the immune system. The immune system refers to the range of defense mechanisms present or acquired in an individual to protect against microbial infection and related pathologies. A malfunctioning immune system results in severe consequences like infection, allergy/hypersensitivity, autoimmunity, and cancer. The course first elaborates on the basic notion of immunity, cells of the immune system, antigens, antibodies, and other components of the immune system. Later the subject ponders upon topics like microbial immunity, hypersensitivity, tolerance, autoimmune disorders, tumor immunology, and transplantation immunology. The subject will also focus on the diagnostic and therapeutic applications of immunology. The topic is valuable for biology students interested in research, medicine, or job in the field of immunodiagnostics/ immunotherapeutics.

Course Outcomes:

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

CO1: Identify the various components of the immune system.

CO2: Understand the mechanism(s) responsible for the varied antigen recognition diversity of B-cells, T-cells and antibodies, and innate immune cells.

CO3: Relate the various mistakes of the immune systems that lead to pathologies.

CO4: Analyze how the host immune system protects against pathogens but plays a villainous role in graft transplantation.

CO5: Evaluate the importance of immunology in the medicine, diagnostic and therapeutic industry.

CO6: Develop or design novel diagnostic and therapeutic strategies using immunological principles.

Course Contents:

Unit-1: Overview of the immune system: Immunity types, cells and organs of the immune system. Innate immunity: physiochemical barriers, cellular innate immune response-recognization (PRR-TLR) and effector mechanisms, inflammation. Cytokines and complement system.

Unit-2: Antigens/immunogens and haptens: immunogenicity, B-cell and T-cell epitopes. Antibodies: Classes, structure, and function of antibodies. Generation of antibody diversity by gene rearrangement. B-cell: BCR, B cell development and activation.

Unit-3: MHC molecules, Antigen processing and presentation. T-cell: TCR, T cell development, activation, and differentiation. Cell cytotoxicity: CTL development, target recognization and killing mechanism, NK cell-mediated cytotoxicity, ADCC

Unit-4: Hypersensitive reactions and chronic inflammation, Transplantation Immunology, Autoimmunity, Immunodeficiency.

Unit-5: Immune responses during bacterial infection (TB), parasitic infection (Malaria), viral infection (HIV). Immune response to cancer. Immunotherapy.

Unit-6: Polyclonal and monoclonal antibodies: Preparation and use (diagnostics and therapy). Antibody engineering. Antigen-antibody interaction: affinity and avidity, immunoassays (precipitation, agglutination, radioimmunoassay, ELISA, ELISPOT, Western blotting, Immunofluorescence, FACS, immunoprecipitation, immunohistochemistry and immunoelectron microscopy). Vaccines and adjuvants: Types and strategy for the development of vaccines.

Textbooks:

1. Kuby Immunology, Eighth edition. Authors: Punt J; Stranford S; Jones P; Owen J. WH Freeman & Co, New York, 2019.
2. Janeway’s Immunobiology, Ninth edition. Authors: Murphy K & Weaver C. Garland Science, New York, 2016.

Reference Books:

1. Immunology, Ninth edition. Authors: Male D, Peebles S, Male V. Elsevier, 2020.
2. Schaum's Outline of Immunology, First edition. Author: Pinchuk G. McGraw-Hill Education – Europe, 2020.

BT XXXX rDNA Technology

Course code	BT XXXX
Course title	rDNA Technology
Number of credits	3 (L: 2, T: 1, P: 0)
Course category	PC

Continuous Assessment (C.A.)	50
End Semester Assessment (E.S.A.)	50
Prerequisite	BT 2020, BT 2098

Course Description:

This course intends to provide the basic concepts of recombinant DNA technology and gene cloning strategies. Students will be introduced to several topics of genetic engineering such as the use of vectors, different enzymes, and techniques like PCR to construct recombinant DNA molecules. Moreover, the topics like construction of DNA libraries, site-directed mutagenesis, sequencing, hybridization methods, gene transfer techniques and gene therapy will help the students to understand the application of rDNA technology. Overall, this course aims to provide both theoretical as well as practical knowledge of the tools and techniques that are most often used for gene editing and genetic manipulation.

Course Outcomes:

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

CO1: Learn the basic concepts, overview and application of genetic engineering.

CO2: Understand different types of cloning and expression vectors, promoters and designing of vectors for gene cloning.

CO3: Understand the principles and application of different techniques like Polymerase Chain Reaction, DNA delivery, sequencing, and nucleic acid hybridization etc

CO4: Comprehend and design the experiments of molecular cloning.

CO5: Design and integrate the knowledge of genetic engineering in understanding advanced courses like genomics and proteomics

CO6: Acquire a comprehensive understanding of the essential aspects of genetic engineering and develop professional skills to apply the knowledge in the related field both in academia and industries.

Course Contents:

Unit-1: Basic techniques of gene manipulation: PCR; colony PCR, hot start, touchdown, multiplex, nested, inverse, and gradient PCR, real-time PCR and their applications; site-directed mutagenesis, agarose and polyacrylamide gel electrophoresis; Southern, Northern, Western and Southwestern blotting and their applications.

Unit-2: DNA restriction and modifying enzymes: Restriction endonucleases: types of restriction-modification systems and types of restriction enzymes and their uses; DNase, RNAse and other nucleases; DNA polymerases and DNA ligases; terminal transferases, kinases, and phosphatases.

Unit-3: Cloning and Expression vectors: Plasmid, cosmid, M13 and lambda phage derived, phagemid, BAC, YAC, HAC, Ti plasmid, vectors for insects and mammals, basic design of cloning and expression vectors, different expression systems (bacterial, viral, animal cells,

plants), advantages and disadvantages of prokaryotic and eukaryotic expression systems, types of promoters, suitable hosts for expression vectors, regulation of gene expression and translational product of a cloned gene.

Unit-4: Gene-cloning strategies: Construction and screening of cDNA and genomic library, methods for generation of oligonucleotide probes, screening with non-radiolabelled methods, Screening of expression library with antibody probes.

Unit-5: Gene transfer techniques: Gene delivery methods to animals, chemical and physical transfection methods, Gene delivery to plants, microprojectile bombardment, Biolistic Gene gun.

Unit-6: Applications of recombinant DNA technology: Genome editing; CRISPR-Cas9 overview, production of useful molecules like therapeutic proteins, improving agronomic traits by genetic modification- golden rice, Bt cotton etc; genetic modification in animals: vaccines, transgenic animals, etc. The future potential of genetic engineering

Text Book:

1. Principle of Gene Manipulation and Genomics, Seventh edition, Authors: Primrose SB, Twyman RM. Blackwell Publishing, 2006.

Reference books:

1. Molecular Biotechnology, fourth edition, Authors: Glick BR, Pasternak JJ, Patten CL. ASM Press, 2010.
2. Gene Cloning and DNA Analysis, 8th Edition, Authors: Brown TA, Wiley Blackwell, 2020.
3. Molecular Cloning: A Laboratory Manual volume I, II & III, fourth edition. Authors: Green MR & Sambrook J. Cold Spring Harbor Laboratory Press, 2012.

Professional Elective – II: Kindly Refer to the Professional Electives section

BT XXXX Immunology Lab

Course code	BT XXXX
Course title	Immunology Lab
Number of credits	3 (L: 0, T: 0, P: 6)
Course category	PC
Continuous Assessment (C.A.)	50
End Semester Assessment (E.S.A.)	50
Prerequisite	Nil

Course Description:

The course aims at developing knowledge of immunological principles and practice. The course will be helpful to clarify their concepts on immunology as well as learn various immunological techniques. Briefly, the students will learn how to process an antigen for immunization, immunize an animal, test the specificity of the immune response generated, and a few of the techniques used for antibody purification. This course is helpful to students interested in a career in biomedical research, diagnostics, and the therapeutic industry.

Course Outcomes:

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

CO1: Gain knowledge about the immunological principles and how immunology is important for the health industry.

CO2: Understand the relevance of the immunological experiments.

CO3: Apply the theoretical knowledge for performing the immunological experiments.

CO4: Analyse the output of the experiments.

CO5: Criticize the experimental read and learn to troubleshoot.

CO6: Modify the experiments after troubleshooting, to get the proper read.

Course Contents:

A. Antigen processing and immunization for antibody production.
    1. Test purity of the antigen to be used for immunization by SDS-PAGE followed by coomassie- blue staining
    2. Quantitate the concentration of the antigen by Bradford assay
    3. Preparation of Protein-Adjuvant emulsion.
    4. Animal immunization, and serum extraction.

B. Validation of antibody specificity.
    5. Evaluate the antibody titers by ELISA.
    6. Evaluate the specificity of antibodies by Western blotting.

C. Purification of Immunoglobulin-G.
    7. Immunoglobulin G enrichment by ammonium sulphate purification followed by protein dialysis.
    8. Final purification of Immunoglobulin G by Size exclusion chromatography.
    9. Analyse the quality of Immunoglobulin-G purified by SDS-PAGE.
    10. Quantify the purified Immunoglobin-G using a spectrophotometer.

D. Immuno- diagnostic experiments.
    11. Immunoprecipitation by Ouchterlony double immunodiffusion assay.
    12. Blood group phenotyping by hemagglutination assay.

Reference Books:

1. Advanced Methods in Cellular Immunology, first edition. Authors: Fernandez-Botran R, Vetvicka V. CRC Press, 2000.
2. Practical Immunology A Laboratory Manual, 1st edition. Authors: Balakrishnan S, Kaliaperumal K, DuraisamyS. LAP LAMBERT Academic Publishing, 2017.

3. A Handbook of Practical and Clinical Immunology, second edition. Authors: Talwar GP, Gupta SK, CBS Publishers, 2006.

BT XXXX rDNA Technology Lab

Course code	BT XXXX
Course title	rDNA Technology Lab
Number of credits	3 (L: 0, T: 0, P: 4)
Course category	PC
Continuous Assessment (C.A.)	50
End Semester Assessment (E.S.A.)	50
Prerequisite	Nil

Course Description

Genetic engineering laboratory course intends to provide the basic concepts of recombinant DNA technology and gene cloning strategies. It aims to provide an understanding of Overview of genetic engineering, Cloning and Expression vectors, Restriction and modifying enzymes, PCR and its applications and screening techniques and methods on genetic engineering and molecular biology. Moreover, this course also provides the theoretical knowledge of the tools and techniques that are most often used for genetic manipulation.

Course Outcomes:

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

CO1: Learn and understand the general laboratory practices and biosafety rules in a working laboratory and gain insights to the theories, applications and working principles of different equipment.

CO2: Understand concepts in recombinant DNA technology to organize/classify the experiments relating to recombinant DNA technology

CO3: Utilize the frequently used enzymes like restriction enzymes that are used in molecular cloning.

CO4: Learn, explore, and utilize the knowledge about basic concepts and different types of Polymerase Chain Reaction techniques.

CO5: Analyze the data from different experiments and present them in a scientifically accepted format.

CO6: Develop the knowledge of the application of genetic engineering techniques for their application in advanced genetic manipulation strategies.

Course Contents:

1. Isolation of genomic DNA from bacteria and/or animal cells
2. Isolation of RNA from plant and bacteria.
3. Estimation of DNA and RNA, and separation by electrophoresis.

