



National Education Policy – 2020
H.N.B. Garhwal University

Revised Syllabus
One-Year M.Sc. (Physics)
w.e.f. 2026-2027

One-year P.G. program (2026-2027 Onwards)

One Year M.Sc. (Physics) – First Semester

Entry requirement	4-year bachelor's degree (160 credits), and candidates who have met the entrance requirements, including specified levels of attainment, in the program admission regulations.				
Semester	Course category	Course title	Credits		Total Credit
			T	P	
I	Discipline Specific Core (DSC)	DSC-7a: Quantum Mechanics	3	2	5
		DSC-8a: Nuclear Physics	3	2	5
		DSC-9a: Statistical Mechanics	3	2	5
		DSC-10a: Reactor Physics	3	2	5
	Discipline Specific Elective (Any 1 out of Minimum 2 electives)	DSE-3a:	3	1	4
		1. Condensed Matter Physics -A			
		2. High Energy Physics – A			
		3. Astrophysics – A			
OR					
	Multidisciplinary Elective (MDE)	MDE-3a: Biophysics	4	--	4
<i>A student may opt for either one Discipline Specific Elective (DSE) or one Multidisciplinary Elective (MDE) as an elective course.</i>					
	SEC (Non-CGPA Course)	Academic Library Systems and Services	1		
Or					
	SEC (Non-CGPA Course)	Entrepreneurship & Startup Awareness	1		
Total			15	9	24

Note:

1. *In lieu of DSE/MDE the departments may offer any one course i.e. dissertation/project/Field work/Swayam Course work of 4 credits. Departments are suggested to offer Swayam courses under DSE/MDE.*
2. *In cases where an elective course includes both theory and practical components, the concerned Department may bifurcate the total of four (4) credits appropriately between the theory and practical components, as per the course requirements and approved curriculum structure.*
3. *If a department intends to introduce any DSC without a practical component or solely with a practical component, it may do so; in such cases, the entire course shall carry 5 credits.*
4. *The Departments may revise the credit allocation between theory and practical components in accordance with the requirements of the respective courses.*
5. *In the first semester of one-year P.G. program, if a department wishes to offer one more Discipline Specific Elective course, it may do so by replacing one of the Discipline-Specific Core courses. The credit value of the additional elective must be equal to that of the core course it replaces. This provision/flexibility is limited to only one additional elective course.*
6. *Research based courses such as Research methodology, Research writing and ethics, etc may be offered in the P.G. programme as core courses.*
7. *The University shall provide a common syllabus for the course titled “Academic Library Systems and Services”*
8. *Entrepreneurship & Startup Awareness- Departments may develop and offer an ‘Entrepreneurship & Startup Awareness’ course or, alternatively, adopt the ‘Entrepreneurship & Startup Awareness’ course prescribed by the University. Departments shall offer this course to familiarize students with entrepreneurial mindset, startup ecosystem, innovation, and self-employment opportunities. The course may include basic business planning, case studies, interaction with entrepreneurs, and awareness of government startup schemes, with assessment based on participation and practical exercises. The course aims to promote creativity, leadership, and employment generation in alignment with NEP 2020.*

One-Year M.Sc. (Physics) – Second Semester

Semester	Course category	Course title	Credits		Total Credit
			T	P	
II	Discipline Specific Core (DSC)	DSC-11a: Advanced Quantum Mechanics	3	2	5
		DSC-12a: Particle Physics	3	2	5
	Optional Component (Research / Skill Oriented) in lieu of DSC	Major Dissertation / Project Work	--	10	10
		Option–II: <i>in lieu of any two DSCs</i>			
	Discipline Specific Elective (Any 1 out of Minimum 2 electives)	DSE-4a: 1. Condensed Matter Physics – B 2. High Energy Physics – B 3. Astrophysics – B	3	1	4
Or					
	Multidisciplinary Elective (MDE)	MDE-4a: Health Physics	4	--	4
<i>A student may opt for either one Discipline Specific Elective (DSE) or one Multidisciplinary Elective (MDE) as an elective course.</i>					
	SEC (Non-CGPA Course)	Community outreach activities	1		
Total			9	15	24
NHEQF Level- 6.5	<i>Student on successfully completing one-year PG programme (i.e., securing minimum required 48 credits will be awarded “Postgraduate Degree”, of one year in related field/discipline/subject.</i>				

Note:

- In lieu of DSE/MDE the departments may offer any one course i.e. dissertation/project/Field work/Swayam Course work of 4 credits. Departments are suggested to offer Swayam courses under DSE/MDE.*
- In cases where an elective course includes both theory and practical components, the concerned Department may bifurcate the total of four (4) credits appropriately between the theory and practical components, as per the course requirements and approved curriculum structure.*
- If a department intends to introduce any DSC without a practical component or solely with a practical component, it may do so; in such cases, the entire course shall carry 5 credits.*
- The Departments may revise the credit allocation between theory and practical components in accordance with the requirements of the respective courses.*
- In the second semester of one-year P.G. program, if a department wishes to offer one more Discipline Specific Elective course, it may do so by replacing one of the Discipline-Specific Core courses. The credit value of the additional elective must be equal to that of the core course it replaces. This provision/flexibility is limited to only one additional elective course.*
- Research based courses such as Research methodology, Research writing and ethics, etc may be offered in the P.G. programme as core courses.*
- Community outreach activities- Departments will offer a community outreach–based non-CGPA course focusing on societal engagement, local needs, and institutional social responsibility. The course may include activities such as field visits, awareness programmss, surveys, or collaboration with local bodies/NGOs, with evaluation based on participation, field reports, and reflective learning. This course aims to inculcate social sensitivity, ethical values, and experiential learning in alignment with NEP 2020.*

M.Sc. (Physics)
Semester - I
DSC - 7a
Quantum Mechanics
(Credits: Theory – 03)

Introduction: A brief review of the foundations of quantum mechanics, basic postulates of quantum mechanics, uncertainty relations, Schrodinger wave equation, expectation value and Ehrenfest theorem. Relationship between space and momentum representation. **Applications:** One dimensional potential step, tunnelling, particle in a three dimensional box.

Matrix Formulation of Quantum Mechanics: Vector representation of states, transformation of Hamiltonian with unitary matrix, representation of an operator, Hilbert space. Dirac bra and ket notation, projection operators, Schrodinger, Heisenberg and interaction pictures. Relationship between Poisson brackets and commutation relations. Matrix theory of Harmonic oscillator.

