Mahatma Education Society's

Pillai College of Arts, Commerce & Science (Autonomous)

Affiliated to University of Mumbai

'NAAC Accredited 'A' grade (3 cycles)'
'Best College Award' by University of Mumbai
ISO 9001:2015 Certified

SYLLABUS

Program: Bachelors of Science (B. Sc.) in Biotechnology

F.Y.B.Sc.Biotechnology

PCACS/BSCBT/SYL/2024-25/FY

As per National Education Policy
Choice Based Credit & Grading System

Academic Year 2024-25

Mahatma Education Society's

Pillai College of Arts, Commerce & Science

(Autonomous)

Affiliated to University of Mumbai

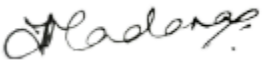
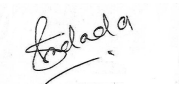
NAAC Accredited 'A' grade (3 cycles)

Best College Award by University of Mumbai

ISO 9001:2015 Certified

Board of Studies of Department of Biotechnology

1	Mrs. Suparna Deepak Assistant Professor, PCACS	Chairperson (Head of Department of Biotechnology)	
2	Mrs. Meenakshi Johri Assistant Professor, PCACS	Member	
3	Mr. Gopakumar Pillai Assistant Professor, PCACS	Member	
4	Mrs. Bindu Rajaguru Assistant Professor, PCACS	Member	
5	Dr. C. K. Prashant Assistant Professor, PCACS	Member	
6.	Mrs Suprita Rao Assistant Professor, PCACS	Member	
7	Dr. D.B. Thakare Former Chairman,BOS of Microbiology,University of Mumbai	Vice Chancellor Nominee	
8	Dr. Mansee Thakur	Subject Expert From outside Parent University	

	Director,MGM School of Biomedical Sciences,Kamothe,Navi Mumbai		
9	Dr.Usha Padmanabhan Senior Scientific Officer&Head,Cell Biology Department,Haffkine Institute of Testing,Training,Research,Parel, Mumbai	Industry Representative (Industry/Corporate/Allied sector)	
10	Dr. Thakamani Marar Dean,Faculty of Science and Technology,Professor,School of Biotechnology, D.Y Patil University,Navi Mumbai	Subject Expert From outside Parent University	
11	Dr. Pankaj Mundada Asistant Production Head, Agri Division Warkem Biotech Pvt Ltd,Mumbai	Post Graduate Meritorious Alumni	
12	Dr. P. S. Goyal Dean, R&D, Pillai College of Engineering	Faculty Specialist	
13	Dr. Gajanan Wader	Principal, PCACS	
14.	Mrs Deepika Sharma	Vice Principal PCACS	

1. Introduction to B. Sc Biotechnology

The interdisciplinary nature of biotechnology integrates living systems including animal, plant and microbes and their studies from molecular biology to cell biology, from biochemistry to biophysics, from genetic engineering to stem cell research, from bioinformatics to genomics- proteomics, from environmental biology to biodiversity, from microbiology to bioprocess engineering, from bioremediation to material transformation and so on. The relevance and application of these studies on living organisms and their bioprocesses is extensively covered in the syllabus B.Sc. Biotechnology program.

The B.Sc. Biotechnology program is a three-year degree. In these three years, students will tackle core subjects to ensure that they receive a solid grounding in fundamentals. In the final year, students can make their choice from a wide range of options and research projects.

Biotechnologists are always in demand as an efficient work force in fundamental research and industries. Education and research sectors require such an interdisciplinary trained workforce to develop future generations of science leaders.

2. Programme Outcomes for B. Sc. Biotechnology Programme

Sr. No.	PO Title	POs in brief
PO 1	**Theoretical Knowledge**	Demonstrate strong theoretical background which they would be able to use in Biotech industry, hospitals, community and institutes or any other profession they would like to pursue.
PO 2	**Practical skills**	Demonstrate the knowledge to manipulate living cells to create and manufacture various products that will help in diagnosis and treatment of diseases as well as in areas like food, agriculture and environment.
PO 3	**Planning Experiments**	Ability to design and conduct experiments, as well as to analyse and interpret scientific data.
PO 4	**Biosafety**	Demonstrate competency in laboratory safety and in routine and specialized biotechnological laboratory skills applicable to biotechnology research or clinical methods, including accurately reporting observations and analysis.
PO 5	**Communication**	Communicate scientific concepts, experimental results and analytical arguments clearly and concisely, both verbally and in writing and also ability to present their work through written, oral, and visual presentations, including an original research proposal
PO 6	**Ethics**	Awareness of the impact of biosolutions in a global, economic, environmental, and societal context and understanding of professional and ethical responsibilities.
PO 7	**Innovation**	Inculcate an attitude of enquiry towards developing innovative ability and enhancing entrepreneurship skills.
PO 8	**Life-long learning**	Interdisciplinary approach helps in providing better solutions and new ideas for the sustainable developments, recognition of the need for, being a better human being and an ability to engage in life-long learning.

3. Programme Specific Outcomes for B. Sc. Biotechnology Programme.

Sr. No	PSO Brief
PSO-1	Apply biotechnology skills (including molecular & micro biology, immunology & genetic engineering, bioprocess & fermentation, enzyme & food technology and bioinformatics) and its applications in core and allied fields.
PSO-2	Exhibit in-depth practical oriented knowledge to students in various thrust areas of biotechnology, so as to meet the demands of industry and academia.
PSO-3	Identify and formulate healthcare, textile, cosmetics, agriculture, marine products for commercialization.
PSO-4	Develop concepts and research approaches for higher career in the field of biotechnology and develop scientific interest required for research.