4. Polymerase chain reaction (PCR) of a given DNA sequence, which includes primer designing against a given gene of interest, performing the reaction and gel analysis after amplification.
5. Gene cloning
a. Plasmid isolation
b. Restriction digestion (single and double digestion)
c. Gel elution
d. Ligation
e. Competent cell preparation
f. Transformation (CaCl2 heat shock method and Electroporation method)
g. Selection of recombinants (blue-white selection or antibiotic selection, PCR, restriction digestion)
6. Restriction mapping of a given plasmid sample.
7. Induction and expression of proteins.
8. Purification of the expressed protein.

Reference Books:

1. Molecular cloning: A laboratory manual, fourth edition. Authors: Sambrook JF and Russell DW, Cold Spring Harbor Laboratory Press, 2001.
2. Principles and techniques of biochemistry and molecular biology, eighth edition. Authors: Wilson K and Walker J. Cambridge University Press, 2018.

SEMESTER-VI

BT XXXX Enzymology and Enzyme Technology

Course code	BT XXXX
Course title	Enzymology and Enzyme Technology
Number of credits	3 (L: 2, T: 1, P: 0)
Course category	PC
Continuous Assessment (C.A.)	50
End Semester Assessment (E.S.A.)	50
Prerequisite	Nil

Course Description:

Enzymology is a branch of biochemistry that deals with the structure, catalytic mechanisms and kinetics of enzymes, and their relationship with the functions of enzymes. Enzyme technology deals with new processes utilizing enzymes as biocatalysts to meet various human needs. The course will provide an overview of enzymology and the technological applications of enzymes in different aspects of biotechnology. The initial portions include the enzyme structures, nomenclature and mechanism of enzyme catalysis. Emphasis will be given to the concepts of enzyme kinetics, regulation and allosterism, because of their prominent roles in enzyme catalysis. The enzyme technology part of this course will focus the enzyme engineering, large-scale extraction and purification of enzymes and their therapeutic and industrial applications in free as well as in immobilized form.

Course Outcomes:

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

CO1: Understand the fundamentals of enzyme properties, nomenclatures, characteristics and mechanisms.

CO2: Relate the mechanism, kinetics and enzyme inhibitors of enzymes to their functions.

CO3: Compare methods for large-scale production, purification, characterization and immobilization of enzymes.

CO4: Apply the concepts of enzyme kinetics equations to solve the problems related to enzyme activity, inhibition and kinetics.

CO5: Discuss various applications of enzymes in biotechnology-driven processes that can benefit human life.

CO6: Design simple processes involving enzymes for various technological applications.

Course contents

Unit 1: Introduction and mechanism of action of enzymes: History of enzymes and enzyme technology, nomenclature and classification of enzymes, cofactors, specificity, active

site, lock-and-key hypothesis, induced-fit hypothesis, strain and transition state stabilization hypothesis, monomeric enzymes - serine endopeptidases, oligomeric enzymes.

Unit 2: Enzyme kinetics: The law of mass action, initial velocity, introduction to enzyme kinetics, kinetics of single-substrate enzyme-catalyzed reactions: Michalis-Menten equation and its significance, Lineweaver-Burke plot, Eadie-Hofstee and Hans plots. Overview of multi-substrate reactions, Effect of pH, ionic strength and temperature on enzyme activity.

Unit 3: Enzyme inhibition and enzyme assays: Enzyme inhibition: Reversible, competitive, uncompetitive, mixed and non-competitive enzyme inhibitions, partial inhibition, substrate and inhibitions, irreversible and suicide inhibitions. Enzyme assay techniques: Spectroscopic assay- UV-visible and fluorescence assay techniques, continuous/time course and endpoint assay, coupled assays.

Unit 4: Enzyme cooperativity: Binding of ligands to enzymes, allosteric enzymes, Hill equation, MWC and KNF models of allosteric enzymes, hemoglobin cooperativity, allosteric enzymes and metabolic regulation.

Unit 5: Enzyme engineering and large-scale extraction of enzymes: Enzyme engineering: Methods to improve the properties of enzymes, strategies of *in vitro* evolution, rational enzyme engineering, catalytic antibodies, synthetic enzymes. Extraction and purification of enzymes: Sources, large-scale extraction and purification, preparation of enzyme formulations for sale, safety and regulatory aspects of enzyme use.

Unit 6: Applications of enzymes in solution: Application of enzymes in starch hydrolysis, production of glucose and maltose syrups, glucose from cellulose, dairy industry, fruit juice, wine, brewing and detergent industries.

Unit 7: Immobilized enzymes and their applications: Principles and methods of enzyme immobilization, properties of immobilized enzymes, membrane systems, methods of immobilization of whole cells, applications of immobilized enzymes in the production of high fructose corn syrup, amino acids and antibiotics, application of enzymes in (glucose) biosensors. The future potential of enzyme technology.

Textbook:

1. Enzymes: Biochemistry, Biochemistry, Biotechnology, Clinical Chemistry, second edition, 2008. Authors: Palmer T and Bonner P. East-West press, 2008.

Reference Books:

1. Biocatalysts and Enzyme Technology, second edition, Authors: Buchholz K, Kasche V and Bornscheuer UT. Wiley-Blackwell, 2012.
2. Enzyme Technology, first edition. Authors: Chaplin FM and Bucke C. Cambridge University Press, 1990
3. Biochemistry, fourth edition. Authors: Voet G & Voet JG, John Wiley and Sons, Inc. 2011.

4. Biochemical calculations, second edition, Authors: Segel IH. Wiley India Private Limited, 2010.
5. Understanding enzymes: Function, design, engineering, and analysis, first edition. Author: Svendsen A. CRC Press, Taylor & Francis Group, 2016.
6. Fundamentals of enzyme engineering, first edition. Authors: Yoo YJ, Feng Y, Kim Y-H, Yagonia C. Springer Netherlands, 2017.

BT XXXX Bioprocess Engineering:

Course code	BT XXXX
Course title	Bioprocess Engineering
Number of credits	3 (L: 2, T: 1, P: 0)
Course category	PC
Continuous Assessment (C.A.)	50
End Semester Assessment (E.S.A.)	50
Prerequisite	Nil

Course Description:

Students will have the knowledge and skills to understand the fundamental bioprocess engineering and relate it to the relevant industries. There will be the scope of entering industries and getting trained in unit operations such as manufacturing, monitoring and operating equipment, preparing fermentation media and reagents, and transferring materials for operational upgrading. Some may also be involved with the scientific, technical, training and business aspects of biotechnology companies.

Course Outcomes:

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

CO1: Explain how microorganisms and biochemical processes can be applied in engineered systems.

CO2: Distinguish among batch, continuous and fed-batch culture systems for the production of biochemical products.

CO3: Describe microbial growth and cultivation, various bioreactor components, and types of bioreactors used in biotechnology industries.

CO4: Design media sterilization and design of air filter in a bioprocess.

CO5: Apply various concepts to improve bioreactor performance and evaluate process variables to analyze a bioprocess

CO6: Correlate and create ideas relevant to industrial products and processes.

Course Contents:

Unit-I: Evolving bioprocess from a farmyard activity to industry, introduction to concepts of upstream activities, strain improvement of industrially important microorganisms, Media preparation for bioprocess and industrial fermentation

Unit II: Methods of heat sterilization of media, thermal death kinetics, design criteria, batch and continuous sterilization. Air Sterilization: Methods of air sterilization, mechanism of air sterilization, filter design.

Unit III: Microbial growth kinetics in batch, fed-batch and continuous culture, introduction to fermentation processes. Enzyme kinetics and concept of immobilization of enzymes.

Unit-IV: Designs of a bioreactor, aseptic operation and containment, achievement and maintenance of aseptic conditions, STR, Bubble driven bioreactors, Packed bed, Fluidized bed and Trickle bed reactors, Photo-bioreactors, Mist bioreactors, Animal cell reactors

Unit-V: Application of oxygen transfer in reactor operations, application of heat transfer, Scale-up criteria in bioreactors

Unit-VI: Case studies: production of Penicillin, wine production, enzymatic hydrolysis of cellulose.

Textbooks:

1. Bioprocess engineering: Basic concepts, Third edition. Authors: Shuler ML, Kargi F, Delisa MP. Pearson, 2017.
2. Principle of fermentation technology, Second edition. Authors: Stanbury P, Whitaker A, Hall SJ. Butterworth-Heinemann, 2016.

Reference Books:

1. Bioprocess engineering principles, Second edition. Author: Doran PM. Academic Press, 2012.
2. Fundamentals of biochemical engineering, First edition, Author: Dutta R. Springer Berlin, Heidelberg, Jointly published with Ane Books India, 2015.

BT XXXX Bioanalytical Techniques:

Course code	BT XXXX
Course title	Bioanalytical Techniques
Number of credits	2 (L: 2, T: 0, P: 0)
Course category	PC
Continuous Assessment (C.A.)	50
End Semester Assessment (E.S.A.)	50
Prerequisite	Nil

Course Description:

Bioanalytical Techniques course focuses primarily on techniques that can be applied to all branches of biology including molecular biology, cell biology, and physiology. The aim of this course is to introduce the students to the classical and modern concepts of instrumentation

techniques commonly used in biotechnological laboratories. Therefore, the topics covered in the course are microscopy, chromatography, centrifugation, spectroscopy, electrophoresis, radioisotopes, etc. The course stimulates the student's mind to understand about designing of molecular experiments and the choice of techniques to address such questions.

Course Outcomes:

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

CO1: Explain the fundamentals of common bioanalytical tools and techniques

CO2: Understand the general principles and applications of spectroscopy and microscopy

CO3: Apply analytical techniques to understand biological systems in the laboratory

CO4: Correlate the techniques including electrophoresis, chromatography and centrifugation to separate the biomolecules

CO5: Judge the use of radioisotopes and other probes to address molecular biology and cell biology questions

CO6: Develop the knowledge of bioanalytical techniques to interpret the biological phenomenon

Course Contents:

Unit-1: Microscopy: Introduction, bright field microscopy, dark field microscopy, phase contrast microscopy, epifluorescence/immunofluorescence microscopy, TIRF microscopy, confocal microscopy, electron microscopy (TEM, SEM), atomic force microscopy.

Unit 2. Spectroscopy: A. Spectrophotometric techniques: Ultraviolet and visible light spectroscopy, surface plasmon resonance, fluorescence spectroscopy, luminometry, circular dichroism spectroscopy, atomic spectroscopy, mass spectroscopy. B. Structure and interactions: Infrared and Raman spectroscopy, X-ray diffraction, nuclear magnetic resonance, electron paramagnetic resonance.

Unit 3. Electrophoresis techniques: General principles, support media; electrophoresis of proteins: SDS-PAGE, native gels, gradient gels, isoelectric focusing gels, two-dimensional PAGE, detection, estimation and recovery of proteins in gels, protein (Western) blotting.

Unit 4. Chromatography: General principles, application, working and different types: adsorption chromatography, partition chromatography, molecular(size) exclusion chromatography, ion exchange chromatography, Affinity chromatography

Unit 5. Centrifugation: Basic principles of sedimentation, types of centrifuges, types of rotors, care and safety aspects of centrifuges, preparative centrifugation, differential and density-gradient centrifugation, analytical ultracentrifugation.

Unit 6. Radioisotope techniques: Nature of radioactivity, detection and measurement of radioactivity, Geiger–Muller counter, scintillation counter, autoradiography, safety aspects.

Textbook:

1. Principles and Techniques of Biochemistry and Molecular Biology; Seventh edition. Authors: Wilson K, Walker J. Cambridge University Press, 2010.

