Biophysics and Bioinformatics (Major)

Semester I

Paper 1: Analytical Physics-I

Unit 1: Biomechanics

Viscoelastic models of tissues (Maxwell, Kelvin–Voigt), lever mechanics in limbs, fluid flow in vessels (Poiseuille's law), bone bending, muscle contraction mechanics and joint load estimation.

Unit 2 Bio-optics & Bioacoustics

Light–tissue interaction, imaging modalities basics and applications (bright-field, fluorescence, optical coherence tomography, X-ray imaging), sound interaction with tissue, ultrasound principles, Doppler Effect in blood flow.

Unit 3: Biophysics of Gas Transport

Diffusion laws (Fick's laws), permeability and solubility of blood in different media, oxygen and CO_2 transport dynamics, Haemoglobin–O_2 binding (oxygen dissociation curves), blood pressures, Fick's principle of diffusion in respiratory physiology.

Unit 4: Bio-thermal Properties

Thermal conductivity, specific heat, heat capacity of tissues, thermal diffusion equation, Bio-heat transfer models (Pennes' bio-heat equation), perfusion effects, thermal therapies (hyperthermia & cryotherapy basics).

References:

1. Fung, Y. C. – Biomechanics: Mechanical Properties of Living Tissues, Springer.
2. Duck, F. A. – Physical Properties of Tissues: A Comprehensive Reference Book, Academic Press.
3. West, J. B. – Respiratory Physiology: The Essentials, Wolters Kluwer.
4. Enoka, R. M. – Neuromechanics of Human Movement, Human Kinetics.
5. Rodney Cotterill – Biophysics: An Introduction
6. Humphrey &Oomens – Biomechanics of Soft Tissues.
7. John D. Enderle – Introduction to Biomedical Engineering

Biophysics and Bioinformatics (Major)

Semester I

Paper 2: Molecular & Cellular Biophysics - I

Unit I: Atomic and Molecular Structure

Structure of atom: models & theories (Qualitative). Concept of bonding: valence of carbon, hybridizations, polar & non-polar molecules, inductive effect. Secondary bonding: weak interactions, hydrogen bonding Bonds within molecules: Ionic, covalent, hydrogen, electrostatic, Van der Waals.

Unit II: Physico-chemical Foundations

Biophysics of water: Physico-chemical properties of water, molecular structure, nature of hydrophobic interactions, water structure. Acid & Bases: acid-base theories, mole concept, molarity, molality & normality, ampholyte, concept of pH, measurements of pH, Henderson– Hasselbatch equation, titration curve & pK values.

Unit III: Physical Foundations of Biophysics

Thermodynamics of biological system: Laws of thermodynamics, activation energy, biological systems as open system, concept of free energy, entropy, enthalpy, negative entropy as significant to biological systems. Bioenergetics: Concept of energy coupling in biological processors, structure and role of mitochondria, electron-transport chain.

Unit IV: Cell Organization

Cell as the basic structural unit, origin of cell, fine structure of Prokaryotic & Eukaryotic cell organization, internal architecture of cell and cell organelles, structure and function of cell membrane.

References:

1. Bloomfield V.A.andHarringtonR.E.(1975). Biophysicalchemistry, W.A.Freeman
2. Cantor C.R.andSchimmel P.R.(1980).Biophysical chemistry.W.A.FremmanandCo.
3. LehningerA.(1981),Biochemistry,ButterWorth Publication.
4. Introduction to Molecular Biophysics: by Jack A. Tuszynski and Michal Kurzynski.
5. Cell and Molecular Biology De By Robertis& De Robertis (Lippincott & Wilkins)
6. Molecular Biology of the Cell By Alberts B et al. (Garland)
7. Molecular Cell Biology By Lodish, H. et al. (Freeman

Biophysics and Bioinformatics (Major)

Semester I

Experiments

Physics

1. To determine the value of acceleration due to gravity using Simple Pendulum plot L-T^2.
2. To determine the surface tension of water by Jaeger's method.
3. To determine the mean deviation, standard deviation and coefficient of variance for systolic & diastolic blood pressure as well as pulse rate of students.

Botany

4. Preparation of buffers (acetate, phosphate, citrate, borate buffers).
5. To measure the pH of given solution.
6. To study the cell structure from onion leaf; shape and size of the cell-simple and differential staining.
7. To study the principle of autoclave and its applications.
8. To study the principle of Laminar Air flow and its applications.
9. To study the principle of BOD incubator and its applications.

Biophysics and Bioinformatics (Minor)

Semester I

Biophysics Basic - I

Unit I: Biomechanics & Bio-Optics

Viscoelastic models of tissues (Maxwell, Kelvin-voight), lever mechanics in limbs, bone bending, muscle contraction mechanics, joint load estimation, Light–tissue interaction, sound interaction with tissue, Doppler effect in blood flow.

Unit II: Gas Transport and Biothermal properties:

Permeability and solubility of blood in different media, blood pressures, Fick's principle of diffusion in respiratory physiology,thermal conductivity, specific heat, heat capacity of tissues, thermal therapies (hyperthermia, cryotherapy basics).

Unit III: Physico-chemical Foundations

Biophysics of Water: Physicochemical properties of water, molecular structure, nature of hydrophobic interactions. Acid & Bases: acid-base theories, mole concept, molarity, molality & normality, ampholyte, concept of pH, measurements of pH, Henderson– Hasselbatch equation, titration curve & pK values. Polar & non polar molecules, inductive effect, Secondary bonding (Qualitative): weak interactions, hydrogen bonding. Bonds within molecules (Qualitative): Ionic, covalent, hydrogen, electrostatic, Van der Waals.

Unit IV: Cell Organization

Cell as the basic structural unit, origin of cell, fine structure of prokaryotic & eukaryotic cell organization, internal architecture of cell and cell organelles. Structure and function of cell membrane.