Course Structure

Semester I						
Course Code	**Course Type**	**Course Title**	**Theory/ Practical**	**Marks**	**Credits**	**Lectures / Week**
PUSBT101	**Major**	Basic Biotechnology	Theory	100	2	4
PUSBT102	**Major**	Basic Microbiology	Theory	100	2	4
PUSBT103	**DISC** Minor	Basic Chemistry	Theory	100	2	4
PUSBT104	**SEC (FLIPPED CLASSROOM)**	Plant Development Biology	Theory	100	2	2
PUSBT105P	**Major**	Basic Biotechnology Practicals	Practical	50	2	4
PUSBT106P	**Major**	Basic Microbiology Practicals	Practical	50	2	4
PUAEC101	**AEC**	Effective Communication Skills	Theory	100	2	3
PUVAC101	**VAC**	To be taken from the Pool	Theory	100	2	3
PUIKS101	**IKS**	General IKS-I	Theory	100	2	3
PUIDC10	**IDC**	To be taken from the Pool	Theory	100	2	3
Total				850	22	38
All Subjects having Field Project as part of Continuous Assessment-2						

Abbreviations:

SEC: Skill Enhancement Course
AEC: Ability Enhancement Course
VAC: Value Added Course
IKS: Indian Knowledge System
IDC: Interdisciplinary Course

Semester II						
Course Code	**Course Type**	**Course Title**	**Theory/ Practical**	**Marks**	**Credits**	**Lectures/ Week**
PUSBT201	**Major**	Biomolecules & Enzymology	Theory	100	2	4
PUSBT202	**Major**	Immunology	Theory	100	2	4
PUSBT203	**DISC** Minor	Applied Chemistry	Theory	100	2	4
PUSBT204	**SEC (FLIPPED CLASSROOM)**	Advanced Environmental Microbiology	Theory	100	2	2
PUSBT205P	**Major**	Biomolecules & Enzymology Practicals	Practical	50	2	4
PUSBT206P	**Major**	Applied Chemistry Practicals	Practical	50	2	4
PUAEC20-	**AEC**	Indian Languages from the pool	Theory	100	2	3
PUVAC20-	**VAC**	To be taken from the Pool	Theory	100	2	3
PUIKS201	**IKS**	General IKS-II	Theory	100	2	3
PUIDC20-	**IDC**	To be taken from the Pool	Theory	100	2	3
Total				850	22	38
All Subjects having Field Project as part of Continuous Assessment-2						

Abbreviations:
SEC: Skill Enhancement Course
AEC: Ability Enhancement Course
VAC: Value Added Course
IKS: Indian Knowledge System
IDC: Interdisciplinary Course

Evaluation Pattern

Marking Code	Marking Scheme
A	60 Marks Final Exam, 20 Marks Internal Exam, 20 Marks Project.
B	50 Marks Continuous Exam, 50 Marks Practical Exam.
C	100 marks distributed within report /case study/ project/ presentation etc.
D	50 Marks Practical Examination.

Semester I

Course Code	Course Type	Course Title	Evaluation
PUSBT101	Major	Basic Biotechnology	A
PUSBT102	Major	Basic Microbiology	A
PUSBT103	Disciplinary Minor	Basic Chemistry	A
PUAEC101	AEC	Basic Communication Skills	C
PUSBT105P	Major	Basic Biotechnology Practicals	D
PUSBT106P	Major	Basic Microbiology Practicals	D
PUIKS101	IKS	IKS-1	D

Semester II

Course Code	Course Type	Course Title	Evaluation
PUSBT201	Major	Biomolecules & Enzymology	A
PUSBT202	Major	Immunology	A
PUSBT203	Disciplinary Minor	Applied Chemistry	A
PUAEC201	AEC	Indian Language	C
PUSBT205P	Major	Biomolecules & Enzymology Practicals	D
PUSBT206P	Major	Applied Chemistry Practicals	D
PUIKS201	IKS	IKS-2	D

Semester I

BOS	Biotechnology
Class	F. Y. B. Sc
Semester	I
Course Name	Basic Biotechnology
Course Code	PUSBT101
Type of Course	Major
Level of the Course	Basic
Total Credits for the Course	4 Theory + 1 Practical

Course Objectives:

1. Acquaint students with various fields of Biotechnology and its applications,create Awareness about ethics in Biotechnology.
2. Impart knowledge about Fundamental concepts of Biotechnology such as ultrastructure of cell and biomolecules.Introduce the concept of Intellectual Property Rights.

Unit No.	Name of Unit	Topic No.	Name of Topic	Hours
I	Introduction, Scope and Cons of Biotechnology	1.1	**History & Introduction to Biotechnology:** What is Biotechnology? Definition of Biotechnology, Traditional and Modern Biotechnology.	10
		1.2	**Indian Knowledge System in Biotechnology:** Development of Biotechnology in India, Indian contributions to Biotechnology Biotechnology Research in India. Biotechnology Institutions in India (Public and Private Sector), Public Perception of Biotechnology	
		1.3	**Types and Branches of Biotechnology**: Plant Biotechnology, Animal Biotechnology, Marine Biotechnology, Agriculture Biotechnology, Healthcare Biotechnology, Industrial Biotechnology, Pharmaceutical Biotechnology, Environmental Biotechnology, Marine Biotechnology	

