GOA UNIVERSITY
Taleigao Plateau, Goa 403 206

R E V I S E D   M I N U T E S

of the 9th Special Meeting of the

X ACADEMIC COUNCIL

Day & Date

Saturday, 30th July, 2022

Time

10.00 a.m.

Council Hall
Goa University

D 3.5	**Minutes of the Board of Studies in Environmental Science meeting held on 20.04.2022.** The Academic Council approved the minutes of the Board of Studies in Environmental Science meeting held on 20.04.2022 with the following suggestions: 1. The month and year mentioned in the heading of the Syllabus document to be corrected from September 2022 to August 2022. 2. The Course Codes for the PG programmes to be revised/changed. **(Action: Assistant Registrar Academic – PG)**
D 3.6	**Minutes of the Board of Studies in Sociology meeting held on 26.04.2022.** The Academic Council approved the minutes of the Board of Studies in Sociology meeting held on 26.04.2022 with the following suggestions: 1. The Course Codes for the PG programmes to be revised/changed. 2. The column indicating Lecture Hours per week in programme structure to be removed/deleted. **(Action: Assistant Registrar Academic – PG)**
D 3.7	**Minutes of the Board of Studies in Public Administration meeting held on 01.07.2022.** The Academic Council approved the minutes of the Board of Studies in Public Administration meeting held on 01.07.2022 with the following suggestions: 1. The duration for the internship to be specified. 2. The Course Codes for the PG programmes to be revised/changed. 3. Number of hours for the Course **PARSOC5 Community Engagement and Rural Development** to be corrected. 4. The proposed syllabus/structure for Semester III and Semester IV was deferred. **(Action: Assistant Registrar Academic – PG)**
D 3.8	**Minutes of the Board of Studies in Physics meeting held on 24.03.2022.** The Academic Council approved the minutes of the Board of Studies in Physics meeting held on 24.03.2022 with the suggestion to revise/change the Course Codes for the PG Programme. The discussion on the proposed syllabus/structure for Semester III and Semester IV was deferred. **(Action: Assistant Registrar Academic – PG)**
D 3.9	**Minutes of the Board of Studies in History meeting held on 25.04.2022.** The House did not consider the minutes of the Board of Studies in History as the Board had not recommended the syllabus for Semester II. The Chairperson expressed his displeasure on behalf of the House about the fact that in spite of the official intimation given almost four months in advance, the said Chairperson did not take up the matter in Board of Studies. The Chairperson, Board of Studies, was advised to hold a meeting of the Board of Studies and submit the Syllabus for Semesters I and II on an urgent basis. The Vice-Chancellor was authorized to approve the Syllabus on behalf of the Academic Council. **(Action: Assistant Registrar Academic – PG)**
D 3.10	**Minutes of the Board of Studies in Biochemistry meeting held on 22.04.2022.** The Academic Council approved the minutes of the Board of Studies in Biochemistry

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F I N A L U P D A T E D A G E N D A

For the 9th Special Meeting of the

X ACADEMIC COUNCIL

Day & Date

30th July, 2022

Time

10.00 a.m.

Venue
Conference Hall
Administration Block

D 3.8	**Minutes of the Board of Studies in Physics meeting held on 24.03.2022.** **Part A** **i) Recommendations regarding courses of study in the subject or group of subjects at the undergraduate level: - NIL** **ii) Recommendations regarding courses or group of subjects at postgraduate level:** BOS discussed the new 80 credit course structure suggested by the University. The BoS discussed and recommend the following: 1. The eight discipline specific core courses were identified in line with CSIR NET Syllabus and keeping in mind the 3+2 and 4+1 course structures (UG+PG) suggested under NEP 2020. 2. Discipline specific optional courses were also identified. Here, Computer Programing Practical Courses offered in three programming languages and student will have a free choice of the programming language, subject to availability of the teacher. 3. The courses belonging to three specializations, Solid State Physics, Computational Physics and Biophysics are designated as Research Specific Optional courses. 4. Under generic optionals, courses like Statistical Methods and Error analysis, Documentation using LaTeX, etc. have been suggested which could be useful to students of other disciplines. 5. The Board also discussed and finalized the syllabus for courses to be offered in the first two semesters. The same is attached at **Annexure I** **(refer page no. 257)** **Part B:** i) Scheme of the Examinations at Undergraduate Level: - NIL ii) Panel of examiners for different examinations at Undergraduate Level: - NIL iii) Scheme of the examinations at post-graduate level:- NIL iv) Panel of examiners for different examinations at post-graduate Level: NIL **Part C** i) Recommendations regarding preparation and publication and selection of Anthologies in any subject or group of subjects and the names of person recommended for appointment to make the selection: - NIL **Part D** i) Recommendations regarding general academic requirements in the Departments of University or affiliated colleges: - NIL ii) Recommendation of Academic Audit committee and status thereof : - NIL **Part E** i) Recommendations of text books for the course for study at the Undergraduate level:NIL ii) Recommendations of text books for the courses of study at the post Graduate level:NIL **Part F** **Important points for consideration/approval of Academic Council:**

	M.Sc. Physics course structure in line with NEP 2020 and syllabi of courses offered in Semester I and II. The declaration by the Chairman, that the minutes were read out by the Chairman at the meeting itself. Date: 24.03.2022 Sd/- Place: Goa University Signature of Chairman **Part G: The remarks of the Dean of the School.** i) The minutes are in order. ii) The minutes may be placed before the Academic Council with remarks if any. iii) May be recommended for approval of Academic Council iv) Special remarks if any: Nil Date: 24-03-2022 Sd/- Place: Goa University Signature of the Dean **(Back to Index)**
D 3.9	**Minutes of the Board of Studies in History meeting held on 25.04.2022.** **Part A**. i. Recommendations regarding courses of study in the subject or group of subjects at the undergraduate level: NIL. ii. Recommendations regarding courses of study in the subject or group of subjects at the postgraduate level: Recommended the courses mentioned in **Annexure I** **(refer page no.287)** **Part B** i. Scheme of Examinations at undergraduate level: NIL ii. Panel of examiners for different examinations at the undergraduate level: NIL iii. Scheme of Examinations at postgraduate level: NIL iv. Panel of examiners for different examinations at post-graduate level: NIL **Part C** i. Recommendations regarding preparation and publication of selection of reading material in the subject or group of subjects and the names of the persons recommended for appointment to make the selection: NIL **Part D** 1. Recommendations regarding general academic requirements in the Departments of University or affiliated colleges: NIL 2. Recommendations of the Academic Audit Committee and status thereof: NIL **Part E** i. Recommendations of the text books for the course of study at undergraduate level: NIL.

D 3.8 Minutes of the Board of Studies in Physics meeting held on 24.03.2022.

Annexure I

M.Sc. Physics Syllabus from Academic year 2022-23

The new structure consists of four categories of courses:

(a) Discipline Specific Core Courses – Total Credits 32
(b) Discipline Specific Optional Courses – Total Credits 8
(c) Research Specific Optional Courses – Total Credits 12
(d) Generic Optional Courses – Total Credits 12 (These courses are open to all)

In addition to these four categories,we have introduced fifth category of courses – Bridge Courses with an objective to help the non-Physics graduates seeking admission to M.Sc. Physics as well as slow learners.Bridge courses will be available as an online resource and could be taken any time before or during their MSc programme or as advised by the teachers. Further, to help Physics students without adequate background in Biology, a bridge course "Introduction to Biology and Biophysics" is also introduced.

