Courses of Study

(Detailed Course Contents)

Integrated B.Sc. (Hons.) Physics – M.Sc. Physics & M.Sc. Physics Programmes

(2020-2021/ 2023-24 Batches)

Semester-X/ Semester-IV

Offered by

School of Physics

Shri Mata Vaishno Devi University

Kakryal, Katra 182320 Jammu & Kashmir

Course Structure of
Integrated B.Sc. (Hons.) Physics – M.Sc. Physics (2020-21 Batch) & M.Sc. Physics (2023-24 Batch)

Semester IX (5th Yr. Int. B.Sc.-M.Sc.) & Semester III (2nd Yr. M.Sc. Physics)

Course Category	Course Code	Course Name	L	T	P	Credits
Major (Core)	PHL 7101	Condensed Matter Physics	4	0	0	Core
Major (Core)	PHL 7071	Atomic and Molecular Physics	4	0	0	Core
Discipline Specific Elective (DSE-V)	PHL 7193/ PHL 7107	Introduction to Nanoscience and Nanotechnology/ Electronic Theory of Solids	4	0	0	Discipline Specific Elective (DSE-V)
Open Elective	XXX XXXX	To be offered by other Schools to our School	X	X	X	4
Minor Project	PHD 7134	Project Part-I	0	0	16	8

Semester X (5th Yr. Int. B.Sc.-M.Sc.) & Semester IV (2nd Yr. M.Sc. Physics)

Course Category	Course Code	Course Name	L	T	P	Credits
Major (Core)	PHL 7091	Nuclear and Particle Physics	4	0	0	4
Major (Core)	PHL 7022	Thermodynamics and Statistical Physics	4	0	0	4
Discipline Specific Elective (DSE-VI)	PHL 7194/ PHL 7094	Thin Films and Vacuum Technology/ Advanced Particle Physics	4	0	0	4
Open Elective-IV	PCE 7133	Philosophy of Yoga	4	0	0	4
Minor Project	PHD 7135	Project Part-II	0	0	16	8

PHL 7091			Nuclear & Particle Physics				Course Type		Major (Core)	
Batch			2020-21		Session	2024-25	Semester		Even	
L	T	P	C	Mid-Term Duration	Major Duration	Two Assignments (10 marks each)	Mid-Term Marks	4 Quizzes (5 marks each)	Major Marks	Total Marks
4	**0**	**0**	**4**	**1.5 hours**	**3 hours**	**20**	**20**	**20**	**40**	**100**

Unit-I **[10]**

Basic nuclear properties: size, shape and charge distribution, spin and parity. Binding energy, semi-empirical mass formula, liquid drop model. Nature of the nuclear force, form of nucleon-nucleon potential, charge-independence and charge-symmetry of nuclear forces.

Unit-II **[10]**

Deuteron problem: Simple theory of ground and excited states of deuteron, spin dependence of nuclear forces, nucleon-nucleon scattering, Evidence of shell structure, single-particle shell model, its validity and limitations, collective model, Rotational spectra.

Unit-III **[10]**

Elementary ideas of alpha, beta and gamma decays and their selection rules. Fission and fusion, Bohr-Wheeler theory of nuclear fission, Nuclear reactions, reaction mechanism, endothermic and exothermic reactions, Compound nucleus model, Resonance scattering: Breit-Wigner formula, optical model, direct reactions.

Unit-IV **[6]**

Sensitivity of detector, response of detector, energy resolution of detector, efficiency of detector, dead time detector, ionization chamber, proportional counter, Geiger-Muller counter, scintillation detector, Synchro-cyclotron, betatron, linear accelerator, nuclear chain reaction, general aspects of reactor design, classification of reactors.

Unit-V **[9]**

Classification of fundamental forces, Elementary particles and their quantum numbers (charge, spin, parity, isospin, strangeness, etc.). Fundamental interactions among particles Gellmann-Nishijima formula. Quark model, baryons and mesons. C, P, and T invariance. Application of symmetry arguments to particle reactions. Parity non-conservation in weak interaction. Relativistic kinematics.