II	Structure of Prokaryotic and Eukaryotic Cell	2.1	**Ultrastructure of Prokaryotic Cell:** Cell theory, Concept of Cell Shape and Size, Detail Structure of Slime Layer, Capsule, Flagella, Pilli, Cell Wall(Gram Positive and Negative), Cell Membrane, Cytoplasm and Genetic Material Storage Bodies and Spores	12
		2.2	**Ultrastructure of Eukaryotic Cell:** Plasma membrane,Cytoplasmic Matrix, Microfilaments, Intermediate Filaments, and Microtubules Organelles of the Biosynthetic-Endoplasmic Reticulum & Golgi Apparatus. Lysosome, Eukaryotic Ribosomes, Mitochondria, and Chloroplasts. Nucleus –Nuclear Structure, Nucleolus External Cell Coverings: Cilia And Flagella Comparison of Prokaryotic And Eukaryotic Cells	
III	Biomolecules: Nucleic Acids	3.1	Nucleic Acids: Structure, Function of Nucleic Acids, Properties and Types of DNA and RNA.	08
		3.2	Structure of Purine and Pyrimidine Bases Hydrogen Bonding between Nitrogenous Bases in DNA, Differences between DNA and RNA	
IV	Applications of Biotechnology and IPR	4.1	Applications of Biotechnology in Agriculture: GM Food - GM Papaya; Insect Resistant Plants - BT Crops: BT Cotton: Pros and Cons	10
		4.2	Biotechnological applications in Crop Improvements: Modifications in Plant Quality - Golden Rice	

		4.4	Introduction and significance of IPR	
			TOTAL LECTURE	**40**

Course Outcomes:

1. Define the term "Biotechnology" and appreciate its historical perspective, scope and importance.
2. Discuss the multidisciplinary nature of Biotechnology and the role of government agencies for enabling technologies in the development of Biotechnology.
3. Explain the concepts of intellectual property rights and ethical issues associated with Biotechnology.
4. Investigate different protocols and strategies for development of genetically engineered crops for novel traits.
5. Evaluate the various aspects of Biotechnological applications in Food and Fermentation Technology.
6. Develop strategies for utilizing Biotechnology in the agricultural, food, industrial and pharmaceutical sector for the benefit of society.

References:

1. Advanced Biotechnology – R.C Dubey
2. A textbook of Biotechnology – R.C Dubey
3. Biotechnology – B.D Singh
4. Ganguli, P. (2001). Intellectual Property Rights: Unleashing the Knowledge Economy. New Delhi: Tata McGraw-Hill Pub.
5. Intellectual Property Rights. Neeraj Pandey, Khushdeep Dharni. PHI Learning Private Ltd.

	CASE STUDY:
1	The GM crops was the first genetically engineered crop product to be commercialized. The research and marketing efforts that produced the GM crops resulted in scientific success, a temporary sales success, and then commercial demise. The GM crops story reveals how difficult it can be to bring genetically engineered products to market, how objections with little or no scientific merit can influence the outcome, and how important public opinion is in determining commercial success. Use of genetically engineered plants for food production has raised many questions about food safety. Scientists, environmentalists, and government regulators have debated safety issues since the advent of genetic engineering. Recently, Calgene, Incorporated became the first company to go to the FDA to request its evaluation of what will likely be the first whole food produced using genetic engineering technology: the GM crops.
2	The introduction of Bt cotton led to a dramatic increase in production across the cotton producing states and soon Bt cotton took over most of the acreage under cotton cultivation. Critics of genetically modified (GM) crops often contend that their introduction enhances the gap between rich and poor farmers, as the former group are in the best position to afford the expensive seed as well as provide other inputs such as fertilizer and irrigation. The seeds are more expensive than local, non-genetically modified varieties. Seeds cannot be reused and farmers need to buy new

	stock for every growing season. This, along with licensing agreements with local seed companies, has given Monsanto a near monopoly on cotton seeds in India that has been the biggest worry for activists. Diffusion of illegal Bt hybrids that hadn't been cleared for bio safety standards, leading to fears of environmental toxicity. The impact of Bt cotton, as perceived by the farmers, has been in terms of enhanced yield; reduced pest and disease incidence; increased income, employment, education and standard of living; and reduced health risk. To foster adoption, availability of quality and quantity of Bt cotton seed to farmers needs greater attention of development agencies, while researchers' attention is called for incorporating resistance/ tolerance to Spodoptera and pink bollworms.

PRACTICALS	
1	Assignment- Study of any branch of biotechnology and its applications
2	Working and use of various Instruments used in Biotechnology Laboratory (Autoclave, Hot air Oven, Centrifuge, Incubator, Rotary Shaker, Filter Assembly, pH meter and Colorimeter)
3	Isolation of genomic DNA from Onion
4	Agarose Gel Electrophoresis
5	Isolation of organisms causing Food Spoilage.
6	Microscopic determination of Microbial flora from Yoghurt and Lactic Acid Determination.
7	Analysis of Milk- Methylene Blue, Resazurin Test, Phosphatase Test.
8	Meat Tenderization using Papain.
9	Components and working of Simple, Compound, Dark Field, Phase Contrast Microscope

BOS	Biotechnology
Class	F. Y. B. Sc
Semester	I
Course Name	Basic Microbiology
Course Code	PUSBT102
Type of Course	Major
Level of the Course	Basic
Total Credits for the Course	4 Theory + 1 Practical

Course Objectives:

1. Introduce field of microbiology with special emphasis on microbial staining, nutrition, cultivation and methods for control of microbes.
2. Give hands on training of basic and very important bacteriological techniques which will give the student a strong base in microbiology.