The course codes are used in tables below are as follows:

PHB – Bridge Courses
PHDC – Discipline Specific Core Courses
PHDO – Discipline Specific Optional Courses
PHSO/PHBO/PHCO – Research Specific Optional Courses in three specializations – Solid State Physics, Biophysics and Computational Physics respectively.
PHGO – Generic Optional Courses

Code	Title	Credits	Hours
PHB100	Bridge Course in Mathematical Methods	2	30
PHB101	Bridge Course in Thermal Physics	2	30
PHB102	Bridge Course in Optics	2	30
PHB103	Bridge Course in Quantum Mechanics	2	30
PHB104	Bridge Course in Electrostatics and Magnetostatics	2	30
PHB200	Introduction to Biology and Biophysics	3	45
Semester I			
PHDC101	Mathematical Methods of Physics	4	60
PHDC102	Classical Mechanics	4	60
PHDC103	Electromagnetic Theory	4	60
PHDC104	Electronics	4	60
PHDO101	Electronics Practical	2	60
PHDO102	Computer Programming in Fortran Practical*	2	60
PHDO103	Computer Programming in C Practical*	2	60
PHDO104	Computer Programming in Python Practical*	2	60
*Any one course			
Semester II			
PHDC105	Quantum Mechanics	4	60
PHDC106	Statistical Mechanics	4	60
PHDC107	Nuclear and Elementary Particle Physics	4	60
PHDC108	Atomic Physics	4	60
PHDO105	General Physics Practical	4	120

Semester III					
PHSO201 PHCO201 PHBO201	Solid State Physics I	Advanced Quantum Mechanics	Molecular Biophysics	4	60
PHSO202 PHCO202 PHBO202	Solid State Physics II	Advanced Statistical Mechanics	Methods of Biophysics	4	60
PHGO201 PHGO211 PHGO221	Solid State Physics Practical	Numerical Techniques Practical	Biophysics Practical	4	120
PHGO2XX	Generic Optional Courses (to be chosen for Optional Set I or from any other disciplines or from SWAYAM)			8	120
Semester IV					
PHSO3xx PHCO3xx PHBO3xx	Courses worth 4 credits to be chosen from Optional Set II or from SWAYAM in consultation with Dissertation Guide			4	60
PHD400	Dissertation			16	

Suggested Optional Courses

Optional Set I – Generic Optional	Credits	Optional Set II – Research Optional	Credits
Solid State Physics Practical	4	X-ray and Nuclear Spectroscopy	2
Numerical Techniques Practical	4	Optical Spectroscopy	2
Biophysics Practical	4	Superconductivity and Superfluidity	2
Neutron Physics	2	Magnetism in Condensed Matter Physics	2
Advanced Optics	2		2
Physics of Phase transitions and Critical Phenomena	2	Introduction to Crystallography and X-ray Diffraction	
Solid State and Biomaterials	2	Particle Physics	2
Physics of Energy Materials	2	Numerical methods and Fortran parallel programming using open mp	2
Physics of Quantum Materials	2		
Physics of Ferroic Materials	2		
Nanoscience and Technology	2		
Documentation using Latex	2		
Statistical Methods and Error Analysis	2		
Laser Physics and Applications	2		

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The syllabi of the courses in first two semesters and the bridge courses are given below.

Programme: M. Sc. (Physics)
Course Code: PHB-100 **Title of the Course:** Bridge Course in Mathematical Methods
Number of Credits: 2
Effective from AY: 2022-23

Prerequisites for thecourse:	NIL	
Objectives:	This course develops problem solving capabilities of students. It also helps to revise and understand the concepts based on Integration, differentiation and such other basic topics of mathematics, which are useful in solving problems based on Physics.	
Content:	**1. Preliminary Calculus** Differentiation from first principles; products; the chain rule; quotients; implicit differentiation; logarithmic differentiation; Leibnitz' theorem; special points of a function; theorems of differentiation, Integration from first principles; the inverse of differentiation; integration by inspection; sinusoidal functions; logarithmic integration; integration using partial fractions; substitution method; integration by parts; reduction formulae; infinite improper integrals; plane polar coordinates; integral inequalities; applications of integration **2. Partial Differentiation** Definition of partial derivative; the total differential and total derivative; Exact and inexact differentials; Useful theorems of partial differentiation; the chain rule; Change of variables; Taylor's theorem for many variable functions; Stationary values of many variable functions; Stationary variables under constraints; Thermodynamic relations; Differentiation of integrals **3. Series and Limits** Series; Summation of series (arithmetic, geometric); convergence of infinite series; Operations with series; Power series; Taylor series; Evaluation of limits. **4. Vector Algebra** Scalars and vectors; Addition and subtraction of vectors; Multiplication by a scalar; Basis vectors and components; Magnitude of a vector; Multiplication of vectors; Equation of lines and planes; Using vectors to find distances; Reciprocal vectors. **5. Ordinary differential equations** Linear equations with constant coefficients; Linear equations with variable coefficients; General ordinary differential equations.	10 hours 5 hours 5 hours 5 hours 5 hours
Pedagogy:	Online lectures along with assignments	
References/Readings	1. K.F. Riley, M.P. Hobson and S.J. Bence, Mathematical Methods for Physics and engineering, Cambridge	

	University Press, Cambridge UK (Reprint 2002). 2. George B. Arfken and Hans J. Weber, Mathematical methods for Physicists, 7/e Elsevier Inc., 2012. 3. Mathematics text books of XI and XII Science prescribed by NTSE/CBSE/Goa Board.	
Learning Outcomes	1. Conceptual understanding of the meaning of the differentiation, partial differentiation, integration, ODE (Ordinary differential equations) and its application to solve the problems based on physics. 2. Understand the vector algebra, series and its application in solving the problems in physics and day to day life.	

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Programme: M. Sc. (Physics)
Course Code: PHB101 **Title of the Course: Bridge Course in Thermal Physics**
Number of Credits: 2
Effective from AY: 2022-2023

Prerequisites for the Course:	B. Sc. Levels courses on mechanics and mathematics	
Objectives:	This course aims to introduce basic concepts of thermodynamics, laws of thermodynamics, entropy its applications.	
Content:	1. **Zeroth and First Law of Thermodynamics:** Extensive and intensive Thermodynamic Variables, Thermodynamic Equilibrium, Zeroth Law of Thermodynamics & Concept of Temperature, Concept of Work & Heat, State Functions, First Law of Thermodynamics and its differential form, Internal Energy, First Law & various processes, Applications of First Law: General Relation between C_P and C_V, Work Done during Isothermal and Adiabatic Processes, Compressibility and Expansion Co-efficient. 2. **Second Law of Thermodynamics:** Reversible and Irreversible process with examples. Conversion of Work into Heat and Heat into Work. Heat Engines. Carnot's Cycle, Carnot engine & efficiency. Refrigerator & coefficient of performance, 2nd Law of Thermodynamics: Kelvin-Planck and Clausius Statements and their Equivalence. Carnot's Theorem. Applications of Second Law of Thermodynamics: Thermodynamic Scale of Temperature and its Equivalence to Perfect Gas Scale. 3. **Entropy:** Concept of Entropy, Clausius Theorem. Clausius Inequality, Second Law of Thermodynamics in terms of Entropy. The entropy of a perfect gas. Principle of Increase of Entropy. Entropy Changes in Reversible and Irreversible processes with examples. Entropy of the Universe. Entropy Changes in Reversible and Irreversible	6 hours 8 hours 6 hours

	Processes. Principle of Increase of Entropy. Temperature–Entropy diagrams for Carnot's Cycle. Third Law of Thermodynamics. The unattainability of Absolute Zero. 4. **Thermodynamic Potentials:** Extensive and Intensive Thermodynamic Variables. Thermodynamic Potentials: Internal Energy, Enthalpy, Helmholtz Free Energy, Gibb's Free Energy. Their Definitions, Properties, and Applications. Surface Films and Variation of Surface Tension with Temperature. Magnetic Work, Cooling due to adiabatic demagnetization, First and second order Phase Transitions with examples, ClausiusClapeyron Equation and Ehrenfest equations. 5. **Maxwell's Thermodynamic Relations:** Derivations and applications of Maxwell's Relations, Maxwell's Relations:(1) ClausiusClapeyron equation, (2) Values of Cp-Cv, (3) TdSEquations, (4) Joule-Kelvin coefficient for Ideal and Van der Waal Gases, (5) Energy equations, (6) Change of Temperature during Adiabatic Process	5hours 5 hours
Pedagogy:	Online lectures and assignments	
References/Readings	1. Heat and Thermodynamics, M.W. Zemansky, Richard Dittman, 1981, McGraw-Hill. 2. A Treatise on Heat, MeghnadSaha, and B.N.Srivastava, 1958, Indian Press 3. Thermal Physics, S. Garg, R. Bansal and Ghosh, 2nd Edition, 1993, Tata McGraw-Hill 4. Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer. 5. Thermodynamics, Kinetic Theory & Statistical Thermodynamics, Sears & Salinger. 1988, Narosa. 6. Concepts in Thermal Physics, S.J. Blundell and K.M. Blundell, 2nd Ed., 2012, Oxford University Press	
Learning Outcomes	• Basic concepts of thermodynamics • Understand the properties of pure substances • Formulate and apply the first and second laws of thermodynamics • Concepts of entropy and the third law of thermodynamics. • Understand thermodynamic potentials and their relations.	