Symmetry in Quantum Mechanics: Unitary operators for space and time translations. Symmetry and degeneracy. Rotation and angular momentum; Commutation relations, eigenvalue spectrum, angular momentum matrices of J_+ , J_- , J_z , J_2 . Concept of spin, Pauli spin matrices, their eigenvalues and eigenvectors, Pauli vectors and spinors, Addition of angular momenta, Clebsch-Gordon coefficients and their properties, Recursion relations. The Hydrogen atom. **Applications:** C. G. coefficients of addition for $j = 1/2, 1/2; 1/2, 1; 1, 1$.

Approximation Methods for Bound States: Time independent perturbation theory for non-degenerate systems up to second order perturbation. Application to a harmonic oscillator, first order Stark effect in hydrogen atom. Time independent perturbation theory for degenerate systems, Variation principle, application to ground state of harmonic oscillator, hydrogen atom, helium atom. WKB approximation: energy levels of a potential well, Quantization rules. application to Coulomb potential, spinless particle in 1D box, Time dependent perturbation theory; transition probability (Fermi Golden Rule).

Reference Books:

1. L.I. Schiff: Quantum Mechanics, McGraw Hill.
2. V.K. Thankappan: Quantum Mechanics, Wiley Eastern.
3. P.M. Mathews and K. Venkatesan: A Text-Book of Quantum Mechanics, TMH
4. Claude Cohen-Tannoudji, Bernard Diu, Franck Laloë: Quantum Mechanics Vols. I & II, Wiley VCH.
5. J.J. Sakurai: Modern Quantum Mechanics, Addison-Wesley.
6. A.K. Ghatak and S. Lokanathan: Quantum Mechanics, 3rd ed., MacMillan.
7. N. Zettili: Quantum Mechanics: Concepts and Applications, Wiley

M.Sc. (Physics)
Semester - I
DSC - 8a
Nuclear Physics
(Credits: Theory – 03)

General Properties & Nuclear Models: Nuclear size, nuclear angular momentum (Spin), Nuclear magnetic moments, statistics, Binding energy, Semi-Empirical Mass Formula, Liquid drop model, Magic Numbers, Shell model, Predictions of Shell model, Collective model.

Nuclear Forces & Interaction of Radiation with Matter – Ground state of deuteron, Low energy neutron-proton scattering, scattering length, phase shift, spin dependence, proton-proton scattering, non-central forces, Exchange and tensor forces, Interaction of charged particles with matter, Energy loss of heavy ions, stopping power, Range and Straggling, Absorption of gamma rays.

Radioactive decay: Radioactive decay equation, equilibrium, units, Gamow's theory of alpha decay and Geiger-Nuttall law, Fermi's theory of beta decay, parity violation in beta decay, electromagnetic decays, Ionization Chamber, G.M. Counter, Scintillation Counter, Cerenkov Counter, Semiconductor Detectors, Nuclear Emulsions.

Nuclear Reactions and Particle Accelerators: Q-value of nuclear reaction, Bohr's Theory of compound nucleus, Scattering cross section of nuclear reaction (phase shift method), Breit-Wigner single-level resonance formula for scattering cross section, Nuclear Fission, Nuclear fusion, Van de Graaff, Tandem Van de Graaff accelerators, Cyclotron, Betatron, Linear accelerator, Proton and Neutron Synchrotron.

References Books:

1. I. Kaplan: Nuclear Physics, Narosa Publishing House
2. A.H. Enge: Introduction to Nuclear Physics, Addison-Wesley Publishing Company
3. R.R. Roy & B.P. Nigam: Nuclear Physics: Theory and Experiments, New Age International Pvt Ltd
4. R.D. Evans: The Atomic Nucleus, Krieger Pub Co
5. W.E. Bucham & M. Jobses: Nuclear and Particle Physics, Prentice Hall
6. D. Halliday: Introductory Nuclear Physics, John Wiley & Sons Inc
7. B.R. Martin & G. Shaw: Nuclear and Particle Physics, Wiley
8. B.L. Cohen: Concepts of Nuclear Physics, McGraw-Hill
9. S.S.M. Wong: Introductory Nuclear Physics, Wiley India Pvt Ltd
10. S.B. Patel: Nuclear Physics: An Introduction, Anshan Ltd
11. S.N. Ghoshal: Nuclear Physics, S Chand Publishing

M.Sc. (Physics)
Semester - I
DSC - 9a
Statistical Mechanics
(Credits: Theory – 03)

Basic Postulates- Phase space, relation between eigen states and phase space volume, Liouville's theorem, ensembles, microcanonical, canonical and grand canonical ensembles, Maxwell-Boltzmann's distribution and Gibbs' formulation for canonical and grand canonical ensembles, partition function, their thermodynamic properties, laws of thermodynamics.

Ideal and Imperfect gases: Degrees of freedom, translational motion, Helmholtz free energy, Gibbs' free energy, entropy and thermodynamic properties, Gibbs' paradox, Sakur-Tetrode equation. Difference between ideal and real gas, imperfect gases, Van der Waals' equation, virial coefficients, condensation of gases, general properties of liquids, Fermi theory, liquid Helium, phase rule.

Quantum Statistics: Drawbacks of M B distribution, Bose-Einstein's and Fermi-Dirac distribution, symmetric and antisymmetric particles, partition functions, non-degenerate, weakly degenerate and strongly degenerate cases, B.E. condensation, application to He, pressure-energy relationship, electronic specific heat of solids and paramagnetism.

Black Body Radiation: Planck's distribution, pressure and energy relationship of photons, black body radiation, Rayleigh-Jeans' formula, Wein's law, Wein's displacement formula, absorption and emission of radiation, Stefan's law, high temperature measurements.