Unit No.	**Name of Unit**	**Topic No.**	**Name of Topic**	**Hours**
I	Study of Different Groups of Microbes	4.1	**IKS in Microbiology**: Sukshmjeevanu in Vedas: The Forgotten Past of Microbiology in Indian Vedic Knowledge	**10**
		4.2	**Viruses**: Historical highlights, General Characters, Classification (Plant, Animal and Bacterial Viruses) and Structure.	
		4.3	**Fungi and Yeast**- Characteristics, structure, Biological and economical importance of fungi.	
		4.4	**Protozoa**- General characteristics, Structure, and Importance of protozoa **Algae** – Characteristics of algae: morphology, Pigments, Biological, Medical and economic importance of Algae.	
II	Microscopy and Stains	2.1	Microscopy-Principle, Parts, Function and Applications- Bright field, Dark field, Phase contrast, Fluorescence	10

			microscope.	
		2.2	Stains and Staining Solutions- a. Dyes and stains: Definition of Dye and Chromogen. Structure of Dye and Chromophore. Types of dyes and stains, Functions of fixatives, mordants, decolorizers	
		2.3	b. Simple, negative, differential and Special staining	
III	Control of micro organisms	3.1	Definition of frequently used terms & Rate of microbial death, Factors affecting the effectiveness of antimicrobial agents & Properties of an ideal disinfectant	10
		3.2	Evaluation of disinfectant –Phenol coefficient. agar plate method.	
		3.3	Physical methods of microbial control ● Dry & moist heat – mechanisms, instruments used and their operations ● Electromagnetic radiations – Ionizing radiations, mechanisms –advantages & disadvantages ● Membrane filters ● Low temperature ● Osmotic pressure ● Desiccation	
		3.4	Chemical methods of microbial control – mechanism, advantages & disadvantages (if any) and applications. a. Phenol and Phenolic compounds b. Alcohols c. Heavy metals and their compounds d. Dyes e. Surfaces active agents/Detergents	
		3.5	Indian Knowledge System: Control of Microbes using Indian Herbs (any two)- mechanism, advantages & disadvantages (if any) and applications.	

IV	Nutrition, Cultivation and growth of microorganisms	4.1	Nutritional Requirements: Carbon, Oxygen, Hydrogen, Nitrogen, Phosphorus, Sulphur, microelements and Growth Factors	10
		4.2	Nutritional Types of Organisms	
		4.3	Culture techniques -Media preparation -Solid and Liquid- Types of Media – Crude, Semi Synthetic, Synthetic, Enriched, Enrichment, Selective, Differential and Assay and transport media, Anaerobic culture technique	
		4.4	Concept of Isolation and Methods of Isolation: Pure Culture Techniques- Streak plate, Tube dilution- Pour, Spread plate.	
		4.5	Growth and its measurement: ● Definition of growth, Mathematical Expression, Growth curve, Arithmetic Growth and Growth Yield. ● Continuous culture- chemostat and turbidostat	
		4.6	Preservation of Cultures: Maintenance and Preservation -Short term – Slant, Stab, Mineral oil overlay -Long term – Lyophilization, Cryopreservation, Storage in sterile soil, Storage in silica gel.	
			TOTAL LECTURES	40

Course outcomes: By the end of the course the student will be able to:

1. Describe basic principles and different kinds of microscope and classify various types of stains and dyes and explain the process of different staining techniques.
2. Discuss the five phases of a microbial growth curve observed when microbes are grown in a batch culture and influence of environmental factors on growth.
3. Illustrate the diversity of microorganisms and microbial communities and recognize the importance of microorganisms.
4. Compare different physical, chemical methods and Indian medicinal plants to control microbial growth.
5. Evaluate efficiency of antimicrobial agents.
6. Perform basic experiments to grow, preserve and study microorganisms in the laboratory.

References:

1. Prescott, L.M J.P. Harley and C.A. Klein 1995. Microbiology 2nd edition Wm, C. Brown publishers.
2. Salle A.J. : Fundamental Principles of Bacteriology 7th edition, Tata Mc Hill Publishing Company Ltd.,
3. Kathleen Park Talaro & Arthur Talaro - Foundations in Microbiology International edition 2002,| McGraw Hill.
4. Michael T.Madigan & J.M.Martin,Brock ,Biology of Microorganisms 12th Ed. International edition 2006, Pearson Prentice Hall.
5. Michael J. Pelczar, Jr. E.C.S. Chan, Moel : Microbiology McGraw Hill Book R. Krieg, 1986 Company
6. Stainer R.Y. Ingraham J.L. Wheolis H.H and Painter P.R. 1986 The Microbial world, 5th edition. Eagle Works Cliffs N.J. Prentica Hall.
7. Wilson. K and Goulding. K.H. 1986. A Biologist's Guide to Principles and Techniques of Practice

	CASE STUDY
1	In a research laboratory studying extremophiles, Dr. Lisa and her team collected samples from Yellowstone's hot springs. They isolated thermophiles using dilution plating and molecular techniques, selecting colonies based on morphology and employing PCR for species identification. These isolated extremophiles have to be preserved through a suitable method ensuring long-term viability and accessibility for future research into their ecological roles and biotechnological applications. What protocol Dr. Lisa would have followed for the isolation of thermophiles and how their team can preserve the culture using cryopreservation?
2	Mr. Z is planning to set-up industry to produce Lipase enzyme. He has isolated a bacterial strain from mangrove soil sample. He has studied its morphological, cultural and biochemical characteristics. After comparing with the available database he found that the culture is novel. He wants to preserve the culture by a technique which will give genetic stability and also he can preserve the culture at ambient temperature.

Practicals:	
1	Monochrome Staining, Negative staining, Gram Staining.
2	Preparation of Media- Nutrient broth and Agar, MacConkey's Agar, Sabouraud's Agar
3	Sterilization of Laboratory Glassware and Media.
4	Inoculation techniques and Study of Growth: a. Inoculation of Liquid Medium b. Inoculation of Solid Media (Slants, Butts and Plates) c. Study of Colony Characteristics of pigment & non pig1ment producing bacteria.

