AC – 07/07/2023
Item No. –**6.21 (N)**

As Per NEP 2020

University of Mumbai

Title of the program

A- P.G. Diploma in Biophysics
B- M.Sc. (Biophysics) (Two Year) } **2023-2024**
C- M.Sc. (Biophysics) (One Year) - **2027-28**

Syllabus for

Semester – Sem I & II

Ref: GR dated 16th May, 2023 for Credit Structure of PG

Preamble

1) Introduction

The subject of Biophysics is one of the important interdisciplinary areas in teaching, training and learning, which is considered to be important in terms of human resource development and national development. Biophysics is the physics of life phenomenon studied at all level, from molecules and cell to the biosphere as whole. It is the branch of knowledge that applies the principles of physics and chemistry and the methods of mathematical analysis and computer modeling to understand how biological systems work.

2) Aims and Objectives

The main emphasis of biophysics is on the quantitative analysis of the physical and chemical aspects of the functions of biological molecules, organisms and entities. The techniques and methodologies that biophysics relies on are closer to physics and chemistry, but areas of application are in the biological, medical and related sciences.Biophysicists mainly use analytical tools that includes UV visible spectroscopy, Gel electrophoresis, X-ray crystallography, macrocalorimetry, Atomic Force Microscopy, FTIR, Raman, SPR, NMR, Fluorescence spectroscopy, Fluorescence Microscopy & spectroscopy, hydrodynamics techniques etc., to address problems in exciting areas in biophysics ranging from structure aided drug design to cell signalling and transcriptional silencing etc.

3) Learning Outcomes

The programme endeavours to provide students a broad based training in Biophysics with strong background of basic concepts as well as exposing them to recent advances in the field. The programme is focussed on recent developments in the areas of biophysics. In addition to theoretical knowledge, significant emphasis has been given to provide hands on experience to the students in the frontier areas of Biophysics. A multidisciplinary approach has been employed to provide best leverage to students to enable them to move into advanced and frontier areas of biological research in future. Another important feature of course is that a sufficient number of elective papers have been introduced. This will enable the addition of new dimension in learning and research skill of students. Biophysicist's are employed in Universities, R & D industry, Medical centres/Colleges, Research Institutes and Government Organisation etc.

4) Program Outcomes

The knowledge of this program will provide an intellectually enlarging experience to students. The course attempts to teach critical thinking, problem solving, and communication skills that can be used throughout a life of learning. The program helps to prepare students and make them competitive to enter in the workforce or further their studies in research (Ph.D.) at professional colleges, pharmaceutical / biomedical industries, medical schools, Universities etc. After completing the M.Sc. in Biophysics Program at University department of Biophysics, the students will be able to acquire the following skills:

1. Students will demonstrate proficiency in principles of physics, chemistry and

mathematical concepts that are needed for a proper understanding of biological process.
2. Students will be able to Integrate knowledge and skills of the physics, chemistry &mathematics with biology and to address research questions.
3. Students will demonstrate knowledge of cell &molecular biology, methods in biophysics, radiation & medical biophysics, physiological biophysics, structure – functions of biological macromolecules, biomathematics and biostatistics, biochemistry & protein
engineering, molecular modelling & drug design etc.
4. Students will gain laboratory skills, enabling them to purify and characterize biological samples using various spectroscopic and microscopic tools. They will be able to collect, evaluate and interpret scientific data, and employ critical thinking to solve problems in biology and supporting fields.
5. Students will demonstrate knowledge of various spectroscopy, microscopy and other analytical tools that are used in biology.
6. Students will communicate scientific information in a clear and concise manner both orally and in writing.
7. Student will identify and describe the impact of biophysics on society.

5) Scheme of Examination: (THEORY AND PRACTICALS) :

a. **Summative assessments (THEORY):**

For 2 credit courses (45min)	**25M**
Q1. Answer any three questions out of six (covering unit I and II)	15M
Q2. MCQ/Match the following/Ture Or False (covering unit I and II)	05M

For 4 credit courses	**50M (1.5h)**
Q1. Answer any 2 questions out of 3 (based on unit I)	10M
Q2. Answer any 2 questions out of 3 (based on unit II)	10M
Q3. Answer any 2 questions out of 3 (based on unit III)	10M
Q4. Answer any 2 questions out of 3 (based on unit IV)	10M
Q5. Write one Essay type answer out of 3 (based on units I-IV)	10M

b. **Formative assessments** (informal and formal tests administered during the learning process).

For 2 credit courses	**25M**
Group tasks/ Assignments/ Quizzes at the time of completion of each unit	15 M
Spoken/oral examination after completion of each unit	10M

For 4 credit courses	**50M**

Open book test/assignments/presentation/quiz/role play/MCQ/problem solving to be designed for each unit

c. **Summative assessments (Practical):**

For 4 credit courses **50M (3 h)**

- Major (20M)
- Minor (20M)
- Journal (5M)
- Viva. (5M)

d. **Formative assessments** (informal & formal tests administered during the learning process).