Reference Books:

1. Essentials of Biophysics, Second edition. Author: Narayanan P. New Age International, 2010.
2. Spectroscopy of Organic Compounds, Sixth edition. Author: Kalsi PS. New Age International, 2007.
3. Lehninger Principles of Biochemistry, eighth edition. Authors: Nelson DL and Cox MM. W. H. Freeman and company, 2021.
4. Physical Biochemistry: Applications to Biochemistry and Molecular.Biology, Second edition. Authors: Freifelder D, W. H. Freeman and Company, 1983.

Professional Elective – II: Kindly Refer to the Professional Electives section

Open Subject – I: Kindly Refer to the Open Subjects section

BT XXXX Enzymology Lab

Course code	BT XXXX
Course title	Enzymology Lab
Number of credits	2 (L: 0, T: 0, P: 4)
Course category	PC
Continuous Assessment (C.A.)	50
End Semester Assessment (E.S.A.)	50
Prerequisite	Nil

Course Description

Enzymology is a branch of science to understand how biocatalysts work. It is laboratory intensive subject where students can test the functions of enzymes. In this course, students will learn about basic enzyme assays, the evaluation of enzyme kinetics and the effects of reaction conditions on catalysis. Students will learn about data analysis and graph plotting to study enzyme kinetics and learn about process optimization enzyme production and characterization.

Laboratory Outcomes:

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

CO1: Plan and perform basic enzyme assays.

CO2: Execute enzyme kinetics studies and plot graphs based on kinetics data.

CO3: Plan and perform process optimization for enzyme-catalyzed reactions - optimization of pH, temperature and time.

CO4: Plan and perform simple enzyme purification and characterization experiments.

CO5: Design a simple process for enzyme purification and characterization.

CO6: Develop an understanding of the application of enzymology techniques in biotechnology.

Laboratory Experiments

1. Preparation of substrate/product standard curve for enzyme assay using maltose and ABTS.
2. Optimization of enzyme concentration for kinetic studies with purified amylase and alkaline phosphatase.
3. Determination of enzyme activity (I.U.) and calculation of specific enzyme activity of amylase, alkaline phosphatase
4. Time course studies for determination of the optimal time required for catalysis.
5. To study the kinetics of enzyme activity and Estimation of Km and Vmax of an enzyme.
6. Determination of optimal temperature for enzyme activity of a given enzyme preparation
7. Determination of optimal pH for enzyme activity of a given enzyme preparation
8. Isolation of an enzyme from a biological source and demonstration of its activity- moong bean amylase, urease, alkaline or acid phosphatase

Reference Books:

1. Enzymes: Biochemistry, Biochemistry, Biotechnology, Clinical Chemistry, second edition, 2008. Authors: Palmer T and Bonner P. East-West press, 2008.

2. Biochemistry, fourth edition. Authors: Voet G & Voet JG, John Wiley and Sons, Inc. 2011.
3. Biochemical calculations, second edition, Authors: Segel IH. Wiley India Private Limited, 2010.

BT XXXX Bioreaction and Bioprocess Engineering Lab:

Course code	BT XXXX
Course title	Bioreaction and Bioprocess Engineering Lab
Number of credits	4 (L: 0, T: 1, P: 6)
Course category	PS
Continuous Assessment (C.A.)	50
End Semester Assessment (E.S.A.)	50
Prerequisite	Nil

Course Description:
In this course, the students will acquire experimental knowledge and skills on the fundamentals of bioprocess engineering and relate it to the relevant industries. There will be the scope of entering industries and getting trained in unit operations such as manufacturing, monitoring and operating equipment, preparing fermentation media and reagents, and transferring materials for operational upgrading. Some may also be involved with the scientific, technical, training and business aspects of biotechnology companies.

Course Outcomes:
At the end of the course, the students will be able to:
CO1: Explain how microorganisms and biochemical processes can be applied in engineered systems.
CO2: Distinguish among batch, continuous and fed-batch culture systems for the production of biochemical products.
CO3: Describe microbial growth and cultivation, various bioreactor components, and types of bioreactors used in biotechnology industries.
CO4: Design the protocol for media sterilization and design the air filter in a bioprocess.
CO5: Apply various concepts to improve bioreactor performance and evaluate process variables to analyze a bioprocess
CO6: Correlate and create ideas relevant to industrial products and processes.

List of experiments:
1. Demonstration of parts of a bench scale fermenter (7 L and 14 L) with concepts of media preparation, CIP and SIP.
2. Growth of *E. coli* culture using a specialized medium in a 7 L bench scale stirred tank reactor (STR).
3. Calculation of growth kinetics using batch reactor data through the graphical method.
4. Biosorption of toxic dyes using tea dust as a sorbent system.
5. Optimization of the process parameters in lab-scale batch reactor.

6. Biosynthesis of metal nanoparticles in a batch reactor and analysis of the data using Surface Plasmon spectroscopy.
7. Effect of process parameters on the yield of the nanoparticles formation and optimization of the process parameters.
8. Enzyme Immobilization process.
9. Comparative activity assay of free and immobilized enzymes.
10. Theoretical understanding of the scale-up perspective of single reactions (batch mode).

Reference Books:

1. Chemical reaction engineering, third edition, (An Indian Adaptation). Author: Levenspiel, Wiley India Pvt Ltd., 2021.
2. Fundamentals of biochemical engineering, First edition, Author: Dutta R. Springer Berlin, Heidelberg, Jointly published with Ane Books India, 2015.

BT XXXX Advanced QA and QC techniques

Course code	BT XXXX
Course title	Advanced QA and QC techniques
Number of credits	1 (L: 0, T: 0, P: 2)
Course category	PS
Continuous Assessment (C.A.)	100
End Semester Assessment (E.S.A.)	0
Prerequisite	Nil

Course Description:

This course is primarily focused on the analytical techniques that are used in the industry. The main objective of the course is to teach the students about the techniques such as GC, HPLC, etc used for the separation of biological molecules and to understand the characterization of separated molecules. In the case of complex proteins, traditional methods of separation are not effective. Hence, the 2D electrophoresis technique is also included in this course. The overall objective of the course is to train students to operate advanced instrumentation techniques.

Course Outcomes:

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

CO1: Learn the characterization of small molecules from different biological sources by chromatography

CO2: Understand the identification of small molecules by mass spectrometry

CO3: Analyze complex protein samples using 2D electrophoresis

CO4: Characterize macromolecules using Dynamic light scattering (DLS), FT-IR

Course Contents:

1. Analysis of food components and API using HPLC
2. Analysis of fatty acids and volatile organic compounds using GC
3. Protein/peptide characterization using LC-MS

4. Analysis of mammalian/bacterial proteome
5. Characterization of protein/peptide using DLS
6. Characterization of biomolecules using FT-IR

Reference Books:

1. Handbook of advanced chromatography/mass spectrometry techniques, First edition. Editors: Holcapek M, and Byrdwell WC. Academic Press, 2017.

2. Chromatography, 6th edition. Fundamentals and applications of chromatography and related differential migration methods. Part A: Fundamentals and techniques. Editor: Heftmann E. Elsevier, 2004.

SEMESTER-VII

BT XXXX Bioseparation:

Course code	BT XXXX
Course title	**Bioseparation**
Number of credits	3 (L: 2, T: 1, P: 0)
Course category	PC
Continuous Assessment (C.A.)	50
End Semester Assessment (E.S.A.)	50
Prerequisite	Nil

Course Description:

A biomolecule or product is either available in plenty from natural sources or produced in a bioreactor or a fermenter. The product is recovered and purified in several subsequent unit operations and the economy of a manufacturing process is determined by the cost-effectiveness of these downstream operations. This course discusses principles and strategies behind various separation techniques in downstream operations. This course will also emphasize about principles and applications of various analytical techniques used for product and process validation as well as validation of the purity and authenticity of the product. Additionally, case studies include the latest development in the field of purification of commercially important bioproducts including biomass, protein, and metabolites produced from fermentation and process industries.

Course Outcomes:

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

CO1: Learn and remember the basic principles of bioseparation and downstream bioprocess.

CO2: Describe the chemical and physical properties of biomacromolecules and how those properties influence the design of assays, downstream processes and product formulation.

CO3: Explain the basic principles underlying common biopharmaceutical analytical, recovery, separation and purification methods such as spectroscopy, flocculation, precipitation, electrophoresis, membrane filtration, centrifugation, and chromatography.

CO4: Organize the sequence of unit operations for downstream processes and develop simple analytical models.

CO5: Evaluate simple downstream process operations and correlate experimental data.

CO6: Create a simple workflow for the purification of biomolecules and validation of product and process obtained thereof.

Course Contents:

Unit-1: Introduction to fermentation cost economics, Purpose of downstream processing; Filtration: Filter Aids (membrane filter and depth filter), filtration equipments (plate filters

and rotary-drum vacuum filters), filtration theory, micro-filters and ultra filtration systems for separation of cells and fermentation medium, Centrifugation: Basic theory, centrifuge equipments (tubular-bowl, disc-stack bowl, ultracentrifuge), Cell Disruption: Basics, Manton-Gaulin homogenization.

Unit-2: Extraction methods, liquid/ liquid, liquid/solid, partition, ion-pairing, counter-current extraction.

Unit-3: Special separation methods, precipitation, crystallization, supercritical liquid chromatography, TFF, RO system, molecular sieve, analytical ultracentrifugation, immune complex methods.

Unit-4: Applications in Process chromatography: gel filtration, ion exchange, affinity, hydrophobic interaction chromatography, reverse phase chromatography, HPLC, flash chromatography.

Unit-5: Method development and validation in gel filtration, ion exchange, affinity, hydrophobic interaction chromatography, reverse phase chromatography, HPLC, flash chromatography.

Unit-6: Analytical chromatography, TLC, GC, GC-MS, LC-MS/MS, UPLC, detectors, columns, resolution methods, method development and optimization, Case studies in bioseparation and downstream processing.

Textbook:

1. Bioseparations: Priniples and techniques, First edition. Author: Shivshankar B. PHI Learning Pvt. Ltd., 2006.

Reference Books:

1. Bioseparations: Downstream Processing for Biotechnology, First edition. Authors: Belter PA, Cussler EL, Hu WS. John Wiley and Sons, 1988.
2. Principles of Bioseparation Engineering, First edition. Author: Ghosh R. World Scientific Publishing Company, 2006.
3. Bioseparations Science and Engineering, Second edition: Authors: Harrison RG, Todd PW, Rudge SR, Petrides DP. Oxford University Press, 2015.
4. Production technologies of the recombinant therapeutic proteins, First edition. Author: Chakraborty C. Publisher: Biotech Books, 2009
5. Membrane Separation Processes, First edition. Author: Nath K. PHI Learning Pvt. Ltd., 2016.
6. Handbook of Bioseparations: Separation Science and Technology, Volume 2. Editor: Ahuja S. Academic Press, USA, 2000.
7. Chromatography Handbooks by Amersham/GE/Cytiva.

BT XXXX Animal and Medical Biotechnology

Course code	BT XXXX
Course title	Animal and Medical Biotechnology
Number of credits	2 (L: 2, T: 0, P: 0)
Course category	PC
Continuous Assessment (C.A.)	50
End Semester Assessment (E.S.A.)	50
Prerequisite	Nil

Course Description:
Animal and medical biotechnology course focus primarily on techniques and concepts that can be applied to develop strategies for prognostic, diagnostic and treatment for various types of diseases. Topics covered in this course have interface with all branches of biology including molecular biology, cell biology, physiology, etc. The aim of this course is to introduce the students to the classical and modern concepts of red biotechnology including the human genome, gene therapy, disease diagnosis, treatment, etc. The topics covered are cell/tissue culture, assisted reproductive technology, pharmaceutical products via rDNA technology, and clinical research.