5	Study of Growth curve of E.coli
6	Enumeration of microorganisms by Direct method-Breed's count, Haemocytometer count
7	Viable count- Serial Dilution, Pour Plate, Spread Plate Method
8	Effect of UV Light, heavy metals (Oligodynamic action), dyes and antibiotics on microbial growth.
9	Fungal Wet mounts & Study of Morphological Characteristics :Mucor,Rhizopus,Aspergillus, Penicillium,Permanent slides of Algae, Protozoa..

BOS	Biotechnology
Class	F. Y. B. Sc Biotechnology
Semester	I
Course Name	Basic Chemistry
Course Code	PUSBT103
Level of Course	Basic
Type of the Course	Disciplinary Minor
Total Credits for the Course	4 Theory + 1 Practical

Course Objectives:

1. To acquaint the students with the basic concept of chemistry like chemical bonding and thermodynamics.
2. To acquaint the students with concepts of titrimetry, kinetics and chemical reactions.

Unit No.	Name of Unit	Topic No.	Name of Topic	Hours
I	Chemical Bonds	1.1	IKS in Chemistry: Rasashastra, alchemical processes, preparation of medicinal formulations.	10
		1.2	Ionic Bond: Nature of Ionic Bond, Structure of NaCl, KCl and CsCl, factors influencing the formation of Ionic Bond.	
		1.3	Covalent Bond: Nature of Covalent Bond, Structure of CH4, NH3, H2O, VSEPR theory.	
II	Titrimetry and Gravimetry	2.1	Titrimetric Analysis: Titration, Titrant,Titrand, End Point, Equivalence Point, Titration Error, Indicator, Primary and Secondary Standards, Characteristics and examples Types of Titration –Acid –Base, Redox, Precipitation, Complexometric Titration.	10
		2.2	Acid – Base Titration.-Strong Acid Vs Strong Base -Theoretical aspects of Titration Curve and End Point Evaluation. Theory of Acid –Base Indicators, Choice and Suitability of	

			Indicators.	
III	Thermodynamics	3.1	State Functions, Internal Energy and Enthalpy: Significance, examples, (Numericals expected.) Laws of Thermodynamics and its Limitations, Mathematical expression.	10
		3.2	Qualitative discussion of Carnot Cycle for ideal Gas and Mechanical Efficiency. Concept of Entropy, Entropy for Isobaric, Isochoric and Isothermal processes, Heat capacity and relation between Cp and Cv.	
IV	Chemical Kinetics and Oxidation Reduction reaction	4.1	Reaction Kinetics: Rate of Reaction, Rate Constant, Measurement of Reaction Rates Order & Molecularity of Reaction.	10
		4.2	Principles of Oxidation & Reduction Reactions–Oxidising and Reducing Agents, Oxidation Number, Rules to assign Oxidation Numbers with examples Ions like Oxalate, Permanganate and Dichromate.	
		4.3	Balancing Redox Reactions by IonElectron Method.	
			TOTAL LECTURES	**40**

Course outcomes: On completion of the course, the will be able to:
1. Discuss and identify the type of bonding interaction involved in any particular molecule.
2. Justify the type of titration technique and also recommend which indicators can be particularly used for the following titration process.
3. Illustrate the thermodynamic properties of a system. Discuss the Laws of thermodynamics and understand the concept of entropy, internal energy and enthalpy.
4. To acquaint the students with the basic concept of thermodynamics, kinetics and redox reactions.
5. To Analyze oxidation – reduction (redox) reaction based on changes in oxidation numbers across the chemical change and acquaint the students with the basic concept of identifying the reaction order for a chemical change.
6. Use of gravimetric analysis techniques for synthesizing and separating water insoluble organic solids.

References:
1. Biophysical Chemistry –Dr. Avinash Upadhyay.
2. Fundamentals of Analytical Chemistry Skoog,West ,Holler and Crouch (4th edition).
3. Concise Inorganic Chemistry .5th edition (2008), Author: J. D. Lee, John Wiley & Sons, USA.
4. Principles of Biochemistry Lehninger ,5 th edition.

5. Basic principles in Physical chemistry by Ghuraman (Seth Publication).
6. Principles of Inorganic Chemistry. 33rd edition, Author: Puri, Sharma & Kalia.

	CASE STUDY
1	Emily, a hardworking student studying chemistry, is doing her first experiment in the lab. She has to find out how much acetic acid is in vinegar. Emily carefully goes through all the lab manuals to search for possible ways to analyse the acetic acid content in the given vinegar sample. She finally learnt titrimetric analysis will help her for quantitative analysis of the sample. She made all the calculations and prepared the reagents. As Emily successfully carried out her first experiment she gained a lot of knowledge about titrimetric analysis techniques.
2	Sam, a student learning engineering. He's doing an internship at a company that makes renewable energy. Sam's job is to make a solar heating system work better. He uses thermodynamics to figure out how to make the system more efficient. Sam studies how heat moves around and finds ways to make sure the system catches as much sunlight as possible and doesn't lose heat when moving water around. By working on these problems, Sam learns a lot about how thermodynamics applies to real-life situations.

Practicals:	
1	Safety Measures and Practices in Chemistry Laboratory
2	Characterization of Organic Compounds containing onlyC, H, O elements (no element test) - Compounds belonging to the following classes: Carboxylic Acid, Phenol, Aldehyde/Ketone, Ester, Alcohol, Hydrocarbon and Characterization of Organic Compounds containing C, H, O, N, S, Halogen Elements (element tests to be done) Compounds belonging to the following classes: Amine, Amide, Nitro Compounds, Thiamine, Haloalkane, Haloarene
3	To Standardize commercial samples of NaOH using KHP(Potassium hydrogen phthalate) and sample of HCl using borax.
4	To determine enthalpy of dissolution of salt like KNO3.
5	Determination of the amount of Fe (II) present in the given solution Titrimetrically
6	Determination of amount of NaHCO3 + Na2CO3 in the given solid mixture Titrimetrically
7	Determination of the amount of Mg (II) present in the given solution complexometrically.
8	Determination of the volume strength of hydrogen peroxide solution by titration with standardized potassium permanganate solution.
9	Determination of the amount of K oxalate and oxalic acid in the given solution titrimetrically.

