University of Mumbai

No. AAMS_UGS/ICC/2024-25/138

CIRCULAR:-

Attention of all the Principals of the Affiliated Colleges, Directors of the Recognized Institutions and the Head, University Departments is invited to this office Circular No. AAMS_UGS/ICC/2023-24/23 dated 08th September, 2023 relating to the NEP UG & PG Syllabus.

They are hereby informed that the recommendations made by the **Ad-hoc Board of Studies in Biophysics** at its meeting held on 11th July, 2024 and subsequently passed by the Board of Deans at its meeting held on 3rd September, 2024 **vide** item No.6.2 (N) have been accepted by the Hon'ble Vice Chancellor as per the power confirmed upon him under section 12 (7) of the Maharashtra Public Universities Act, 2016 and that in accordance therewith syllabus for **M.Sc.(Biophysics) Sem - III & IV** is introduced as per appendix (NEP 2020) with effect from the academic year 2024-25.

(The Circular is available on the University's website www.mu.ac.in).

MUMBAI – 400 032
21st September, 2024

(Dr. Prasad Karande)
REGISTRAR

To

All the Principals of the Affiliated Colleges, Directors of the Recognized Institutions and the Head, University Departments.

BOD 6.2(N) 03/09/2024

Copy forwarded with Compliments for information to:-

1) The Chairman, Board of Deans,
2) The Dean, Faculty of Science,
3) The Chairman, **Ad-hoc Board of Studies in Biophysics**
4) The Director, Board of Examinations and Evaluation,
5) The Director, Department of Students Development,
6) The Director, Department of Information & Communication Technology,
7) The Director, Centre for Distance and Online Education (CDOE) Vidyanagari,
8) The Deputy Registrar, Admission, Enrolment, Eligibility & Migration Department (AEM),

Copy forwarded for information and necessary action to :-	
1	The Deputy Registrar, (Admissions, Enrolment, Eligibility and Migration Dept)(AEM), dr@eligi.mu.ac.in
2	The Deputy Registrar, Result unit, Vidyanagari drresults@exam.mu.ac.in
3	The Deputy Registrar, Marks and Certificate Unit,. Vidyanagari dr.verification@mu.ac.in
4	The Deputy Registrar, Appointment Unit, Vidyanagari dr.appointment@exam.mu.ac.in
5	The Deputy Registrar, CAP Unit, Vidyanagari cap.exam@mu.ac.in
6	The Deputy Registrar, College Affiliations & Development Department (CAD), deputyregistrar.uni@gmail.com
7	The Deputy Registrar, PRO, Fort, (Publication Section), Pro@mu.ac.in
8	The Deputy Registrar, Executive Authorities Section (EA) eau120@fort.mu.ac.in He is requested to treat this as action taken report on the concerned resolution adopted by the Academic Council referred to the above circular.
9	The Deputy Registrar, Research Administration & Promotion Cell (RAPC), rapc@mu.ac.in
10	The Deputy Registrar, Academic Appointments & Quality Assurance (AAQA) dy.registrar.tau.fort.mu.ac.in ar.tau@fort.mu.ac.in
11	The Deputy Registrar, College Teachers Approval Unit (CTA), concolsection@gmail.com
12	The Deputy Registrars, Finance & Accounts Section, fort draccounts@fort.mu.ac.in
13	The Deputy Registrar, Election Section, Fort drelection@election.mu.ac.in
14	The Assistant Registrar, Administrative Sub-Campus Thane, thanesubcampus@mu.ac.in
15	The Assistant Registrar, School of Engg. & Applied Sciences, Kalyan, ar.seask@mu.ac.in
16	The Assistant Registrar, Ratnagiri Sub-centre, Ratnagiri, ratnagirisubcentar@gmail.com
17	The Director, Centre for Distance and Online Education (CDOE), Vidyanagari, director@idol.mu.ac.in
18	Director, Innovation, Incubation and Linkages, Dr. Sachin Laddha pinkumanno@gmail.com
19	Director, Department of Lifelong Learning and Extension (DLLE), dlleuniversityofmumbai@gmail.com

Copy for information :-	
1	P.A to Hon'ble Vice-Chancellor, vice-chancellor@mu.ac.in
2	P.A to Pro-Vice-Chancellor pvc@fort.mu.ac.in
3	P.A to Registrar, registrar@fort.mu.ac.in
4	P.A to all Deans of all Faculties
5	P.A to Finance & Account Officers, (F & A.O), camu@accounts.mu.ac.in

To,

1	The Chairman, Board of Deans pvc@fort.mu.ac.in
2	**Faculty of Humanities,** **Dean** 1. Prof.Anil Singh Dranilsingh129@gmail.com **Associate Dean** 2. Dr.Suchitra Naik Naiksuchitra27@gmail.com 3.Prof.Manisha Karne mkarne@economics.mu.ac.in
	Faculty of Commerce & Management, **Dean** 1. Dr.Kavita Laghate kavitalaghate@jbims.mu.ac.in **Associate Dean** 2. Dr.Ravikant Balkrishna Sangurde Ravikant.s.@somaiya.edu 3. Prin.Kishori Bhagat kishoribhagat@rediffmail.com

	Faculty of Science & Technology **Dean** 1. Prof. Shivram Garje ssgarje@chem.mu.ac.in **Associate Dean** 2. Dr. Madhav R. Rajwade Madhavr64@gmail.com 3. Prin. Deven Shah sir.deven@gmail.com
	Faculty of Inter-Disciplinary Studies, **Dean** 1.Dr. Anil K. Singh aksingh@trcl.org.in **Associate Dean** 2.Prin.Chadrashekhar Ashok Chakradeo cachakradeo@gmail.com
3	Chairman, Board of Studies,
4	The Director, Board of Examinations and Evaluation, dboee@exam.mu.ac.in
5	The Director, Board of Students Development, dsd@mu.ac.in@gmail.com DSW direcotr@dsw.mu.ac.in
6	The Director, Department of Information & Communication Technology, director.dict@mu.ac.in