Course Outcomes:
At the end of the course, the students will be able to:
CO1: Learn the basic concepts, and overview of animal and medical biotechnology and techniques used routinely in assisted reproduction.
CO2: Understand the use of recombinant DNA technology for the diagnosis of diseases, treatment, and production of pharmaceutically important bio-molecular products.
CO3: Understand the basic and advanced knowledge about infertility, treatment as well as future challenges for society.
CO4: Comprehend the process of biotechnology-based product formation in a company for direct animal and human use.
CO5: Design and integrate the knowledge of physiology and biochemistry in understanding how biotechnological tools be applied on animals and humans.
CO6: Develop and design approaches to problems in animal and medical biotechnology both in academia and industries.

Course Contents:

Unit-1: General concepts: Concepts of cell and tissue culture, requirement for cell culture infrastructure, media for cultured cells and tissues – natural and defined media, preparation of various tissue culture media, contamination and removal and biohazards.

Unit-2: Development of cell lines and their applications: Different cell lines (primary and secondary), Development and maintenance of cell lines - biology and characterization, cell synchronization, senescence and apoptosis. Cell viability, cytotoxicity, cell transformation and cloning.

Unit-3: Assisted reproductive technology: Manipulation of reproduction in animals – Artificial insemination, embryo transfer, molecular mechanism in mammalian fertilization, Estrus synchronization (of ovulation) and IVF, conventional methods of animal improvement –selective breeding.

Unit-4: Gene therapy: Strategies of gene therapy: *ex-vivo, in-vivo, in-situ* gene therapy, ADA deficiency, cystic fibrosis, prodrug therapy/suicide gene, antisense therapy, ribozymes, biological vectors– retrovirus, gene therapy trials.

Unit-5: Diagnosis of diseases using biotechnology: DNA/RNA/Protein in disease diagnosis and medical forensics (methods of assay, infectious disease, genetic disease, environmental monitoring, fingerprinting, etc.)

Unit-6: Pharmaceutical product and application: Pharmaceutical products of recombinant DNA Technology – Insulin, tissue plasminogen activator, growth hormone/somatostatin, interferon, recombinant vaccines, application.

Textbook:

1. Animal cell culture and technology, Second edition. Author: Butler M. Taylor & Francis, 2003.

Reference books:

1. Culture of animal cells: a manual of basic technique and specialized applications, Seventh edition. Author: Freshney IR. Wiley-Blackwell, 2016.
2. Animal cell culture - Practical approach, Third edition. Author: Masters JRW. Oxford University Press, 2000.
3. Biotechnology, First edition. Author: Sathyanarayana U. Books and Allied (P) Ltd, 2020.
4. Medical Biotechnology: Principles and Applications of Recombinant DNA, First edition. Glick BR, Patten CL, Delovitch TL. ASM Press, 2013.

BT XXXX Plant Biotechnology

Course code	BT XXXX
Course title	Plant Biotechnology
Number of credits	2 (L: 2, T: 0, P: 0)
Course category	PC
Continuous Assessment (C.A.)	50
End Semester Assessment (E.S.A.)	50
Prerequisite	Nil

Course Description:

The course comprises the basic concepts of plant biotechnology along with its application in generating high-yield and stress-tolerant plant varieties. In this course, students will be introduced to several topics of plant tissue culture, genetic transformation, transgenic stability and expression, molecular markers and their application in tagging different stresses related genes for indirect selection of genetically improved qualities of crop plants. Overall, this course will provide knowledge of the tools and techniques used in plant biotechnology for commercial as well as application-oriented research.

Course Outcomes:

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

CO1: Learn the basic concepts of plant biotechnology.

CO2: Understand different types of tools and techniques used in the improvement of the plants.

CO3: Comprehend the principles of marker-assisted plant breeding.

CO4: Evaluate the outcome of genetically modified plants.

CO5: Integrate the knowledge of plant biotechnology in the production of improved varieties of crop plants.

CO6: Acquire the skills of plant biotechnology for both academic knowledge and commercial applications.

Course Contents:

Unit-1: Introduction to cell and tissue culture, general and specific techniques of plant tissue culture. totipotency, types of culture, clonal propagation (micropropagation); callus culture, cell suspension and single cell culture, cytodifferentiation, protoplast culture and somatic hybridization; production of haploid plants (anther and pollen culture); somatic embryogenesis and artificial seeds, somaclonal variation, germplasm conservation and cryopreservation.

Unit-2: Gene transfer and editing techniques: Vector-mediated gene transfer, virus-mediated gene transfer (plant viruses as a vector), direct or vector-less DNA transfer, marker genes for plant transformation, particle bombardment, electroporation, microinjection, transformation of monocots, transgene stability, expression and gene silencing (siRNA, CRISPR-Cas). chloroplast transformation: chloroplast genome, vectors for chloroplast transformation.

Unit-3: Application of transgenic technology: Resistance to biotic stresses (Bt crops), tolerance to abiotic stresses. Improvement of crop yield and quality: Green revolution, genetic engineering for extended shelf-life of fruits. transgenic plants with improved nutrition: golden rice-the provitamin 'A' enriched rice, genetic engineering to increase vitamins and minerals, amino acids of seed storage proteins, commercial transgenic crop plants.

Unit-4: Molecular markers and marker-assisted plant breeding: Introduction to plant breeding, morphological markers, biochemical markers, molecular markers. transgenic plants as bioreactors.

Unit-5: Secondary metabolites: Production and application, plant as bio-factory for secondary metabolites.

Textbook:

1. Plant biotechnology; the genetic manipulation of plants, Second edition. Authors: Slater A, Scott NW, Fowler MR. Oxford University Press, 2008.

Reference books:

1. Plant Tissue Culture: Theory and Practice, First edition, Authors: Bhojwani SS, Razdan MK. Elsevier Publication, 1996.
2. Plant Biotechnology, Third edition. Author: Singh BD. Kalyani Publishers, 2019.
3. An Introduction to Plant Breeding, Second edition. Authors: Brown J, Caligari P, Campos H. Wiley-Blackwell publishers, 2014.

BT XXXX Intellectual Property Rights (IPR) and Regulatory Practices

Course code	BT XXXX
Course title	Intellectual Property Rights (IPR) and Regulatory Practices
Number of credits	2 (L: 2, T: 0, P: 0)
Course category	HS
Continuous Assessment (C.A.)	50
End Semester Assessment (E.S.A.)	50
Prerequisite	Nil

Course Description:

The modern biotechnology-driven industry needs a very robust process of bio-risk management and ethical processes for handling preclinical and clinical studies. Biological safety requirements are rapidly evolving in terms of risk evaluation and mitigation processes. The focus shifted from checking compliance with prescribed requirements to manage the system to identify, adapt and mitigate emerging threats via detailed assessment. People responsible for bio-risk management in an organization are challenged to cope with the increasing complexity and diversity of questions. Though the vast majority learn their role “on the job”, there is a strong requirement for a course to train the students in various aspects and rules of biosafety and ethical practices. This course will delve into policies and procedures pertaining to the use of biological materials in research and industry. These policies and procedures are designed to safeguard personnel and the environment from biologically hazardous materials without unduly limiting potential benefits. They will make the students aware of international, national and state regulatory requirements.

Emerging knowledge in biotechnology research is creating a wealth of intellectual properties in research laboratories and industry alike. This knowledge needs to be adequately protected for personal, organizational and national benefits. The intellectual property rights (IPR) part of

this course will teach the students about the national and international rules and laws related to IP protection. They will be able to impart this knowledge for the befit of their organization and pursue a career in IP counseling, patent protection, etc.

Course Outcomes

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

CO1: State the concepts of intellectual properties (IP), copyright, biosafety and bioethics. To be aware of current trends in IPR and biosafety rules.

CO2: Understand national and international guidelines related to ethical practices in biological research and IP issues.

CO3: Understand the roles and responsibilities of different regulatory authorities and safety procedures in risk management during operations.

CO4: Apply appropriate biosafety processes operations in laboratories. ethical issues linked to research on animal models, transgenics, and clinical trials.

CO5: Evaluate the standard procedures of biosafety, bioethics, and IP and regulatory affairs as biosafety officer/IP counsel/patent examiner/patent agent.

CO6: Use their biosafety, bioethics, and IP knowledge in developing new products, and processes.

Course Contents:

Unit-1: Intellectual Property Rights (IPR): Introduction: Conceptual analysis: Concept of property and concept of intellectual property (IP), need for IPR, rationale behind IPR protection. Kinds of IPR: patent, copyright, trademark, geographical indication, protection of new plant varieties, protection of biological resources and associated traditional knowledge under IPR framework: role of access and benefit sharing mechanism. (Discussions on the various types of IPR specifically in the light of various Indian IP Laws on various types of IP with relevant case law analysis). IPR at the international Scenario - major international instruments concerning IPR: Paris convention, 1883, the Berne convention, 1886, TRIPS agreement, 1994, Govt. of India's step towards promoting IPR through India`s New National IP Policy, 2016, career opportunities in IPR.

Unit-2: Biosafety: Regulatory framework for GMOs in India & at the international level: Regulatory framework in India governing GMOs- Recombinant DNA Advisory Committee (RDAC), Institutional Biosafety Committee (IBSC), Review Committee on Genetic Manipulation, Genetic Engineering Approval Committee (GEAC), Cartagena protocol on biosafety – objectives and salient features of Cartagena protocol. Principles and components of containment: Classification of chemical, biological and radiation hazards, components in containment- physical containment, safety equipment, biological containment, laboratory monitoring, health and medical surveillance, decontamination and disposal, emergency procedures. Microbiological biosafety level (BSL) facilities. Guidelines for import, export and exchange of biological materials, convention of biological diversity (1992), guidelines for safety assessment of genetically engineered plants and animals.

Unit- 3: Bioethics: Guidelines for conducting research with human subjects, Nuremberg code, Belmont report, declaration of Helsinki. patenting live microorganisms, human genome project and ethical issues, animal cloning, human cloning and their ethical issues, experiments on animals. Guidelines for human preclinical and clinical trials

Textbooks:

1. Intellectual Property Rights: Protection and Management, First edition. Author: Nithyananda KV. Cengage Learning India Private Limited, 2019.
2. Intellectual Property Rights, First edition. Authors: Neeraj P, Khusdeep D. PHI Learning Private Limited, 2014.
3. Bioethics and Biosafety in Biotechnology, First edition. Author: Sreekrishna V. New Age International publishers, 2017.