Semester II

BOS	Biotechnology
Class	F. Y. B. Sc
Semester	II
Course Name	Biomolecules and Enzymology
Course Code	PUSBT201
Type of Course	Major
Level of the Course	Basic
Total Credits for the Course	4 Theory + 1 Practical

Course Objectives:

1. To gain knowledge about structure, classification and properties of carbohydrates and lipids.
2. To learn the structure, classification and properties of amino acids and proteins.

Unit No.	Name of Unit	Topic No.	Name of Topic	Hours
I	Water and Chemical bonds	1.1	Chemistry of Water: Properties of Water, Interaction of Water with Solutes (Polar,Non-Polar, Charged), Non-Polar Compounds in Water – Change in its Structure and the Hydrophobic Effect, Role of Water in Biomolecular Structure and Function.	10
		1.2	Solutions: Normality, Molarity, Molality,Mole fraction, Mole concept, Solubility,Weight ratio, Volume ratio, Weight to Volume ratio, ppb, ppm, millimoles, milliequivalents(Numericals expected).	
		1.3	Acids and Bases: Lowry-Bronsted and Lewis,Concepts. Strong and Weak Acids and Bases - Ionic Product of Water pH,pKa, pKb.Hydrolysis of Salts.Buffer solutions –Concept of Buffers,Typesof Buffers, Buffer action, pH of Buffer Solution	

II	Carbohydrates and Lipids	2.1	Carbohydrates: Structure, Function,Classification, Characteristic Reactions,Physical and Chemical Properties, D & L Glyceraldehydes, structure of Monosaccharide, Disaccharides, and,Polysaccharides Isomers of Monosaccharides, Chemical/Physical,Properties of Carbohydrate	10
		2.2	Lipids: Classification of Lipids, Properties of Saturated,Unsaturated Fatty Acids,Rancidity, and Hydrogenation of Oils, Phospholipids:Lecithin Cephalin,Plasmalogen Triacylglycerol-Structure and Function	
		2.3	Sterols: Cholesterol: Structure and Function ,Lipoproteins: Structure and Function, Storage,Lipids, Structural Lipids.	
III	Proteins and Amino Acids	3.1	History of biochemistry Indian contribution to	10
		3.2	Classification of amino acids, Properties, Isoelectric Point, Peptide Synthesis, Structure of Peptides. Reactions of Amino Acids, Concept of Isoelectric pH, Zwitter ion.	
		3.3	Denaturation of proteins. Proteins: Classification based on Structure and Functions, Primary, Secondary, Tertiary and Quaternary Structure	
		3.4	N-terminal (Sanger and Edmans Method) and C-terminal Analysis (Enzyme).	
4	Enzymes	4.1	Definition, Classification, Nomenclature, Chemical Nature, Properties of Enzymes, Active Sites	
		4.2	Effect of pH, Temperature, Substrate, Concentration on Enzyme Activity, Enzyme Kinetics, Michelis-Menten Equation	
		4.3	Mechanism of Enzyme Action, Enzyme Specificity, Units of Enzyme activity	
		4.4	Types of Enzyme Inhibitions-Competitive, Uncompetitive, Non-Competitive, Allosteric Modulators	

TOTAL LECTURES	40

Course outcomes

1. Understand the role of water in Biochemistry, identify different types of chemical bonds and prepare different buffers.
2. Describe the properties of carbohydrates, proteins and lipids and their importance in biological system
3. Interpret basic reaction of biomolecules and determine the presence of carbohydrates, amino acids, proteins and lipids in samples
4. Generate knowledge on determining amino acid sequences of proteins
5. Determine the enzymes and acquire fundamental knowledge & their importance in biological reactions
6. Develop understanding on optimum pH, temperature for the enzyme activity & Km, Vmax to analyse enzyme kinetics

References:

1. Biochemistry – 4th Edition by U. Satyanarayan and U. Chakrapani (Elsevier).
2. Fundamentals of Biochemistry – Revised Edition by J. L. Jain, Sunjay Jain and Nitin Jain (S. Chand).
3. Outlines of Biochemistry: 5th Edition, (2009), Erice Conn & Paul Stumpf ; John Wiley and Sons, USA.
4. Biochemistry – 3rd Edition by U. Satyanarayan and U. Chakrapani (Elsevier).
5. Lehninger , Principles of Biochemistry. 5th Edition (2008), David Nelson & Michael Cox, W.H. Freeman and company, NY.

	CASE STUDY
1	A biotechnology company extracted an enzyme from a fungal source. The enzyme was precipitated and then purified by suitable methods. The enzyme worked only on one of the isomeric forms of the substrate. The pure enzyme was then utilized for an industrial process. Unfortunately during the reaction process, it was seen that the enzyme was getting inhibited and the product formation rate drastically reduced. Upon investigation it was observed that one of the compounds present in the raw material was covalently associating with the enzyme blocking its activity. The reaction could not be reversed. Identification and separation of the interfering compound from raw material led to enhanced enzyme activity
2	Isomers of carbohydrates are molecules that have the same molecular formula but differ in their structural arrangement, leading to distinct chemical properties. One of the most common types of carbohydrate isomers are structural isomers, where molecules have the same molecular formula but differ in the arrangement of atoms.