BOD – 3/9/2024
12 (7) of M.P.U.A. 2016
Item No. – 6.2 (N)

As Per NEP 2020

University of Mumbai

Title of the program
M.Sc. (Biophysics)

Syllabus for

Semester – Sem III & IV

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

(With effect from the academic year 2024-25)

(As per NEP 2020)

Sr. No.	Heading	Particulars
1	**Title of program** **O:_____**	**M.Sc. (Biophysics)**
2	**Scheme of Examination** **R: _____**	**NEP** **50% Internal** **50% External,** **Semester End Examination** **Individual Passing in Internal and External Examination**
3	**Standards of Passing** **R: _____**	**40%**
4	**Credit Structure** **R: SP – 65 B**	**Attached herewith**
5	**Semesters**	**Sem. III & IV**
6	**Program Academic Level**	**6.5**
7	**Pattern**	**Semester**
8	**Status**	**New**
9	**To be implemented from Academic Year**	**2024-25**

Sign of the BOS Chairman
Dr. Varsha Kelkar-Mane
Ad-hoc BoS (Biotechnology)

Sign of the Offg. Associate Dean
Dr. Madhav R. Rajwade
Faculty of Science & Technology

Sign of the Offg. Dean
Prof. Shivram S. Garje
Faculty of Science & Technology

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 modeling & 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)

SUMMATIVE ASSESSMENTS (THEORY)

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

	For 2 credit courses	**25 M (1 hr)**
Q1.	Answer any *four* questions out of six (covering unit I and II)	20 M
Q2.	Do as directed. (MCQ/True or false/ Fill in the blanks/Match the following *etc*.) (covering unit I and II)	05 M

FORMATIVE ASSESSMENTS (THEORY) (informal and formal tests administered during the learning process).

For 4 credit courses	**50 M**
Open book test/ assignments/problem solving	15 M
Combination of any 2: Topic presentation/MCQ test/Viva	35 M

For 2 credit courses	**25 M**
Open book test/ assignments/problem solving	15 M
Topic presentation/MCQ test	10 M

SUMMATIVE ASSESSMENTS (PRACTICAL)

	For 4 credit courses	**50 M (3 hrs)**
Q1.	Major	25 M
Q2.	Minor	15 M
Q3.	Journal	05 M

Q4.	Viva	05 M
	For 2 credit courses	**25 M (1.5 hrs)**
Q1.	Major	18 M
Q2.	Journal	02 M
Q3.	Viva	05 M

FORMATIVE ASSESSMENT (PRACTICAL)

For 4 credit courses	**50 M**
Analytical problem test/spots based on techniques/experiments performed.	30 M
Submission of Assignments, poster/presentations based on history / discovery /application	10 M
Viva and/ field visit report	10 M

For 2 credit courses	**25 M**
Submission of assignment/solving experiment based analytical problems	15 M
Poster presentation/powerpoint topic presentation	10 M

R: SP – 65 B									
II	**6.5**	**Sem III**	**Course 1: Advanced Biophysical Techniques** Credits 4 **Course 2: Nanobiophysics** Credits 4 **Course 3: Practical- lab work** Credits 4 **Course 4: Environmental Biophysics** Credits2	**Credits 4** **Course 1: Structural Biophysics** Theory 2 credits + Practical 2 credits OR **Course 2: Medical Biophysics** Credits 4 OR MOOCs			4	22	**PG Degree After3-YrUG**
		Sem IV	**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**	

Sem. III

Syllabus
M.Sc. (Biophysics) (Sem. III & IV)

PSBP 601 Course 1	**ADVANCED BIOPHYSICAL TECHNIQUES**	Credits 04

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

1. Understand the principle and working of diverse thermal biophysical methods like ITC, DSC and MST

2. Apply the key concepts of the advanced thermal methods for probing biomolecular interactions and conformations

3. Gain knowledge on the use of force spectroscopic methods such as AFM, optical traps and magnetic tweezers

4. Realize the potential of label free optical tools such as biolayer interferometry, CARS microscopy

5. Understand the various mixer designs and methods available to investigate pre-steady state enzyme kinetics.

Unit I: Thermal techniques **(15L)**

Isothermal Calorimetry (ITC): Thermodynamic Background to Isothermal Titration Calorimetry, Basic principles, Isothermal Titration Calorimetry of Biomolecules, study of Protein-drug interaction, study of DNA-Drug Interactions, Dehydration and Salt Effects in Protein-DNA interactions. Microcalorimetry of Protein- Protein Interactions.

Differential Scanning Calorimetry (DSC): Principle, equilibrium, thermodynamics analysis, the colorimeter criteria for two state behaviour, characterization of ligand binding, unfolded states of protein. Microscale thermophoresis (MST) theoretical background, MST for the investigation of biomolecular interaction and the determination of binding parameters

Unit II: Force spectroscopy I **(15L)**

Atomic force microscopy: principle, technique, single molecule manipulation, protein mechanics, relevant forces in biology, mechanical proteins, mechanical unfolding proteins, AFM for probing single membrane protein, structure –function characterization of protein, Understanding high speed AFM for protein – protein interaction. Single molecule force spectroscopy (SMFS): Principle and methodology, SMFS for protein study, Technical limitation of SMFS.

Unit III: Force spectroscopy II **(15L)**

Optical traps and Magnetic tweezers: Overview of optical traps, methodology, application to study of single molecule (structural and mechanical properties), overview of magnetic tweezers, experimental design, determination of applied force, nucleic acid under force & torque.

Unit IV: Advanced optical methods **(15L)**

Biolayer interferometry: principle, instrumentation and methodology. BLI versus surface plasmon resonance. BLI to study kinetics of protein-protein interactions, DNA-protein interactions and allosteric ligand effects. BLI for CRISPR-Cas system. Raman Microscopy, CARS microscopy, DIC, Patch Clamp technique, Rapid mixing techniques for the study of enzyme catalysis, mixer designs, stopped flow and continuous flow methods, freeze quenching methods.