References

1. Fung, Y. C. – Biomechanics: Mechanical Properties of Living Tissues, Springer.
2. Duck, F. A. – Physical Properties of Tissues: A Comprehensive Reference Book, Academic Press.
3. West, J. B. – Respiratory Physiology: The Essentials, Wolters Kluwer.
4. Enoka, R. M. – Neuromechanics of Human Movement, Human Kinetics.
5. BloomfieldV.A.andHarringtonR.E.(1975). Biophysicalchemistry, W.A.Freeman
6. Cantor C.R.andSchimmel P.R.(1980).Biophysical chemistry,W.A.FremmanandCo.
7. LehningerA.(1981),Biochemistry,ButterWorth Publication.
8. Introduction to Molecular Biophysics: by Jack A. Tuszynski and Michal Kurzynski.
9. Cell and Molecular Biology De By Robertis& De Robertis (Lippincott & Wilkins)

Biophysics and Bioinformatics (Minor)

Semester 1

Experiments

Physics

1. To determine the value of acceleration due to gravity using Simple Pendulum plot $L\text{-}T^2$.
2. To determine the mean deviation, standard deviation and coefficient of variance for systolic & diastolic blood pressure as well as pulse rate of students.

Botany

3. Preparation of buffers (acetate, phosphate, citrate, borate buffers).
4. To measure the pH of given solution.
5. To study the principle of autoclave and its applications.
6. To study the principles of Laminar Air Flow and its applications.
7. To study the principles of BOD incubator and its applications.

Biophysics and Bioinformatics (Major)

Semester 2

Paper 1: Analytical Physics-II

Unit I: Bioelectricity

Resting membrane potential, action potential generation and propagation, Nernst equation, Goldman equation, ionic gradients, Electroencephalography (EEG), Electrocardiography (ECG), Electromyography (EMG), Bioelectrical properties of tissues: Conductivity, permittivity, impedance, Nerve conduction studies, pacemakers, defibrillators, electrical safety in biomedical instruments.

Unit II: Sensors and Transducers

Definition, classification, and characteristics of sensors and transducers, Physical sensors: Temperature (thermistors, RTDs), Pressure (piezoelectric, capacitive), Displacement (LVDT), Biosensors: Enzyme-based, Immunosensors, DNA biosensors, Optical Sensors: Fiber-optic biosensors, Fluorescence based sensors, Silicon photonics biosensors.

Unit III: Application of Sensors in Biophysics and Bioinformatics

Signal Conditioning & Output: Amplification, filtering, digitization, Applications of sensors in clinical diagnostics, environmental monitoring, wearable health devices and glucose monitoring.

Unit IV: Biometrics

Introduction to biometrics: definition, types, and scope in healthcare, security, and research, Physiological biometrics: fingerprint, iris, retina, face recognition, Behavioural biometrics: gait, voice, keystroke dynamics, Biometric data acquisition & processing: image capture, pre-processing, feature extraction, matching algorithms, Performance metrics: False Acceptance Rate (FAR), False Rejection Rate (FRR), accuracy, sensitivity.

References:

1. Sensors and Transducers by D. Patranabis
2. Human Physiology Vol. I& II- C.C Chatterjee
3. S.C. Bhargava – Transducers and Instrumentation.
4. Anil K. Jain, Arun Ross, KarthikNandakumar – Introduction to Biometrics

Biophysics and Bioinformatics (Major)

Semester 2

Paper 2: Molecular & Cellular Biophysics -II

Unit I : Diversity of Life

Introduction to micro-organisms like viruses, bacteria and protozoa, algae & fungi.

Unit III: Cell cycle and growth

The cell cycle, interphase - G1, S, G2, M-phase molecular events at different cell cycle phases. Mitosis & cell division: molecular mechanism, events in mitosis, significance of mitosis. Meiosis: molecular mechanism of meiosis, significance of meiosis.

Unit III: Basics of Cell Signalling

General principle of cell signalling: paracrine, autocrine, endocrine & synaptic signalling, G-Protein structure and role in signalling, Intracellular cyclic AMP, Ca^{++} in cell signalling, CAM kinases, bacterial chemotaxis.

Unit IV: Biomolecules as alphabets of life

Bioenergetics: Concept of energy coupling in biological processors, structure and role of mitochondria, structure and role of mitochondria, Electron-transport chain. Nucleic acids: nucleosides, nucleotides, basic differences in structure and function of RNA and DNA. Amino acids & Proteins: Amino acid general structure & types, peptide bond, structure of proteins. Carbohydrates: Structure and function of carbohydrate.Lipids, Vitamins & Hormones: Structure, classification & function.

References:

1. Cell and Molecular Biology De By Robertis & De Robertis (Lippincott & Wilkins)
2. Molecular Biology of the Cell By Alberts B et al. (Garland)
3. Molecular Cell Biology By Lodish, H. et al. (Freeman)
4. Molecular and Cellular Biophysicsby Jack A. Tuszynski
5. Integrated Molecular and Cellular Biophysics by Valerica Raicu and Aurel Popescu.
6. Cellular Biophysics Transport Volume 1 by Thomas Fischer Weiss

Biophysics and Bioinformatics (Major)

Semester 2

Experiments

Physics

1. To determine the coefficient of viscosity of the given liquid by Stoke's Law
2. To determine the viscosity of a liquid by Posieulli's method.
3. To determine the Body Mass Index and statistical parameter of the group of students.

Botany

4. To learn a) use of Microscope b) principles of fixation and staining
5. To differentiate between bacteria on the basis of their Gram +ve and Gram –ve characteristics using curd, gram plant (root), *Citrus canker*
6. Cell division- Examination of various stages of mitosis and meiosis - mitosis & meiosis.
7. To estimate the presence of reducing sugars in the given solution
8. To estimate the presence of proteins from the given solution.
9. Histochemical test for starch.
10. Histochemical test for protein.
11. Histochemical test for fat and oil.