Reference Books:

1. E.S. Raj Gopal: Statistical Mechanics and Properties of Matter, John Wiley & Sons
2. E. Mayer & G. Mayer: Statistical Mechanics, John Wiley & Sons Inc.
3. S. Glasstone: Theoretical Chemistry, Van Nostrand Reinhold Inc.
4. L.D. Landau & E M Lifshitz: Statistical Physics, Butterworth-Heinemann Ltd
5. A.J. Pointon: Introduction to Statistical Physics, Prentice Hall Press
6. K. Huang: Statistical Mechanics, Wiley & Sons
7. G.H. Wannier: Statistical Physics, Dover Publications
8. E. Guha: Statistical Mechanics, Narosa Publishing House
9. Satya Prakash: Statistical Mechanics, Kedar Nath Ram Nath Publications

M.Sc. (Physics)
Semester - I
DSC - 10a
Reactor Physics
(Credits: Theory – 03)

Fundamentals of Nuclear Reactor Physics: Basics of nuclear fission and fusion; Energy release in fission reactions; Neutron-induced fission and chain reactions; Multiplication factor and criticality (Subcritical, critical, and supercritical systems); Neutron life cycle and six-factor formula; Reactor materials (Fuels, Moderators, Reflectors, Coolants, Control materials); Neutron cross-sections and reaction rates; Neutron diffusion and slowing down theory

Nuclear Reactor Types and Reactor Kinetics: Classification of nuclear reactors (Thermal reactors, Fast breeder reactors, Research reactors, Power reactors); Pressurised Water Reactor (PWR); Boiling Water Reactor (BWR); Pressurised Heavy Water Reactor (PHWR); Fast Breeder Reactor (FBR); Reactor kinetics and point reactor equations; Prompt and delayed neutrons; Reactor startup, shutdown, and control mechanisms; Reactivity coefficients and reactor stability

Reactor Heat Transfer, Safety, and Shielding: Heat generation and heat removal in reactors; Heat transfer mechanisms in reactor systems; Coolant flow and thermal hydraulics (introductory level); Reactor efficiency and power distribution; Radiation shielding principles (Gamma shielding, Neutron shielding); Reactor safety systems (Emergency core cooling system, Containment structures, Safety interlocks); Reactor accidents and safety analysis; Nuclear waste management and disposal methods

Advanced Reactor Physics and Computational Methods: Reactor core design principles; Fuel burnup and breeding ratio; Fast neutron reactors and breeder technology; Fusion reactor basics (Tokamak, Magnetic confinement); Reactor monitoring and instrumentation; Introduction to reactor simulation methods (Neutron transport methods, Monte Carlo techniques); Computational tools in reactor physics; Current trends (Small Modular Reactors (SMRs), Generation-IV reactors, Thorium-based reactors).

Reference Books:

1. Anthony J. Baratta & John R. Lamarsh: Introduction to Nuclear Engineering. *Pearson Education Limited*
2. Samuel Glasstone & Alexander Sesonske: Nuclear Reactor Engineering. *CBS Publishers and Distributors Pvt Ltd.*
3. M. M. El-Wakil: Nuclear Power Engineering, *McGraw-Hill Inc.*
4. M. M. El-Wakil: Nuclear Heat Transport. *American Nuclear Society*
5. Kenneth Shultis, Richard E. Faw: Radiation Shielding. *J Amer Nuclear Society*
6. Gianni Petrangeli: Nuclear Safety. *Butterworth-Heinemann*
7. Fast Breeder Reactors — *International Atomic Energy Agency (IAEA Publications)*

M.Sc. (Physics) Semester - I DSC Practical

DSC 7a: Quantum Mechanics (Credits: 02)

List of experiments: At least **four** experiments are to be performed

1. To determine Planck's constant and work function using the photoelectric effect.
2. Solve the time-independent Schrödinger equation numerically and compute reflection/transmission coefficients.
3. Compute eigenvalues and eigenfunctions for a cubic box.
4. Represent position, momentum, and Hamiltonian operators as matrices in a chosen basis.
5. Construct the Hamiltonian matrix and compute the energy eigenvalues numerically.
6. Compute first- and second-order corrections for a harmonic oscillator
7. To determine the wavelength of light using the Fabry-Perot interferometer

DSC 8a: Nuclear Physics (Credits: 02)

List of experiments: At least **four** experiments are to be performed

1. Measure alpha particle range in air or foil.
2. Analyze beta particle distribution using detector data.
3. Verify the inverse square law for γ -ray using a Geiger-Müller counter.
4. To determine the dead time of the Geiger-Müller counter using the single-source method
5. To perform energy calibration of the NaI detector and determine the energy resolution of a known decay transition.
6. Study of Silicon Controlled Rectifier
7. Millikan Oil Drop Experiment

DSC 9a: Statistical Mechanics (Credits: 02)

List of experiments: At least **four** experiments are to be performed

1. Generate particle velocities numerically and verify MB distribution.
2. Plot isotherms and compare ideal vs real gas behaviour.
3. Compute entropy change during mixing of gases.
4. Plot spectral radiance vs wavelength at different temperatures.
5. Plot spectral radiance vs wavelength at different temperatures.
6. Compute heat capacity vs temperature using Einstein and Debye models.
7. Simulate thermodynamic behaviour near the lambda transition.

DSC 10a: Reactor Physics (Credits: 02)

List of experiments: At least **four** experiments are to be performed

1. Measure the activity variation of a radioactive source with time using a GM counter
2. Measure count rate at different distances from a radioactive source.
3. Determine attenuation coefficient using absorbers like lead/aluminium.
4. Simulate or experimentally study neutron attenuation through moderator materials.
5. Use computational tools to model subcritical, critical, and supercritical systems.
6. Compare attenuation through concrete, paraffin, lead, etc.
7. Simulate fuel burnup and power distribution in simplified reactor core models.

M.Sc. (Physics)
Semester - I
DSE - 3a
Condensed Matter Physics – A
(Credits: Theory – 03)

Defects in Crystals: Point Defects: Vacancies (intrinsic and extrinsic), Interstitials, Substitutional impurities, Ionic Defects: Schottky and Frenkel defects — definitions and concentration expressions, Impurity Defects: Doping and extrinsic conductivity, Line Defects (Dislocations): Edge and Screw dislocations, Burgers vector, Strain fields around dislocations, Planar and Volume Defects: Grain boundaries, Twin boundaries, Stacking faults, Voids, Diffusion in Solids: Fick's laws, Diffusion mechanisms, Colour Centres: F-centres, V-centres, Other types (e.g., M-centres, R-centres).

Magnetism: Classification of magnetic materials: Dia, Para, and Ferromagnetism, Langevin's theory of Para magnetism, Weiss molecular field theory of Ferromagnetism, Concept of Ferromagnetic domains and hysteresis, Antiferromagnetism: Basic concepts and characteristics, Neel's theory of Antiferromagnetism, Two-sublattice model for Antiferromagnetic and Ferrimagnetic materials, Introduction to Ferrites: Structure, properties, and applications.