References

1. Biocalorimetry: Foundations and contemporary approaches, Magarida Bastos, Taylor and Francis Biophysical Approaches determining ligand binding to Biomolecular Targets, Alberto Podjarny, Annick Dejaegere, RSC publishing
2. Atomic force microscopy: Fundamental concepts and laboratory investigations, Wesley C Sanders, Taylor and Francis
3. Comprehensive Biophysics, Vol 1-9, Edward Egelman, Elseiver
4. Advanced Techniques in Biophysics, José Luis R. Arrondo, Alicia Alonso, Springer
5. Biophysical Chemistry, Dagmar Klostermeier, Markus G. Rudolph, 1st edition, CRC Press

PSBP 602	**NANOBIOPHYSICS**	Credits

Course 2		04

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

1. *Understand the diverse nature of nanomaterials and their novel physico-chemical properties*
2. *Gain insights into the physical, chemical and biological methods to synthesize nanomaterials*
3. *Assess the methods that can be employed to characterize the size and morphology of nanomaterials*
4. *Gain mechanistic insights into nanomaterial-cell/biomolecule interaction*
5. *Correlate the toxicological effects of nanomaterials to their physical and chemical properties*
6. *Explain the functioning of nanomachines in nature*

Unit I: Introduction (15L)

Origins of nanotechnology, nanoscience, the unit nanometer, Types of nanomaterials: classification based on material type and dimension, metallic, organic, inorganic, semiconductor nanomaterials, quantum dots, dendrimers, carbon nanotubes, nanocrystals, gadolinium-based nanoparticles, silica based, polymeric nanomaterials, nanocomposites. Nanobiomaterials (lipoprotein based, liposomes, peptide-based). Self-assembled nanomaterials. Physico-chemical properties of nanomaterials, optical, mechanical, electrical, magnetic, thermal properties etc.

Unit II: Synthesis and characterization of nanomaterials (15L)

Concept of bottom- up approach, Top-down approach. Principles of gas, liquid & solid phase synthesis of nanomaterials. Biological methods of synthesis of nanomaterials. Synthesis of various nanomaterials from bacteria, fungi, plants, algae, DNA & protein templates etc. Physical and chemical methods to synthesize nanomaterials. Nanopatterning: chemical, topographical and 3D patterning.

Characterization techniques for nanomaterials using spectroscopic and microscopic techniques (UV-visible, fluorescence, light scattering, Force microscopy, Transmission and Scanning electron microscopy, High resolution Transmission Electron Microscopy, X-ray diffraction, Ellipsometry, surface tensiometry etc)

Unit III: Nanotoxicology (15L)

Introduction a general view, physicochemical properties of NPs influencing their toxic effects on biological system, cell, tissue and organs, mechanism related to nanotoxicity. Interaction of nanomaterials with biological system i.e cell, cell membranes, tissues, organ, protein, DNA, RNA and enzymes. Pharmaceutical development based on cytotoxicity of nanomaterials, in vitro testing methods for nanomaterial toxicity, Nanomaterials and immune system, biocompatibility and stability. Health effects of nanomaterials.

Unit IV: Biomimetics and applications of nanomaterials (15L)

Nano inspired from nature. Nanomotors in biological system: ATP synthase, flagellar motor in bacteria, kinesin, myosins, dynein etc. DNA nanotechnology, DNA nanodevices, nanopore technology for DNA sequencing. Biomimicry in nanomedicine (tissue engineering, nanorobots), Biomimicry and nano energy harvesting. nanobiomaterials for molecular imaging, nanotechnology for the environment, agriculture, food technology, diagnostics, therapeutics etc.

References

1. Introduction to Nanotechnology, Charles P. Poole, Wiley
2. Textbook of Nanoscience and Nanotechnology, B S Murty, P Shankar et al., Springer
3. Nanotechnology: Principles and Practices, Sulabha K Kulkarni, 3rd edition, Springer
4. Nanomaterials, B.Vishwanathan, Alpha Science
5. Nanostructures and Nanomaterials: synthesis, properties and applications, Guozhang Cao, Ying Wang, 2nd edition, World scientific
6. Nanobiomaterials Handbook, Balaji Sitharaman, 1st edition, Taylor and Francis
7. Toxicology of Nanomaterials, Weiyue Feng, Yuliang Zhao, Zhiyong Zhang, 2016, Wiley

PSBP 603	**PRACTICAL LAB WORK- III**	Credits

Course 3		04

Course outcome*: On the completion of the course the learner will acquire the skill to perform structural analysis of biomolecules using spectroscopy and microscopy tools. They will be able to synthesize nanomaterials and characterize it using various biophysical methods.*

1. The study of biological samples/cells using fluorescence /DIC microscopy.
2. Study of fluorescence sensitivity and quenching using spectrofluorimeter.
3. Study of DNA-Protein interaction using fluorimetry.
4. Study of interaction of acridine orange with DNA.
5. Determination of partition coefficient of amino acids and hydrophobicity/association studies.
6. Study of DNA damage using comet assays.
7. Synthesis of metallic/semiconductor nanoparticles using chemical methods (Silver, gold, zinc oxide, TiO_2, CdSe etc).
8. Synthesis of nanoparticles using biological methods like plants, microorganisms, proteins/DNA templates.
9. Characterization of nanoparticles using UV-Visible spectroscopy, Dynamic Light Scattering etc.
10. Characterization of nanoparticles using XRD, SEM & AFM etc (Demo)
11. Study of nanoparticle-biomolecule corona.
12. Biofunctionalization / surface modification of nanoparticles.
13. Preparation of PEGylated liposomes and drug encapsulation.
14. To find out the stomatal frequency and transpiration index of a leaf.
15. Effect of light and temperature on seed germination.
16. Isolation of chloroplast and study of evolution of oxygen by DCPIP method.
17. Demonstrate the process of microbial nitrification/denitrification in soil.
18. Isolation of nitrogen fixing bacteria from soil.
19. Measurement of nitrates/phosphates in soil.