Biophysics and Bioinformatics (Minor)

Semester 2

Biophysics Basic - II

UnitI: Bioelectricity& Biometrics

Electroencephalography (EEG), Electrocardiography (ECG), Electromyography (EMG).Bioelectrical Properties of Tissues: Conductivity, permittivity, impedance.Introduction to Biometrics: Definition, types, and scope in healthcare, security, and research. Physiological Biometrics: Fingerprint, iris, retina, face recognition. Biometric Data Acquisition & Processing: Image capture, preprocessing, feature extraction, matching algorithms.

Unit II: Sensors and Transducers

Definition, classification, and characteristics of sensors and transducers. Physical Sensors: Temperature (thermistors, RTDs), pressure (piezoelectric, capacitive), displacement (LVDT).Biosensors: Enzyme-based biosensor, Glucose monitoring sensors. Optical Sensors: Fiber-optic biosensors, fluorescence-based sensors.

Unit III: Diversity of Life, Cell cycle, growth and Cell Signalling

Introduction to micro-organisms like viruses, bacteria and protozoa, algae & fungi. Cell cycle, Interphase -G1, S, G2, M-phase molecular events at different cell cycle phases. Mitosis & cell division: Significance of mitosis and Meiosis. General principle of cell signalling: Paracrine, autocrine, endocrine & synaptic signalling. G-Protein structure and role in signalling. Intracellular Cyclic AMP, Ca++ in cell signalling.

Unit IV: Biomolecules as alphabets of life

Nucleic acids: nucleosides, nucleotides, basic differences in structure and function of RNA and DNA. Amino acids & proteins: Amino acid general structure & types, peptide bond, structure of proteins. Carbohydrates: Structure and function carbohydrate. Lipids, vitamins & hormones: Structure, classification & function.

References:

1. Sensors and Transducers by D. Patranabis
2. Human Physiology Vol. 1& II- C.C Chatterjee
3. S.C. Bhargava – Transducers and Instrumentation.
4. Anil K. Jain, Arun Ross, KarthikNandakumar – Introduction to Biometrics
5. Cell and Molecular Biology De By Robertis& De Robertis (Lippincott & Wilkins)
6. Molecular Biology of the Cell By Alberts B et al. (Garland)
7. Molecular and Cellular Biophysicsby Jack A. Tuszynski

Biophysics and Bioinformatics (Minor)

Semester 2

Experiments

Physics

1. To determine the coefficient of viscosity of the given liquid by stoke's Law
2. To determine the Body Mass Index and statistical parameter of the group of students.

Botany

3.To learn a) use of Microscope b) principles of fixation and staining

4.To differentiate between bacteria on the basis of their Gram +ve and Gram –ve characteristics using curd, gram plant (root).Citrus canker.

5. To estimate the presence of reducing sugars in the given solution.

6. To estimate the presence of proteins from the given solution.

Biophysics and Bioinformatics (Major)

Semester III

Paper 1: Biostatistics

Unit 1: Statistical Methods: Measure of central tendency (mean, median, mode), measure of dispersion (range, inter-quartile range, mean deviation, standard deviation), Methods of least square, correlation, regression.

Unit 2: Probability Theory: Probability, random variables, distribution theory, binomial distribution, Poisson distribution, normal distribution, exponential distribution, theory of estimation, test (chi square, F- test, t- test), p value.

Unit 3: Applied Statistics: Analysis of variance, assumption of analysis of barriers, one way and two way ANOVA, limitations of analysis of variance.

Unit 4: Design of Experiments: Design of experiments, principle of design of experiments, complete randomized design (CRD), randomized block design (RBD), limitations of design of experiments.

References:

1. Mathematical Statistics (Vol-1): S.C. Gupta and V.K. Kapoor
2. Applied Statistics (Vol-2): S.C. Gupta and V.K. Kapoor
3. Fundamentals of Statistics (Vol-1&2): A.M. Goon, M.K. Gupta and B. Das Gupta.
4. An Introduction to Probability and Statistics: B.K. Rohatgi and A.K. Md. Ehsanes Saleh
5. Mathematical Statistics: J. E-Ferund.

Biophysics and Bioinformatics (Major)

Semester III

Paper 2: Physiological Biophysics

Unit 1. Digestive & Excretory systems: Digestive system - Structure and function of Alimentary canal and accessory digestive organs. Problems and treatments. Excretory systems - Structure and functions of excretory organs, excretory waste formation.

Unit 2. Cardiovascular & Respiratory system: Cardiovascular system - Study of blood pigments, blood vessels (arteries and veins), Structure and function of Heart, cardiac cycle, ECG. Respiratory system - Structure and function of Respiratory organs, Process of respiration, Transport and exchange of oxygen and carbon dioxide in body.

Unit3. Nervous system & Sense organs: Nervous system - Structure of neuron, Myelinated and unmyelinated nerve fibers. Action potential. Properties of nerve fibers: excitability, conductivity, all-or none law, accommodation, adaptation, summation refractory period, synaptic potentials, synaptic transmission of the impulse.
Sense organs - Physiology of Vision, audition, olfaction, taste, tactile sensation.

Unit 4. Endocrine System: Structure and function of Endocrine glands, Role of hypothalamus, functions of pituitary, thyroid, adrenal glands, parathyroid and gonads.