Free Electron, Nearly Free Electron Model and Band Theory: Free Electron Model, Nearly Free Electron Model: Weak periodic potential, Formation of energy gaps, Brillouin zone boundaries and effective mass, Bloch Theorem and Bloch Functions, Kronig-Penney Model: Analytical solution for a periodic potential, Formation of allowed and forbidden bands, Brillouin Zones and Reciprocal Space, Tight Binding Approximation: Energy bands from atomic orbitals, Overlap and hopping integrals, Advanced Band Structure Methods: Orthogonalized Plane Wave (OPW) method, Pseudopotential method.

Dielectric and Electrical Properties of Insulators: Polarization Mechanisms: Electronic, Ionic, Orientation, and Space-charge polarization, Dielectric Parameters: Macroscopic dielectric constant, Internal/Lorentz field, Clausius–Mossotti relation, Complex dielectric constant and dielectric loss, Relaxation and Dispersion: Dielectric relaxation time, Frequency dependence, Optical Properties: Optical absorption, Refractive index, Absorption edge.

Reference Books:

1. S.O. Pillai: Solid State Physics, New Age International
2. R.K. Puri & V.K. Babbar: Solid State Physics and Electronics, S. Chand
3. J.P. Srivastava: Elements of Solid-State Physics, PHI
4. C.M. Kachhava: Solid State Physics, TMH
5. C. Kittel: Introduction to Solid State Physics, Wiley
6. J.M. Ziman: Principles of the Theory of Solids, Cambridge University Press
7. J. Callaway: Quantum Theory of Solids, Academic Press Inc
8. A.J. Dekker: Solid State Physics, Laxmi Publications
9. N.D. Mermin and N.W. Ashcroft: Solid State Physics, Brooks/Cole
10. Ajay Kumar Saxena: Solid State Physics, Laxmi Publications
11. A N Tripathi: Condensed Matter Physics, New Age International

M.Sc. (Physics)
Semester - I
DSE - 3a
High Energy Physics - A
(Credits: Theory – 03)

Classical and Quantum Field Equations: Coordinates of the Field, Classical Lagrangian Equation, Classical Hamiltonian Equations, Quantum Equations for the Field, Canonical coordinates for the fields, Real scalar field, Complex Field, Schrodinger's field, Dirac fields, Maxwell's field.

Relativistic Kinematics: Minkowski Space, Lorentz Transformations, Four Vectors, Matrix Tensor, Relativistic Energy-Momentum, Einstein Summation Convection, Lorentz Rotation and Boost Matrices, Weyl Spinors, Lorentz Invariance, Scalar Fields, Vector Fields, Tensor Fields. The Klein-Gordon Equation; its Plane Wave Solutions, Probability Density, The Dirac Equation and its Solutions, Dirac Hamiltonian Operator, Dirac Spinors.

Quantization of Fields: Fock Space, Second quantization, Quantization of Neutral and Complex Scalar Fields, Quantization of Dirac Field, Quantization of Electromagnetic Field. Interaction between fields, Polarisation States of Massless and Massive Spin-1 Particles, Photon propagator, Unequal time commutators, Normal and time ordered (chronological) product.

Scattering Matrix and Feynman Rules: The S-Matrix, Reduction of S-Matrix, Chronological Product, Wicks Theorem, Feynman Diagrams and Feynman Rules for QED, and Calculation of Scattering Matrix for Bhabha scattering, Compton scattering, Moller Scattering, Coulomb scattering, Electron-positron annihilation.

Reference Books:

1. J.M. Jauch and E. Rohrlich: Theory of Photons and Electrons, Springer-Verlag
2. J.D. Bjorken and S. D. Drell: Relativistic Quantum Fields, McGraw-Hill
3. A.I. Akhiezer and V.B. Berestetski, Quantum Electrodynamics, John Wiley & Sons Inc
4. Walter Greiner & Joachim Reinhardt: Quantum Electrodynamics, Springer
5. Amitabha Lahiri, Palash B. Pal: A First Book of Quantum Field Theory, Narosa
6. Ashok Das: Lectures on Quantum Field Theory, World Scientific
7. Matthew D. Schwartz: Quantum Field Theory and the Standard Model, Cambridge University Press
8. Fayyazuddin and Riazuddin: A Modern Introduction to Particle Physics, World Scientific Publishing Co. Pvt. Ltd.
9. M.E. Peskin and D.V. Schroeder: An Introduction to Quantum Field Theory, CRC Press

M.Sc. (Physics)
Semester - I
DSE - 3a
Astrophysics - A
(Credits: Theory – 03)

Physics of the Stars: Apparent and Mean Position of Stars. Effects of atmospheric refraction, aberration, precession, nutation, and proper motion on the coordinates of stars. Types of Parallaxes, Reduction from apparent to mean places and vice versa. Spectra of Stars. Distribution of stars in space. Local standard of rest. Solar motion and its determination. Comparison with the solar neighbourhood. Bottlinger diagram.

HR diagram, HD, and MK spectral classification of stellar spectra. Radiation laws and basic ideas on spectral line formation. Explanation of stellar spectra in terms of the Boltzmann and Saha equations.

Fundamental Equations: Equation of mass distribution. Equation of hydrostatic equilibrium. Equation of energy transport by radiative and convective processes. Equation of thermal equilibrium. Equation of state. Stellar opacity. Stellar energy sources. Stellar models: The overall problem and boundary conditions. Russell Voigt theorem. Dimensional discussions of the mass-luminosity law.

Stellar Evolution: Abundance of elements in the sun by the method of fine analysis-Stromgren's method, use of weight functions, abundances of elements in normal stars. Composition of differences in population I and II stars. Anomalous abundances in cool stars. Peculiar A stars and metallic line stars. Magnetic field in stars. Pre-main-sequence contraction under radiative and convective equilibrium. Evolution in the main sequence. Growth of the isothermal core and subsequent development. Ages of galactic and globular clusters.