Practicals:	
1	Spot test for Carbohydrates, Fats, Proteins and Amino Acids
2	Estimation of Reducing sugar by DNSA method
3	Estimation of Protein by Lowry method
4	Iodine value of Oil/Fat
5	Saponification value of Fat/Oil
6	Qualitative Assay of Enzyme Amylase. Lipase, Protease, Urease, Catalase and Dehydrogenease.
7	Enzyme Kinetics: Study of the effect of pH, Temperature on activity of Enzyme
8	Study of Effect of Substrate Concentration on enzyme activity and determination of Vmax and K value

BOS	Biotechnology
Class	F. Y. B. Sc
Semester	II
Course Name	Immunology
Course Code	PUSBT202
Type of Course	Major
Level of the Course	Basic
Total Credits for the Course	4 Theory + 1 Practical

Course Objectives:

1. To introduce students to the human immune system.
2. Give a basic foundation on the innate and adaptive arm of immunity.Introduction and overview of vaccines.

Unit No.	Name of Unit	Topic No.	Name of Topic	Hours
I	Human Immune System	1.1	Cells and organs of immune system: Cells of immune system – lymphoid cells, NK cells, mononuclear phagocytes, granulocytic cells Organs of the immune system – primary lymphoid organs, secondary lymphoid organs.	10
		1.2	Innate and acquired immunity: First, second and third line of defense. Mechanism of innate immune response. Natural - Active and passive immunity. Artificial immunity - Active and passive immunity.	
II	Antigens and Antibodies	2.1	Antigens, antigenicity and immunogenicity. Characteristics of an immunogen, B and T cell epitopes, haptens, adjuvants.	10
		2.2	Immunoglobulins: basic structure, Immunoglobulin classes, functions, antigenic determinants on immunoglobulins.	

		2.3	Polyclonal Antibody, Monoclonal antibody: Production and clinical uses.	
III	Membrane receptors for antigens and Immunotechnology	3.1	Membrane receptors for antigens: MHC–Class I and class II molecule. TCR– structure of TCR and its role, TCR accessory membrane molecule– CD4 and CD8. BCR– structure with the heterodimer, and accessory membrane molecule–B7	10
		3.2	Immunotechnology: Principles of Antigen-antibody interaction. Types of reactions - precipitation, agglutination, flocculation reaction. Immunoassay - RIA with types, ELISA with types and ELISPOT Immunoprecipitation. Immunofluorescence – direct, indirect, FACS. Immunoblotting. Diagnostic tests – complement fixation test, Coomb's test.	
IV	Vaccines	4.1	Concept of vaccines, History of Vaccines, Indian Knowledge system in vaccine and vaccination	10
		4.2	Types of immunization; Designing vaccines for active Immunization.	
		4.3	Whole-organism Vaccines, Purified Macromolecules as Vaccines	
		4.4	Recombinant- Vector Vaccines, DNA Vaccines, Multivalent Subunit Vaccines.	
			TOTAL LECTURES	40

Course outcomes:

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

1. Remember the major components of the mammalian host immune system-cells and organs and their functions to explain in general terms how the immune system protects the host.
2. Predict the types of molecules that can serve as antigens and factors affecting immunogenicity.
3. Discover how the multiple immunoglobulin classes and subclasses can have common, but also distinct, mechanisms for antigen inactivation, elimination, tissue distribution, and other biological activities.
4. Relate cellular receptors involved in immune function.
5. Summarize the immune reactions with reference to its use in diagnosis.
6. Write principle strategies available for developing antibodies and vaccine.

References:

1. Kuby immunology, Judy Owen , Jenni Punt , Sharon Stranford., 7th edition (2012), Freeman and Co., NY.
2. Textbook of basic and clinical immunology, 1st edition (2013), Sudha Gangal and Shubhangi Sontakke, University Press, India.
3. Principles of Physical Chemistry, 46th edition, Author: Puri, Sharma & Pathania
4. Immunology, 7th edition (2006), David Male, Jonathan Brostoff, David Roth, Ivan Roitt, Mosby, USA.
5. Introduction to Immunology- C V Rao- Narosa Publishing House.

	CASE STUDY
1	John was diagnosed with diffuse large B lymphoma (DLBCL) and sino-pulmonary infections at 16 years of age. In June 2020, he was diagnosed with a relapsed DLBCL and a pulmonary atypical mycobacterial infection, confirmed by sandwich ELISA on bronchoalveolar lavage fluid specimen. He was treated with rituximab, ibrutinib, and bendamustine until December 2020 and a triple-drug anti-mycobacterial regimen for 1 year until June 2021. A few days after contact with a positive family member on January 15, 2021, an antigenic test on a nasal swab (NS), performed as a screening for SARS-CoV-2 required to perform routine investigations, resulted positive. He was treated with multiple therapeutic agents including remdesivir and SARS-CoV-2-neutralizing monoclonal antibodies. The clearance of the virus was detected 105 days from the first positive swab and 7 days after monoclonal antibody administration
2	Jane, a 35-year-old woman, presented to the emergency department with a high fever, fatigue, and body aches. She reported feeling generally unwell for the past few days. On examination, her vital signs were elevated, and she appeared visibly ill. To gain insights into Jane's immune response, the medical team focused on the innate immunity aspects. The medical team examined Jane for any breaches in the skin and they found multiple scratches on the skin. Jane's symptoms included fever and body aches, which suggested an ongoing inflammatory response. The medical team explored the potential source of infection and whether it has triggered the release of inflammatory mediators. After careful analysis, it was determined that Jane was suffering from a bacterial infection caused by a strain of Streptococcus pyogenes. This bacterium entered her body through a small cut on her hand. Significant recovery rate was shown after being administered vancomycin antibiotic. Further as a preventive measure for any future infections, she was vaccinated with a recombinant vaccine, containing polysaccaride antigen of Streptococcus pyogenes.