Submission of two Assignments poster/presentation (15M each) based on history/discovery/application/ problems based on techniques/experimentsperformed **30M**

Viva and/ field visit report **20**

Sign of HOD
Prof. Varsha Kelkar-Mane:
Department of Biophysics

Sign of Dean,
Prof. S.S. Garje
Science

6) Credit Structure of the Program (Sem I, II, III & IV) (Table as per Parishisht 1 with sign of HOD and Dean)

R_____

Post Graduate Programs in University Parishishta - 1

Year (2 YrPG)	**Level**	**Sem.** (2Yr)	**Major**		**RM**	**OJT / FP**	**RP**	**Cum. Cr.**	**Degree**
			Mandatory*	**ElectivesAny one**					
I	**6.0**	**SemI**	**Course 1: General Physico-chemical principles**Credits 4 **Course 2: Basic analytical tools in Biophysics**Credits 4 **Course 3: Practical- lab work** Credits 4 **Course 4: Molecular and cellular Biophysics**Credits 2	**Credits4** **Course 1: Biomolecular hydrodynamic methods** Theory 2 credits + Practical 2 credits OR **Course 2: Recombinant DNA technology and protein engineering** Theory 2 credits + Practical 2 credits OR MOOCs	4	-	-	22	**PG Diploma(after3YearDegree)**
		SemII	**Course 1: Membrane Biophysics and Ion channels**Credits4 **Course 2: Radiation Biophysics**Credits 4 **Course 3: Practical- lab work** Credits 4 **Course 4: Biochemistry**Credits2	**Credits4** **Course 1 Biocrystallography and magnetic resonance techniques** Credits 4 OR **Course 2 Proteomics** Theory 2 credits + Practical 2 credits OR MOOCs		4		22	
Cum. Cr. For PGDiploma			**28**	**8**	**4**	**4**	**-**	**44**	

Exitoption:PGDiploma (44Credits)afterThreeYearUGDegree									
II	**6.5**	**SemIII**	**Course 1: Advanced Biophysical Techniques** Credits 4 **Course 2: Nanobiophysics** Credits 4 **Course 3: Practical-lab work** Credits 4 **Course 4: Environmental Biophysics**Credits2	**Credits4** **Course 1: Structural Biophysics** Theory 2 credits + Practical 2 credits OR **Course 2: Medical Biophysics** Credits 4 OR MOOCs			4	22	**PG DegreeAfter3-YrUG**
		SemIV	**Course 1: Physiological Biophysics** Credits4 **Course 2: Biomathematics & Biostatistics** Credits4 **Course 3: Elements of Bioinformatics** Credits4	**Credits4** **Course 1: Nanomedicine** Or **Course 2: Advanced microscopy and single molecule biophysics** Or MOOCs			6	22	
Cum.Cr. for1 Yr PG Degree			**26**	**8**			**10**	**44**	
Cum.Cr. for2 Yr PG Degree			**54**	**16**	**4**	**4**	**10**	**88**	

HOD Sign
Prof. Varsha Kelkar-Mane
Department of Biophysics

Sign of Dean,
Prof. S.S. Garje
Science

Syllabus
M.Sc. (Biophysics)
(Sem. I & II)

SEMESTER I

Course 1	**GENERAL PHYSICO-CHEMICAL PRINCIPLES**	Credits 04

Course outcome: On the completion of the course the student will be to understand

1. The basic concept of atomic structure, bonding, sub-atomic particles and the forces that stabilize molecules.
2. The fundamental chemical and physical principles that govern biological systems.
3. The significance of buffers and biological solutions.
4. The basics of radioactivity, units of measurement, their detection modes and biological applications.

Unit I: General principles of physical chemistry (15L)

The electronic structure of atom, Ionic bond, Covalent bonds, Hydrogen bonds Van der Waals forces, Electric dipoles, Polarization and induced Dipoles, Casimir interactions. General understanding of Quantum mechanics, wave-particle duality, atomic and molecular orbital, hybridization. Pauli Exclusion Principle, Ionization energy, Electron affinity and Chemical bonding, Electronegativity and strong bond, Secondary bonds. Interatomic potentials for strong bonds, Interatomic potential for weak bonds, Noncentral forces, Bond energies, Spring constants.

Unit II: Thermodynamics & Principles of chemical kinetics and biomolecular properties (15L)

Thermodynamic equilibrium, laws of thermodynamics and living system, Entropy, Enthalpy and free energy, Internal energy, Carnot cycle, Chemical potential, Oxidation reduction potential. 0^{th}, $1^{st,}$ 2^{nd}, and 3^{rd} order reaction, Activation energy and Rate constant, Diffusion, Osmosis, Osmotic pressure, Osmoregulation, Surface tension, Adsorption, Dialysis.

Unit III: Solvent, Solute & Solution in Biological System (15L)

Liquids, Solvents, Solubility, Saturated and unsaturated Solutions, Super saturated solutions, Dilute and concentrated solution, types of solutions, Methods of expression of concentration of solution, Molality, Mole fraction.

Hydrogen ion concentration, Dissociation of water, (water as electrolyte), concentration of equilibrium, Mechanisms of Ionization and Characterization, Acid & Basic solutions, pH and its biological importance, pH meter and its working. General concept of acid, bases and their dissociation constant, Bronsted-Lowry theory, Inductive effect of groups on acid strength, (Carboxyl group, Carbonyl group). Salts & their characteristics & importance in biological system.