Superdense Objects: Mechanism of Mass Transfer in Binary Stars. Mass-radius relation. Non-degenerate upper layers and abundance of Hydrogen. Stability of white dwarfs. Final cooling of white dwarfs. Accretion by white dwarfs and its consequences. Pressure ionisation and mass-radius relation for cold bodies. Formation, features, and properties of Neutron stars, Pulsars, and black holes

Recommended Books:

1. Baidyanath Basu: An introduction to astrophysics, Prentice Hall India Learning Private Limited
2. Erika Böhm-Vitense: Introduction to Stellar Astrophysics: Volume 2, Cambridge University Press
3. K.D. Abhyankar: Astrophysics of Stars and Galaxies, Univ. Press India Limited
4. Bradley W Carroll and Dale A Ostlie: An Introduction to Modern Astrophysics, Cambridge University Press
5. Donald D. Clayton: Principles of Stellar Evolution and Nucleosynthesis, The University of Chicago Press
6. Stuart L. Shapiro and Saul A. Teukolsky: Black Holes, White Dwarfs and Neutron Stars: The Physics of Compact Objects, Wiley-Interscience Pub, New York
7. Carl J. Hansen, Steven D. Kawaler: Stellar Interiors: Physical Principles, Structure, and Evolution, Virginia Trimble, New York, Springer-Verlag

M.Sc. (Physics)
Semester - I
DSE Practical

DSE 3a: Condensed Matter Physics - A
(Credits: 01)

List of experiments: At least **four** experiments are to be performed

1. Determination of the elastic constant of crystals by optical methods
2. Study of fluorescence spectra of a given compound
3. Study of colour centers
4. Determination of lattice parameters using the powder method.
5. Determination of the Hall coefficient using the Hall effect
6. Determination of the Energy gap of a semiconductor by the four-probe method
7. Electron Spin Resonance
8. Dielectric constant

OR

DSE 3a: High Energy Physics - A
(Credits: 01)

List of experiments: At least **four** experiments are to be performed

1. Measurement of the non-radiative decay rate for a known sample.
2. Characteristic curve of a GM Detector and Absorption coefficient of aluminium using GM Detector.
3. Absorption coefficient of aluminium using gamma-ray spectrometer.
4. Characteristics of Scintillation Detector.
5. Study of gamma-gamma unperturbed angular correlations.
6. Study of particle tracks using a Nuclear Emulsion Detector.
7. Classification of tracks in interaction with Nuclear Emulsion and determination of excitation energy.
8. Mossbauer spectrometer

OR

DSE 3a: Astrophysics - A
(Credits: 01)

List of experiments: At least **four** experiments are to be performed

1. Study of Hubble's law (from given data)
2. Study of a constant-density neutron star
3. Study of the static parameters of a Neutron Star model with inverse square density distribution
4. Study of a star cluster from a given dataset
5. Study of Extinction Coefficients
6. Study of the variability of stars

M.Sc. (Physics)
Semester - I
MDE – 3a
Biophysics
(Credits: Theory – 04)

Fundamentals of Biophysics: Scope and significance of biophysics; Water, pH, buffers, and biomolecular interactions; Thermodynamics of biological systems; Chemical and enzyme kinetics; Structure and properties of biomolecules; Intermolecular forces in biological systems.

Molecular Biophysics: Structure of DNA, RNA, and proteins; Protein folding and stability; Membrane structure and transport mechanisms; Diffusion, osmosis, and active transport; Molecular motors and biomolecular mechanics; Spectroscopic techniques (UV–Vis, fluorescence).

Cellular Biophysics: Cell as a physical system; Membrane potential and ion transport; Nerve impulse and signal transmission; Muscle contraction; Biomechanics of cells and tissues; Introduction to systems biology.

Biophysical Techniques & Applications: Microscopy (optical and electron); X-ray diffraction and crystallography; NMR and MRI basics; Electrophoresis and centrifugation; Imaging in medicine and biology; Applications in biotechnology and nanobiophysics.

Reference Books:

1. Roland Glaser: Biophysics. *Springer-Verlag Berlin*.
2. R. N. Roy: A Text Book of Biophysics. *New Central Book Agency*.
3. P. Narayanan: Essentials of Biophysics. *New Age International Private Limited*.
4. Rob Phillips, Jane Kondev, Julie Theriot, Hernan G. Garcia, Nigel Orme: Physical Biology of the Cell. *Garland Science*
5. Greg Conradi Smith: Cellular Biophysics and Modeling. *Cambridge University Press*
6. Iain Campbell: Biophysical Techniques. *Oxford Univ Press*.
7. P. Narayanan: *Essentials of Biophysics*, *New Age International Publishers*
8. Vasantha Pattabhi and N. Gautham: *Biophysics*, *Narosa Publishing House*
9. Textbook of Biophysics, R. N. Roy, *New Central Book Agency*
10. Debajyoti Das, *Biophysics and Biophysical Chemistry*. *Academic Publishers*
11. S. Mahajan and Rangwala: Biophysics, *McGraw-Hill Education (India)*
12. K.V. Chaitanya: *Fundamentals of Biophysics*, *Himalaya Publishing House*
13. Upadhyay, Upadhyay and Nath: *Biophysical Chemistry*. *Himalaya Publishing House*
14. G.R. Chatwal and Harish Anand *Biophysical Chemistry*. *Himalaya Publishing House*

M.Sc. (Physics)
Semester - II
DSC - 11a
Advanced Quantum Mechanics
(Credits: Theory – 03)

Scattering Theory: General considerations; kinematics, wave mechanical picture, scattering amplitude, differential and total cross-section. Green's function for scattering. Partial wave analysis: asymptotic behaviour of partial waves, phase shifts, scattering amplitude in terms of phase shifts, cross-sections, Optical theorem. Phase shifts and its relation to potential, effective range theory. Application to low energy scattering; resonant scattering, Breit-Wigner formula for one level and two levels, non-resonant scattering. s-wave and p-wave resonances. Exactly soluble problems; Square-well, Hard sphere, coulomb potential. Born approximation; its validity, Born series.

Identical Particles: The Schrodinger equation for a system consisting of identical particles, symmetric and antisymmetric wave functions, elementary theory of the ground state of two electron atoms; ortho- and Para-helium. Spin and statistics connection, permutation symmetry and Young tableaux. Scattering of identical particles.

Relativistic and Non-Relativistic Quantum Mechanics: Generalization of the Schrodinger equation; Klein-Gordon equation, plane wave solutions, charge and current densities, interaction with electromagnetic fields, Hydrogen-like atom (to show it does not yield physical spectrum), non-relativistic limit. Extension of Klein-Gordon equation to spin 1 particles.