Practicals:	
1	Phagocytosis (Demonstration)
2	Determination of WBC count
3	Determination of RBC count

4	Differential Staining of blood cells
5	Oxidative burst Assay
6	Blood Grouping
7	Sterility checking of vaccine
8	Widal Test
9	Study of antigen antibody interaction by Ouchterlony method.

BOS	Biotechnology
Class	F.Y.BSc
Semester	II
Course Name	APPLIED CHEMISTRY
Course Code	PUSBT203
Type of Course	Discipline Minor
Level of the Course	Medium
Total Credits for the Course	4 Theory + 1 Practical

Course Objectives:

1. To build knowledge of Sampling and separation techniques and study the chromatographic techniques of separation and the instruments used for analysis..
2. To understand the importance of green chemistry as well as to build Knowledge of natural products, nanomaterials and polymers.

Unit No.	Name of Unit	Topic No.	Name of Topic	Hours
I	Sampling and Separation Techniques	1.1	Separation Techniques: Types of Separation Techniques - Filtration, Zone Refining, Distillation, Vacuum Distillation. Solvent Extraction - Partition Coefficient and Distribution Ratio, Extraction Efficiency, Separation Factor. Advantages and disadvantages of solvent extraction. Solid phase extraction.	**10**
II	Analytical Chemistry	2.1	Chromatography:Definition, Principles, Types Introduction to Paper Chromatography,Thin Layer Chromatography, Column Chromatography and its Applications.	**10**
		2.2	Chromatographic Separation of Natural Products: Gas Chromatography and its Applications. Liquid Chromatography: HPLC and its Applications. HPTLC for Separation and Analysis of Natural	

			Products.	
		2.3	Study the working and principle of pH meter, flame photometer and FTIR.	
III	Green Chemistry Natural Products and	3.1	Classification of Natural Products based on Structure- Alkaloids, Phenolics, Steroids and Terpenes. Commercial importance of terpenoids and alkaloids. Structure Determination of Natural Products. Commercial Synthesis of Natural Products.	**10**
		3.2	Principles of Green Chemistry.Synthesis of Organic Compounds: Microwave Assisted Organic Synthesis, Ultrasound in Synthesis and Polymer supported Synthesis	
IV	Polymer and Nanomaterials	4.1	Polymers: Introduction to Polymers. Types of Polymers -Monomer, Polymer, Homopolymer, Copolymer, Thermoplastics and Thermosets,	**10**
		4.2	Stereochemistry of Polymers, Biodegradable Polymers, Biomedical uses of polymer, Recyclable polymers and their uses.	
		4.3	Nanomaterials: Introduction to Nanomaterials. Forms of Nanomaterials: Nanoparticles, Nanofilms and Nanotubes Synthesis and Characterization of Nanomaterials. Applications of Nanomaterials.	
			TOTAL LECTURES	**40**

Course Outcomes: By the end of the course the student will be able to:

1. Remember the principles of green chemistry and apply while synthesizing any new organic compound.
2. Classify and understand chromatographic techniques and its applications.Explain the use of GC, HPLC and HPTLC techniques for separation and analysis of natural products.Understand the working and principle of pH meter, polarimeter,potentiometer, flame photometer and FTIR.
3. Classifying natural products based on their structure and biosynthesis process also

remembers their structural characteristics and commercial importance.

4. Outline the techniques for sampling of solids, liquids and gasses.Define solvent extraction, partition coefficient, distribution ration, chelation.
5. Evaluate the stereochemistry of polymers and listing biomedical uses of polymers. Interpret various techniques of synthesizing organic compounds using microwave assisted organic synthesis, ultrasound and polymer support organic synthesis.
6. Synthesis nanomaterials using different techniques and characterisation of them.

REFERENCES

1. Chemistry of natural products- S.V.Bhat.
2. Principles of polymer chemistry- Paul J.Flory.
3. Selection of the HPLC Method in Chemical Analysis- Serban C. Moldoveanu, Victor David.
4. Basic Concepts of Analytical Chemistry- 2nd Edition by S.M.Khopkar.
5. Modern Sample Preparation for Chromatography- Serban Moldovenu Victor David.
6. Solid Phase Extraction-Principles, Techniques and Applications- by Nigel J.K. Simpson.

	CASE STUDY
1	F.Y.B.Sc. students wanted to separate the mixture of dyes constituting a sample of Natural colours. They coated a layer of silica gel on the glass slide they got in their dissection box. After drying they spotted the sample of the coated layer and sprayed with the certain chemicals magically different coloured spots were observed on the filter paper at particular distances.
2	Dr. Shetty , a chemist, noticed that the water supplied in his area has some impurities. . She analyed a sample of water using filtration, distillation, and chromatography, she successfully purified the water. She remained the town's trusted expert for separation challenges, ensuring the well-being of its residents.

Practicals:	
1	Functioning and Standardization of pH Meter, Optical Activity of a Chemical Compounds by Polarimeter.
2	1. Chemistry: Separation of Binary Mixtures. ● Solid-Solid. ● Volatile and Non-volatile liquids.
3	Chemistry: Identification of Organic compounds of known chemical type.
4	Separation of Cu, Ni and Fe using Paper Chromatography and amino acids - paper chromatography

5	Separation of alkaloids by TLC.
6	HPLC of Plant secondary metabolite.
7	GC of plant essential oils.
8	HPTLC is a medically important plant.
9	Synthesis of Nanoparticles and characterization by UV spectrophotometry: ● Chemical synthesis. ● Biological synthesis. ● Characterization of Nanoparticles