PSBP 604 Course 4	**ENVIRONMENTAL BIOPHYSICS**	Credits 02

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

1. *Understand the interaction of living organisms and their environment*
2. *Compute the rates of energy and mass transfer*
3. *Determine the mass and energy budgets of living organisms*

Unit I: Biophysical properties of the environment **(15L)**

Introduction to environment, microenvironment, energy exchange, mass and momentum transport, conservation of energy and mass, continuity in the biosphere. Atmospheric temperature and its behaviour, temperature variation, modelling of vertical and temporal variation in air temperature, thermal time, temperature and biological development. Water potential in organism and their surrounding.

General understanding of conductance of heat, mass and transport; molecular diffusion, diffusive conductance of integument, conductance of heat, mass and transport in laminar force convection Animal shapes and heat conductance. Radiation fluxes in natural environment, direct, diffuse and reflected radiation, direct and diffuse shortwave irradiance, solar radiation under clouds, absorptivities for thermal and solar radiation.

Unit II: Energy budget of animals and plants **(15L)**

Energy concept, metabolism, conduction of heat in animal coats and tissues, quantitative analysis of animal thermal response, operative temperature, complexities of animal energetic, animal and water; human and their environment: metabolism, evaporation, survival I cold heat,

Leaf temperature, aerodynamics temperature of plant canopies, transpiration, canopy transpiration, assimilation models, biochemical model, stomatal conduction, leaf area index and light transmission, light transmission through stomatal conductance, transmission of diffuse radiation, light scattering in canopies, reflection of light in plants, light scattering in canopies, reflection of light by plant. Introduction to gravity, space flight and human health.

References

1. An Introduction to Environmental Biophysics, Gaylon S. Campbell, John M,Norman, 2nd edition, Springer

2. Principles of Environmental Physics, John L. Monteith and Mike H. Unsworth, 4th edition, Elsevier

Electives - 1

PSBP 605 E1 Elective Course 1	**STRUCTURAL BIOPHYSICS**	Credits 02

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

1. *Identify the biophysical tools for three-dimensional structure determination of biomolecules*
2. *Analyze the similarities and differences involved in NMR, X-ray crystallography and cryo-EM for structure-determination of biomolecules*
3. *Corelate the structure-function dependence of biomolecules*
4. *Realize the potential of 2D IR and mass spectrometry for probing biomolecular interactions*

Unit I: Biomolecular structure determination I **(15L)**

Introduction to Structural Biophysics, importance and scope. Determination of protein secondary structure and biomolecular interactions using circular dichroism, FTIR and Raman spectroscopy. Determining the 3-dimensional structure of proteins, nucleic acids, biomolecular complexes by X-ray crystallography and cryo-EM. Protein nanocrystallisation methods. Structure Determination of Membrane Proteins Using X-Ray Crystallography (eg. GPCRs, photosynthetic reaction centres, KCsA potassium ion channel *etc*.) Cryo-EM studies of ribosome-translocon complex in *E.coli*. Protein structure determination in solution by NMR spectroscopy (COSY, TOCSY).

Unit II: Biomolecular structure determination II **(15L)**

Infrared reflectance absorption spectroscopy, Instrumentation, absorption studies of peptide, structure conformation, Two-dimensional infrared correlation spectroscopy, principle, technique, 2-D IR studies of protein, protein unfolding study, protein aggregation, denaturation etc. Principle and methods of ultrafast structural dynamics of biological systems. Cross-Linking Mass Spectrometry for Investigating Protein Conformations and Protein−Protein Interactions

References

1. Introduction to protein structure, Carl Branden and John Tooze, 2nd edition, Garland Publishing
2. Membrane Structural Biology, Mary Luckey, 2nd edition, Cambridge University Press
3. Understanding NMR spectroscopy, James Keeler, 2nd edition, Wiley
4. Advanced Techniques in Biophysics, José Luis R. Arrondo, Alicia Alonso, Springer
5. Principles of physical biochemistry, Kensal Edward Van Holde, W. Curtis Johnson, (1998) Prentice Hall

PSBP 605 E1P	**ELECTIVE 1 STRUCTURAL BIOPHYSICS PRACTICAL LAB WORK**	Credits 02

Course outcome*: On the completion of the course the learner will acquire the skill to perform protein unfolding and folding experiments and analyse using UV-visible and fluorescence spectroscopy. They will be trained in performing structural analysis of proteins and nucleic acids.*

1. Protein (BSA/RNAse) unfolding using chaotropic denaturants (Urea/guanidium hydrochloride)
2. Protein refolding/renaturation by dialysis/dilution method
3. DNA damage by physical/chemical agents and analysis using electrophoresis/spectroscopy
4. Secondary and tertiary structure analysis of proteins using circular dichroism/FTIR/Raman
5. Protein-protein/protein-ligand/protein-nucleic acid interactions using spectroscopy (fluorescence/UV visible)
6. Study of membrane equilibria and ligand binding studies by dialysis method
7. Preparation, observation and characterization of macromolecular crystals.
8. Study of ligand binding interaction using Gel electrophoresis

Electives - 2

PSBP 605 E2 Elective course 2	**MEDICAL BIOPHYSICS**	Credits 04

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

1. *Have an overview of the important concepts of radiotherapy*
2. *Understand the principles of X-ray diagnosis, CT and PET scanning*
3. *Demonstrate knowledge on radiopharmaceuticals and radionuclide imaging*
4. *Relate to and apply the concepts of radiation protection*

Unit I: Biophysical Aspects of Radiotherapy (15L)