References:

1. Essentials of Human Physiology – Sembulingam & Sembulingam
2. Textbook of Physiology – A. K. Jain.
3. Guyton & Hall: Textbook of Medical Physiology (Short or Pocket edition).
4. Introduction to Immunology – C.V. Rao.
5. Practical Physiology Book – C.L. Ghai

Biophysics and Bioinformatics (Major)

Semester 3

Experiments

Physics

1. To draw the I/O characteristics for NPN transistor in the common emitter configuration and evaluate the current gain.
2. To verify the truth table for AND, OR, NOT, NAND and NOR gates and to draw I/O characteristics of AND, OR and NOT gates.
3. To draw the static characteristics of the given FET and determine the parameters, mutual conductance, output resistance, amplification factor and pinch-off voltage.

OR

4. To determine the wavelength of different spectral lines emitted by light source with a plane transmission grating.
5. To determine the wavelength of sodium light with the help of Newton's Ring.
6. To determine the specific rotation of an optically active substance with the help of Polarimeter.

Zoology

7. To observe and study the transverse section of the liver under a microscope.
8. To observe and study the transverse section of the pancreas under a microscope.
9. To study and understand the external and internal structure of the human heart, including its chambers, valves, blood vessels.
10. To study and understand the external and internal structure of the human lungs.
11. To understand the structure of a neuron and identify its main parts—cell body, dendrites, and axon.
12. To understand and identify the different kinds of neurons based on their structure and function.
13. To study and understand the external and internal structure of the human kidney.
14. To observe and study the transverse section of Thymus gland under a microscope.
15. To observe and study the transverse section of Ovaries under a microscope.
16. To observe and study the transverse section of Adrenal gland under a microscope.
17. To observe and study the transverse section of Thyroid gland under a microscope.
18. To observe and study the transverse section of Parathyroid gland under a microscope.

Biophysics and Bioinformatics (Minor)

Semester 3

Biostatistics & Physiological Biophysics

Unit 1: Statistical Methods: Measure of central tendency (mean, median, mode), measure of dispersion (range, inter-quartile range, mean deviation, standard deviation), Methods of least square, correlation, regression.

Unit 2: Probability Theory: Probability, random variables, distribution theory, binomial distribution, Poisson distribution, normal distribution, exponential distribution, theory of estimation, test (chi square, F- test, t- test), p value.

Unit 3. Digestive & Excretory systems: Digestive systems - Structure and function of Alimentary canal and accessory digestive organs. Problems and treatment. Excretory systems - Structure and functions of excretory organs, excretory waste formation.

Unit 4. Cardiovascular & Respiratory system: Cardiovascular system - Structure and function of Heart. Respiratory system - Structure and function of Respiratory organs, Problems and treatments.

Unit 5. Nervous system & Endocrine system: Nervous system - Structure and function of nerve. Endocrine system - Structure and function of Endocrine glands.

References:

1. Essentials of Human Physiology – Sembulingam & Sembulingam
2. Textbook of Physiology – A. K. Jain.
3. Guyton & Hall: Textbook of Medical Physiology (Short or Pocket edition).
4. Applied Statistics (Vol-2): S.C. Gupta and V.K. Kapoor.
5. Fundamentals of Statistics (Vol-1&2): A.M. Goon, M.K. Gupta and B. Das Gupta.

Biophysics and Bioinformatics (Minor)

Semester 3

Experiments

Physics

1. To draw the I/O characteristics for NPN transistor in the common emitter configuration and evaluate the current gain.
2. To draw the static characteristics of the given FET and determine the parameters, mutual conductance, output resistance, amplification factor and pinch-off voltage.

OR

3. To determine the wavelength of different spectral lines emitted by light source with a plane transmission grating.
4. To determine the wavelength of sodium light with the help of Newton's Ring.

Zoology

5. To observe and study the transverse section of the liver under a microscope.
6. To observe and study the transverse section of the pancreas under a microscope.
7. To study and understand the external and internal structure of the human heart, including its chambers, valves, blood vessels.
8. To study and understand the external and internal structure of the human lungs.
9. To understand the structure of a neuron and identify its main parts—cell body, dendrites, and axon.
10. To observe and study the transverse section of Thymus gland under a microscope.
11. To observe and study the transverse section of Ovaries under a microscope.
12. To observe and study the transverse section of Adrenal gland under a microscope.
13. To observe and study the transverse section of Thyroid gland under a microscope.
14. To observe and study the transverse section of Parathyroid gland under a microscope.

Biophysics and Bioinformatics (Major)

Semester IV

Paper 1: Biospectroscopy

Unit 1: Visible & UV Spectroscopy: Regions of the spectrum, hydrogen atom spectrum. Principle and biological applications of UV photoelectron spectroscopy (UPES) and X-ray photoelectron spectroscopy (XPES).

Unit 2: IR Spectroscopy: Principle, instrumentation and application of IR spectroscopy & Fourier Transform IR spectroscopy.

Unit 3: Raman Spectroscopy: Classical and Quantum theory of Raman Effect, Raman spectrometer, comparison of structure determination from Raman and IR spectroscopy.

Unit 4: Fluorescence Spectroscopy: Principle of Fluorescence & phosphorescence spectroscopy, fluorescence spectrometer, Circular Dichroism (CD) spectroscopy- Principle and use of CD spectroscopy in structural biology.

References:

1. Biological spectroscopy: J.D cambel and R. A. Dwek
2. Modern Approach to physical chemistry vol. I &II: R.C. Mukherjee and V. Bhadauria.
3. Organic Spectroscopy: J. Singh.
4. Mass spectrometer: G. Siuzadak.
5. Modern Physics: R. Murugesan

Biophysics and Bioinformatics (Major)

Semester IV

Paper 2: Python Programming

Unit 1: Introduction to Computers and Programming: Introduction, Hardware and Software, Python Installation, Input, Processing, and Output: Displaying Output with the print Function, Comments, Variables, Reading Input from the Keyboard, Performing Calculations.