Programme: M. Sc. (Physics)
Course Code: PHB102 **Title of the Course: Bridge Course in Optics**
Number of Credits: 2
Effective from AY: 2022-2023

Prerequisites for the Course:	B. Sc. Levels courses on mechanics and mathematics	

Objectives:	This course aims to understand the various concepts of geometric and wave optics	
Content:	**1. Geometric Optics** Brief history, Propagation of light, Scattering, Reflection and Refraction of light, Fermat's principle, Ray equations, Refraction and reflection by spherical surfaces, Paraxial optics, lenses, mirrors, prisms, optical systems, Total internal reflection, thick lenses, Aberrations. Introduction to eyepieces, Ramsden and Huygens eyepieces. **2. Wave Optics** Simple harmonic motion, vibrations, origin of refractive index, sinusoidal waves, one-dimensional wave equation, transverse and longitudinal vibrations, Huygen's principle, plane waves, spherical and cylindrical waves. **3. Interference** Superposition of Waves, Division of wavefront& division of amplitude, Formation of colors in thin film- reflected system, transmitted system, wedge shaped film, Newton's Rings and its application to determine refractive index of liquid (Normal Incidence only), Interferometry: Michelson interferometer-its principle, working and its application to determine wavelength and difference between two wavelengths, Coherence. **4. Diffraction** Fraunhofer diffraction, Single slit and Double slit patterns, Limit of resolution, Diffraction grating, Fresnel diffraction, zone-plates, Diffraction by circular discs and apertures, Holography. **5. Polarization of light** Nature of polarized light, Dichroism, Birefringence, Scattering and Polarization,Polarization by reflection, Brewster angle, Circular polarizers, Wave plates.	6 hours 6 hours 6 hours 6hours 6 hours
Pedagogy:	Online lectures and assignments	
References/Readings	1. Optics, AjoyGhatak, 7th Edition, Tata-McGraw-Hill (2020). 2. Optics, Eugene Hecht, Pearson, 5th Edition, (2019). 3. A Textbook of Optics, 25th edition, Brij Lal, M N Avadhanulu& N Subrahmanyam, S. Chand & Company (2012). 4. Fundamental of Optics, F.A. Jenkins and H.E. White, Tata McGraw-Hill (1981).	
Learning Outcomes	Students will develop a conceptual understanding of Geometrical and Wave optics	

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Programme: M. Sc. (Physics)
Course Code: PHB103 **Title of the Course: Bridge Course in Quantum Mechanics**
Number of Credits: 2

Effective from AY: 2022-2023

Prerequisites for the Course:	B. Sc. Levels courses on mechanics and mathematics	
Objectives:	This course aims to understand the various phenomena of early quantum physics and develop the essential ideas of the old quantum theory.	
Content:	1. THERMAL RADIATION AND PLANCK'S POSTULATE Thermal Radiation, Classical Theory of Cavity Radiation, Planck's Theory of Cavity Radiation, Planck's Postulate and Its Implications. 2. PHOTONS—PARTICLE-LIKE PROPERTIES OF RADIATION Introduction, The Photoelectric Effect, Einstein's Quantum Theory of the Photoelectric Effect, The Compton Effect, The Dual Nature of Electromagnetic Radiation. 3. DE BROGLIE'S POSTULATE—WAVE-LIKE PROPERTIES OF PARTICLES Matter Waves, The Wave-Particle Duality, The Uncertainty Principle, Properties of Matter Waves, Some Consequences of the Uncertainty Principle, The Philosophy of Quantum Theory 4. BOHR'S MODEL OF THE ATOM Thomson's Model, Rutherford's Model, The Stability of the Nuclear Atom, Atomic Spectra, Bohr's Postulates, Bohr's Model, Atomic Energy States. 5. SCHROEDINGER'S THEORY OF QUANTUM MECHANICS Introduction, Plausibility Argument Leading to Schrödinger's Equation, Born's Interpretation of Wave Functions, Expectation Values, the time-independent Schrödinger Equation, Required Properties of Eigen functions, Energy Quantization in the Schrodinger Theory. 6. SOLUTIONS OF TIME-INDEPENDENT SCHROEDINGER EQUATIONS Introduction, The Zero Potential, The Step Potential (Energy Less Than Step Height), The Step Potential (Energy Greater Than Step Height), The Barrier Potential, Examples of Barrier Penetration by Particles, The Square Well Potential, The Infinite Square Well Potential, The Simple Harmonic Oscillator Potential	3 hours 2 hours 2 hours 3hours 5 hours 15hours
Pedagogy:	Online lectures along with assignments	
References/Readings	1. Quantum Physics of Atoms, Molecules, Solids,Nuclei, and Particles, by Robert Eisberg and Robert Resnick, John Wiley & Sons (2006) 2. Quantum Mechanics, Theory and Applications by Ghatak and Lokanathan, Mc Millan (2004). 3. A Textbook of Quantum Mechanics, P. M. Mathews, and K. Venkatesan, 2nd Ed., 2010, McGraw Hill	

	4. Quantum Mechanics, Leonard I. Schiff, 3rd Edn. 2010, Tata McGraw Hill.	
Learning Outcomes	• Concept of the wave-particle duality of radiation and particles • Understanding of energy quantization • understanding of wave mechanics in one dimension describe the structure of the hydrogen atom and show an understanding of quantization of angular momentum	

Programme: M. Sc. (Physics)
Course Code: PHB104 **Title of the Course: Bridge Course in Electrostatics and Magnetostatics**
Number of Credits: 2
Effective from AY: 2022-2023

Prerequisites for the Course:	B. Sc. Levels courses on mechanics, mathematics, and vector algebra	
Objectives:	This course is aimed at revising the electrostatics and magnetostatics	
Content:	**1. Electrostatics** Coulomb's law, Electric field and potential, Gauss's law, Application of Gauss's law, the electric field in various circumstances, Electrostatic energy, dielectrics. **2. Magnetostatics** Electric current, the magnetic field, the magnetic force of a current, Ampere's law, magnetic field of a straight wire and of a solenoid, atomic currents, the relativity of magnetic and electric fields, the magnetic field in various situations, the vector potential, induced currents, the Maxwell equations.	15 hours 15 hours
Pedagogy:	Lectures/tutorials/assignments. Sessions shall be interactive in nature to enable peer group learning	
References/Readings	1. The Feynman lectures on Physics, Vol-2, Pearson (2013) 2. University Physics with modern Physics, Young and Freedman, Pearson (2016) 3. Concepts of Physics, vol-2, H. C. Verma, BharatiBhawan Publishers & Distributors (2019).	
Learning Outcomes	Students will develop a conceptual understanding of Electrostatics and Magnetostatics and their applications.	