Tumour Biology, Growth Kinetic Factors, Cell Cycle, Potentially Doubling Time, Volume Doubling Time, Cell Loss Factor, Studies with Transplanted Tumour System, Basis of Fractionated Radiotherapy, Brachytherapy, 4 R's of Fractionated Radiotherapy, Causes of Clinical Radio resistance and Approaches to Overcome Radio resistance. New Modalities of Radiotherapy, Light Ion Particles, Neutrons, Boron Capture Therapy, Radiolabelled Immunotherapy, Recent Developments, Bio- Effect Models for Radiotherapy, Strandquist's Cube Root Rule, NSD, TDF, BED, Application of LQ Model in Developing Bio-effect Models for Radiotherapy

Unit II: Physics of Radiotherapy, Nuclear Medicine and Diagnostic Radiology (15L)

Physical Principles of X-Ray Diagnosis - Interactions of X-Rays with Human Body, Differential Transmission of X-Ray Beam, Spatial Image Formation, Visualization of Spatial Image, Image Quality -Density, Contrast, Detail and Definition of Radiographs, Choice of kV, mA, Filtration, FSD, Screens, Films, Grids, Contrast Media. CT Scanners and Their Applications, Overview of Digital Subtraction Radiography and Mammography.

Scope of Radiotherapy - Beam Therapy and Brachytherapy, Construction and Working Principles of Radiotherapy Delivery Devices - Telecobalt Unit, Medical Electron Linear Accelerator, Remote after Loading Brachytherapy Units, Output and Source Strength Measurements, Central Axis Dosimetry Parameters, Overview of Modern Radiotherapy Techniques, Need and Necessity of Quality Assurance Programme in Radiotherapy.

Unit III: Introduction to Nuclear Medicine (15L)

Unsealed Sources, Production of Radionuclides Used in Nuclear Medicine - Reactor and Accelerator Based Radionuclides, Radionuclide Generators and Their Operation Principles, assessment of radiochemical purity of Radiopharmaceuticals, particle sizing, stability & pyrogenic testing, Principle of localization and usages of radiopharmaceuticals,

General Concepts of Radionuclide Imaging. Principle of dynamics studies in radiation medicine imaging of various body organs. Physics of positron emission tomography and cyclotron, operational characteristics of scanner, magnetic resonance imaging. Absorption Studies using labelled Compounds, Quality Control in Radiation Medicine.

Unit IV: Basics of Radiation Protection (15L)

Basic Principles of Radiation Protection, Justification, Optimization and Dose Limitation. Practical Aspects of Implementation of Radiation Protection in Medical Applications, Regulatory Aspects of Radiation Protection. Medical radioprotection in children, diathermy, short wave and micro wave diathermy. Thermal response of tissues, use of diathermy therapy. Effect of heat and cold on body tissues. Applications in therapy and contradiction for use.

References

1. Fundamentals of 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. Introductory physics of nuclear medicine (1976) Ramesh Chandra
5. Principles and practice of nuclear medicine and correlative medical imaging, Lele, R.D. 1st edition Jaypee Brothers Medical Publishers

6. Technology and interpretation of nuclear medicine procedures by Sodee. D.B. and Early, P.J
7. Principles of Nuclear Medicine, Wagnar, H.N.
8. Medical physics, J. G. Skofronick, J. R. Cameron
9. Radiation Protection: A Guide for Scientists, Regulators and Physicians, Jacob Shapiro, 4th edition
10. The Physics of Radiation Therapy, Faiz M. Khan, 3rd edition, Lippincott Williams and Wilkins

RESEARCH PROJECT: 4 credits

The student is expected to carry out a detailed literature review on a research problem/topic in Biophysics that needs to be addressed. Each student will be assigned one or more mentor(s), who will be a faculty of the department/University. The student can opt for the review to be supplemented with experimental/ computational preliminary data from a project work related to the review topic. The primary data collection/project work may be carried out either in the University itself or in any recognized research institute/industry, with appropriate approvals. The review/findings of the project work should be submitted in the form of a dissertation for evaluation during the University end semester examination.

Sem. IV

SEMESTER IV

PSBP 611 Course 1	**PHYSIOLOGICAL BIOPHYSICS**	Credits 04

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

1. *Understand the mechanism of transmission of nerve impulses*
2. *Explain different types of muscles and their mode of action*
3. *Correlate the physical properties of blood to their function*
4. *Have a holistic understanding of the circulatory, respiratory and excretory system*
5. *Understand how individual organ systems interact to yield integrated physiological responses*
6. *Recognise the physical principles underlying the functioning of special senses such as ear, eye, tongue etc.*

Unit I: Biophysics of Nerve & Muscle (15L)

Structure of nerve, classification of nerves, myelinated and non-myelinated nerve, generation of nerve impulse, propagation of nerve impulse, synapse, synaptic transmission, Inhibitory post synaptic potential (IPSP), excitatory post synaptic potential (EPSP), glial cell, blood brain barrier, Brain Waves (EEG) : origin of alpha, beta, delta & theta, sleep and wakefulness. Regulation of body temperature by physical, chemical & neural mechanisms, acclimatization.

Molecular structure of skeletal, cardiac and smooth muscle, motor unit, molecular basis of muscle contractions (isometric, isotonic & lengthening), work done by muscle, excitation contraction coupling, properties of muscle, neuromuscular transmission, Electromyography.

Unit II: Biophysics of Circulatory & Excretory system (15L)

Initiation and conduction of cardiac impulse, Electrocardiogram (ECG) and its characteristics, Hemodynamic principles, Physics of Blood viscosity, specific gravity, physics of plasma and serum. Different blood vessels present in the vascular system, arterial blood Pressure, measurement, effect of hydrostatic pressure on arterial and venous blood pressure, blood volume, blood flows (laminar & turbulent), Reynolds number. Peripheral resistance and its role in vascularity. Cardiac output, factors affecting on cardiac output (Exercise, Haemorrhage & blood pressure), myocardial infarction.