Biological Importance of Acids & Bases, Biological & buffering system, Buffer solution, mechanism of buffer action, Factors influencing buffer capacity and pH, Henderson and Hasselbach equation, Buffer systems in the body. (Bicarbonate, Phosphate, Protein buffer, Ammonia buffer, etc.)

Unit IV: Radioactivity (15L)

Energy of Radiation, Radioactive emission, α-ray, β-ray, ϒ -ray, and their properties, Radioactive decay, (α, β decay), Half-life, Units of measurement of radioactivity, types of radioactivity, Isotopes, Isobar, Isotones and their characteristics. Detection of nuclear radiation, Geiger-Muller counter, Proportional counter, Solid and liquid scintillation counter. Radioactive equilibrium, Radioactive isotopes, Nuclear reaction and production of artificial radioactivity, Autoradiography.

References
1.Physical Chemistry for Life Sciences,Peter Atkins and Julio de Paula, 2006, Oxford Press
2. Introduction to Biophysics by Cortell
3. Molecular and Cellular Biophysics, Meyer B Jackson (2006), Cambridge
4. Text Book of Biophysics , R N Roy, New Central Agency (P) Ltd, Calcutta
5. Physical Chemistry for the Biosciences, Raymond Chang,(2004), University book Science
6.Biological Thermodyanamics, Donald, T Hayine, (2007), Cambridge

Course 2	**BASIC ANALYTICAL TOOLS IN BIOPHYSICS**	Credits: 04

Course outcome: On the completion of the course the student will be able to
1. Achieve a holistic understanding of the interaction of electromagnetic radiation with biomolecules
and the application of the spectroscopy tools to decode biomolecule structure and function.
2. Gain understanding of the basics of various types of microscopies and their application to biological systems.
3. Explain various physiochemical techniques that can be employed to study physical properties of biomolecules.

Unit I: Spectroscopy I (15L)

Interaction of Light and Matter. Principle, instruments and application of spectroscopic instruments: UV Visible: absorption of light, radiation sources, sample holders, monochromators, radiation detectors, single and double beam instruments, colorimeter.
Fluorescence: Fluorescence and phosphorescence, fluorimeter, fluorophores, quenching, energy transfer, and applications. Luminometry: bioluminescence and chemiluminescence phenomenon, Atomic absorption spectroscopy: Principle and instrumentations.

Unit II: Spectroscopy II (15L)

IR spectroscopy: Rotational and vibration spectra, Instrumental features, applications. Raman effect, stokes and anti-stokes lines, advantages, applications. CD ORD principles and applications. Basics of NMR and ESR spectroscopy.

Unit III: Microscopy (15L)

Principle, instrumentation and application of microscopy, image formation, magnification, resolving power. optimum resolution, image defects, different types of Microscopy: Dark field, Phase contrast, polarization microscopy, Interference microscopy, Fluorescence microscopy, Electron microscopy: Electron guns, Electron lens, electrostatic focusing, magnetic focusing, SEM, STEM, Atomic force microscopy.

Unit IV: Physiochemical techniques in Biochemistry (15L)

Antigen-Antibody interaction, Principle and application of Immunologicaltechniques in Biology and medicine. ELISA, RIA. Chromatography: paper, TLC, adsorption, partition, ion exchange, gel filtration, affinity and FPLC, GLC, HPLC: mobile phase systems, modes of operations, application. Flow cytometry, Surface plasmon resonance for binding interaction studies.

References:
1.Methods in Molecular Biophysics, Igor N S, N Zaccai & J Zaccai, (2007)
Cambridge
2. Biophysical Chemistry, Dagmar (2017) 1st edition CRC press
3. Physical Biochemistry, David Sheehan, 2nd edition, Wiley
4. Essentials of Biophysics, Narayanan, 3rd edition, New age international publishers
5. Biophysical Chemistry, Upadhyay & Upadhyay (2016) Himalaya Publishing

Course 3	**PRACTICAL – LAB WORK**	Credit 04
Course outcome: Students will acquire the skill to prepare solutions, buffers, characterize biological cells, biomolecules such as proteins and nucleic acids using microscopy and spectroscopy tools.		
1. pH Meter: Standardization of pH meter, Preparation of Buffers 2. pH titration curve of acid-base 3. Determination values of Iso-electric point: Amino acids, proteins, phosphoric acids. 4. Study of diffusion of biomolecules/ions (Fick's Law) 5. Effect of hypertonic/ hypotonic/isotonic conditions on RBC membrane. 6. Purification of substances by dialysis 7.Colorimeter: determination of absorption maxima of coloured compounds, 8. Verification of Beer's-Lambert law, determination of molar extinction coefficient. 9. Absorption spectra of Hb, DNA, RNA 10. Protein tryptophan fluorescence measurement. 11. Microscopy: Familiarization with bright field, phase contrast, fluorescent, polarization microscopes. 12. Study of bacterial cell growth/ survival by spectrophotometry 13. Observe cell division and determine mitotic index 14. RBC, WBC counting and Differential leukocyte count 15. Paper chromatography/TLC: Amino acids/ sugars/ fruit juice/oil		