Reference Books:

1. WIPO Intellectual Property Handbook. World Intellectual Property Organization 2008. https://www.wipo.int/edocs/pubdocs/en/intproperty/489/wipo_pub_489.pdf
2. Regulations & Guidelines for Reocminant DNA Research and Biocontainment. Department of Biotechnology (DBT), Government of India, 2017. https://ibkp.dbtindia.gov.in/DBT_Content_Test/CMS/Guidelines/20181115134719867_Regulations-Guidelines-for-Reocminant-DNA-Research-and-Biocontainment-2017.pdf
3. Guidelines for the Safety Assessment of Foods Derived from Genetically Engineered Plants. Department of Biotechnology (DBT), Govt. of India, 2017. https://dbtindia.gov.in/sites/default/files/Final_%2011052022_Annexure-I%2C%20Genome_Edited_Plants_2022_Hyperlink.pdf
4. Guidelines on Similar Biologics. Department of Biotechnology (DBT), Government of India, 2016. https://ibkp.dbtindia.gov.in/DBT_Content_Test/CMS/Guidelines/20181115140059519_Guidelines-on-Similar-Biologics-2016.pdf
5. National Ethical Guidelines For Biomedical And Health Research Involving Human Participants. Indian Council for Medical Research ICMR. Government of India, 2017. https://main.icmr.nic.in/sites/default/files/guidelines/ICMR_Ethical_Guidelines_2017.pdf
6. Biosafety in Microbiological and Biomedical Laboratories, 6th edition (2020), Centre for Disease Control, National Institutes of Health, USA. https://www.cdc.gov/labs/pdf/CDC-BiosafetyMicrobiologicalBiomedicalLaboratories-2020-P.pdf

Professional Elective – III: Kindly Refer to the Professional Electives section

Open Subject – II: Kindly Refer to the Open Subjects section

BT XXXX Animal and Plant Biotechnology Lab

Course code	BT XXXX

Course title	Animal and Plant Biotechnology Lab
Number of credits	3 (L: 0, T: 0, P: 6)
Course category	PC
Continuous Assessment (C.A.)	50
End Semester Assessment (E.S.A.)	50
Prerequisite	BT 2019, BT 2022

Course Description

This lab course is designed to provide both basic and advanced knowledge of animal and plant biotechnology for future research and development. The students will gain knowledge about how different growth factors and hormones regulate the growth and development of plant and animal cells. The effectivity and toxicity of different drugs and their consequences on cell viability will be evaluated. On completion of this course, the student will gain expertise in different tools and techniques used in animal and plant biotechnology for both academics and industries.

Course Outcomes:

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

CO1: Gain basic knowledge and background in animal and plant biotechnology.

CO2: Learn different tools and techniques and their applications in industry.

CO3: Understanding of various counting/culture techniques of animal and plant cells.

CO4: Analyze the effect of different hormones and growth factors on animal and plant cells/tissues.

CO5: Identifying and analyzing cell survival, cytotoxic ability of drug and the effect of different factors on animal cell lines.

CO6: Gain and apply plant and animal biotechnology-related advanced knowledge for future research and development.

Course Contents:

Animal Biotechnology (any 6)

1. Isolation, characterization of sperm cells from goat epididymis.
2. Determination of highly motile sperm from semen samples by microscopic methods.
3. Determination of DNA damaging capability of DNA damaging agents using the comet assay.
4. Determination of specific cells specific markers using immunocytochemistry methods
5. Determination of apoptosis using the DAPI staining method.
6. Preparation of sample for H&E staining and IHC of the tissue sample.
7. Dissection of cancer-bearing mice and normal mice and isolation of different organs.
8. Determination of short-term toxicity of a drug using mammalian cell lines (MTT assay).
9. Determination of cell viability after long-term exposure to a drug using cancer cells (clonogenic assay).
10. Determination of DNA damage using comet assay

Plant Biotechnology (any 6)

11. Preparation of Murashige and Skoog's medium (1962)/ MS medium (1962) for plant tissue culture experiments.
12. Study the effect of natural and synthetic cytokinin on embryo culture and study the effect of phytohormones/plant growth regulators on callus development.
13. Separate and study the leaf pigments by paper chromatography.
14. Estimation of the pigment content of supplied leaf samples of different environmental conditions by UV-Visible spectrophotometer.
15. Isolation of DNA/RNA/protein from supplied plant samples and visualization using gel electrophoresis assays.
16. Mechanical/enzymatic isolation, culture and fusion of leaf cell protoplasts, and counting of protoplast density by hemocytometer.
17. A transient assay using Agrobacterium-mediated plant transformation.
18. Cell suspension culture and single cell culture from leaf/callus tissue.

Reference Books:

1. Molecular cloning: A laboratory manual, fourth edition. Authors: Sambrook JF and Russell DW, Cold Spring Harbor Laboratory Press, 2001.
2. Plant Tissue Culture: Techniques and Experiments, Fourth edition. Author: Park S. Academic Press Inc., 2021.
3. Animal Cell Biotechnology: Methods and Protocols, Part of Methods in Molecular Biology Book Series, volume 2095. Editor: Pörtner R. Springer, 2020.

BT XXXX Bioseparation Lab

Course code	BT XXXX
Course title	Bioseparation Lab
Number of credits	2 (L: 0, T: 0, P: 4)
Course category	PC
Continuous Assessment (C.A.)	50
End Semester Assessment (E.S.A.)	50
Prerequisite	Nil

Course Description:

The bioseparation lab deals with the purification of small molecules, natural products, synthetic peptides, recombinant as well as native proteins, monoclonal antibodies, and vaccines. The techniques learned are cost-effective, validatable, and mostly scalable. The techniques covered in this course will enable the students to set up their modular platform without having to buy an expensive system. This will train the student to bring out his/her product with minimal cost of production. The student will learn the setup, the operational qualification, the method of development, method validation, analysis of the data, and scale-up using these separation methods. The course prepares the student for technology development/product analysis, especially in the context of purity, potency, and stability of the product in question.

Course Outcomes:

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

CO1: Describe the solvent handling and solvent extraction process.

CO2: Understand the cost-effective protein, peptides, monoclonal antibody, etc separation methods for process development.

CO3: Apply the techniques for the separation of macromolecules and others.

CO4: Analyze *E. coli*/other suitable microbe-mediated downstream separation methods.

CO5: Evaluate the mammalian cell-mediated downstream process.

CO6: Develop the core concepts of small molecule and natural products separation procedure.

Course contents:

1. Extrinsic miscibility of solvents.
2. Successive solvent extraction of organic compounds.
3. Separation of proteins by salting out gradient.
4. Chloroform/methanol system for protein separation.
5. Sucrose gradient centrifugation for protein separation.
6. Separation of the complex mixture by gel permeation chromatography.
7. Separation of amino acids by thin-layer chromatography.
8. Pre-partition buffer for HPLC application.
9. Protein separation by trichloro acetic acid system
10. Protein separation from *E. coli* broth.
11. Estimation of acetate by GC from *E. coli* broth.
12. Estimation of kanamycin by GC from *E. coli* broth.
13. Separation of proteins using PEG-6000.
14. Separation of active lysozyme using PEG-4000 and ammonium sulphate

Reference Books:

1. Principle and practice of chromatography, First edition, Author: Scott RPW. Library For Science LLC, 2012.
2. The Protein Protocol Handbook, Third edition. Author: Walker JM. Humana Press, 2009.

BT XXXX Seminar

Course code	BT XXXX
Course title	Seminar
Number of credits	1 (L: 1, T: 0, P: 4)
Course category	PS
Continuous Assessment (C.A.)	100

End Semester Assessment (E.S.A.)	0
Prerequisite	Nil

Course Description:

The course is intended to (1) provide information on current professional, research and development issues across the field of biotechnology, (2) stimulate scientific interaction and discussion, and (3) promote students' oral presentation and scientific communication skills. The students will research the assigned topics and prepare presentations. The topics may be on any aspect of biotechnology and must be approved by the instructor in advance. Each student will receive feedback from their peers and the instructor, which will help them to improve their scientific communication skills. Students will also gain exposure on the ongoing issues and new developments in biotechnology.

Course Outcomes:

By the end of this seminar series, students will be able to:

CO1: Augment the breadth of knowledge in various aspects of biotechnology.

CO2: Critically analyze and engage in issues relating to professional careers in biotechnology.

CO3: Search, read and review scientific literature.

CO4: Design and deliver presentations in an effective and engaging seminar.

CO5: Develop oral communication skills.

CO6: Critique ideas and engage in scientific discussions.

Course Content:

Students will research topics and prepare presentations on the topics approved by the instructor. The topics may be any aspect of biotechnology. However, the students will be encouraged to give the seminar on a topic closely related to their area of interest. Students will submit abstract (250 words) along with a detailed outline (1 page) of their presentation in advance to the instructor for approval.

The students should be thoroughly familiar with the literature on the selected topic and organize the presentation cohesively. The students should explain the concepts simply and clearly, and be able to define all terms and acronyms. The jargon of the field needs to be avoided since the audience will be unfamiliar with the topic. The visual aids should look professional and be readable in the entire room. Whereas most students choose to use PowerPoint to present their seminar, the chalkboard is also acceptable for visual aids. Each student will be allowed to give a 20-minute presentation.

Attendance at each seminar is mandatory for all students and the students are expected to participate actively by asking questions to the speaker. The presenter will also receive feedback from their peers and the instructor.

Reference Books/ Resources:

1. The Craft of Scientific Presentations: Critical Steps to Succeed and Critical Errors to Avoid, Second edition. Author: Alley M. Springer-Verlag New York Inc., 2011.
2. Designing Science Presentations: A Visual Guide to Figures, Papers, Slides, Posters, and More, Second edition. Author: Carter M. Academic Press Inc., 2020.

SEMESTER-VIII

BT XXXX Genomics and Proteomics:

Course code	BT XXXX
Course title	Genomics and Proteomics
Number of credits	3 (L: 2, T: 1, P: 0)
Course category	PC
Continuous Assessment (C.A.)	50
End Semester Assessment (E.S.A.)	50
Prerequisite	Nil

Course Description:

The course comprises the fundamental concepts of genomics and proteomics and their applications such as functional genomics and metagenomics. Students will be introduced to several topics of genome organization, genome sequencing, mapping, metagenomics and glycoproteomics. Moreover, the topics such as NGS-based data analysis, metagenomics-based studies, mass-spectrometry, HPLC, and ChIP-seq will help the students to understand the applications of genomics and proteomics. Overall, this course aims to provide both theoretical as well as practical knowledge of the tools and techniques for application-oriented research.

Course Outcomes:

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

CO1: Learn the basic concepts, an overview of genome organization, sequencing and proteomics.

CO2: Understand different types of tools and techniques used for DNA and RNA sequencing.

CO3: Comprehend the principles and applications of different techniques used in metagenomics and proteomics.

CO4: Evaluate the outcome of genomics and proteomics datasets.

CO5: Integrate the knowledge of genomics and proteomics in deciphering the cellular function and complexity of the organism.

CO6: Acquire the skills to resolve scientific problems pertaining to genome function and develop professional skills to apply the knowledge in the related field both in academia and industries.

Course Contents:

Unit-1: Genome organization: Organization and structure of genomes (size, complexity), virus and bacterial genomes, organelle genome, architecture of the mitochondrial genome, conserved chloroplast DNA. Genomes of bacteria, archaea and Eukaryota (case studies) evolution of genomes.

Unit-2: Mapping of the genome: Genetic and physical maps, physical mapping (restriction mapping, fluorescence in situ hybridization, sequence tagged site mapping), map-based cloning, Southern and fluorescence in situ hybridization for genome analysis, molecular markers in genome analysis (RFLP, RAPD, AFLP, SSLPs, EST, STRs and SNPs), optical mapping, radiation hybrids, STS assembly, gap closure; pooling strategies.

Unit-3: Genome sequencing: Gene sequencing and human genome project, strategies for sequencing genomes, sample preparation and construction of libraries for DNA and RNA sequencing, high throughput Next Generation Sequencing (454, Solexa, MiSeq, HiSeq), introduction to quality control and workflow for the analysis of NGS dataset, recognition of coding and non-coding regions, gene annotations, base calling and sequence accuracy, applications of NGS, DNA microarray profiling, processing and presentation of RNA-, ChIP-sequencing data, single cell isolation, gene and transcript analysis of single cells using PCR and NGS.