Structure of nephron, glomerulus, tubules. Tubular functions: Reabsorption & Excretion. Osmotic equilibrium: maintenance of osmotic pressure, regulation of body fluid osmolarity. Glomerular filtration rate and factors affecting it, oedema. Function of kidney (autoregulation, acid base balance). Renal blood flow

Unit III: Biophysics of respiration (15L)

Introduction to respiratory system, structure of lungs, diffusion, exchange and transport of gases, physics of pulmonary circulation, perfusion and ventilation. Control of respiration (neuronal & chemical), lung capacities and volumes, lung function tests. Effect of altitude changes on body, high altitude- mountain sickness, low altitude- deep sea driving, adaptive changes, effect of changes in gravitational forces on body (space, aviation), adaptive changes

Unit IV: Biophysics of special senses (15L)

Structure of the eye, Optics of Vision: refraction, refractive errors, visual acuity, monocular & binocular vision, size of image, role of ocular lens, cataract formation, retinal pigments, rods and cones, Photochemistry of vision, visual cycle. Neurophysiology of vision, colour vision, visual pathway, blindness. Structure of ear, physics of audition (amplitude, frequency, pitch), unit of measurement of sound, intensity, conduction of sound through bone ossicles, impedance matching. Role of inner ear (cochlear mechanism), mechanisms of hearing, detection of localization of sound (direction), loudness of sound (amplitude), discrimination of pitch of sound, Audiometry, deafness, hearing aids. Taste & Smells: taste receptors & their role, conduction, pathway of smell. Balance & Rotation: Biophysics of posture movement, organisation of vestibular apparatus, mechanical sensors, fluid dynamics of semicircular canals, role of utricle, saccule & otolith organs, importance of vestibular function.

References

1. Textbook of Medical Physiology, Guyton and Hall, 14th edition, Elsevier
2. Textbook of Physiology, A K Jain, 10th edition, Arya
3. Ganong's Review of Medical Physiology, Kim E Barett, Susan M Barman, 26th edition, Mc Graw Hill
4. Human Physiology, Stuart Fox and Krista Rompolski, 16th edition, Mc Graw Hill
5. CC Chatterjee's Human Physiology, Nitin Ashok, 12th edition, CBS Publishers

PSBP 612 Course 2	**BIOMATHEMATICS & BIOSTATISTICS**	Credits 04

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

1. *Understand the importance of statistics in biology*
2. *Apply appropriate statistical methods required for a research design*
3. *Develop appropriate research hypothesis and test the hypothesis*
4. *Understand the concept of probability*
5. *Apply the test of significance*
6. *Interpret biological data based on statistical results*
7. *Analyse and interpret results from basic parametric and nonparametric tests.*

Unit I: Biomathematics **(15L)**

Limits of functions, derivatives of functions. Probability Calculation, Differential and integral calculus, Derivative and its physical significance, basic rules for differentiation (Without derivation) Maximum and Minimum their application in chemistry, Geometric meaning of integration, application in biology and chemistry.

Unit II: Biostatistics I **(15L)**

1. Introduction, scope, application and use of statistics, collection and classification of data, census and sampling, graphs and diagrams, arithmetic mean, median standard deviation.

2.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 liner form ($Y=Ab^x$, Ya^xb)

3. Probability, definition, addition and multiplicative laws (without proof). Random variable and its distribution, binominal probability distribution, examples and conditions means and variances, continuous variable, normal distribution, use of normal probability table for finding probabilities.

Unit III: Biostatistics II **(15L)**

1. Population parameter and sample statistics, sampling techniques, simple random sampling stratified random sampling, systematic sampling standard error of mean.

2. Estimation, Point & interval, confidence interval for proportion.

3.Hypothesis attesting, Type I and Type II errors levels of significance, one-tailed and two tailed test, application to single proportion, equality of the population means and two population proportions.

4. Chi-square test for independent attributes in r x c table, special case of 2 x 2 tables.

5. Students test for significance of correlation coefficient y for p=0 (small sample test)

Unit IV: Biostatistics III **(15L)**

1.Fishers z transformation coefficient for getting yp-0 in large samples test of significance for y (p=0)

2. Design of experiment: Principle and concepts of completely randomized design, randomized block design and Latin square design,

3.Variance ratio F-test-Analysis of variance in one-way classification.

4.Non-parametric test: Distribution-free method, sign test for method pairs, Wilcoxon test for unpaired data Run test.

References

1. Biostatistics, Veer Bala Rastogi, 3rd edition (2024) Medtec
2. Introductory Biostatistics, Chap T. Le, Lynn E. Eberly, 2nd edition, Wiley
3. Biostatistics: A Foundation for Analysis in the Health Sciences, Wayne W. Daniel, Chad L. Cross, 11th edition, Wiley
4. Basic Biostatistics for Geneticists and Epidemiologists: A Practical Approach, Robert C. Elston, William Johnson (2008) Wiley
5. The Essentials of Biostatistics for Physicians, Nurses, and Clinicians, Michael R. Chernick, 1st edition (2011) Wiley

PSBP 613 Course 3	**ELEMENTS OF BIOINFORMATICS**	Credits 04

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

1. *Search and extract biological information from appropriate databases*
2. *Implement various sequence alignment tools*
3. *Perform genomic analysis*
4. *Predict secondary and tertiary structure of proteins*
5. *Find homology for studying evolutionary relationship among different species*
6. *Perform molecular modelling and molecular dynamics methods to study structure from sequence*
7. *Apply key concepts of de novo drug design*

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

Introduction to bioinformatics and Biological databases, major bioinformatics resources, Types of databases, sequence databases, formats, organisation and query system, nucleotide sequence database and protein sequence database, Information & retrieval form biological databases. Database search algorithms- FASTA & BLAST

Gene prediction: Gene prediction programs in prokaryotes and eukaryotes.