SUGGESTED BOOKS

1. Cohen, B.L., Concepts of Nuclear Physics, 2005, Tata McGraw-Hill, New Delhi
2. Griffiths, D., Introduction to Elementary Particles, 1987, John Wiley & SonsHeyde, K., Basic Ideas and Concepts in Nuclear Physics, 2005, Overseas Press, India
3. Kaplan, I., Nuclear Physics, 1998, Narosa Publishing House, New Delhi
4. Wong, S.S.M., Introductory Nuclear Physics, 2005, Prentice-Hall, India

PHL 7022			Thermodynamics and Statistical Physics				Course Type		Major (Core)	
Batch			2020-21		Session	2024-25	Semester		Even	
L	T	P	C	Mid-Term Duration	Major Duration	Two Assignments (10 marks each)	Mid-Term Marks	4 Quizzes (5 marks each)	Major Marks	Total Marks
4	**0**	**0**	**4**	**1.5 hours**	**3 hours**	**20**	**20**	**20**	**40**	**100**

Unit-I: **[12]**

Laws of thermodynamics and their consequences. Thermodynamic potentials, Maxwell relations, chemical potential, phase equilibrium. The macroscopic and microscopic states – contact between statistics and thermodynamics – the classical ideal gas.

Unit-II: **[12]**

Phase space, density of distribution in phase space, ergodic hypothesis, Classical distribution law: micro- and macro-states. Micro-canonical, canonical and grand-canonical ensembles and partition functions. Free energy and its connection with thermodynamic quantities. Postulate of equal a priori probability.

Unit-III: **[12]**

Ideal Bose and Fermi gases. Energy and pressure of gas, Bose Einstein condensation, thermal properties of BE gas, liquid helium, London theory, Ideal Fermi Dirac gas, energy and pressure of gas, slight and strong degeneracy, thermodynamic function of FD gas. Principle of detailed balance. Blackbody radiation andderivation of Planck's distribution law.

Unit-IV: **[12]**

Classification of phase transitions, First- and second-order phase transitions. Critical exponents, Ising model, Bragg William Approximation, Diamagnetism, paramagnetism, and ferromagnetism. Fluctuations in thermodynamic quantities: energy, pressure, volume, enthalpy.

Unit-V: **[12]**

Diffusion equation. Random walk and Brownian motion, Fokker Planck equation, Wiener and Khintchine theorem, electrical noise. Introduction to non-equilibrium processes. Boltzmann transport equation-drift variation and collisions or scattering variations, chamber's equation.

SUGGESTED BOOKS

1. Walter Greiner, Ludwig Neise, Horst Stocker "Thermodynamics and Statistical Mechanics" Springer
2. Kerson Huang "Introduction to Statistical Physics" Taylor and Francis, 2001
3. P K Pathria "Statistical Mechanics" 2nd Ed.
4. J K Battacharjee, Statistical Physics; Allied Publishers (India)
5. F Reif, Statistical and Thermal Physics, McGraw Hill
6. C Kittel, Thermal Physics, CBS Indian Ed.

PHL 7194			Thin Films and Vacuum Technology				Course Type		DSE-VI	
Batch			2020-21		Session	2024-25	Semester		Even	
L	T	P	C	Mid-Term Duration	Major Duration	Two Assignments (10 marks each)	Mid-Term Marks	4 Quizzes (5 marks each)	Major Marks	Total Marks
4	**0**	**0**	**4**	**1.5 hours**	**3 hours**	**20**	**20**	**20**	**40**	**100**

Unit-I
Introduction to Thin films **[6]**

Thermodynamics and Thin Film growth

Unit -II
Vacuum Technology **[8]**

Gas Laws, Kinetic Theory of Gases, Conductance and Throughput, Gas Sources in a Vacuum Chamber, Vacuum Pumps vacuum pumps (Rotary, diffusion and turbo molecular pump) and measurement gauges.