Unit 2: Decision Structures and Boolean Logic: The if Statement, The if-else Statement, Comparing Strings, Nested Decision Structures and the if-elif-else Statement, Logical Operators, Boolean Variables, Repetition Structures: Introduction to Repetition Structures, The while Loop: A Condition-Controlled Loop, The for Loop: A Count-Controlled Loop, Calculating a Running Total, Sentinels, Input Validation Loops, Nested Loops.

Unit 3: The math Module, Storing Functions in Modules Lists and Tuples: Sequences, Introduction to Lists, List Slicing, Finding Items in Lists with the in Operator, List Methods and Useful Built-in Functions, Copying Lists, Processing Lists, Two-Dimensional Lists, Tuples, Plotting List Data with the matplotlib Package.

Unit 4: More About Strings: Basic String Operations, String Slicing, Testing, Searching, and Manipulating Strings, Dictionaries and Sets: Dictionaries, Sets, Serializing Objects, Files and Exceptions: Introduction to File Input and Output, Using Loops to Process Files, Processing Records, Exceptions, Object-Oriented Programming: Procedural and Object-Oriented Programming, Classes, Working with Instances, Techniques for Designing Classes, Introduction to Inheritance, Polymorphism.

Biophysics and Bioinformatics (Major)

Semester IV

Experiments

Physics

1. To determine the wavelength of different spectral lines emitted by light source with a plane transmission grating.
2. To determine the wavelength of sodium light with the help of Newton's Ring.
3. To determine the specific rotation of an optically active substance with the help of polarimeter.

OR

4. To draw the I/O characteristics for NPN transistor in the common emitter configuration and evaluate the current gain.
5. To verify the truth table for AND, OR, NOT, NAND and NOR gates and to draw I/O characteristics of AND, OR and NOT gates.
6. To draw the static characteristics of the given FET and determine the parameters, mutual conductance, output resistance, amplification factor and pinch-off voltage.

Computer Programming and Statistics

7. Problem based on calculation of measure of central tendency.
8. Problem based on calculation of Dispersion.
9. Problem based on calculation of Moments, Measure of Skewness and Kurtosis.
10. Problem based on of fitting of curves by Method of least squares e.g. fitting of straight line, second degree polynomial, power curve, exponential curve etc.
11. Problem based on determination of Regression lines and calculation of Correlation coefficient- grouped and ungrouped data.
12. The essential Python programming core syntax like variables, data types (strings, numbers, Booleans), and operators.
13. Python programming for control structures such as if/else statements and for/while loops for program flow, along
14. Python programming for code reusability.
15. Python programming for date Structure Lists: Tuples, Dictionaries,
16. Python programming for fundamental Programming Operations, Etc.

Biophysics and Bioinformatics (Minor)

Semester - IV

Paper: Bio-spectroscopy & PYTHON programming

Unit 1: Visible, UV and IR Spectroscopy: Principle and biological applications of UV photoelectron spectroscopy (UPES) and X-ray photoelectron spectroscopy (XPES), IR spectroscopy & Fourier Transform IR spectroscopy.

Unit 2: Raman Spectroscopy: Classical and Quantum theory of Raman Effect, Biological application of Raman spectroscopy, comparison of structure determination from Raman and IR spectroscopy.

Unit 3: Introduction to Computers and Programming: Introduction, Hardware and Software, Python Installation, Input, Processing, and Output: Displaying Output with the print Function, Comments, Variables, Reading Input from the Keyboard, Performing Calculations, More about Data Output.

Unit 4: Decision Structures and Boolean Logic: The if Statement, The if-else Statement, Comparing Strings, Nested Decision Structures and the if-elif-else Statement, Logical Operators, Boolean Variables, Repetition Structures: Introduction to Repetition Structures, The while Loop: A Condition-Controlled Loop, The for Loop: A Count-Controlled Loop, Calculating a Running Total, Sentinels, Input Validation Loops, Nested Loops.

References:

1. Biological spectroscopy: J.D Cambel and R. A. Dwek
2. Modern Approach to physical chemistry vol. I &II: R.C. Mukherjee and V. Bhadauria.
3. Organic Spectroscopy: J. Singh.
4. Mass spectrometer: G. Siuzadak.
5. Modern Physics: R. Murugesan
6. Gaddis, T. Starting out with Python.
7. Dierbach, C. Introduction to computer science using Python.
8. Chun, W. J. Core Python programming

Biophysics and Bioinformatics (Minor)

Semester IV

Experiments

Physics

1. To determine the wavelength of different spectral lines emitted by light source with a plane transmission grating.
2. To determine the wavelength of sodium light with the help of Newton's Ring.

OR

3. To draw the I/O characteristics for NPN transistor in the common emitter configuration and evaluate the current gain.
4. To draw the static characteristics of the given FET and determine the parameters, mutual conductance, output resistance, amplification factor and pinch-off voltage.

Computer Programming and Statistics

5. Problem based on calculation of measure of central tendency.
6. Problem based on calculation of Dispersion.
7. Problem based on calculation of Moments, Measure of Skewness and Kurtosis.
8. The essential Python programming core syntax like variables, data types (strings, numbers, Booleans), and operators.
9. Python programming for control structures such as if/else statements and for/while loops for program flow, along
10. Python programming for code reusability.

Biophysics and Bioinformatics

Skill Enhancement Course (SEC)

Paper : Medical Diagnostic techniques

Unit I: Medical Diagostics

Introduction for the Need of Medical Diagnostics, Medical Diagnostics and its Importance ethics in medical diagnosis, safety measures during diagnostic.

Unit II: Diagnostics Methods

Blood composition, Preparation of blood smear, CBC using analyzer machine, Routine Urine Analysis.