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X AC- 9 (Special)
30.07.2022

Programme: M.Sc (Physics)(Biophysics)
Course Code: PHB-200 **Title of the Course: Introduction to Biology and Biophysics**
Number of Credits: 4
Effective from AY: 2022-23

Prerequisites for the course:	Understanding of basic concepts in biology, chemistry and physics	
Objective:	This is a bridge course for the students for introducing them to the concepts in biology and biophysics.	
Content:	**Introduction to Biology** Origin and evolution of life, prokaryotic cells, photosynthesis, eukaryotic cells, elementary building blocks of life **Biochemistry I** Chemical components of the cell, energy, catalysis and biosynthesis, cellular membranes, transport across membranes, energy generation in cells, cytoskeletons, cell division, **Biochemistry II** Proteins-structure and function, DNA, RNA and chromosomes, Genes, genetics, carbohydrates, lipids and enzymes **Biophysics** Biological motion, free energy transduction, chemochemical machines, pumps and motors as chemochemcial machines, flux force dependence, molecular motors, mechanochemistry of molecular motors, biomolecular forces, biomechanics of muscle contraction and cardiovascular system.	5 hours 15 hours 15 hours 10 hours
Pedagogy:	Online Lectures/Assignments/Self Study Interactive sessions will be conducted to enable peer group learning.	
References/Readings	1. The Cell: A Molecular Approach, Geoffrey M. Cooper and Robert E. Hausman, Seventh Edition, Oxford University Press (2018). 2. Essential Cell Biology, Bruce Alberts, Dennis Bray, Karen Hopkin, Alexander D. Johnson, Julian Lewis, Martin Raff, Keith Roberts, and Peter Walter, Fourth Edition Garland Science (2013). 3. Molecular Biology, David Clark Nanette Pazdernik Michelle McGehee, Third Edition, Elsevier (2019). 4. Introduction to Molecular Biophysics, Jack A Tuszynski and Michal Kurzynski, First Edition, CRC Press, (2003). 5. Biophysics: An Introduction, Rodney Cotterill, Wiley (2002). 6. Applied Biophysics, A Molecular Approach for Physical Scientist, Thomas A Weigh, First Edition, Wiley, (2007).	

	7. Molecular & Cellular Biophysics, Mayer & Jackson, Cambridge Press (2006).	
Learning Outcomes:	1. The students will be familiarized with the basic concepts of molecular biophysics 2. The students will have gained sufficient knowledge in the structure and functioning of molecular processes 3. The students will be exposed to the recent developments in biomechanics and molecular motion.	

Programme: M.Sc. (Physics)
Course Code: PHDC – 101 **Title of the Course:** Mathematical Physics
Number of Credits: 4
Effective from AY: 2022-23

Prerequisites for thecourse:	Should have studied the courses in Physics at graduation level.	
Objective:	Students will get exposed to necessary mathematical skills that are essential to understand different phenomena in physics. The course also helps students to understand the theoretical background of other core courses in physics.	
Content:	**1. Ordinary Differential Equations** Second order homogeneous and inhomogeneous equation, Wronskian, General Solutions, Ordinary and Singular points, Series Solutions. Polynomial solutions, Legendre's equation, Bessel's equation, Gamma function	14 hours
	2.Functions of Complex Variable Limits, Continuity, Analyticity of Functions of a Complex Variable, Taylor and Laurent Series, Isolated and Essential Singularities, Branch Cuts, Cauchy Formula, Contour Integration, Application of Residue Theorem.	15 hours
	3. Linear Vector Spaces Linear Operators, Matrices, Coordinate Transformations, Eigenvalue Problems, Diagonalization of Matrices, Infinite Dimensional Spaces, Elements of Group Theory.	9 hours
	4. Integral Transforms Fourier Series, Fourier Transforms, Laplace Transforms, Applications of Integral Transforms.	12 hours
	5. Boundary Value and Initial Value Problems Vibrating String in one Dimension, Heat Conduction, and Wave Equation.	10 hours
Pedagogy:	Lectures/ tutorials or a combination of these. Sessions shall be interactive in nature to enable peer group learning.	
References/Readings	1. George B. Arfken and Hans J. Weber, Mathematical methods for Physicists, 7/e Elsevier Inc., 2012. 2. K.F. Riley, M.P. Hobson and S.J. Bence, Mathematical	

	Methods for Physics and engineering, Cambridge University Press, Cambridge UK (Reprint 2002) 3. J. Mathew and R. L. Walker, Mathematical Methods for Physics, Benjamin Publishers (1973). 4. James W. Brown and R. V. Churchill Complex Variables and Applications, 6th Edition (international), McGraw - Hill (1996**).** 5. L. A. Pipes, Applied Mathematics for Engineers and Physicists, 3rd Edition, McGraw-Hill (1971). 6. W. W. Bell, Special Functions for Scientists and Engineers, D. Van Nostrand Company Ltd (2004). 7. Charlie Harper, Introduction to Mathematical Physics, PHI. 8. Murray R. Spiegel, Theory and problems in Complex Variables by (Schaum' series) (2009). 9. Murray R. Spiegel, Theory and problems of advanced Mathematics for Engineers and Scientists by (Schaum's series) (1980).	
Learning Outcomes	1. Develop sufficient mathematical skills and apply them in other courses of physics. 2. Develop understanding of the mathematical background of various concepts in physics.	

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Programme: M. Sc. (Physics)
Course Code: PHDC-102 **Title of the Course:** Classical Mechanics
Number of Credits: 4
Effective from AY: 2022-23

Prerequisites for thecourse:	Should have studied basic courses in mechanics in B.Sc. and Mathematics.	
Objective:	This course is aimed at understanding intermediate to advanced classical mechanics and to build the necessary framework for other topics that requires classical mechanics such as quantum mechanics, statistical mechanics and electromagnetism.	
Content:	**1. Newton's Laws of Motion** Mechanics of a single particle, Mechanics of a system particles, Constraints and their classification, Principle of virtual work, D'Alembert's principle. **2. Lagrangian Formulation** Degrees of Freedom, Generalized Coordinates, Calculus of variations, Hamilton's principle, Euler-Lagrange's equations of motion, Application to non-holonomic systems, Advantages of a variational principle formulation, Conservation theorems and symmetry properties.	6 hours 10 hours 8 hours

	3. Rigid Body Dynamics Eulerian angles, Inertia tensor, Angular momentum of rigid body. Free motion of rigid body, Motion of symmetric top.	10 hours
	4. Hamilton's equation of motion Legendre transformation and the Hamilton equations of motion, cyclic coordinates and conservation theorems, Routh's procedure and oscillation about steady motion, Derivation of Hamilton's equations from a variational principle, Principle of least action.	8 hours
	5. Canonical Transformations Equations of canonical transformations, Examples of canonical transformations, Poisson brackets and other canonical invariants, Equations of motion, Infinitesimal canonical transformation theorems in Poisson bracket formulation, Angular momentum, Poisson brackets relations, Lagrange brackets.	6 hours
	6. Hamilton - Jacobi Theory H-J equation for Hamilton's principal function, Harmonic oscillator problems, H -J equation for characteristic function, Action angle, Kepler's problem.	7 hours
	7. Two-body Central Force Problem Equations of motion and first integrals, Classification of orbits, virial theorem, Differential equation and integrable power law potentials, Kepler's problem.	5 hours
	8. Small Oscillations Simple Harmonic Oscillations, Damped Oscillations, Forced Oscillations without and with damping, Coupled Oscillations.	
Pedagogy:	Lectures/ tutorials/ assignments. Sessions shall be interactive in nature to enable peer group learning.	
References/Readings	1. H. Goldstein, Classical Mechanics; McMillan, Bombay.1998. 2. N. C. Rana, and P. S. Joag; Classical Mechanics, Tata Mcgraw-Hill;1991. 3. J. C. Upadhyaya, Classical Mechanics, Himalaya, Publishing House, Mumbai;1991. 4. P. V. Panat; Classical Mechanics; Alpha Science International Ltd; 2004. 5. M. G. Calkin, Lagrangian and Hamiltonian Mechanics, World Scientific, 1996.	
Learning Outcomes	1. Study basic principles of classical mechanics. 2. Apply different techniques to solve mechanical problems.	