Unit -III
Film Formation and Structure **[12]**

Stages of thin film formation: Nucleation, Adsorption, Surface diffusion, capillarity theory of nucleation, statistical theory of nucleation, growth and coalescence of islands, grain structure and microstructure of thin films, diffusion during film growth, polycrystalline and amorphous films.

Unit -IV
Methods of Preparation of Thin Films **[15]**

Physical vapour deposition: Vacuum evaporation-Hertz- Knudsen equation, evaporation from a source and film thickness uniformity, Sputtering (Plasma Physics (DC Diode), rf Plasmas, Magnetic Fields in Plasmas, Sputtering Mechanisms) and sputtering yield, Sputtering of alloys; magnetron Sputtering, Reactive sputtering; Pulsed laser deposition (PLD). Chemical vapour deposition: Mechanisms, Materials, Chemistries, Systems, PECVD.

Unit -V
Characterization of thin films **[9]**

Deposition rate, Film thickness and uniformity, Structural properties: Crystallographic properties, defects, residual stresses, adhesion, hardness, ductility, electrical properties, magnetic properties; optical properties.

Reference Books:

1. R. K. Waits, Thin Film Deposition and Patterning, American Vacuum Society, 1998.
2. M. Ohring, The Materials Science of Thin Films, Academic Press, Boston, 1991.
3. LudmilaEckertova, Physics of Thin Films, 2nd Plenum Press New York, 1986
4. Kasturi L. Chopra, Thin Film Phenomena (McGraw-Hill, 1969)

PHL 7094			Advanced Particle Physics				Course Type		DSE-VI	
Batch			2020-21	Session		2024-25	Semester		Even	
L	T	P	C	Mid-Term Duration	Major Duration	Two Assignments (10 marks each)	Mid-Term Marks	4 Quizzes (5 marks each)	Major Marks	Total Marks
4	**0**	**0**	**4**	**1.5 hours**	**3 hours**	**20**	**20**	**20**	**40**	**100**

Unit-I **[8]**

Elementary particles and the fundamental forces, Quarks and Leptons, The mediators of the electromagnetic, weak and strong interactions. Interaction of particles with matter; Decays and conservation laws, Unification schemes

Unit-II **[8]**

Relativistic kinematics: Lorentz transformations, Four-vectors, Four-forces, Energy and momentum, Collisions, Classical and relativistic collisions, Examples and applications.

Unit-III **[12]**

Symmetries, group theory, The group SU(2), Finite Symmetry Group: P and C, SU(2) of Isospin, The group SU(3), Angular momentum and its addition, Spin ½, Flavor symmetries, Discrete symmetries, Parity, Charge conjugation, CP, Neutral kaons, CP violation, Time reversal, the CPT theorem, Bound states.

Unit-IV **[12]**

Decay rates and Cross sections, Feynman diagrams, Introduction to Feynman integrals. The Dirac equation and its solution, Feynman rules for quantum electrodynamics (no derivation), Examples, Quark content of Mesons and Baryons,Color factors, Pair annihilation in quantum chromodynamics, Asymptotic freedom.

Unit-V **[10]**

Charged leptonic weak interactions, Decays of Muon, Neutron and Pion, Charged Weak interactions of Quarks, Neutral weak interactions, Electroweak unification, Beyond the standard model (elementary idea only).

Reference Books:

1. Francis Halzen and Allan D. Martin, Quarks and Leptons: An Introductory Course in Modern Particle Physics, John Wiley and Sons
2. B.R. Martin and G. Shaw, Particle Physics, 2nd edition, J. Wiley and Sons (1997).
3. The Review of Particle Physics, (Particle Data Group)
4. David Griffiths: Introduction to Elementary Particles.
5. Byron Roe: Particle Physics at the New Millennium.
6. Donald Perkin: Introduction to high energy physics.
1. Nuclear and Particle Physics, W.E. Burcham, Pearson.

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