Dirac Equation and Its Implications in Quantum Mechanics: Dirac Equation; relativistic Hamiltonian, probability density, expectation values, Dirac gamma matrices, and their properties, non-relativistic limit of Dirac equation. Covariance of Dirac equation and bilinear covariance, plane wave solution, energy spectrum of hydrogen atom, electron spin and magnetic moment, negative energy sea, hole interpretation and the concept of positron. Spin-orbit coupling, hyperfine structure of hydrogen atom.

Reference Books:

1. P.M. Mathews and K. Venkatesan: A Text book of Quantum Mechanics (TMH)
2. A.S. Davydov: Quantum Mechanics (Pergamon).
3. L.I. Schiff: Quantum Mechanics (McGraw Hill).
4. J.D. Bjorken and S. D. Drell: Relativistic Quantum Mechanics (McGraw Hill).
5. J.J. Sakurai: Advanced Quantum Mechanics (Addison Wesley).
6. V.K. Thankappan: Quantum Mechanics (Wiley Eastern).
7. R.P. Feynman and A.R.Hibbs; Quantum Mechanics and Path Integrals.
8. L.H. Ryder: Quantum Field Theory (Academic Press).

M.Sc. (Physics)
Semester - II
DSC - 12a
Particle Physics
(Credits: Theory – 03)

Classification and Properties of Elementary Particles: Elementary Particles and their Classification based on their mass and spins, Fermions and Bosons, Leptons, Mesons, Baryons, and field quanta, General Properties (mass, spins, lifetime, production and decay modes) of Elementary Particles, Antiparticles, Strange Particles.

Conservation Laws and Gauge Invariances: Conservation of Energy, Linear and Angular momentum, Spin, Charge, Lepton Number, Baryon Number, Isospin, Hypercharge, Parity, Strangeness, τ - θ puzzle, Charge conjugation (C), Parity (P), Time Reversal (T), CP Violation, CPT theorem, Gauge Symmetries, Global and Local gauge invariances, U(1), SU(2) and SU(3) local gauge invariance.

Fundamental Interaction: Basic Idea of Different Fundamental Interactions with Suitable Examples, Qualitative Ideas (Relative strengths, Ranges, Characteristic times and Mediators) of Gravitational, Electromagnetic, Strong and Weak Nuclear interactions, The Quest to Unify Strong, Weak, and Electromagnetic Forces, General Idea of Electroweak and Grand Unification.

Quark Model: The Eightfold Way, Six Quarks (up, down, strange, charm, top, and bottom), Antiquarks, General Properties (Charge, Mass, Colour, Isospin) of Quarks, Quark flavours and their Quantum Numbers, Quarks as Constituents of Hadrons, Qualitative idea of Quark Confinement and Asymptotic Freedom, Evidences for Quarks (Lepton scattering, Hadron Spectroscopy, Jet production), Necessity of Introducing the Colour Quantum Number, Quark Compositions of Mesons and Baryons. General Idea of the Standard Model, Idea of the Higgs Boson.

Reference Books:

1. D. Griffiths: Introduction to Elementary Particle Physics, John Wiley & sons
2. V.K. Mittal, R.C. Verma & S.C. Gupta, Introduction to Nuclear & Particle Physics, Prentice Hall of India Pvt. Ltd.
3. D.H. Perkins: Introduction to High Energy Physics, Cambridge University Press
4. Francis Halzen & A D. Martin: Quarks and Leptons - An Introductory course in Modern Particle Physics, John Wiley & Sons, Inc.
5. M.P. Khanna: Introduction to Particle Physics, Prentice Hall of India
6. Fayazuddin & Riyazuddin: A Modern Introduction to Particle Physics, World Scientific Publishing Co Pvt Ltd
7. M. Leon, Particle Physics: An Introduction, Academic Press

M.Sc. (Physics)
Semester - II
DSC Practical
(Credits: 02)

DSC 11a: Advanced Quantum Mechanics
(Credits: 02)

List of experiments: At least **four** experiments are to be performed

1. Quantum Mechanics: Particle in a 1D/2D Potential Well - Solve the time-independent Schrödinger equation via the finite difference method.
2. Eigenvalue Problems in Quantum Wells: Discretise and solve matrix eigenvalue problems.
3. Phonon Dispersion in 1D/3D Lattices: Construct and diagonalise the dynamical matrix.
4. Density of States (Numerical Integration/Histogram Method): Use tight-binding or free-electron approximation.
5. Matrix Diagonalisation (Jacobi / QR Method): For eigenvalue problems in lattice or QM systems.
6. Numerical Integration (Trapezoidal/Simpson's Rule): Evaluate definite integrals of physical functions.
7. Solving ODEs (Euler/Runge-Kutta Methods)

DSC 12a: Particle Physics
(Credits: 02)

List of experiments: At least **four** experiments are to be performed

1. Analyse sample reactions and verify conservation laws.
2. Study decay data of mesons and baryons (e.g., pion, kaon).
3. Construct meson and baryon multiplets (octet/decuplet).
4. Arrange hadrons in SU(3) weight diagrams.
5. Analyse scattering cross-section data from experiments.
6. Show the invariance of the Lagrangian under local phase transformation.
7. Map all known particles and simulate the symmetry-breaking conceptually.

M.Sc. (Physics)
Semester - II
DSE - 4a
Condensed Matter Physics – B
(Credits: Theory – 03)

Electronic Properties and Band Applications: Effective mass of electrons and holes, Crystal momentum and charge carrier dynamics, Concept of holes and hole band construction, Constant energy surfaces, Fermi energy and Fermi level in metals and semiconductors, Classification of Solids: Metals, insulators, and semiconductors based on band filling and band gaps, Band Gap Engineering: Direct and indirect band gaps, Tuning band gaps through doping, strain, and confinement, Applications in semiconductor and optoelectronic devices.

Piezoelectric and Ferroelectrics: Definition and origin of piezoelectricity, Direct and inverse piezoelectric effects, Crystal symmetry requirements for piezoelectric behaviour, Piezoelectric coefficients and tensor notation, Natural piezoelectric crystals (e.g., quartz, tourmaline), Synthetic materials, Structure-property correlations, Applications of Piezoelectric Materials. Ferroelectric crystals, classification of ferroelectric crystals, displacive transition, soft optical phonons, Landau theory of phase transition, Second and first order transition, antiferroelectricity, ferroelectric domains, Ferroelasticity, optical ceramics, Applications of Ferroelectric materials.