Unit-4: Metagenomics: Introduction - from genomics to metagenomics, 16S rRNA analysis and culturing, culture-independent insight, approaches to metagenomics analysis - 16S rRNA based survey, 16S rRNA – microarray (phylochip), sequence base analysis, function-based analysis, heterologous expression, identifying active clones - clone screens, selection and functional anchors, identifying habitats and collecting metadata, gene expression system. Data management and bioinformatics challenges of metagenomics - databases for metagenomics data, software, and analysis of metagenomics sequence data.

Unit-5: Comparative proteomics: Differential proteins identification: 2D gel electrophoresis, mass spectrometry, MALDI-TOF, Tandem-MS, HPLC, amino acid sequencing, peptide mass fingerprinting sequence data. Protein interactome: immuno-precipitation, protein-chromatin interaction using ChIp-Seq, solid phase peptide synthesis and its applications, Glycoproteomics: Identification of differential glycosylation patterns of proteins using affinity columns, HPLC, application of glycoproteomics.

Textbooks:

2. Principle of gene manipulation and genomics, Seventh edition, Authors: Primrose SB, Twyman RM. Blackwell Publishing, 2006.
3. Introduction to genomics, Third edition, Authors: Lesk A. Oxford University Press, 2017.

Reference books:

1. Functional genomics, A practical approach, First edition, Authors: Hunt SP, Livesey FJ. Oxford University Press, 2000.
2. Principle of proteomics, Second edition, Authors: Twyman RM. Taylor and Francis Group, 2013.
3. Introduction to proteomics, First edition, Authors: Liebler DC. Springer, 2002.

Professional Elective – IV: Kindly Refer to the Professional Electives section

Professional Elective – V: Kindly Refer to the Professional Electives section

Open Subject – III: Kindly Refer to the Open Subjects section

BT XXXX Minor Project:

Course code	BT XXXX
Course title	Minor Project
Number of credits	6 (L: 0, T: 2, P: 8)
Course category	PS
Continuous Assessment (C.A.)	50
End Semester Assessment (E.S.A.)	50
Prerequisite	Nil

Course Description:

This course will be conducted largely as an individual or small group project under the direct supervision of a member of the academic staff. The specific project topic undertaken will reflect the common interests and expertise of the student(s) and supervisor. The purpose of this course is to help students organize ideas, material and objectives for their project work and to begin the development of communication skills. This will help in preparing the students to present their topic of research and explain its importance to their classmates and teachers.

Course Outcomes:

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

CO1. Demonstrate a sound technical knowledge of their selected project topic.

CO2: Undertake problem identification, formulation and solution working in a group.

CO3: Design experimental solutions applying theoretical knowledge to complex problems utilizing a systematic approach.

CO4: Conduct experiments related to the project and analyze the data.

CO5: Evaluate the outcome of the project and communicate with team members and the community at large in written and oral forms.

CO6: Demonstrate the knowledge, skills and attitudes of a professional biotechnologist.

Course Contents:

The minor project may be carried out in one or more forms of the following in a group of students: Product preparations, working/non-working models, prototype development, laboratory experiment development, process modification/development, simulation, statistical data analysis, survey, and creating awareness in society. The student is required to submit and present a report based on the work for the evaluation of the project.

BT XXXX Scientific Writing and Communication

Course code	BT XXXX
Course title	Scientific Writing and Professional Communication
Number of credits	2 (L: 2, T: 0, P: 0)
Course category	HS
Continuous Assessment (C.A.)	100
End Semester Assessment (E.S.A.)	0
Prerequisite	Nil

Course Description:

The school of biotechnology has thoughtfully analyzed the needs of academia and industries and prepared content for this course to strengthen the skills and efficiencies required. This course gives various inputs on soft skills. Apart from taking the student on a smooth journey from 'English for General Purposes (EGP)' to 'English for Specific Purposes (ESP)' to 'English for Occupational Purposes (EOP)', the syllabus makes sure that the student's personality is nurtured and groomed so that they can prove themselves to be responsible individuals as well as professionals in whatever vocation they choose to pursue. The students are taught the need-specific skills including components addressing the real-time needs of professionals in India and beyond.

Course Outcomes:

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

CO1: Define the basic parameters of professional communication.

CO2: Understand the specific requirements of academia and industries and update the information and knowledge.

CO3: Apply the knowledge gained to solve the simulation exercise given and in the future in the real world.

CO4: Analyze the situation and act accordingly.

CO5: Evaluate the situation and redefine the proceedings.

CO6: Create a professionally accountable personality and engage in a life-long learning process.

Course Contents:

1. Course introduction and requirement of such course in a technical world.
2. Preparation of an impeachable resume and curriculum vitae – Give examples of good vs bad resumes, resume length, and customized resume, How much information shall be present in the resume?
3. The cover letter preparation.

4. Digital profile management: How is an individual's profile in the digital world, social media sites, and how to write an email? How to approach a person of repute in academia or industry. How to address a person, email/social media etiquette.
5. Personal interview skills and etiquette.
6. Self-marketing and elevator pitch.
7. Employability quotient.
8. Personal grooming.
9. English language proficiency: Via article writing, report writing, and communication with peers, superiors and juniors.
10. Attitude and motivation: Importance of positive attitude and self-motivation; self-esteem; time management, and character-building.
11. Decision-making skills, promoting creative & critical thinking.
12. Work ethics.

Reference books:

1. Personality Development and Career Management, Authors: Onkar, R. M, and S. Chand Publishers, 2014.
2. Effective Technical Communication, Authors: Rizvi, A. TMGH Publishers, 2017.

BT XXXX Good Manufacturing and Lab Practices:

Course code	BT XXXX
Course title	Good Manufacturing and Lab Practices
Number of credits	1 (L: 1, T: 0, P: 0)
Course category	PC
Continuous Assessment (C.A.)	100
End Semester Assessment (E.S.A.)	0
Prerequisite	Nil

Course Description:

Familiarity with the Good Manufacturing Practices (GMP) and Good Laboratory Practices (GLP) regulations is necessary for everyone engaged in the manufacture, regulation, quality assurance, and control of drugs and biologics. GMP applies from product development till the product is delivered to the end-user and is mandatory to follow at each stage to ensure consistent product quality each time and all the time. This course is designed to impart fundamental knowledge on various good regulatory practices viz., GMP and GLP, and to understand the rationale behind these requirements and will propose ways and means of complying with them.

Course Outcomes:

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

CO1: Understand the key regulatory and compliance elements concerning GMP and GLP

CO2: Develop an understanding of how GMP regulations are applied in daily operations, and why the regulations are considered necessary.
CO3: Follow proper documentation procedures as outlined in the GLP and GMP.
CO4: Prepare themselves to work in a GMP environment and follow the regulations.

Course Contents:

Unit-1: Current Good Manufacturing Practices (cGMP): Introduction, principles of cGMP, US and WHO guidelines on cGMP, medical device and IVDs guidelines.

Unit-2: Good Laboratory Practices (GLP): Introduction, USFDA GLP regulations, GLP inspection process, documentation, audit, relevant ISO and Quality Council of India(QCI) standards.

Unit-3: Good Automated Laboratory Practices (GALP): Introduction, principles, requirements, SOPs, training documentation, relevant ISO and QCI standards.

Unit-4: Good Distribution Practices (GDP): Introduction, principles, personnel, documentation, premises and equipment, deliveries to customers, returns, self-inspection, provision of information, stability testing principles, WHO, CDSCO guidance and ISO standards.

Unit-5: Quality management systems: Concept of quality, specifications, change control. validation: types of validation, validation of utilities, [Compressed air, steam, water systems, Heat Ventilation and Air conditioning (HVAC)] and cleaning validation. ICH guidelines to establish quality, safety, and efficacy of drug substances and products, ISO and other relevant CDSCO regulatory guidance documents.

Reference Books:

1. Current Good Manufacturing Practices: Pharmaceutical, Biologics, and Medical Device Regulations and Guidance Documents, Concise Reference, Second Edition. Authors: Counts KA, Allport-Settle MJ. Pharmalogika Books, 2018.
2. International Conference on Harmonisation (ICH) Quality Guidelines: Pharmaceutical, Biologics, and Medical Device Guidance Documents Concise Reference, First edition. Author: Allport-Settle MJ. Pharmalogika, 2010.
3. Good Manufacturing Practices for Pharmaceuticals: Gmp in Practice, First edition. Author: Cooper BN. Createspace Independent Publishing, 2017.
4. Principles of Good Laboratory Practice, First edition. Author: Deshmukh P. Adhyyan Books, 2020.
5. Good Laboratory Practice Regulations: 168 (Drugs and the Pharmaceutical Sciences). Editor: Weinberg S. CRC Press, 2007.

SEMESTER-IX

BT XXXX Biomedical Instrumentation

Course code	BT XXXX
Course title	Biomedical Instrumentation
Number of credits	3 (L: 2, T: 1, P: 0)
Course category	ESC
Continuous Assessment (C.A.)	50
End Semester Assessment (E.S.A.)	50
Prerequisite	Nil

Course Description:
The course is designed to give the basic concepts of Instrumentation involved in the medical field and human physiology. The students will learn key measurement principles of sensors found in health technologies, ranging from medical devices used in hospitals to wearables for fitness monitoring. The students will gain insight into the working principles underlying the instrumentation for measuring several electrical and non-electrical parameters, medical imaging and robotics.

Course Outcome:
At the end of the course, the students will be able to have concepts regarding:
CO1: Understand the fundamental concepts in biomedical instrumentation and analysis
CO2: Discuss the application of electronics in the diagnostics and therapeutic field.
CO3: Inspect common biomedical signals and distinguish characteristic features.
CO4: Relate the design aspects of various assist and therapeutic devices.
CO5: Analyze the working principles of various Imaging techniques.
CO6: Identity, explain and judge patient safety issues related to biomedical instrumentation.

Course Contents:

Unit-1: Introduction: Medical devices, classification, *in vitro* diagnostic devices, physiological signals, transducers, selection criteria for transducers, piezoelectric, ultrasonic transducers, temperature measurements, fiber optic temperature sensors.

Unit-2: Measurement of non-electrical parameters and analysis: measurement of blood pressure, cardiac output, heart rate, heart sound, pulmonary function measurements, spirometer, photoplethysmography, body plethysmography, blood gas analyzers, pH of blood, measurement of blood pCO2, pO2, finger-tip oximeter, ESR, GSR measurements.

Unit-3: Acquisition of electrical parameters and analysis: Electrodes, limb electrodes, floating electrodes, pre-gelled disposable electrodes, micro, needle and surface electrodes, amplifiers, preamplifiers, differential amplifiers, chopper amplifiers, Isolation amplifier, ECG,

EEG, EMG, ERG, lead systems and recording methods, typical waveforms, electrical safety in the medical environment, shock hazards, leakage current, Instruments for checking safety parameters of biomedical equipment.

Unit-4: Biomedical imaging and analysis: Radiographic and fluoroscopic techniques, computer tomography, MRI, ultrasonography, endoscopy, thermography, different types of biotelemetry systems, retinal imaging, imaging application in biometric systems.