Course 4	**MOLECULAR AND CELLULAR BIOPHYSICS**	Credits 02
Course outcome: On the completion of the course the student will be able to understand 1.The various types of biomacromolecules, their building blocks, and their three-dimensional conformation 2. The detailed structural organization of proteins and their biophysical properties. 3. The structure of nucleic acids and their interaction with proteins. 4. The complete organization of prokaryotic and eukaryotic cells, their mechanism of growth and cell division.		
Unit I: Biomacromolecules and their biophysical properties (15L) Amino acids and their properties. Primary structure of proteins, Secondary structure: alpha and beta conformation, collagen structure, stability of alpha helix, Ramchandran plot, Tertiary structure, structure of myoglobin and hemoglobin, Quaternary structure, symmetry consideration, Analysis of subunits and chain arrangement of subunits, stability of globular quaternary structure. Nucleic acid composition, structure of DNA and RNA. A, B & Z DNA structure. Primary and secondary structure of nucleic acids. Protein-DNA interactions. Carbohydrates: classification and types, biological significance.		
Unit II: General organization of cells (15L) Origin and evolution of cell, shape and size of cell; General organization of prokaryotic and eukaryotic organisms basic concepts and their detailed structure and functions, Prokaryotic cell wall, Eukaryotic cell wall, their functions, ribosomes, physical and biological properties of protoplasm. Cytoskeleton – basic components, properties and functions in prokaryotic and eukaryotic cells. Bacterial growth and cell division. Cell cycle in higher organisms. Basics of cell signallingeg. G protein and GPCRs.		

References

1. Molecular Biology of the Cell, Bruce Albert, Alexander Johnson et al (2002), Taylor & Francis Group.
2. Principles of Biochemistry, Lehninger, 8th edition, W H Freeman & Co
3. Biochemistry by Stryer, 9th edition, W H Freeman & Co
4. Molecular Cell Biology, Harvey Lodish, 9th edition, W H Freeman & Co
5. Fundamentals of Biochemistry Voet and Voet, 6th Edition Wiley

ELECTIVE Course 1	**BIOMOLECULAR HYDRODYNAMIC METHODS**	Credits 02

Course outcome: On the completion of the course the student will be able to understand

1. The detailed working ofthe electrophoresis method, the practical set up involved and characterization of nucleic acids and proteins.
2. The principle of centrifugation, their types and important practical considerations.
3. The flow properties in biological fluids and its significance in functioning of organisms.

Unit I: Biomolecular analytical techniques I (15L)

Electrokinetics methods: electrophoresis, electrophoretic mobility (EPM), factors affecting EPM, Paper, PAGE, SDS-PAGE, Disc gel, gradient gel, electrophoresis of nucleic acid and its application, Pulse field electrophoresis, single cell gel electrophoresis, Isolectrophoresis, preparative electrophoresis, 2-D gel electrophoresis, Capillary, Iso-Electric focusing, applications in biology and medicine.

Unit II:Biomolecular analytical techniques II (15L)

Centrifugation: principle, preparative centrifuge, analytical, ultracentrifuge, Ultracentrifugation and their applications in molecular weight, size determination.

Sedimentation filtration of biological fluid, Precipitation, Biological significance of precipitation, Colloids & their types, Kinetic & electrical properties of colloids, Stability of colloids, Gibbs Donnan Equilibrium in living systems. Liquids and flow in biological systems: Viscosity and its application, blood flow, cytoplasmic streaming in plants, bacterial motion in water. Static and dynamic light scattering, small angle scattering.

References

1.Methods in Molecular Biophysics, Igor N S, N Zaccai & J Zaccai, (2007) Cambridge
2. Biophysical Chemistry, Dagmar (2017) 1st edition CRC press
3. Physical Biochemistry, David Sheehan 2nd edition, Wiley
4. Essentials of Biophysics, Narayanan 3rd edition, New age international publishers
5. Biophysical Chemistry, Upadhyay & Upadhyay (2016) Himalaya Publishing
6. Principles and techniques of Biochemistry and Molecular Biology, Wilson & Walker

ELECTIVE Course 2	**RECOMBINANT DNA TECHNOLOGY AND PROTEIN ENGINEERING**	Credit 02

Course outcome: On the completion of the course the student will be able to understand

1.The steps involved in isolation and analysis of genomic DNA from various sources.
2. The tools involved in genetic manipulation and protein engineering.

Unit I: Isolation, synthesis of nucleic acids & enzymatic manipulation (15L)

Genomic DNA from bacteria, plant and mammalian tissue. Recovery of large and small fragments of DNA. Chemical synthesis of oligonucleotides, genes and their uses. Analysis of DNA sequences by blotting and hybridization. Restriction endonuclease and mapping enzymes for modification. Radioactive labelling of nucleic acids, construction of hybrid DNA molecules. Polymerase chain reaction (PCR). Preparation and analysis of RNA.