Unit III: Non-infectious Diseases

Causes, types, symptoms, complications, diagnosis and prevention of Diabetes, Hypertension

Unit IV: Infectious Diseases and Tumors

Causes, types, symptoms, diagnosis and prevention of Tuberculosis, Hepatitis, Types of Tumours (Benign/Malignant) Detection and metastasis; Medical imaging: X-Ray of Bone fracture, CT Scan (using photographs), ECG (calculate heart rate).

Books Recommended:

1. Park, K.(2007),Preventive and Social Medicine, B.B. Publishers
2. Godkar P.B.andGodkar D.P. Textbook of Medical Laboratory Technology, II Edition, Bhalani Publishing House
3. Chees brough M.,A Laboratory Manual for Rural Tropical Hospitals, A Basis for Training Courses
4. Guyton A.C.and Hall J.E.Textbook of Medical Physiology, Saunders
5. Robbins and Cortan, Pathologic Basisof Disease,VIII Edition, Saunders
6. Prakash, G.(2012),Lab Manual on Blood Analysis and Med Diagnostics, S. Chand

Skill Enhancement Course (SEC): Intelligent Bio-sensing Systems: From Lab to Market

Credits: 2

Course Objectives

- To impart knowledge of biosensors, intelligent sensing technologies, and their applications.
- To build skills in sensor design, fabrication, characterization, and integration with AI/IoT.
- To expose students to translational research, commercialization pathways, and entrepreneurship in bio-sensing.

Unit-wise Syllabus

Unit I: Introduction to Biosensors

- Definition, history, and evolution of biosensors.
- Components: Bioreceptor, transducer, signal processor.
- Classification: Enzyme-based, immunosensors, DNA biosensors, microbial biosensors, Optical fibre and photonics based biosensors.
- Characteristics: Specificity, sensitivity, response time, stability, reproducibility.

Unit II: Materials and Technologies for Biosensing

- Nanomaterials in biosensing (graphene, gold nanoparticles, quantum dots)
- Microfluidics & Lab-on-a-Chip systems.
- Flexible & wearable biosensing platforms
- Smart packaging and point-of-care devices

Unit III: Applications of Biosensors

- Healthcare: Glucose monitoring, pregnancy kits, infectious disease detection, wearable sensors.
- Food Industry: Detection of contaminants, spoilage, toxins, food quality monitoring.
- Environmental Monitoring: Detection of pollutants, pesticides, heavy metals, BOD estimation.
- Agriculture: Soil nutrient sensors, plant disease detection, smart farming.

Unit IV: From Lab to Market

- Biosensor prototyping & validation.
- Regulatory frameworks (FDA, ICMR, CDSCO guidelines in India)
- Entrepreneurship & innovation in biosensing.
- Case studies of successful biosensor startups in India & abroad.

Sem V

First Paper : Medical Physics-I

45 Lectures 60 Marks

1. **Microbiology :**

   Introduction to Microbiology : Louis Pasteur & Koch's postulates & Experiments, Prokaryotic and Eukaryotic Cell microorganisms, Moore's drawning, Phylogenetic tree (bacteria, protozoa, viruses, yeast, molds, parasitic worms, arthropods, etc.)

2. **Immune system**

   Introduction to Immune system: Viral Activation of Immunity; IgG, IgM & IgA, Humeral Immunity, Virus - Induced Immunopathology.

3. Diseases

   Classification, cause and symptoms : Tuberculosis, Cholera, Typhoid, Diphtheria, Pneumonia, Meningitis, Gonorrhoea, Tetanus.

4. Molecular Diagnostic:

   Venereal Disease Research Laboratory test (VDRL) Mechanism, Anti-HIV-Antigen/Antibody combination test; ELISA, ELISA Dongle Western blot, Nucleic Acid test. Polymerase Chain Reaction (PCR)-component and limitation of PCR and RT-PCR.

Sem V

Second Paper : Biophysical Technique - I

45 Lectures 60 Marks

1. Sonography

   Introduction & Principle of Ultrasonography, Echo, Doppler, High resolution sonography And Applications.

2. Chromatography

   Introduction & Principle of Chromatography, Classification, HPLC and Applications. Chromatography: Theory, operations and applications of partition, Adsorption, Gel permeation, Ion exchange and Affinity chromatography, Chromatography on paper, thin layer and column. Gas-liquid and high performance liquid chromatography techniques : hydrophobic interaction chromatography, covalent chromatography, DNA-cellulose chromatography, Hydroxyapatite chromatography aad Reverse phase chromatography

3. Electrophoresis

   Introduction & Principle of Electrophoresis, Classification and Applications. Electrophoresis : Theory, operations and application of Electrophoresis, Electrophoresis on paper, cellulose and gel. Sodium dodecyl sulphate-

polyacrylamide gel Electrophoresis (SDS-PAGE). Disc electrophoresis in polyacrylamide gel. Electrical parameters in electrophoresis. Agarose gel electrophoresis. Electrophoretic transferSouthern, Northern and Western. Isoeletric focusing. Combined electrophoresis and chromatography- Finger printing. Homochromatography Pulse field electrophoresis.

4. Auto Analyser

Introduction & Principle of analyser, Classification and Applications. CBC, Blood analysis electron microscope, Principle, application and limitation in operational procedures, X-ray microanalysis. EKFT/LFT, HbA1C.

Sem. V

Third Paper (Evolutionary Computation)

45 Lecture **60 Marks**

1. **Artificial Neural Network :**

Introduction, history, structure and function of single neuron, neural net architectures, neural learning, use of neural networks, Learning algorithms, Basic principle of backpropagation.

2. **Genetic Algorithm : Introduction,**

The basic (binary) Genetic algorithm, Genetic operators - Selection, Crossover, Mutation, Different types of selection strategies, Real-coded Genetic Algorithm, Applications of Genetic Algorithms.