Promoter & Regulatory Elements Prediction: Program for promoter and regulatory elements prediction in prokaryotes and eukaryotes.

Unit II: Phylogenetics & Structural Bioinformatics **(15L)**

Terminology, forms of tree representation, gene phylogeny vs species phylogeny. Molecular phylogeny Methods – distance based, character based; programs for construction of phylogenetic trees.

Structural Bioinformatics: Pair-wise and multiple sequence alignment, sequence alignment algorithms, pairwise alignment algorithms (global & local), multiple sequence alignment, sequence identity, similarity and homology concept, scoring matrices, scoring functions, algorithms, profiles and HMMs, prediction of protein motifs and protein domains, derived databases; patterns, profiles, motif and domain. Prediction of secondary and tertiary structure of proteins, homology modelling, threading, ab initio prediction.

Unit III: Molecular mechanics & conformational analysis **(15L)**

Molecular Mechanics and the forcefield. General form of a generic force field, force field parametrization. Comparison between the different forcefields in existence at present time

Conformational analysis: Systematic search, Monte Carlo simulations, Molecular dynamics simulations, distance geometry, strengths and limitations of each method

Molecular docking & Energy minimization: Docking by energy minimization, superimposition, molecular dynamics, Metropolis Monte Carlo, genetic algorithms, build-up approach. Different types of scoring function, e.gs of successful application of docking

Energy minimization: Steepest descents, conjugate gradients, Newton Raphson method, advantages and limitations of each method.

Unit IV: de novo ligand design & 3D –QSAR: **(15L)**

Classes of de novo ligand design – active site analysis methods, whole-molecule methods, connection methods, random connection and disconnection methods, e.g of successful application of de novo ligand design. Fragment based drug design, Self. Study – Successful applications of de novo drug design.

3D-QSAR: CoMFA and CoMSIA. Mention of other 3D-QSAR techniques and introduction to the 4^{th}, 5^{th} and 6^{th} dimension in QSAR. 3D-QSAR methods other than CoMFA and CoMSIA.

Pharmacopore Modeling &Virtual screening:

Techniques of developing a pharmacophore map covering both ligand based and receptor based approaches, incorporating additional geometric features into a 3D pharmacophore, use of a pharmacophore model in drug design.

Virtual Screening based on similarity, docking, pharmacophore maps and filters for drug-likeness and ADME.

References

1. Essential bioinformatics Jin Xiong, (2006) Cambridge University Press
2. Introduction to Bioinformatics, Arthur M Lesk, (2019) 5th edition, Oxford
3. Introduction to Bioinformatics, T K Attwood, (2009) Pearson Education
4. Molecular Modelling – Principles and Applications, Leach A. R., (2001) Prentice Hall.
5. Practical Application of Computer-Aided Drug Design, Charifson P. (1997) Taylor & Francis
6. 3D QSAR in Drug Design: Theory, Methods and Applications, Kubinyi H., Kluwer/Escom.
7. Molecular Modelling and Simulation -An Interdisciplinary Guide, Schlick T., 2nd edition (2010) Springer

Electives - 1

PSBP 614 E1 Elective Course 1	**NANOMEDICINE**	Credits 04

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

1. *Realize the progress of nanotechnology in therapeutics and diagnosis in the last two decades*
2. *Recognize the potential of intelligent nanosystems in drug delivery*
3. *Be aware of the advancements in cancer therapy*
4. *Explain the role of nanotechnology in tissue engineering*
5. *Evaluate the safety and regulatory concerns of nanomaterials*

Unit I: Nanomaterials in thernostics (15L)

Nanomaterials for drug delivery, Physicochemical Principles of Nanosized Drug Delivery Systems, Mechanism of cellular targeting: Passive and active. Multifunctional drug carriers, Smart materials for drug delivery, stimuli responsive nanoparticles for targeted drug delivery (pH, light, temperature, magnetism etc.) mechanism of targeted drug delivery across blood brain barrier, Nanoparticles for gene therapy, genome editing, Nanotechnology in nonviral gene delivery. Pharmacokinetics of nanocarrier-mediated drug and gene delivery, Peptide-Based Nanomaterials for siRNA Delivery, nanoplatforms for protein and peptide delivery, Nanobiosensors, Nanovaccines

Unit II: Nanomaterials for cancer therapy (15L)

Cancer pathophysiology, Enhanced Permeability and Retention Effect, Nanostructures/nanovectors (polymeric, liposomes, nanotubes, dendrimers etc) for cancer therapy, Bio-functionalized nanomaterials for targeting cancer cells (eg folate) Bio-inspired protein based nanoformulations for cancer thernostics (albumin ferritin, transferrin etc.), Nanotherapeutics in conjunction with chemotherapy and radiotherapy for cancer, Magnetic hyperthermia in cancer therapy, Mechanism of nanomaterials in overcoming drug resistance, Nanotechnology to overcome biological barriers to cancer therapy, Photodynamic therapy of cancer, Nano-enabled Cancer Immunotherapy, smart nanozymes for cancer therapy and diagnosis

Unit III: Nanomaterials for Tissue Engineering (15L)

Nanostructured extracellular matrix, Nanobiomaterials for Tissue Engineering: Nanoparticles, nanofibers, nanocomposites, polymers etc. Nanomaterials for Artificial Cells, Collagen: A Natural Nanobiomaterial for Tissue Engineering, scaffolds used for tissue engineering based on nanomaterials –bones, skin and neurons, nanobiomaterials for neural tissue engineering, bone and heart regeneration, Electrospinning and applications of electrospun materials in tissue engineering. Nanotechnology for regenerative medicine.