Unit II: Protein engineering (15L)

Cloning and expression vectors, gene expression in bacteria, yeast and mammalian cells. Preparation of Genomic and c-DNA libraries. Screening of Recombinant DNA Libraries: Screening by DNA hybridization, Immunological assay and protein activity. Transformation of DNA using calcium Phosphate, DEAE, Dextrin and Electroporation and its optimization and uses. Site-directed mutagenesis, Production of recombinant proteins and purification using protein fusion tags. Hybridoma technology. Development and use of transgenic animals.

References

1. Molecular cloning a laboratory manual, Russell and Sambrook, 2001, Cold Spring Harbor
2. iGenetics, Russell, 3rd edition Pearson
3. Principles of gene manipulation and genomics, Primrose, 7th edition, John Wiley & Sons
4. Gene cloning and DNA analysis, T A Brown, 7th edition, Wiley

	PRACTICAL ELECTIVE COURSE 1	Credit 02
	1.Viscosity: Determination of viscosity of biofluids and chemicals 2.To study of conformational changes in biomolecules using Ostwald viscometer 3. Fractionation of proteins using: PAGE 4. Differential centrifugation of cellular components 5. Agarose gel electrophoresis 6. Isolation of casein protein from milk	
	PRACTICAL ELECTIVE COURSE 2	Credit 02
	1. Isolation of genomic DNA from bacteria 2. Isolation of DNA from onion 3. Restriction endonuclease digestion and separation of fragments by gel Electrophoresis 4. Amplification of DNA by PCR 5. Low protein concentration detection by silver staining 6. Gel filtration chromatography 7. Detection of DNA modification 8. DEAE cellulose chromatography of DNA	

	RESEARCH METHODOLOGY	Credits 04
Course outcome: On the completion of the course the student will be able to 1. Gain insights into the research methodologies, research ethics and research design. 2. Acquire scientific writing skills. 3. Achieve scientific presentation skills.		

Unit I: Introduction to research methodology (15L)

Meaning of research, Objectives of Research, Motivation in Research, Types of Research, Research Approaches, Significance of Research, Research and Scientific Method, Research Process, Criteria of Good Research, Formulating a research problem, selecting, defining and designing a research problem, quantitative and qualitative research designs, identifying variables, constructing hypothesis. Reviewing the literature, Writing a research proposal, Challenges Encountered by Researchers in India

Unit II: Data collection, processing and analysis (15L)

Methods of Data collection, ethical issues in data collection, Statistics in Research, Measures of Central Tendency, Measures of Dispersion, Type I and Type II errors levels of significance, one-tailed and two tailedtest,Correlation and regression for ungrouped data, scatter diagram, calculation

and interpretation of correlation coefficient, linear regression coefficients and equation of the

Lines of regression, nonlinear relationship transformable to linear form, Chi-square test for independent attributes in r x c table, special case of 2 x 2 tables, Students test for significance of correlation coefficient y for p=0 (small sample test)

Unit III: Documentation and scientific writing (15L)

Preparation of manuscript forPublication of Research paper, Presenting a paper in scientific seminar, Thesis writing. Structureand Components of Research Report, Types of Report: research papers, thesis, Research ProjectReports, Pictures and Graphs, citation styles, writing a review of paper, Bibliography

Unit IV: IPR & Copyrights (15L)

IPR& Copyrights: Historical prospective of IPR, Invention & creativity, invention v/s innovation, importance and need for protection of IPR, Patents, concept of patents, type of patents, benefit of patents, procedure of application, preparation of documents, process of patent examination of patent application, patent database and information system, recent development in patent, patents in science. Copyright in scientific work, scientific misconduct, falsification, code of ethics in research, types of plagiarism, trade marks

SEMESTER II

Course 1	**MEMBRANE BIOPHYSICS & ION CHANNELS**	Credits 04

Course outcome: On the completion of the course the student will be able to understand

1.The architecture of biological membranes.

2. Their physical properties that aid in functioning of cellular membranes.

3. Various crucial transport mechanism in plasmamembranes.

4. The electrophysiological properties of membranes and their role in transmission of nerve impulses.

5. The designing of membrane mimics for research.

Unit I: Membrane structure and Models (15L)

Lipids: types of lipids, classification and biological significance. Membrane architecture, Lipid bilayer and early models, Fluids mosaic model, Evidence from model system and biomembranes. Membrane permeability, transmembrane helices, hydropathy plot, Membrane asymmetry, Membrane fluidity, Functional reconstitution of membranes. Models of membrane fusion: bilayer fusion, viral fusion, cellular fusion, SNAREs, cell-cell fusion, fusion in mitochondria,

Unit II: Membrane transport (15L)

Membrane channels and carriers, voltage gated channels, ligand gated channels. Transport system with non-electrolytes and electrolytes. Transport with chemical reaction system: Primary and secondary active transport. Transports of molecules bysimple and facilitated diffusion, Transport by flux coupling. Transport by phosphotransferase system, Transport by vesicle formation, Ionophores, epithelialtransport.