3. **Structure Determination of Protein & DNA**

Concepts and strategies of protein structure predication, methods of secondary structure prediction, methods of protein tertiary structure prediction. Structure visualization tool - RasMol. Structural studies of DNA and proteins using absorption of ultraviolet light. Reporter groups. Absorption of polarized light. Instrumentation and application of microspectrophotometry, densitometry, cytophotometry, UVand polarized UV microspectrophotometry, Flame photometry and atomic absorption spectrophotometry.

4. **Denaturation and Renaturation of DNA.**

Protein evolution from exon shuffling, Recombination, and transposons: Holiday model for general recombination, recombiatnion of circular DNA, duplex forms, Transposons (as mobile genetic elements), insertion sequences, composite transposons, rearrangement of DNA; Retroposons, life cycle, integration into chromosomes. Denaturation of DNA double helix takes place by the following denaturating agents. Denaturation by Temperature, absorption of UV-light, specific optical

rotation, viscosity; Chemical agent, effect of Ph; Renaturation by cooling, log plot (Cot)

Books :

1. Intriduction to algoritlun : Thomson H Cormen
2. Genetic Algorithms: David E. Goldberg, Addison-Wesley
3. Gene IX, by Benzamin Lewin, Oxford University Press 2007.
4. Molecular Biology and Biotechnology 4th edition by J.M. Walker and R. Rapley, Panimp Publishing.
5. Deep Learning : Ian Goodfellow.
6. Fundamental of Neurvas Network : L. Fausett.
7. Neural Network Fuzzy logic & Genetic AG : Rajasekaran
8. Fazzy logic & Neural Network : Chennakesava R. Alavala
9. Fazzylogic : A. K. Bhargava
10. Neural Network Design : M.T. Hagan

Sem VI

First Paper (Medical Physics-II)

45 Lecture 60 Marks

1. Diagnosis of Diseases

Introduction to Diagnosis of Diseases in various organ system using Protein in diseases diseases of protein aggregation, Serpins: Serine Protease Inhibitors--conformational diseases, cancer and protein structures. Ultrasonic Electrocardiography, Block diagram of electrocardiograph; The ECG leads, effects of artefacts on ECG recording, vector cardiography. Electroencephalography; Block diagram of EEG, Electrode

locations, The normal EEG, clinical value of the EEG. Electromyography; Block diagram of EMG, clinical value of the EMG. Electroretinography: Superconducting quantum interference device (SQUID).

2. **Community health**

Introduction to Community health: Revitalization, capacity building and core concepts underlying community health. Trend of health care delivery, cost effective, high quality & innovative system of health care.

3. **Instruments used in medical Science (OT & ICU):**

Centrifuge, Microscope Binocular, Incubator, Hot air sterilizer, Bacteriological light, Tracheotomy Set, Fibre Bronchoscope, Ventilator ICU, Pulsoximeter, Patient Monitor, ICU & anaesthesia, Oxygen Concentrator. Physical Principle and applications of MRI, CT, PET Scanning - Cancer.

4. **Low Temperature in Biology and Medicine:**

Cryogenic fluids, storage and cryosurgical systems, Safety with cryogenics, Biological freezing, freeze-thawing cycle, freezing injury in cells and tissues, intra and extra cellular crystallization, mechanical effects of freezing, Biochcmical consequences of freezing, preservation of biological tissues and living organism, Advantage of cryosurgery.

Books :

1. Medical Physics by J R. Cameron and J.G. Skofronick, John Wiley New York, 1978.
2. Molecular cloning by Maniatis, Cold Spring Harbor Laboratory 1982.

3. DNA cloning by Glover, Oxford University Press, 1995, 1996.
4. Medical Physics by J. R. Cameron and J.G. Skofronick, John Wiley New York, 1978.
5. Modern Bioelectricity by Marino, A.A. Marcel Dekker Inc. New York 1998.
6. Principles of Appied Biomedical Instrumentation by Geddes, L.A. ahd Baker, L.E. John Wiley
7. The Essential Physics Of Medical Imaging by J.T. Bushberg et al., Lippincott Williams & Wilkins, Philadelphia, USA, 2002.
8. Cryobiology by Meryman, J.T. Academic Press, New York, 1966.
9. Unclev Standing Cryobiolohy : G. P. Garg, M. Prakesh
10. Preventive & Social Medicine : K. Park

Sem VI

Second Paper : Biophysical Technique - II

45 Lecture **60 Marks**

1. **Radiography & Radiotherapy:**

Digital radiography: computed radiography, charged couple devices, flat panel detectors, and digital mammography. Computed tomography: Introduction to tomography, First generation CT scanner, Image reconstruction, Five generation of CT scanners, Spiral CT, Image quality, Image artefacts, and quality assurance.

Radiation units : Units of measurement of radioactivity. Units of exposure, units of measurement of dose, does

equivalent. Radiation dosimetry for external radioactive source and internally deposited radioactive source. Introduction, classification of radiation in radiobiology, cell cycle and cell death irradiation of cells, type of radiation damage, cell survival curves, measurements of radiation damage in a tissue, normal and tumour cells, therapeutic ratio, oxygen effect, relative biological effectiveness, dose rate and fractionation, radio protectors and radio sensitizers.

2. **X-ray Crystallography:**

Concept of crystallization; Parameters governing crystallisation: Crystallisation of proteins and nucleic acids; Analysis of diffraction data. Analysis of structure of proteins, nucleic acids, DNA-RNA and triple helical complexes.

3. **NMR & ESR :**

NMR Spectroscopy: Nuclear spin and the splitting of energy levels in a magnetic field, Relaxation processes (Spin - lattice relaxation and spin - spin relation), Chemical shift, spin-spin coupling. Structure of biomolecules using NMR spectroscopy.