Superconductivity: Experimental Survey, Occurrence of superconductivity, destruction of superconductivity by magnetic field and temperature, Meissner effects, Type-I and Type-II superconductors, Isotope effect, Thermodynamics of Superconducting transition, London Equations, Coherence length, BCS Theory, Cooper pairs, Josephson superconductor tunnelling, AC & DC Josephson effect, High temperature superconductors, critical fields and critical currents.

Nano Material Science and Technology: History, Origin, Quantum dots, Synthesis, Applications and advantages, Quantum wires, Quantum well & application, Fullerenes, Carbon nanobuds, carbon nanotubes as quantum wires, Areas of Nanotechnology, nanomaterials, nanoelectronics, nanobiotechnology, nanofabrication, microelectromechanical systems (MEMS).

Reference books:

1. S.O. Pillai: Solid State Physics, New Age International.
2. R.K. Puri & V.K. Babbar: Solid State Physics and Electronics, S. Chand.
3. J.P. Srivastava: Elements of Solid-State Physics, PHI
4. C.M. Kachhava: Solid State Physics, TMH
5. B.S. Saxena, R.C.Gupta, P.N.Saxena, Mandal: Solid State Physics, Pragati Prakashan
6. R.L. Singhal: Solid State Physics, Kedar Nath Ram Nath.
7. P.M. Chaikin & T.C. Lubensky: Principles of Cond. Matter Physics, Camb. Univ. Press
8. R. Kubo: Solid State Physics. McGraw-Hill Inc
9. O. Madelung: Introduction to Solid State Theory, Springer-Verlag Berlin
10. J. Patterson and B. Bailey: Introduction to Solid State Physics, Springer-Verlag Berlin
11. C. Kittel: Introduction to Solid State Physics, Wiley
12. N.D. Mermin and N.W. Ashcroft: Solid State Physics, Brooks/Cole
13. Ajay Kumar Saxena: Solid State Physics, Laxmi Publications
14. A N Tripathi, Condensed Matter Physics, New Age International

M.Sc. (Physics)
Semester - II
DSE - 4a
High Energy Physics - B
(Credits: Theory – 03)

General idea of groups and their properties: Lie groups and their generators, Lie algebra, Basic idea of Unitary, Special unitary, Orthogonal and Special orthogonal groups. Noether's theorem, Concept of gauge fields, Principle of gauge invariance, Global and Local gauge invariance, Abelian and non-Abelian gauge invariance, U(1) gauge invariance of quantum electrodynamics, Yang–Mills gauge field, non-Abelian gauge field theory SU(2), Spontaneous symmetry breaking, Goldstone bosons, Higgs mechanism.

Weak Interactions: Purely Leptonic, Semi-leptonic, and Non-leptonic Interactions, Parity, Helicity, Chirality, Charge Conjugation, Two Component Theory of Neutrinos, Relativistic Fermi Theory of Beta Decay: The V-A Interaction, The Chiral Structure of Weak Interactions, Universality of Weak Interactions, Intermediate Vector Boson, W-Boson Propagator, Cabibbo Theory, Weak Decay of Quarks: GIM model and CKM Matrix, CP violation, Neutral Weak Interactions.

Electroweak Unification and Gauge Symmetry: SU(2) Global and Local Gauge Invariance, Yang Mills Field, Weinberg-Salam Theory of Electroweak Unification, Weak Isospin and Hypercharge, The Matter Fields, The Gauge Fields, The Gauging of SU(2)×U(1), Fermion Assignments in the Electroweak Model, Spontaneous Symmetry Breaking and Choice of Higgs Field, Lepton and Quark Masses, Gauge Boson Masses

QCD and Standard Model: Colour Gauge Invariance and QCD, Basic Idea of Standard Model of Fundamental Interaction, General Mass Terms, Experimental Evidence of the Standard Model: QED, Weak Interactions, Colours.

References Books:

1. Syed Afsar Abbas: Group Theory in Particle, Nuclear and Hadron Physics, CRC Press
2. Fayyazuddin and Riazuddin: A Modern Introduction to Particle Physics, World Scientific Publishing
3. G.L. Kane: Modern Elementary Particle Physics, Addison-Wesley
4. Graham Ross: Grand Unified Theories, Benjamin-Cummings Pub. Co.
5. D.H. Perkins: Introduction to High Energy Physics, Cambridge University Press
6. C. Quigg: Gauge Theories of Strong, Weak, and Electromagnetic Interactions, Addison–Wesley
7. T.D. Cheng and Ling Fong Li: Gauge Theory of Elementary Particle Physics, Clarendon Oxford
8. D. C. Joshi: Introduction to Quantum Electrodynamics and Particle Physics, Tech Sar Pvt. Ltd.

M.Sc. (Physics)
Semester - II
DSE - 4a
Astrophysics - B
(Credits: Theory – 03)

Detectors Photometry and Spectroscopy: Detectors for optical and infrared regions. Application of CCD's to stellar imaging, photometry, and spectroscopy. Techniques of observations of astronomical sources from space in different regions of the electromagnetic spectrum.

Astronomical photometry. Simple design of an astronomical photometer. Observing technique with a photometer. Correction for atmospheric extinction. Astronomical spectroscopy. Simple design of an astronomical spectrograph. Radial velocity measurements. Radio Astronomy Techniques. Radio window. Design and construction of a simple Radio Telescope.

Galactic System: Interstellar Matter: Composition and properties of interstellar matter. Oort limit. Interstellar extinction. Estimate of colour excess. Visual absorption. Interstellar reddening law and magnetic fields. Stromgren's theory of H II regions. Galactic Structure: General galactic rotational law. Oort's theory of galactic rotation. Determination of Oort's constants. Size and mass of our galaxy. Spiral structure of our Galaxy from optical and radio Observations.

Extragalactic Systems: Classification of galaxies and clusters of galaxies. Hubble sequence. Galaxy interactions. Determination of the extragalactic masses and distances. Active galactic nuclei (AGNs), Radio galaxies, and Quasars. Energy problem in active galaxies and accretion discs. Flat rotation curves of galaxies and Dark Matter.