Unit III: Physics of membrane (15L)

Membrane deformations: bending, shearing shape fluctuation etc. Differential geometry of membranes, Elastic properties, Elastic constants, Charge-induced microstructures and domain. Hysteresis of domains formation, Lateral phase separation, selective lipid protein interactions, Membrane melting.Cell surface charge, Resting membrane potential, Action potential, properties of action potential, Nernst equation, Goldman equation, Nernst-Planck equation, Hodgkin-Huxely equation, Hodking-Kartz experiment, Voltage clamp, Na^+, K^+ conductance, channel conductance, membrane impedance and capacitance, Transmembrane potential, Zeta, stern and total electrochemical potential, Chemical synapse, post synaptic potential.

Unit IV: Mitochondrial membrane and membrane mimics (15L)

Electron Transport & oxidative phosphorylation: Reduction potential and free energy changes in redox reaction, organization of electron transport chain in mitochondrial membrane, chemiosmotic coupling, proton gradient drive and synthesis of ATP, P/O ratio for oxidative phosphorylation, Cytosolic NADH electron feeding into electron transfer.

Historical perspective of lipid model systems lipid monolayer. Liposomes: small and large unilamellar and multilamellar vesicles, planar lipid bilayer, synthesis and purification methods. Application of liposomes in biology and medicine

References

1. Cell biology, Karp, Global edition, Wiley
2. Biophysics, Hoppe and Lohman, 2nd edition Springer Verlag
3. Membrane Structural Biology, Mary Luckey, 2014, 2nd edition, Cambridge University Press
4. Biochemistry, Stryer, 9th edition, W H Freeman & Co
5. Molecular Biology of the Cell, Bruce Albert, Alexander Johnson et al (2002), Taylor & Francis Group.
6. Principles of Biochemistry, Lehninger, 8th edition, W H Freeman & Co

Course 2	**RADIATION BIOPHYSICS**	Credits 04

Course outcome: On the completion of the course the student will be able to

1. Understand the basic properties of radiation, their types and modes of interaction of radiation with matter.
2. Evaluate their implications on cells and organs.
3. Assess the effect of radiation on the genome.
4. Gain insights into the permissible radiation exposure levels.

Unit I: Interaction of Radiation with Matter (15L)

Ionization and Excitation of matter by charged particles, Specific ionization, Linear Energy Transfer (LET), Bragg's law, Range Energy Relations, Bremsstrahlung, Interaction, of Gamma rays with Matter, Photoelectric effect, Compton effect, pair production, Attenuation and Absorption Coefficients, Radiation Units-Unit of Exposure, KERMA, Absorbed Dose and Derived Units- Equivalent Dose and Effective Dose.

Unit II: Interaction of radiation with living cells I (15L)

Kinetics of induction of damage in irradiated cells-physical stage, physicochemical stage, chemical stage, biochemical stage, induction of cellular level damage. Mechanism of direct and indirect action of radiation, radiolytic products of water, radical reactions in the biological system. Critical target in the living cells evidences for DNA to be the primary target, Nature of the DNA damage Induced by Radiation. Relationship between DNA content and radiosensitivity. Cell lethality, mitotic death, interphase death and apoptosis, Models of Cell survival, Target Theory, its modifications multi target- single hit and single target- multi hit hypothesis, target size calculation, survival curve parameters-D_q, D_0, n, slope etc and limitations of target theory, Linear Quadratic Model of cell survival and the mechanistic support to LQ model , α/β values for normal and tumour cells.

Unit 3: Interaction of radiation with living cells II (15L)

Factors modifying cellular radiation response: Physical factors modifying cell survival: dose, dose Rate, dose fractionation, LET, hyperthermia. Biological factors: Cell cycle stage, repair and recovery, Elkind and Sutton type (SLD repair), Repair of potentially lethal damage (PLDR). Mammalian cell sensitivity protocol, Law of Bergonie and Tribondeau, classification of cells into different sensitivity groups. Chemical modifiers: Oxygen, Chemical radioprotectors, sensitizers, repair inhibitors, Radiation induced Division delay, biochemical and biophysical changes. Induction of Mutations and Chromosomal Aberrations (CA), factors modifying chromosomal damage, Application of CA analysis in biodosimetry of absorbed radiation.

Unit IV: Biological Effects of Radiation (15L)

Introduction, Historical Data Base, Somatic and Genetic Effects, Immediate and Late Effects. Stochastic and Deterministic Effects. Damage to Individual Organs. Skin, Eye Lens, Reproductive System, Lungs, Endocrine Glands, Threshold Doses, Radiation Sickness, Radiation Syndromes: Haemopoietic Syndrome, G.I. Syndrome, CNS Syndrome LD50 (60) Dose, Late Damage in Skin, Lung and Other Organs. Prenatal Radiation Effects, Radiation Carcinogenesis, Human Data, Risk Evaluation by A-Bomb Survivor Data, Genetic Risk Evaluation, Radiobiological Basis for Radiation Protection Standards, Maximum Permissible Limits For Radiation Exposure