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Programme: M. Sc. (Physics)
Course Code: PHDC-103 **Title of the Course:** Electromagnetic Theory
Number of Credits: 4
Effective from AY: 2022-23

Prerequisites for thecourse:	Should have studied electrostatics and magnetostatics at the graduation level.	
Objective:	The aim of this course is to develop understanding of time varying scalar and vector electromagnetic fields and relativity. To inculcate fundamental concepts related to electromagnetic waves, their transmission via wave guides, radiation and plasma.	
Content:	1. **Maxwells Equations:** Displacement current, Maxwell's equations, Vector and Scalar potentials, Gauge transformation, Lorentz and Coulomb gauge, Poynting's theorem, Conservation of energy and momentum for charged particles and fields. 2. **Electromagnetic Waves** Plane electromagnetic waves and their propagation in non- conducting and conducting media, Frequency dispersion in conductors 3. **Electromagnetic Radiation** Retarded Potentials, Fields and radiation by localized dipole, LienerdWeichert potentials, Power radiated by an accelerated charge. 4. **Physics of Plasmas** Electrical neutrality in a plasma, Particle orbits and drift motion in a plasma, Magnetic mirrors, The hydro-magnetic equations, The pinch effect, Plasma oscillations and wave motion, Reflection from a plasma (ionosphere). 5. **Wave Guides** Propagation of Waves between conduction planes, Wave guides in arbitrary cross-section, Wave -guides in Rectangular Cross-section, Coaxial Wave guide, Resonant Cavities, Dielectric wave guides. 6. **Relativistic Electrodynamics** Lorentz transformation as four dimensional orthogonal transformation, Lorentz matrix, four vectors in mechanics and electrodynamics, Lorentz covariance of Maxwell equations, field tensor, transformation of fields, field due to a point charge in uniform motion.	10 hours 9 hours 10 hours 9 hours 10 hours 12 hours
Pedagogy:	Lectures/ tutorials/ assignments. Sessions shall be interactive in nature to enable peer group learning.	

References/Readings	**Text Books / References:** 1. J. B. Marion, Classical Electromagnetic Radiation, Academic Press, New York (1980). 2. J. R. Reitz and F. J. Milford, Foundations of Electromagnetic theory, Addison – Welsey, Reading (1960). 3. B. B. Laud, Electromagneties, Wiley Eastern Ltd., New Delhi (1983). 4. S. P. Puri, Classical Electrodynamics, Tata McGraw-FEII Publishing Co. Ltd. New Delhi (1997). 5. David J. Griffiths, Introduction to Electrodynamics, Prentice - Hall of India Pvt. Ltd., New Delhi (1995). 6. J. D. Jackson, Classical Electrodynamics, Wiley, New York (1995). 7. W. H. Panofsky and M. Philips, Classical Electricity and Magnetism, Addison-Wesley Publication, 1962.	
Learning Outcomes	1. Apply Maxwell's equations and their application to time-harmonic fields, boundary conditions, wave equations, and Poynting's power-balance theorem. 2. Describe the properties of plane waves in unbounded space, and understand such concepts as wavelength, phase velocity, and attenuation.	

Programme: M. Sc. (Physics)
Course Code: PHDC-104 **Title of the Course:** Electronics
Number of Credits: 4
Effective from AY: 2022-23

Prerequisites for the course:	Should have studied the Electronics courses in Physics at graduation level.	
Objective:	The aim of the course is to introduce students to wide range of electronic circuits and their applications in Physics such as OP-AMPs. They also get basic understanding of opto-electronic devices, modulation, signals, microprocessor and memories.	
Content:	1. **OP-AMP Applications** OP-AMPS with negative feedback, Voltage controlled voltage source (VCVS), Current controlled voltage source (ICVS), Voltage controlled current source (VCIS), Current controlled current source (ICIS), Inverting and noninverting amplifier circuits, Open-loop frequency and phase response, Closed-loop frequency response, Differential amplifier, Instrumentation amplifier, DC and AC amplifiers, Summing, scaling and averaging amplifier, Voltage to current converter, Current to voltage converter. 2. **Opto-electronic devices**	15 hours 15 hours

	Radiative and non-radiative transitions, Characteristics of LED, Photoconductor, Photo diode, Photo transistor, Photo detector, Solar cell, Semiconductor laser; Optical fiber, Optical fiber waveguides, Fundamentals of optical communication 3. **Communication Electronics** Analog and digital signals, Modulation, Types of modulation, Basic principles of amplitude, frequency and phase modulation, Simple circuits for amplitude modulation and demodulation, Digital modulation and demodulation, Microwave Oscillators, Cavity resonators, Standing wave detector. 4. **Digital Electronics** Types of signals, Digital signal processing (DSP) basics, A/D and D/A conversion methods, DSP applications; Introduction to Microprocessors, Elements of 8-bit Microprocessors (INTEL 8085); Memory and storage, RAM, ROM, PROM and EPROM, Flash memories, Magnetic and optical storage.	15 hours 15 hours
Pedagogy:	Lectures/tutorials/assignments. Sessions shall be interactive in nature to enable peer group learning.	
References/Readings	1. Millman, J. and Halkias, C. C., Integrated Electronics, Analog and Digital Circuits and Systems, McGraw – Hill Book Co. Tokyo (1997) 2. Boylestad, R. L. and Nashelsky L., Electronic Devices & Circuit Theory, XI Edn. Prentice-Hall of India (2015). 3. Floyd, T. L., Electronic Devices, V Edn. Pearson Education Asia (2001). 4. Gayakwad, R, A., Op-Amps and Linear Integrated Circuits, IV Edn. Prentice-Hall of India (2002). 5. Chen, Chin-Lin, Elements of Optoelectronics and Fiber Optics, McGraw-Hill Book Co. New Delhi (2014). 6. Kennedy, G., Electronics Communication Systems, IV Edn, Tata McGraw-Hill Book Co. New Delhi (2003). 7. Shrader, R., Electronic Communication, Glencoe Division of MacMillan (1993). 8. Kasap, S. O., Optoelectronics and Photonics: Principles and Practices, Dorling Kindersley India (2009) 9. Floyd, T. L., Digital Fundamentals, VII Edn. Pearson Education (2002). 10. Smith, S. W., Digital Signal Processing, Elsevier India (2006).	
Learning Outcomes:	1. Understanding the principles and circuits in electronics and use them in various applications. 2. Students acquire knowledge about working principles of opto-electronic devices and communication electronics.	

	3. Students get exposure to microprocessor and memory devices.	

Programme: M. Sc. (Physics)
Course Code: PHDO-101 **Title of the Course:** Electronics Practical
Number of Credits: 2
Effective from AY: 2022-23

Prerequisites for thecourse:	Nil	
Objective:	This course provides laboratory training in designing, and constructing electronics circuits commonly used in a Physics laboratory.	
Content:	Experiments are to be performed on following topics (minimum 8) with emphasis on designing and constructing the circuit on a bread board. 1. Operational Amplifier parameters 2. Design and Construction of Wien Bridge Oscillator 3. Design and Construction of phase shift oscillator 4. Design and Construction of AstableMultivibrator 5. Design and Construction of MonostableMultivibrator 6. Schmitt Trigger circuit and its use as a zero crossing detector and squaring circuit 7. Voltage Regulator 8. Constant Current Source 9. Design and Construction of DC differential amplifier using op-amps 10. Design and Construction of Function generator 11. Design and construction of Negative nonlinear resistor 12. J. K. flip-flop counter: Scale of 16 and 10 using IC 13. Adder and Subtractor Circuits	60hours
Pedagogy:	Laboratory Experiments	
References/Readings	1. J. Millman and C. C. Halkias, Integrated Electronics: Analog and Digital Circuits and Systems, Mc Graw Hill International Student Ed. (1972). 2. LM317 – 3 Terminal Adjustable Voltage regulator datasheet Rev. X, Texas Instruments 3. Wikibooks – Negative resistance, Negative differential resistance. https://en.wikibooks.org/wiki/Circuit_Idea 4. D. P. Leach, A. P. Malvino and G. Saha, Digital Principles and Applications, Tata Mc Graw Hill 7e (2011).	