Gravitation and Cosmology: Conceptual foundations of GR and curved spacetime: Principle of equivalence. Connection between gravity and geometry. Metric tensor and its properties. Form of metric in Newtonian limit. Einstein's field equations, Cosmological Constant, Observational tests of general relativity. Hubble's law. Models of the universe: Steady State Models. Standard Model: The expanding universe model. Microwave background radiation (CMBR). Friedmann-Lemaître-Robertson-Walker (FLRW) model. The early universe. Thermodynamics of the early universe. Primordial Black Holes (PBHs). Implications of the Dark Energy in modern cosmology.

Recommended Books:

1. T. Padmanabhan: Theoretical Astrophysics: Stars and Stellar Systems, Cambridge University Press
2. Linda S. Sparke and John S. Gallagher: Galaxies in the Universe: An Introduction, Cambridge University Press
3. J. B. Hartle: Gravity: An Introduction to Einstein's General Relativity, Pearson
4. Robert M. Wald: General Relativity, University of Chicago Press
5. Bradley W Carroll and Dale A Ostlie: An Introduction to Modern Astrophysics, Cambridge University Press
6. C.R. Kitchin: Astrophysical Techniques, CRC Press
7. Barbara Ryden: Introduction to Cosmology, Cambridge University Press

**M.Sc. (Physics)
Semester - II
DSE Practical**

**DSE 4a: Condensed Matter Physics – B
(Credits: 01)**

List of experiments: At least **four** experiments are to be performed

1. Measure the conductivity of metals and semiconductors using a four-probe setup.
2. Measure the voltage generated due to applied mechanical stress.
3. Determine the resonance frequency of the quartz crystal oscillator.
4. Record polarisation versus electric field (P–E loop).
5. Measure resistance variation with temperature for superconducting material.
6. Observe magnetic levitation or flux exclusion below the critical temperature.
7. Study electrical or structural properties of CNTs/nanomaterials using microscopy or conductivity measurements.

Or

**DSE 4a: High Energy Physics – B
(Credits: 01)**

List of experiments: At least **four** experiments are to be performed

1. Construct multiplication tables for cyclic and symmetry groups.
2. Derive conserved quantities for translational and rotational invariance using simple Lagrangians.
3. Demonstrate invariance of the electromagnetic Lagrangian under U(1) gauge transformation.
4. Construct SU(2) gauge transformations and compare with the Abelian case.
5. Plot and analyse Mexican-hat potential numerically.
6. Study beta decay and weak interaction processes using particle data.
7. Classify particles into leptons, quarks, gauge bosons, and the Higgs sector using Standard Model symmetries.

Or

**DSE 4a: Astrophysics – B
(Credits: 01)**

List of experiments: At least **four** experiments are to be performed

1. Capture stellar images using a CCD camera and determine stellar brightness.
2. Observe a star at different zenith angles and calculate extinction correction.
3. Record spectra of stars using a diffraction grating spectrograph.
4. Measure wavelength shift in stellar spectra and determine radial velocity.
5. Use stellar velocity and distance data to estimate Oort constants.
6. Plot recession velocity versus distance for galaxies.
7. Analyse observed galaxy rotation curve data.

M.Sc. (Physics)
Semester - II
MDE – 4a
Health Physics
(Credits: Theory – 04)

Fundamentals of Radiation and Dosimetry: Types of ionizing radiation (α , β , γ , X-rays, neutrons); Interaction of radiation with matter; Units and quantities: exposure, absorbed dose, equivalent dose, effective dose; Radiation detection principles (gas-filled detectors, scintillation, semiconductor detectors); Basic dosimetry concepts and dose measurement; Natural and artificial sources of radiation.

Biological Effects of Radiation: Mechanisms of radiation interaction with biological systems; DNA damage and repair processes; Deterministic and stochastic effects; Acute and chronic radiation exposure; Radiosensitivity of tissues and organs; Radiation risk models and dose–response relationships.

Radiation Protection and Safety: Principles of radiation protection: justification, optimization (ALARA), dose limits; International guidelines (ICRP, IAEA standards); Shielding design and calculations (alpha, beta, gamma, neutron shielding); Personal and area monitoring (TLD, film badge, survey meters); Radiation safety in medical, industrial, and research facilities; Radioactive waste management.

Applications of Health Physics: Medical applications: radiology, radiotherapy, nuclear medicine; Occupational health physics and radiation monitoring; Environmental radiation and pollution; Nuclear accidents and emergency preparedness; Regulatory framework and radiation safety standards; Recent advances (digital dosimetry, radiation protection technologies).

Reference Books:

1. H. Cember & T. E. Johnson: Introduction to Health Physics. *McGraw-Hill*.
2. Pravina S. Ugile-Pawar: An Introduction to Nuclear Radiation & Health Physics. *IIP Iterative International Publishers*.
3. Alan Martin, Sam Harbison, Karen Beach & Peter Cole: An Introduction to Radiation Protection. *CRC Press*.
4. M. G. Stabin: Radiation Protection and Dosimetry. *Springer Nature*.
5. Glenn F. Knoll: Radiation Detection and Measurement. *John Wiley & Sons*.
6. A.K. Ghosh: An Introduction to Radiation Protection, *PHI Learning Pvt. Ltd.*
7. H.C. Verma, Radiation Physics, *Narosa Publishing House*
8. S.N. Ghoshal, S. Chand. Atomic and Nuclear Physics. *S Chand Publishing*
9. D.C. Tayal: Nuclear Physics, *Himalaya Publishing House*
10. R.R. Vora and P.B. Godkhindi: Medical Physics, *CBS Publishers & Distributors*
11. K. Thayalan: Textbook of Radiological Physics, *Jaypee Brothers Medical Publishers*
12. K. Padhy: Radiation Safety in Nuclear Medicine, *All India Publishers & Distributors*
13. Sushil Kumar: Fundamentals of Radiological Physics, *Jaypee Brothers Medical Publishers*
14. S.P. Sood: Basic Radiological Physics. *CBS Publishers & Distributors*

M.Sc. (Physics)
Semester - II
Dissertation/Project Work
(Credits: 10)

Dissertation/Project work:

This course will be based on preliminary research-oriented topics, both in theory and experiment. The teachers who will act as supervisors for the projects will float projects, and any one of them will be allocated to the students. At the completion of the project by the end of the semester, the student will submit a Project Report in the form of a dissertation, which will be examined by the examiners. The examinations shall consist of a presentation and a comprehensive viva voce.

Evaluation Process:

Evaluation by External and Internal – Dissertation (40) + Viva (20) – Total 60 Marks
Internal assessment (Test, Seminars, etc) = 40 Marks