References

1. Fundamental and Radiobiology (1966) 2nd Edition Bacq Z.H.Alexander P., Pergammon Press, New York.

2. Radiation Biophysics (1990) Alpen E.L.Printice hall, Engel Wood.

3.Radiation Chemistry (1973) Hughes G. Clarendon Press

4. Radiation Biology, Alison P. Casserette

5. Radiation Biophysics by J.Kiefer

Couse 3	**PRACTICAL-LAB WORK**	Credit 04
Course outcome: On the completion of the course the student will be able to demonstrate the working of radiation detectors, perform dosimetry and evaluate the effect of radiation on cells. They will be able to probe cells/cellular growth/membrane effects microscopically and biochemically.		
1. Preparation of liposome's / artificial membrane: Lipid mixture/ BSA /Ovalbumin 2. Estimation of cell viability by dye exclusion assay. 3. Study of volume regulation of erythrocyte and osmotic fragility. 4. Classification of gram –ve& +ve organisms 5. Observe cell death by physical and chemical agents 6. To determine melting temperature (T_m) of proteins 7. Study of phase transition of membrane phospholipids 8. To study the membrane potential using fluorescence spectroscopy 9. Ionophore effect on erythrocyte 10. Osmolarity: Determination of osmotic pressure of salts. 11. To study the characteristics of GM tube and determination of its operating voltage. 12. To verify inverse square law of gamma/ alpha/beta/UV rays 13. To study the nuclear counting statistics 14. To determine linear and mass attenuation co-efficient using gamma source for aluminium, lead and copper. 15. Estimation of efficacy of the GM detector for gamma and beta source 16. To study Beta particle range and maximum energy 17. To measure short half-life of radiation source 18. To measurement of UV radiation dose by chemical and physical methods 19. To determine gamma radiation dose using Fricke Dosimeter. 20. Effect of UV/gamma radiation on bacterial /mammalian cell survival.		

Course 4	**BIOCHEMISTRY**	Credit 02
Course outcome: On the completion of the course the student will be able to 1. Understand the detailed mechanism of action of enzymes and their kinetics. 2. Quantify enzyme activity, and understand the effect of inhibitors on enzymes. 3. Gain insights into the central dogma of molecular biology i.e transcription and transcription.		

Unit I: Enzyme structure & mechanisms **(15L)**

Enzymes, classification & structure, active site and its identification, mechanisms of enzyme action with special reference to chymotrypsin, carboxypeptidase and lysozyme, Enzyme kinetics, Michaelis-Menten equation, Inhibitors, kinetics of competitive, non-competitive and uncompetitive inhibitors, Allosteric cooperative behaviour, ligand protein interaction, Hill equation, Metalloenzymes. Determination of V_{max}, K_m, various graphical plots.

Unit II: Molecular and cellular biology **(15L)**

Various modes of DNA replication, semi-conservative mechanism of replication, DNA polymerases, role of various proteins/enzymes in DNA synthesis in prokaryotes and eukaryotes. Molecular basis of mutations, DNA repair mechanisms. RNA polymerases, transcription in prokaryotes and eukaryotes.

Messenger RNA, transfer RNA, attachment of amino acids to tRNA, the ribosome - initiation, elongation and termination of translation. Comparison of prokaryotic and eukaryotic protein synthesis. Regulation of Gene expression in prokaryotes Operator-operon concept: Lac and Trp operon

References

1. Principles of Biochemistry, Lehninger, 8th edition, W H Freeman & Co
2. Biochemistry by Stryer, 9th edition, W H Freeman & Co
3. Fundamentals of Biochemistry Voet and Voet, , 6th Edition Wiley
4. iGenetics, Russell, 3rd edition Pearson

ELECTIVE Course 1	**Biocrystallography& Magnetic resonance techniques**	Credits 04

Course outcome: On the completion of the course the student will be able to understand the

1. Principle of NMR, ESR spectroscopy and its role in elucidation of three-dimensional structure of proteins.
2. Physical principle of X-ray diffraction, experimental approaches to form crystals and solve the three-dimensional structures of biomolecules.

Unit I: NMR Spectroscopy **(15L)**

Modern techniques for structure elucidation FT and FFT. Nuclear over Hauser effect. Basic 2D Spectroscopy benefits of 2D experiments (COSY NOESY). Assignment problem in biopolymers, Ligand binding to macromolecules, Chemical exchange, ^{1}HNMR spectroscopy, monitoring of cellular pH, gradient in tumour cells etc. Fluidity gradient in lipids, chemical shift, anisotropy of P resonance in membranes.

Unit II: ESR Spectroscopy **(15L)**

Spin labeling: a reporter group technique requirement of such a group, Nitro-oxide spin label probes and their molecular structures, anisotropy of the order parameters, dynamics information obtained from ESR, molecular polarity from biochemical data, orientation Intra-molecular distances. Applications of these concepts to study the structure and function of enzyme i.e. lysozyme etc. conformational change in trypsin, spin labelled ligands as probe for binding sites, lipid spin label in the biological membranes

Unit III: X-ray diffraction of the macromolecules **(15L)**

Brags law, Parameters governing crystallization of protein and nucleic acids; Analysis of diffraction data, evaluation of unit cell dimension and space group, phase determinations; Calculation and interpretation of electron density map crystal structure; Analysis of structures of proteins, nucleic acids, DNA-RNA and triple helical complexes**.**