Unit-5: Life assisting, therapeutic and robotic devices: pacemakers, defibrillators, ventilators, nerve and muscle stimulators, diathermy, heart-lung machine, audio meters, dialyzers, lithotripsy, ICCU patient monitoring system, nanorobots, robotic surgery, orthopedic prostheses fixation.

Textbooks:

1. Introduction to biomedical equipment technology, Fourth edition. Authors: Carr JJ and Brown JM. John Wiley and Sons, New York, 2002.
2. Handbook of Biomedical Instrumentation, Third edition. Author: Khandpur RS. McGraw Hill Education, 2014.
3. Biomedical Instrumentation and Measurements, Second edition. Author: Cromwell L, Weibell FJ, Pfeiffer EA. Pearson Education India, 2015.

Reference Books:

1. Medical Instrumentation Application and Design, Fifth edition. Author: Webster JG. John Wiley and Sons, 2020.
2. Fundamentals of Biomechanics, Second edition. Author: Knudson D, Springer, 2007.
3. The Biomedical Engineering Hand Book, Four Volume Set, Fourth edition. Author: Bronzino JD, Peterson DR. CRC Press, 2015.

BT XXXX Bioentrepreneurship and Startup:

Course code	BT XXXX
Course title	Bioentrepreneurship and Startup
Number of credits	2 (L: 2, T: 0, P: 0)
Course category	HS
Continuous Assessment (C.A.)	50
End Semester Assessment (E.S.A.)	50
Prerequisite	Nil

Course Description:

The goals of this course are to introduce the basic concepts of entrepreneurship in the field of biotechnology, inspire students to learn about the basics and help them imbibe an entrepreneurial mindset. The students will learn the role of bioentrepreneurship in health, agriculture and other developmental processes thereby creating a greater economic impact on

their country and the world. They will be introduced to key processes, traits and essentials of a bioentrepreneur, and will be given an opportunity to assess their strengths and identify gaps that need to be addressed to become successful entrepreneurs. The course comprises several units, each focusing on a specific entrepreneurial knowledge or skill requirement such as creative thinking, communication, risk-taking, and resilience and helping them become career ready. The students will be able to develop personal creativity and entrepreneurial initiative while adopting the key steps in the elaboration of business ideas, understanding the stages of the entrepreneurial process and the resources needed for the successful development of entrepreneurial ventures. Moreover, the course is structured to give details of starting their enterprises, and the essential requirements before, during and after incorporating their start-ups.

Course Outcomes:

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

CO1: Identify the terms used, scope and importance of biotechnology and bioentrepreneurship.

CO2: Understand the role of bioentrepreneurship in the country's economic development and identify business opportunities and the elements of success.

CO3: Discover the role of market survey, legal and financial compliances for starting a biotech business venture.

CO4: Analyze the role of IPR and basic regulatory compliances.

CO5: Evaluate a structured business plan using certain performance indicators.

CO6: Design a case study of any top three biotechnology companies (start-up, various stages in the establishment, etc.,)

Course Contents:

1. Overview of the Indian biotech landscape and the role of technology business incubators in promoting startups.
2. Entrepreneurship redefined - Understanding the effectual thinking, identifying the skill, identifying the resource, stages of product development.
3. Identify the problem: Detailing the problem statement, identifying the direct cause(s) of it, state significance, opportunity, value proposition, USP.
4. Pre-market research - PMR: Identify user market segments affected by the problem, defines an end-user profile, identify the beachhead market - the low-hanging fruit, estimate the total addressable market (TAM).
5. Conceptualize the solution: Define the solution, define high-level product benefits product design.
6. Customer value proposition: Build, capture and quantify the value proposition.
7. Competitive landscape: Overcoming competition, chart the competitive graph.
8. Capturing value: Setting the pricing framework, cost economics.
9. Business plan: Understanding the components of building a business model, and creating a win-win strategy.
10. Grant writing and funding schemes for every stage of product development, tips on writing a winning proposal, and developing and delivering a sharp pitch.

11. Basics of intellectual property rights: Patents, copyright, trademark.
12. Basics of regulatory compliances for medical devices, drugs and clinical trials, bioethics, biosafety, national biodiversity act.
13. Case studies of innovative deep tech-driven startups in various biotechnology fields, entrepreneurial my story session.

Textbooks:

1. Handbook of bioentrepreneurship, First edition. Editors: Patzelt H, Brenner T. Springer Science & Business Media, 2010.
2. The lean startup: How today's entrepreneurs use continuous innovation to create
3. radically successful businesses, First edition. Author: Ries E. Crown Publishing, 2011.

Reference books:

1. The business of biotechnology: From the bench of the street, First edition: Ono RD, Butterworth- Heinemann, 1991.
2. Entrepreneurship in biotechnology: Managing for growth from start-up, First edition. Author: Mann MG. Physica, 2003
3. Innovation and entrepreneurship in biotechnology: Concepts, theories & cases, First edition. Author: Hyne D, Kapeleris J. Edward Elgar Publishing Ltd, 2007.
4. Dynamics of entrepreneurial development and management, Sixth edition. Author: Desai V. Himalaya, Publishing House, 2011.
5. Projects planning analysis, selection, implementation & review, Ninth edition. McGraw-Hill, 2019.
6. Best practices in biotechnology education, Third edition. Editor: Friedman Y. Logos Press, 2008.
7. Entrepreneurship development, First edition. Author: K Ramachandran. McGraw-Hill, 2008.
8. Small business management: An entrepreneur’s guidebook, Seventh edition. Authors: Byrd MJ, Megginson L. McGraw-Hill Education, 2012.
9. Entrepreneurship and new value creation: The Dynamic of the Entrepreneurial Process, First edition. Fayolle A. Cambridge University Press, 2007.
10. World Encyclopedia of Entrepreneurship, First edition. Editor: Dana LP. Edward Elgar Publishing Ltd. 2013.

BT XXXX Synthetic Biology:

Course code	BT XXXX
Course title	Synthetic Biology
Number of credits	3 (L: 2, T: 1, P: 0)
Course category	PC
Continuous Assessment (C.A.)	50
End Semester Assessment (E.S.A.)	50
Prerequisite	BT2013, BT2020, rDNA technology

Course Description:

Synthetic biology is the application of science, technology and engineering to facilitate and accelerate the design, manufacture and/or modification of genetic materials in living organisms. This course introduces the students to a rapidly emerging field and equips them with the basic skills and necessary critical mindsets that are required to explore synthetic biology. It will cover the synthetic biology tools such as the design, synthesis and manipulation of genomes; genome editing; synthetic alternatives; and design and development of artificial genetic and signaling circuits. Later, this course will explore the applications of synthetic biology methods in the production of natural products and to engineer mammalian and plant cells well as their biomedical uses.

Course Outcomes:

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

CO1: Define synthetic biology and understand its applications and importance in the current scenario.

CO2: Understand advanced molecular biology techniques that facilitate synthetic biology.

CO3: Develop working knowledge on the design and development of genetic circuits.

CO4: Develop an understanding of the integrated approaches in metabolic engineering and the production of small molecules.

CO5: Evaluate the applications of synthetic biology including engineering cells, tissues, and medicine.

CO6: Design basic genetic circuits and develop critical thinking about synthetic biological systems.

Course content:

Unit-1: Design, synthesis, and manipulation of genomes: Introduction to Synthetic Biology, Synthetic DNA synthesis and assembly: column and microarray-based oligonucleotide and gene synthesis. Reimagining the bare minimum requirement for cells with essential, quasi-essential, and non-essential genes, determination of essential gene sets, genome minimization by top-down and bottom-up approaches. Principle of genome-editing Technologies with targeted nucleases and applications.

Unit-2: Re-engineering the central dogma: Alternative Watson–Crick Synthetic Genetic Systems: Artificially expanded genetic information systems (AEGIS) and their molecular biology, using AEGIS instead of natural nucleotides, AEGIS in large-scale DNA synthesis, AEGIS as a platform for evolution and moving AEGIS into living cells. Expanding the genetic code by genetically encoding non-coding amino acids (ncAAs), probing the protein structure and function with ncAAs, design of proteins with novel properties using ncAAs.

Unit-3: Cell-free synthesis and computational approaches: Pure and crude extract systems for cell-free protein synthesis technologies, cell-free production of complex proteins, protein assemblies and proteins for novel functionalities, building up to genetic networks in cell-free

systems. Building spatial control and directing protein localization through scaffolds, membrane barriers, and other compartments. Design automation with a focus on specification and design of synthetic genetic systems.

Unit-4: Metabolic engineering and small molecule production: Current approaches and need for integrated approaches in metabolic engineering, engineering at the transcriptome, translatome and reactome levels, manipulations toward reliable enzyme expression, and catalysis. Application of synthetic biology in diversity and discovery of natural products, novel natural products and building natural product production strains.

Unit-5: Applications to higher organisms and ethical perspectives: transcriptional and post-transcriptional gene switches, engineering gene circuits, DNA based digital data storage. Applications of genome-editing and targeted transcriptional regulation. Programmable tissues and organs, synthetic biomaterials and synthetic morphogenesis. Synthetic biology approaches to treat infections, cancer and other diseases. Challenges, ethics and future of synthetic biology.

Textbook:

1. Synthetic Biology: Tools for Engineering Biological Systems, First edition. Editors: Gibson DG, III CA, Smith HO, Venter JC. Cold Spring Harbor Laboratory Press, 2017.

Reference Books:

1. Synthetic Biology - A Primer, first edition. Authors: Baldwin G, Bayer T, Dickinson R, Ellis T, Freemont PS, Kitney RI, Polizzi K, Stan GB. Imperial College Press, 2012.
2. Synthetic Biology, first edition. Editors: Glieder A, Kubicek CP, Mattanovich D, Wiltschi B, Sauer M, Springer international publishing, 2016.
3. Synthetic Biology: Parts, Devices and Applications, First edition. Editor: Smolke C. Wiley-Blackwell, 2018.

Professional Elective – VI: Kindly Refer to the Professional Electives section

Open Subject – IV: Kindly Refer to the Open Subjects section

BT XXXX Industrial Biotechnology Lab:

Course code	BT XXXX
Course title	Industrial Biotechnology Lab
Number of credits	3 (L: 0, T: 0, P: 6)
Course category	PC
Continuous Assessment (C.A.)	50
End Semester Assessment (E.S.A.)	50
Prerequisite	Nil

Course Description:

This lab course is intended to provide basic level knowledge in the areas of health, food, environment and nanobiotechnology. The students will be acquainted with the use of different types of microorganisms, enzymes, materials and their applications for various bio-based products in different sectors. The course will also include the development of various micro and nano-formulations in food and pharmaceutical industries, their characterization techniques and their industrial applications.

Course Outcomes:

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

CO1: Gain knowledge about different types of industrial processes and their applications.

CO2: Design micro and nano-based formulations.

CO3: Compare and characterize the formulations.

CO4: Evaluate the practical efficiencies of the formulations in food, drug and environmental industries.

CO5: Interpret and relate the standard operative procedures of current Good Manufacturing Practices (cGMP) followed in the food, pharmaceutical and environmental biotechnology industries.

CO6: Apply the techniques to improvise and innovate on the industrial processes.