Unit IV: Nanomedicine and safety (15L)

Applications of nanomaterials in orthopedics, dentistry. Ocular and dermal applications. Nanomaterial Applications for Neurodegenerative Diseases. Nanorobotics in Nanomedicine. Antimicrobial, antifungal and antiviral nanomaterials. Nanomaterials for Preclinical and Clinical studies, Clinical Translation and Safety Regulation of Nanomaterials, nanodrugs approved by the FDA for clinical application, nanomedicines for cancer therapy approved by FDA. Challenges in the Clinical Application of Nanoparticles

References

1. Nanomaterials and Nanotechnology in Medicine, Visakh P. M, (2023) Wiley
2. Nanostructures for Cancer Therapy, Alexandru Mihai Grumezescu, Anton Ficai (2017) Elsevier science
3. Nanobiomaterials Handbook, Balaji Sitharaman, 1st edition, Taylor and Francis
4. Nanobiomaterials: Classification, Fabrication and Biomedical Applications, XiuMeiWang, Murugan Ramalingam (2018) Wiley-VCH
5. Nanoparticles in Cancer Therapy: Novel Concepts, Mechanisms and Applications, Bing Yan, Qingxin Mu, (2019) Frontiers Media SA
6. Nanomedicine - Basic and Clinical Applications in Diagnostics and Therapy, C. Alexiou, Karger
7. Nanotechnology Volume 5: Nanomedicine, Günter Schmid (2008) Wiley

Electives - 2

PSBP 614 E2 Elective Course 2	**ADVANCED MICROSCOPY AND SINGLE MOLECULE BIOPHYSICS**	Credits 04

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

1. *Understand the recent tools and advances in super-resolution microscopy*
2. *Have an in-depth understanding of cryo-electron microscopy and its potential in structure determination of biomolecules*
3. *Have a broad insight into the various single molecule methods that can probe biomolecular and cellular dynamics*
4. *Evaluate the applications of single molecule methods in the study of enzymes, membranes and molecular rotors.*

Unit I: Super-resolution microscopy (15L)

High-resolution and super-resolution imaging techniques, principle, instrumentation and applications of structured illumination microscopy (SIM), stimulated emission depletion (STED) microscopy, single-molecule localization microscopy (SMLM), stochastic optical reconstruction microscopy (STORM) and photo activated localization microscopy (PALM), fluorescence photoactivation localization microscopy (FPALM), 3D imaging. Fluorescence Lifetime Imaging Microscopy (FLIM)

Unit II: Cryo-electron microscopy (15L)

Principle and methodology & applications of electron microscopy, structure determination of macromolecular complexes by cryo-electron microscope, analysis of 2D crystal by electron microscopy. Cryo electron microscopy & tomography of virus particles. CLEM - Correlative Light and Electron Microscopy.

Unit III: Single molecule fluorescence methods (15L)

Single molecule paradigm, Single molecule fluorescence principle, optics for single molecule studies, technical advancements, Basics of Fluorescence Correlation spectroscopy, instrumentation and applications, one photon and two photon excitation, FCS in living cells. Image correlation spectroscopy: principle, types, instrumentation and applications. Understanding FRET, single molecule FRET, quantitative single molecule FRET to bimolecular system. Principle of single particle tracking, tracking the movement of molecular motor, tracking flurophores inside living cells, rotational movement, single molecule imaging in living cells, Fluorescence speckle microscopy.

Unit IV: Biomolecular analysis using single molecule methods (15L)

Single molecule analysis of biomembranes, applications in synthetic lipid bilayers and live cell plasma membrane. Single molecule enzymology, single molecule studies of rotary molecular rotor eg ATP synthase, bacterial flagellar motors, helicases, myosin, kinesin etc. Single molecule studies of chromatin structure and dynamics, Single molecule approaches to study DNA replication, translation, single molecule studies of protein folding/unfolding

References

1. Comprehensive Biophysics, Vol 1-9, Edward Egelman, Elseiver
2. Handbook of Single-Molecule Biophysics, Peter Hinterdorfer, Antoine van Oijen, Springer
3. Single Molecule Dynamics in Life Sciences, Toshio Yanagida, Yoshiharu Ishii, Wiley
4. Advanced Techniques in Biophysics, José Luis R. Arrondo, Alicia Alonso, Springer
5. Principles of fluorescence spectroscopy, Joseph R Lackowicz, 3rd edition, Springer
6. Single-molecule Biology, Alex E Knight, Elsevier

RESEARCH PROJECT: 6 credits

The student is expected to carry out a project work (experimental/computational) on a research problem/topic in Biophysics that needs to be addressed. Each student will be assigned one or more mentor(s), who will be a faculty of the department/University. The project work may be carried out either in the University itself or in any recognized research institute/industry, with appropriate approvals. The project work has to be complied in the form of a dissertation for evaluation during the end semester examination. The dissertation must include detailed information on background of research problem, review of literature, aims and objective of the research work, materials and methodologies applied, results, discussion, conclusion and bibliography.

Letter Grades and Grade Points:

Semester GPA/ Programme CGPA Semester/ Programme	% of Marks	Alpha-Sign/ Letter Grade Result	Grading Point
9.00 - 10.00	90.0 - 100	O (Outstanding)	10
8.00 - < 9.00	80.0 - < 90.0	A+ (Excellent)	9
7.00 - < 8.00	70.0 - < 80.0	A (Very Good)	8
6.00 - < 7.00	60.0 - < 70.0	B+ (Good)	7
5.50 - < 6.00	55.0 - < 60.0	B (Above Average)	6
5.00 - < 5.50	50.0 - < 55.0	C (Average)	5
4.00 - < 5.00	40.0 - < 50.0	P (Pass)	4
Below 4.00	Below 40.0	F (Fail)	0
Ab (Absent)	-	Ab (Absent)	0

Sign of the BOS Chairman
Dr. Varsha Kelkar-Mane
Ad-hoc BoS (Biotechnology)

Sign of the Offg. Associate Dean
Dr. Madhav R. Rajwade
Faculty of Science & Technology

Sign of the Offg. Dean
Prof. Shivram S. Garje
Faculty of Science & Technology