Unit IV: Fiber Structure Determination **(15L)**

Diffraction by poly crystalline system; Diffraction by a helical chain and a discontinuous helix; X-ray scattering of helix; Analysis of the structure of fibrous proteins; Effect of intermolecular packing; X-ray scattering from nucleic acid fibers

References

1. Principles of Physical Biochemistry, van Holde, 2008 Prentice Hall
2. Physical Biochemistry, David Sheehan, 2nd edition, Wiley
3. NMR in biological systems, KVR Chary, Girjesh Govil, 2008 Springer
4. Understanding NMR spectroscopy, James Keeler, 2nd edition, Wiley
5. Protein NMR spectroscopy, John Cavanagh, 2nd edition, Elsevier

ELECTIVE Course 2	**PROTEOMICS**	Credit 02

Course outcome: On the completion of the course the student will be able to

1. Learn advanced tools of protein analysis and detection.
2. Understand the detailed principle and working of mass spectrometry.
3. Gain insights into the use of mass spectrometry in proteomics.

Unit I: Introduction to proteomics **(15L)**

Protein sequencing strategies: Edman degradation, DABITC/ PITC methods. Solid phase microsequencing; Fast atom Bombardment (FAB) mass spectra in protein sequencing. The genome, transcriptome and proteome. Need for proteomics, scope, challenges and applications in proteomics. Tools of proteomics, protein digestion techniques, protein identification and analysis by 2D-gel electrophoresis. Multidimensional liquid chromatography strategies in proteomics. Protein microarrays: analytical, functional and reverse phase. Detection methods of proteins on microarrays. Cell microarrays.

Unit II: Mass spectrometry for proteomics **(15L)**

Mass spectrometry: Basic principle and instrumentation, Ionization techniques, mechanism of ionization, mass analyzers and ion detectors, Tandem mass spectrometry, peptide and protein analysis by FAB, MALDI, Electrospray. Peptide Mass Fingerprinting, Peptide Sequence Analysis by Tandem Mass Spectrometry. Protein enrichment strategies, Quantitative protein expression mapping by metabolic labeling of proteins with radioactive amino acids, stable isotopes, In vitro labeling of proteins using isotope-coded affinity tags. Mass spectrometry for posttranslational modifications: phosphoproteomics, glycoproteomics and ubiquitinomics.

References

1. Principles of proteomics, Richard Twyman, 2014, 2nd edition, Taylor and Francis group
2. Introduction to proteomics: Principles and applications, Nawin C. Mishra, 2010 Wiley
3. Introduction to proteomics, Daniel Liebler, 2002 Humana Press
4. Proteomics Protocols Handbook, John Walker, Springer

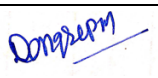
	ELECTIVE PRACTICAL COURSE 2	Credit 02
	1. Enzyme Assays (beta galactosidase, acid phosphatase, Succinic De – hydrogenase): Substrate concentration, Time, Temperature, Ph, enzyme concentration, cofactors. Determination of K_m& V_{max}. 2. Estimation of Protein by Lowery/Biuret/Bradford methods 3. Isolation of casein protein from milk 4. Enzymatic digestion of proteins 5. Fractionation of proteins using PAGE 6. Column chromatography for protein/pigment 7. 2-D gel electrophoresis of protein & Isoelectric focusing (Demonstration)	

Letter Grades and Grade Points:

Semester GPA/ Programme CGPA Semester/ Programme	% of Marks	Alpha-Sign/ Letter Grade Result
9.00 - 10.00	90.0 -100	O (Outstanding)
8.00 - < 9.00	80.0 < 90.0	A+ (Excellent)
7.00 - < 8.00	70.0 < 80.0	A (Very Good)
6.00 - < 7.00	60.0 < 70.0	B+ (Good)
5.50 - < 6.00	55.0 < 60.0	B (Above Average)
5.00 - < 5.50	50.0 < 55.0	C (Average)
4.00 - < 5.00	40.0 < 50.0	P (Pass)
Below 4.00	Below 40.0	F (Fail)
Ab (Absent)	-	Absent

Sign of HOD
Prof. Varsha Kelkar-Mane:
Department of Biophysics

Team for Creation of Syllabus

Name	College Name	Sign
Prof Varsha Kelkar Mane	I/c Head, Department of Biophysics, University of Mumbai	
Prof (Dr.) P M Dongre	Principal, PRES ACS Senior College, Satral, Ta. RahuriDistAhmadnagar Director, Research, Pravara Rural Education Society, Pravaranagar	
Dr Jessy John	Ad-hoc Assistant Professor, Department of Biophysics, University of Mumbai	
Dr A V Chitre	Visiting faculty, Department of Biophysics, University of Mumbai	
Prof S Sivakami	Visiting faculty, Department of Biophysics, University of Mumbai	
Prof B S Rao	Visiting faculty, Department of Biophysics, University of Mumbai	

Sign of HOD
Name of the Head of the Department:
Prof. Varsha Kelkar-Mane
Name of the Department:
Department of Biophysics

Sign of Dean,
Name of the Dean:
Prof. S.S. Garje
Name of the Faculty:
Science