Learning Outcome	1. The student should be able to prepare for laboratory work, by reading from books / laboratory manual / datasheet. 2. Should be able to design and construct electronic circuits by identifying and fetching different components. 3. Should be able to record observations from different measuring instruments and record them neatly. 4. Plot graphs and analyze the results. 5. Demonstrate the ability to maintain a laboratory notebook. 6. Prepare lab reports in standard scientific format.	

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Programme: M. Sc. (Physics)
Course Code: PHDO-102 **Title of the Course**: Computer Programming in Fortran 95
Number of Credits: 2
Effective from AY: 2022-23

Prerequisites for thecourse:	Nil	
Objective:	This course develops concepts of computer programming in general and introduces programming language FORTRAN 95.	
Content:	**1. Fundamentals of Computer Programing** Programming Languages, Fortran Evolution, Character Set, Intrinsic Types, Numeric Storage, Literal Constants, Names, Significance of Blanks, Implicit Typing, Numeric and Logical Type Declarations, Character Declarations, Initialisation, Constants (Parameters), Comments, Continuation lines, Expressions, Assignment, Intrinsic Numeric Operations, Relational and Intrinsic Logical Operators, Intrinsic Character Operations, Operator Precedence, Mixed Type Numeric Expressions, Mixed Type Assignment, Integer Division, Formatting input and output, WRITE Statement, READ Statement, Prompting for Input, Reading and writing to a file, How to Write a Computer Program, Statement Ordering, Compiling and Running the Program, Practical Exercise 1 **2. Logical Operations and Control Constructs** Relational Operators, Intrinsic Logical Operations, Operator Precedence, Control Flow, IF Statement, IF ... THEN ... ELSE Construct, IF ... THEN ELSEIF Construct, Nested and Named IF Constructs, SELECT CASE Construct, The DO construct, Conditional Exit Loop, Conditional Cycle Loops, Named and Nested Loops, Indexed DO Loops, Practical Exercise 2	15 hours 15 hours 15 hours

	3. Arrays Declarations, Array Element Ordering, Array Sections, Array Conformance, Array Syntax, Whole Array Expressions, WHERE statement and construct, COUNT, SUM, MOD, MINVAL, MAXVAL, MINLOC and MAXLOC functions, Array I/O, The TRANSPOSE Intrinsic Function, Array Constructors, The RESHAPE Intrinsic Function, Named Array Constants, Allocatable Arrays, Deallocating Arrays, Vector and Matrix Multiplication, Practical Exercise 3. **4. Procedures** Program Units, Introduction to Procedures, Intrinsic Procedures, Intrinsic statement Mathematical Intrinsic Function Summary, Numeric Intrinsic Function Summary, Character Intrinsic Function Summary, Main Program Syntax, Functions, Subroutine and Functions, Practical Exercise 4	15 hours
Pedagogy:	Lectures/ Laboratory work/self-study	
References/Readings	1. V. Rajaraman, Computer Programming in FORTRAN 90 and 95, Prentice-Hall of India, New Delhi 1999. 2. Martin Counihan, Fortran 95, UCL Press Limited University College London (1996). 3. Stephen Chapman, Fortran 95/2003: for Scientists and Engineers, McGraw-Hill (2007).	
Learning Outcomes	1. Understand programming in general; 2. Understand FORTRAN programming language; 3. Understanding how to write and run simple programs. 4. Understanding how to do plotting, regression analysis and error analysis	

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Programme: M. Sc. (Physics)
Course Code: PHDO-103 **Title of the Course:** Computer programming with C
Number of Credits: 2
Effective from AY: 2022-23

Prerequisites for thecourse:	Nil	
Objective:	This course develops concepts of computer programming in general and introduces programming language C.	

Content:	**1. Introductory Concepts** Introduction to computers, Introduction to Linux OS, Linux basics, Introduction to C, writing a C Program, Compiling and Executing the Program, Error Diagnostics, Some simple C Programs, Desirable Program Characteristics. **2. C Fundamentals** The C character set, Identifiers and Keywords, Data types, Constants, variable and Arrays, Declarations, Expressions, Statements, Symbolic Constants **3. Operators and Expressions** Arithmetic Operators, Unary Operators, Relational Logical Operators, Assignment Operators, the Conditional Operators, Library Functions. **4. Data Input and Output** Preliminaries, Single character input and output, entering Input data, writing output data, Opening and closing data file, format statements. **5. Control Statements** Preliminaries, Branching statements, Looping statements, nested control structure, switch, break, continue, go to statements. Practical Exercise **6. Functions** Defining functions, accessing functions, Passing arguments to a function. Practical Exercise **7. Arrays** Defining an array, processing an array, passing arrays to functions, multidimensional arrays. Practical Exercise	7 hours 10 hours 10 hours 7 hours 10 hours 8 hours 8 hours
Pedagogy:	Lectures/ Laboratory work/self-study	
References/Readings	1. Byron Gottfried, Programming with C, Tata McGraw-Hill (1996).	
Learning Outcomes	1. Understand programming in general; 2. Understand C programming language; 3. Understanding howto write and run simple programs. 4. Understanding how to do plotting, regression analysis and error analysis	

Programme: M. Sc. (Physics)
Course Code: PHDO-104 **Title of the Course:** Computer programming with Python
Number of Credits: 2
Effective from AY: 2022-23

Prerequisites for thecourse:	Nil	

Objective:	This course develops concepts of computer programming in general and introduces programming language Python.	
Content:	1. Fundamentals of Python: Introduction to programming in Python, installation and writing, and running Python programs on Windows and Linux	8 hours
	2. Handling data: Data types and variables, user input and output, mathematical operators	8 hours
	3. Decision making and looping: Logical expressions and operators, conditional operators, lists, for loop, while loop	12 hours
	4. Arrays and Functions: Lists, tuples, sets, special arrays, writing and calling user-defined functions,	12 hours
	5. Data plotting and fitting: scattered plots, bar plots, histograms, reading data and plotting, linear or quadratic least square fitting	10 hours
	6. Error analyses: Propagation of errors, significant figures, Gaussian distribution, mean, median, standard deviation, variance, weighted average.	10 hours
Pedagogy:	Lectures/ Laboratory work/self-study	
References/Readings	1. “Python Cookbook: Recipes for Mastering Python 3” by by David Beazley and Brian K. Jone, O'Reilly Media (2013) 2. “Python: The Complete Reference” by Martin C. Brown, McGraw Hill (2018)	
Learning Outcomes	1. Understand programming in general 2. Understand Python programming language; 3. Understanding howto write and run simple programs. 4. Understanding how to do plotting, regression analysis and error analysis	

Programme: M. Sc. (Physics)
Course Code: PHGC-105 **Title of the Course:** Quantum Mechanics
Number of Credits: 4
Effective from AY: 2022-23