Course content:

1. Study of antibacterial/anti-fungal activities of nanomaterials synthesized using different
2. techniques.
3. Drug formulations using a suitable nano-carrier system.
4. Nanoparticles-based detection of antibiotics/proteins.
5. Nano-formulation of efficient packaging materials for enhancing the shelf-life of foods.
6. Proximate analysis of food samples using FDA and FSSAI guidelines.
7. Designing food safety procedures for fresh produces using different hurdle technology.
8. Protein profiling of dairy substrates using SDS-PAGE.
9. Formulation and characterization of semisolid dosage forms.
10. Spectrophotometric method for drug identification in pharmaceutical formulation.
11. Drug protein interaction studies.
12. Cultivation of microalgae/cyanobacteria in wastewater and estimating its bioremediation efficiency.
13. Biomass harvest and extraction/production of value-added components from the microalgal/cyanobacterial biomass (such as lipid, C-phycocyanin, bioethanol etc.)

Reference Books:

1. Food Analysis, Fourth edition, Authors: Suzsanne N. Springer Verlag, New York, 2011.
2. A Practical Book of Industrial Pharmacy I, First edition, Authors: Hajare AA, Honmane SM. Nirali Prakashan, 2019.
3. Microalgal Production for Biomass and High-Value Products, First Edition, Editors: Stephen P. Slocombe SP, Benemann JR. CRC Press, 2016.

4. 4. A Practical Guide to Environmental Biotechnology, Authors: Patra JK, Das G, Das SK, and Thatoi H. Springer, 2020.
5. Food Packaging Technology, First edition. Editors: Coles R, McDowell D, Kirwan MJ, CRC Press, 2000.
6. Guide to Quality Management Systems for the Food Industry, First edition. Authors: Early R. Blackie Academic and Professional, London, 2006.
3. Pharmaceutical Manufacturing Handbook: Production and Processes, First edition. Editor: Gad SC. John Wiley & Sons, Inc., 2008.

BT XXXX Molecular Diagnostics Lab:

Course code	BT XXXX
Course title	Molecular Diagnostics Lab
Number of credits	2 (L: 0, T: 0, P: 4)
Course category	PC
Continuous Assessment (C.A.)	50
End Semester Assessment (E.S.A.)	50
Prerequisite	BT2020, Genomics and Proteomics

Course Description:

Molecular diagnosis is the process of identifying pathophysiological conditions by studying molecules, such as proteins, DNA, and RNA, in biological samples. It is a new discipline that captures genomic and proteomic expression patterns and uses the information to distinguish between two or more conditions at the molecular level. Presently, the majority of the applications are focused on human genetic diseases or infectious diseases, however, molecular diagnostics can be used in animal or plant diseases, environmental monitoring, food processing, etc. The broad objective of this course is learning and understanding how molecular techniques that were studied in earlier courses can be developed and utilized in diagnosis and used in practical life. Students will a) be familiarized with molecular diagnostic technologies, (b) learn computational methods used to analyze molecular diagnostic data and (c) build abilities to interpret molecular diagnostic testing data and integrate results into clinical decision-making.

Course Outcomes:

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

CO1: Describe the principles and applications of the various molecular diagnostics techniques.
CO2: Plan and perform selected molecular diagnostics techniques for the detection of specific biological conditions.
CO3: Detailed analysis of experimental results and correlation with biological/ pathophysiological conditions.
CO4: Gain thinking and analysis skills to understand new diagnostic methods that can be useful in practical life.
CO5: Create a simple workflow for the detection of other pathophysiological conditions.
CO6: Develop the ability to collect information to develop a new diagnostic kit.

Course Contents:

1. PCR-based diagnostics
    i. Human/animal pathogen detection and identification – *E. coli*, *Salmonella sp.*, *Vibrio sp.*, *S. aureus*, Dengue virus, Human papillomavirus (HPV), etc.
    ii. Plant pathogen detection
    iii. Amplification-refractory mutation system (ARMS) PCR analysis of point mutations
2. Real-time PCR (RT-PCR)-based diagnostics:
    i. Detection of RNA viruses – COVID19, influenza, plant viruses
    ii. Gene copy number determination in tumour tissue
    iii. Targeted gene expression analysis under simulated pathophysiological conditions
3. Sanger DNA sequencing-based diagnostics
    i. Targeted gene sequencing for genus and species identification
    ii. Identification of genetic mutations
4. Next-generation sequencing-based diagnostics (virtual experiment+ data analysis demo)
    i. Exome sequencing for cancer detection
    ii. SNP-based predictive healthcare
    iii. Non-invasive prenatal test (NIPT).
5. HPLC and MS-based diagnostics
    i. Biological fluid (e.g. serum, urine, culture media) analysis by HPLC, LC-MS
    ii. Small molecule (e.g. metabolite, pesticide, antibiotics, etc.) profiling by GC, GC-MS

Reference books:

1. Molecular Diagnostics: A Practical Manual, First edition. Authors: Singh D, Suthar KP, Mehta R. NIPA Books. 2020.
2. Tietz Fundamentals of Clinical Chemistry and Molecular Diagnostics, Eighth edition. Author: Rifai N. Elsevier, 2019.
3. Principles and Applications of Molecular Diagnostics, Edited by: Rifai N, Horvath AR, Wittwer CT. Elsevier, 2018.
4. Clinical Molecular Diagnostics, First edition. Editors: Pan S. and Tang J. Springer, 2021.

BT XXXX Project Proposal Preparation and Presentation

Course code	BT XXXX
Course title	Project Proposal Preparation and Presentation
Number of credits	1 (L: 1, T: 0, P: 0)
Course category	PC
Continuous Assessment (C.A.)	100

End Semester Assessment (E.S.A.)	0
Prerequisite	Nil

Course Description:

This course will help students develop research skills through its focus on writing and critiquing research proposals. All enrolled students are required to sign up for the course with a faculty advisor who will actively support the proposal development process. Students will develop a research or project proposal, and milestones for the proposal development process. Students will review components of research proposals and practice developing effective aims, hypotheses, background materials and analytical strategies. To get credit in this course, the student will submit a research proposal and complete all other class assignments, provide the class with progress updates, participate in peer editing, write critiques for two research proposals written by peers, participate in the study section and score all proposals, actively participate in class discussions, and hand in additional written assignments.

Course Outcomes:

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

CO1: Remember and describe the important concepts of scientific research, scientific misconduct and plagiarism.

CO2: Understand and identify the key components of a research proposal.

CO3: Demonstrate the ability to conduct literature reviews and gather critical scientific information related to the research proposal.

CO4: Demonstrate writing skills by writing a clear, concise research proposal with scientifically defensible aims, methods and conclusions.

CO5: Create the key components of a research proposal.

CO6: Develop the skills to objectively review and evaluate a colleague's scientific proposal.

Course Contents:

1. Class readings, assignments, and active participation in class discussions. Readings are intended to support students' development as a scientist. Often, they will form the basis for class discussion. Most written assignments are intermediate drafts of the thesis proposal. Students are required to turn in assignments on time. For intermediate drafts, due dates are intended to support the work throughout the semester.

2. Student is expected to meet with a research mentor multiple times over the semester and solicit their feedback on their respective work. Mentor meetings should include conceptual discussions, plus feedback on the main study objective(s), proposal title, specific aims and hypotheses, study design, analysis approach, and other details. Students are required to turn in the mentor's feedback on the proposal draft as part of the required coursework.

3. Student is expected to hand in a complete research proposal. The proposal format to guide the students for details will be provided by the research mentor.

4. Student is expected to actively participate in the “Study Section” review of other student proposals. The class will be divided into peer review groups or “study sections”. Each group will review the proposals from all students in the other group.

Reference books:

1. The Only Grant-Writing Book You’ll Ever Need: Top Grant Writers and Grant Givers Share Their Secrets, Third edition. Authors: Karsh E, Arlen SF. Basic Books, 2009.
2. Proposals That Work: A Guide for Planning Dissertations and Grant Proposals, Sixth edition. Authors: Locke LF, Spirduso WW, Silverman S. SAGE Publications, Inc, 2013.
3. Guide to Effective Grant Writing: How to Write a Successful NIH Grant Application. Second edition. Author: Yang OO. Springer-Nature, 2012.

BT XXXX Summer training seminar:

Course code	BT XXXX
Course title	Summer training seminar
Number of credits	2 (L: 0, T: 0, P: 4)
Course category	PC
Continuous Assessment (C.A.)	100
End Semester Assessment (E.S.A.)	0
Prerequisite	Nil

Course Description:

An internship for at least four weeks needs to be done in summer breaks after semester IV or semester - VI and will be considered for evaluation in Semester - VIII. The summer internship should give the students exposure to the practical aspects of biotechnology. In addition, the student may also work on a specified task or project which may be assigned to him/her. The outcome of the internship should be presented in the form of a report. The purpose of this course is to help students to organize ideas, material and objectives for their dissertation, to develop communication skills, to prepare the students to present their topic of research and to explain its importance to their classmates and teachers.

Course Outcomes:

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

CO1: Recognize and recall the theoretical knowledge in the field of biotechnology

CO2: Understand the applications of theoretical knowledge to the practical requirements of a workplace for the society

CO3: Apply various soft skills such as time management, positive attitude and communication skills during the performance of the tasks assigned in the internship organization.

CO4: Relate the theoretical knowledge for the interactions between research, development and business in the biotechnology sector.

CO5: Evaluate or test the theoretical learning in practical situations by accomplishing the tasks assigned during the internship period.
CO6: Compile information and generate knowledge based on biotechnological skills within the workplace environment.

Course Contents:
Summer internships should provide hands-on training in tools and techniques in biotechnology and allied areas to generate skills. It should provide exposure to students through the observation process in various fields of biotechnology.

SEMESTER-X

BT XXXX Major Project:

Course code	BT XXXX
Course title	Major Project
Number of credits	20 (L: 0, T: 0, P: 40)
Course category	PC
Continuous Assessment (C.A.)	100
End Semester Assessment (E.S.A.)	0
Prerequisite	Nil

Course Description:

This course provides the opportunity to complete a 15-week scientific project in the different areas of biotechnology in academic institutions or industries. This experience will provide a different perspective and context for academic learning and allows theory to be put into practice. The course requires students to integrate real-world skills and experience with theoretical concepts and knowledge obtained during their program. Students will undertake a work-integrated placement to position themselves for a career upon graduation. This is achieved through integrating real-world skills and experience with work-integrated, experiential learning. Students will be able to undertake their work-integrated learning experience in a broad spectrum of work environments. Project work shall be assigned individually and it must be carried out under the guidance of a supervisor.

Course Outcomes:

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

CO1: Remember and describe the important concepts of scientific research.

CO2: Understand and identify the key components of a project proposal demonstrating fundamental concepts and methods in ways appropriate to their principal areas of study.

CO3: Apply various skills, knowledge and techniques related to current information specific to the field of biotechnology through literature study.

CO4: Examine, analyze and illustrate creatively through sustained critical investigation and use effective oral, written and visual communication to integrate information from multiple sources.

CO5: Demonstrate an awareness, creativity and application of appropriate personal, societal, and professional ethical standards in the execution of the project.

CO6: Compile information and knowledge gained to generate new solutions, prepare and present the report/thesis related to the project work.

Course Contents:

Biotechnology is a very interesting subject that combines biology with technology and offers a vast opportunity for making innovations. Students have to choose a topic in the emerging fields of research in biotechnology. Each student has to undertake a project/dissertation work under the guidance of a supervisor/guide. The outcome will be the intellectual property of the student and the guide which cannot be published without written permission of the guide. Students have to conduct extensive literature searches which will help them to write and submit the thesis. The dissertation thesis has to be presented in the following sub-heads like Contents, Acknowledgements, Introduction, Review of literature, Material and methods, Results and Discussion, References, Appendices, etc.