ESR SPECTROSCOPY Magnetic moment of unpaired electrons, Basic Resonance Condition,. Hypertine interaction , Application of ESR spectroscopy in dose measurements for sterilization of medical goods and detection of irradiated foods.

4. **LASER & MASER :**

Biophysics of laser & Maser, laser tissue interaction, Different types of laser; Biomedical applications in surgery

and therapy, photocoagulative effect and its use to control gasteric haemorrhage, CO2 laser.

Books :

1. Molecular cloning by Maniatis, Cold Spring Harbor Laboratory 1982.
2. DNA cloning by Glover, Oxford University Press, 1995,1996.
3. Genome analysis - a practical approach by Davis KE. Oxford University Press, 1988.
4. Molecular Bioteclmology, Principal cmd applications of recombinant DNA by Glick and Pastemak ASM Press: 3 edition 2003.
5. Biochemistry - 3re edition by Lubert Stryer , W.H.FreeMall and Company 1995.
6. RadiationDosimetry by Frank Herbert Attix, Wiley Interscience Publication, John Wiky.

Sem VI

Third Paper (Environmental Physics)

45 Lectures **60 Marks**

1. Solar & Terrestrial Radiation :

Radiation: basic Laws-Rayleigh and Mie scattering, multiple scattering, radiation from sun, solar constant, effect of clouds, surface and planetary albedo, net radiation budget. Green house gases and global warming.

2. Global & Regional Climate :

Cloud formation and precipitation processes, Rossby Richardson, Reynolds and, Froude number. Basic theory of Indian Monsoon.

Dynamic Meteorology: Basic equation and fundamental forces, Pressure, gravity, central and coriolis forces, continuity equation in Cartesian and isobaric coordinates, Momentum equation in Cartesian and spherical coordinates; scale analysis, inertial £lov", geostrophic and gradient winds, thermal winds. Circulation, vorticity and divergence;.

3. Environmental Changes & Remote Sensing :

Themodynamics of dry and moist air : specific gas constant, Adiabatic and isoentropic processes, Entropy and Enthalpy, Moisture variable, virtual temperature; Clausius-claperyon equation, adiabatic process of moist air; thermodynamic diagram: Hydrostatics equation, variation of pressure with height, geopotential, standard atmosphere, altimetry, Vertical stability of atmosphere : Dry and moist air parcel and slice methods. lapse rate and stability, scale height, Tropical convection.

4. Indoor Environment :

Pollutants and contaminants of the in - house environment: problems of the environment linked to urban and rural lifestyles: possible adulterants of the food: uses and harms of plastics and polythene: hazardous chemicals, solvents and cosmetics.

Global Environmental issues: Global concern, creation of UNEP; Conventions on climate change, Convention on biodiversity: Stratospheric ozone depletion, dangers associated and possible solutions.

Books :

1. An Introduction to Dynamic Meteorology JAMES R. HOLTON 4th Edition Atmospheric Science (Second Edition)

2. An Introductory Survey, Author(s) : John M. Wallace and Peter V. Hobbs.

3. The Monsoons, P.K.Das, ISBN:8123711239/ 9788123711232

Biophysics & Bioinformatics

Skill Enhancement Course- Subject Specific

Sem. VI. "Radiation Biophysics"

(2 Credit)

Unit-I: Basics of Radiation Physics: Qualitative Discussion

Introduction about Radiation, Classification of Radiation - Ionizing and Non-ionizing, Radioactivc and Non-radioactive Radiation, Thermal Radiation, Rayleigh Lmv, Wein's Law, Stefan's Law, Planck's Radiation Law, Compton's Effect, Spectruni and Spectral Lines, pair production, characteristic radiation, properties in the view of the biomolecules,. Different Sources of Non- Ionizing Radiation and their Physical Properties, First Law of Photochemistry, Law of Reciprocity, Electrical Impedance and Biological Impedance.

Unit II : Basic Quantity and Units for Measurements

Radioactivity, law of Radioactivity, Specific Radioactivity, General Properties of Alpha, Beta and Gamma Radiations. Activity Concentration, Radon Emanation Factor, Porosity, Diffusion-Coetlicient-

(i) **Emission Related Quantities:** Radon Mass Exhalation Rate, Radon Surface Exhalation Rate, Radon Flux.

(ii) Specific Quantities: Potential Alpha Energy (PAE),

Potential Alpha Energy Concentration in Air (PAEC), PAEC Exposure, Equilibrium Equivalent Concentration (EEC), Equilibrium Factor.

Unit-III: Dosimetric Principles, Quantities and units

Lung dosimeter, Photon Fluence and Energy Fluence, Kerma, Cema, Absorbed Dose, Quantities used in Describing a Photon Beam, Photon Fluence and Rate, Energy Fluence and Rate, Inverse Square Law, Penetration of Photon Beam into a Phantom or Patient, Surface Dose, Buildup Region, Depth of Dose Maximum, Exit Dose, Percentage Depth Dose (PDD), Tissue Air Ratio (TAR), Tissue Maximum Ratio (TMR), Physics of Radiation Therapy (Qualitative Concept),The Biological Effect of Radiation Exposure: Exposure, Absorbed Dose, severt, Gray, rad, rem, Equivalent Dose (Biological Dose), Effective Dose, Dose Rate, Quality Factor.

Books :

1. Radiation Detection and Measurement by Glenn knol, John Wiley and Sons INC.
2. Radiation Physics for Medical Physicists (Biological and Medical Physics, Biomedical engineering)" by Ervin B Podgorsak, Springer.
3. Basics of Radiobiological Principle by Thayalan, Jaypee Brothers Medical Publisher.
4. Primer in Applied Radiation Physics by F. A, smith
5. Radiation biophysics by E. L. Alpen
6. Radiation Detection & measurement by G. F, Knoll