Prerequisites for thecourse:	Studied Physics, including an introductory course on Quantum Mechanics at graduate level	
Objective:	1. To develop basic formalisms of non-relativistic Quantum Mechanics. 2. To illustrate the concepts for analyzation of simple quantum mechanical systems	
Content:	**1. Schrodinger's Equation and Hermitian operators** (a) Time-dependent Schrodinger equation, continuity equation, expectation values, Ehrenfest's theorems, time-independent Schrodinger equation and stationary states. (b) Hermitian operators, eigenvalues and eigenstates of Hermitian operators, momentum eigenfunctions, orthogonality and completeness of wave functions, Computability and compatibility of observables, parity operation.	8 hours
	2. The Schrodinger equation in three dimensions Separation of the Schrodinger equation in Cartesian coordinates, Central potential, separation of the Schrodinger equation in spherical polar coordinates, The free particle, The three-dimensional square well potential, The hydrogen atom, The three-dimensional isotropic oscillator.	12 hours
	3. Vector space formulation of quantum mechanics Dirac Notation, representation of states and observables, bra and ket vectors, linear operators, relation with wave mechanics, algebra of Hermitian operators, matrix representation, unitary operators, Schrodinger and Heisenberg representations, linear harmonic oscillator problem by operator method.	5 hours
	4. Angular Momentum theory Angular Rotations in Classical and Quantum Mechanics, Rotational Symmetry and conservation of angular momentum, Treatment of general angular momentum by operator method, eigenvalues and eigenvectors, Eigen values and eigenfunctions of L^2 and Lz operators, ladder operators L^+ and L^-, spin angular momentum, algebra of Pauli matrices, Pauli representation of angular momentum operators. Addition of two angular momenta, spin-orbit interaction, Clebsch Gordon coefficients.	10 hours
	5. Approximation methods for stationary problems Time-independent perturbation theory for a non-degenerate energy level, Time-independent perturbation theory for a degenerate energy level, The variational	8 hours 7 hours

	method, The WKB approximation. **6. Approximation methods for time-dependent problems** Time-dependent perturbation theory, General features, Time-independent perturbation, periodic perturbation, The adiabatic approximation, The sudden approximation **7. Quantum Collision Theory** Scattering experiments and cross-sections, potential scattering and general features, the method of partial waves, Application of the partial-wave method, the integral equation of potential scattering, The Born approximation, Collision between identical particles, Collision involving composite systems.	10 hours
Pedagogy:	lectures/ tutorials/ assignments. Sessions shall be interactive in nature to enable peer group learning.	
References/Readings	**Text Books / References** 1. A. K. Ghatak and S. Lokanathan, Quantum Mechanics: Theory and Applications, Springer (2004) 2. P. M. Mathew and K. Venkatesan, A Text Book of Quantum Mechanics, 2/e, Tata McGraw Hill (2017) 3. L. I. Schiff and JayendraBandhyopadhyay, Quantum Mechanics, 4/e, McGraw-Hill (2017). 4. V. K. Thankappan, New Age International Publishers (2012)). 5. V. Devanathan, Quantum Mechanics, 2/e Narosa Publishing House (2015). 6. David J. Griffiths, Introduction to Quantum Mechanics 2/e, Cambridge India, (2016). 7. J. J. Sakurai Modern Quantum mechanics, Addition-Wesley Publishing Company, (1994). 8. R. Eisberg and R. Resnick, Quantum Physics of atoms, molecules, solids, nuclear and particles, 2/e, John Wiley and Sons, (1985). 9. W. Greiner, Introductory Quantum mechanics, Springer Publication, (2001). 10. R. L. Liboff, Introductory Quantum Mechanics, 4e, Pearson Education Ltd (2003). 11. NouredineZettili, Quantum Mechanics: Concepts and Applications 2/e, Wiley India (2016)	
Learning Outcomes	1. Students will be able to solve wave equations for simple three dimensional system 2. Students will have the knowledge and skills to describe the structure of the hydrogen atom and show an understanding of quantisation of angular momentum and spin as well as the rules for quantisation and addition of these. 3. Students will learn the concepts of approximation	

	methods for solving Schrodinger equations 4. Students will gain the knowledge about fundamental scattering of quantum particles.	

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Programme: M. Sc. (Physics)
Course Code: PHDC-106 **Title of the Course:** Statistical Mechanics
Number of Credits: 4
Effective from AY: 2022-23

Prerequisites for thecourse:	Should have studied Physics or Mathematics at graduation level. It is assumed that students have a basic working knowledge of classical and quantum mechanics, including Hamiltonian formulation and density matrices.	
Objective:	This course develops concepts in classical laws of thermodynamics and their application, postulates of statistical mechanics, statistical interpretation of thermodynamics, microcanonical, canonical and grant canonical ensembles; the methods of statistical mechanics are used to develop the statistics for Bose-Einstein, Fermi-Dirac and photon gases.	

Content:	**1. Kinetic Theory and Equilibrium state of Dilute Gas** Formulation of problem, binary collisions, Boltzmann transport equation, Boltzmann's H theorem, Maxwell-Boltzmann distribution, Method of the most probable distribution, analysis of the H theorem, recurrence and reversal paradoxes, Validity of the Boltzmann transport equation.	12 hours
	2. Classical Statistical Mechanics Review of laws of thermodynamics, Entropy, Thermodynamic Potentials, Postulate of Classical Statistical Mechanics, Microcanonical ensemble, derivation of thermodynamics, equipartition theorem, Classical ideal gas, Gibbs paradox.	12 hours
	3. Canonical and Grand Canonical Ensembles Canonical ensemble, energy fluctuations in canonical ensemble, grand canonical ensemble, density fluctuations in grand canonical ensembles, equivalence of canonical and grand canonical ensembles, behaviour of W(N), meaning of Maxwell construction.	12 hours
	4. Quantum Statistical Mechanics Postulates of quantum statistical mechanics, density matrix, ensembles in quantum mechanics, third law of thermodynamics, ideal gases in microcanonical and grand canonical ensembles, foundations of statistical mechanics.	8 hours
	5. Ideal Fermi Gas Equation of state of Ideal Fermi Gas, theory of white dwarfs, Landau diamagnetism, deHass-Van Alphen effect, Pauli paramagnetism.	8 hours
	6. Ideal Bose Gas Photons, phonons, Bose-Einstein condensation.	8 hours
Pedagogy:	Lectures/ tutorials/assignments. Sessions shall be interactive in nature to enable peer group learning.	
References/Readings	1. Statistical Mechanics, Kerson Huang, 2/e, Wiley India 2008.	

	2. Fundamentals of Statistical Mechanics, B. B. Laud, New Age International Ltd. New Delhi 1998. 3. Fundamentals of Statistical and Thermal Physics, F. Reif, Waveland Press 2009. 4. Statistical Mechanics L. D. Landau and E. M. Lifshitz, Pergamon Press 1969. 5. Statistical Physics, R. P. Feynmann, The Benjamin Cummings Publishing Co 1981. 6. Introduction to Statistical Physics, S. K. Sinha, Narosa Publishing House, New Delhi 2007. 7. Statistical Physics, Tony Guenault, New Age International Ltd. New Delhi 2007. 8. Francis W. Sears , Gerhard Salinger, Thermodynamics, Kinetic Theory, and Statistical Thermodynamics, Addison- Wesley Principles of Physics Series, 1975.	
Learning Outcomes	1. Explain statistical physics and thermodynamics as logical consequences of the postulates of statistical mechanics. 2. Apply the principles of statistical mechanics to selected problems. 3. Apply techniques from statistical mechanics to a range of situations.	

Programme: M. Sc. (Physics)
Course Code: PHDC-107 **Title of the Course:** Nuclear and Elementary Particle Physics
Number of Credits: 4
Effective from AY: 2022-23

Prerequisites for thecourse:	Concepts like Radioactivity, Nuclear fission, and knowledge of solution of 1 dimensional Schrodinger Equation	
Objective:	To introduce students to the fundamental principles and concepts governing nuclear and particle physics and have a working knowledge of their application to real-life problems.	
Content:	**1. Basic Properties of Nuclei:** a. Nuclear mass, charge, radius, binding energy, nuclear spin, and parity. b. Magnetic moments and electric quadrupole moments. **2. Two-BodyProblem:** a. Brief review of quantum mechanics tools, properties of deuteron, theory of the ground state of deuteron, magnetic moment, and electric quadrupole moment of deuteron. b. Theory of nucleon-nucleon scattering at low energy, phase shift and scattering length, effective range theory, experimental determination of low energy	8 hours 12 hours

	parameters. c. Nature of nuclear forces and Meson theory of nuclearforce.	10 hours
	3. NuclearModels: a. Liquid drop model, Weizsacker's mass formula, stable and unstable nuclei, massparabolas. b. Nuclear shell model, energy levels in a three dimensional harmonic oscillator well potential, spin orbit interaction, prediction of magic numbers, ground state spinsandparities, c. Magneticmoments,Schmidtlines, nuclear quadrupole moments, and collective model.	10 hours
	4. Nuclear Transformations: a. Alpha decay, barrier penetration problem, Gamow's theory of alpha decay, Geiger-Nuttal law, alpha spectra and nuclear energylevels. b. Beta decay, experiments in beta spectra, neutrino hypothesis, Fermi's theory of beta decay, Kurie plots, ft values, allowed and forbidden transitions, selection rules, electron capture, parity violation in beta decay, experimental verification, measurement of neutrino helicity. c. Gamma transitions, multipole radiations, quantum theory of the transition probability, selection rules, angular correlation, calculations of transition rates and comparison with experiments, internalconversion.	4 hours 10 hours
	4. NuclearReactions: a. Rutherford scattering, cross-sections, decay rates, resonances,Breit-Wigner formula, nuclear fission and fusion processes.	
	6. Elementary Particles: a. Classification of elementary particles; properties of quarks and leptons, properties of mesons and baryons. Classification of fundamental forces; Strong, Weak and Electromagnetic interactions. b. Introduction to Feynman diagrams, relativistic kinematics, quark model and eightfold way. c. Particle quantum numbers; charge, isospin, strangeness and parity, Gell-Mann Nishijima formula, conservation laws and symmetries.	6 hours
	7. **Particle accelerators and detectors:** a. Introduction to modern accelerators, event rates and luminosity. Large detector systems at electron-positron, electron-proton and hadron colliders. b. Interaction of particles with matter, principle of gas chambers, silicon detectors, scintillators, time-of-	

	flight detectors, and calorimetry.	
Pedagogy:	Lectures / tutorials/assignments. Sessions shall be interactive in nature to enable peer group learning.	
References/Readings	1. H. Enge, Introduction to Nuclear Physics, Addison- Wesley (1974). 2. E. Segre, Experimental Nuclear Physics, John Wiley (1960). 3. V. Devanathan, Nuclear Physics, Alpha Science International Ltd, (2011). 4. S. N. Ghoshal, Nuclear Physics, S. Chand and Co. (2019)	
Learning Outcomes	Student will be able to 1. Apply the models describing the basic nucleon and nuclear properties. 2. Describe the properties of strong and weak interaction. 3. Explain the different forms of radioactivity and account for their occurrence. 4. Classify elementary particles and nuclear states in terms of their quantum numbers.	

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Programme: M. Sc. (Physics)
Course Code:PHDC108 **Title of the Course:** Atomic Physics
Number of Credits: 4
Effective from AY: 2022-2023

Prerequisites for the Course:	Knowledge of concepts like Bohr model of atom, Electronic transition in atoms and atomic spectra.	
Objectives:	This course is aimed at understanding the atomic structure and atomic spectra	
Content:	**1. Early Atomic Physics** Atomic spectra of hydrogen, The Bohr's theory, Relativistic effects, Moseley and atomic number, Radiative decay, Einstein A and B coefficients, The Zeeman effect. **2. One-electron atoms**: The Schrödinger equation for one-electron atoms, energy levels, the Eigen functions of the bound states, expectation values. Transitions, selection rules, parity, spin of the electron, the spin-orbit interaction, Fine structure of hydrogenic atoms, The Lamb shift, transitions between fine-structure levels. **3. Two-electron atoms:** The Schrödinger equation for two-electron atoms, The ground state of two-electron atoms, Excited states of two-electron atoms. Doubly excited states of two electron atoms. **4. Many-electron atoms**: Shell structure and the periodic table, The central field approximation, The Hartree-Fock method and the self-	6 hours 12 hours 12 hours 15 hours

	consistent field, Corrections to the central field approximation. Correction effects, *L-S* coupling and *j-j* coupling. Fine structure in the alkalis. **5. Interaction of atoms with electromagnetic radiation and with static and magnetic field:** Many electron atoms in an electromagnetic field, selection rules for electric dipole transitions, Oscillator and line strengths, Retardation effects, Magnetic dipole and electric quadrupole transitions, The spectra of the alkalis, Helium and the alkaline earths, Atoms with several optically active electrons, Multiplet structure, X-ray spectra, The stark effect, The Zeeman effect.	15 hours
Pedagogy:	Lectures/tutorials/assignments. Sessions shall be interactive in nature to enable peer group learning	
References/Readings	1. Atomic Physics, C. J. Foot, Oxford Master Series in Physics (2005) 2. Physics of Atoms and Molecules, B. H. Bransden, C. J. Joachain, Pearson (2004) 3. Atomic Physics, D. C. Jones, CRC Press/Sarat Book House (2018) 4. Atomic Physics, S. N. Ghoshal, S. Chand Publishing (2007)	
Learning Outcomes	Students will understand about 1. atomic structure 2. the optical and x-ray spectra of atoms 3. the interaction of atoms with electric and magnetic fields.	

Programme: M. Sc. (Physics)
Course Code: PHGO-105 **Title of the Course:** General Physics Practical
Number of Credits: 4
Effective from AY: 2022-23

Prerequisites for thecourse:	Nil	
Objective:	This course provides laboratory training in performing experiments that verify important physical laws and using modern and novel techniques of measurements.	
Content:	Short Lecture Course on – Theory of errors, Treatment of Errors of observation, linear least squares fitting and Data analysis. The experiments on the following topics (any 12) are to be performed with emphasis on the estimation and calculation of errors. 1. Types of Statistical Distributions 2. Analysis of Sodium Spectrum – Quantum defect and Effective quantum number 3. Michelson Interferometer/Fabry-Perot Interferometer 4. Diffraction experiments using laser– single slit,	120 hours

	double slit, grating 5. Polarization experiments using laser –linearly and elliptically polarized light 6. Statistical Distribution of radioactive decay 7. Verification of Inverse Square Law using GM counter 8. Linear Absorption Coefficient of Aluminium using GM counter 9. Verification of Debye Relaxation Law and measurement of thermal relaxation of serial light bulb 10. Thermal diffusivity of Brass 11. Thermometry – measurement of thermoemf of Iron-Copper (Fe-Cu) thermocouple as a function of temperature and verification of law of intermediate metals 12. Calibration of Lock-in Amplifier 13. Measurement of mutual inductance of a coil using lock-in amplifier 14. Measurement of low resistance using lock-in amplifier 15. X-ray Emission – characteristics lines of a W target 16. Experiments using Strain Gauge 17. Ultrasonic Interferometer 18. Nonlinear dynamics – Feigenbaum circuit 19. Nonlinear dynamics – Chua's circuit 20. Verification of Percolation phenomena 21. Measurement of electrical resistance of Ni wire to verify para to ferromagnetic phase transition 22. Measurement of electrical resistance of NiTi based shape memory alloy 23. Measurement of Young's modulus of Brass by Flexural vibrations	
Pedagogy:	Lectures and Laboratory Experiments.	
References/Readings	1. P. R. Bevington and D. K. Robinson, Data Reduction and Error Analysis for the Physical Sciences, McGraw Hill (Indian Edition) 2015. 2. R. Srinivasan, K. R. Priolkar and T. G. Ramesh, A Manual on Experiments in Physics, Indian Academy of Sciences, 2018.	
Learning Outcomes	1. Employ proper techniques when making scientific measurements 2. Demonstrate the ability to use selected pieces of measuring devices including the multimeter, oscilloscope, and AC and DC power supplies, Lock-in Amplifier 3. Demonstrate the ability to use the computer as a data analysis tool 4. Demonstrate the ability to maintain a laboratory	

	notebook 5. Apply the appropriate physics to the physical situation presented 6. Quantitatively analyse experimental data 7. Estimate and translate errors and report quantities up to last significant digit 8. Formulate and report scientific conclusions based on data analysis 9. Prepare lab reports in standard scientific format	

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