TEERTHANKER MAHAVEER UNIVERSITY

(Established under Govt. of U. P. Act No. 30, 2008)

Delhi Road, Moradabad (U.P.)

PhD PROGRAMME

SYLLABUS FOR DISCIPLINE-SPECIFIC COURSE

PHYSICS

Course Code: PDS240126	Advances in Physics	L	T	P	C
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Objective:	To familiarize the research scholar with the fundamentals of scientific research.				
Course Outcomes:	On completion of the course, the students will be able to:				
CO 1:	Understand Mathematical and classical Physics.				
CO 2:	Understand Electrostatics and quantum theory.				
CO 3:	Understand Thermodynamic and Statistical Physics.				
CO 4:	Understand Atomic & Molecular Physics.				
CO 5:	Analyze the Condensed Matter and Nuclear Physics.				
Course Content:					
Unit 1:	Mathematical and classical Physics: Dimensional analysis, Vector algebra and vector calculus, Linear algebra, matrices, Cayley-Hamilton Theorem. Eigenvalues and eigenvectors. Linear ordinary differential equations of first & second order, Special functions (Hermite, Bessel, Laguerre and Legendre functions), Fourier series, Fourier and Laplace transforms. Elements of complex analysis, analytic functions; poles, residues and evaluation of integrals. Classical Mechanics Newton's laws. Dynamical systems, Phase space dynamics, stability analysis. Central force motions. Two body Collisions - scattering in laboratory and Centre of mass frames. Rigid body dynamics- moment of inertia tensor. Non-inertial frames and pseudo forces. Variational principle. Generalized coordinates. Lagrangian and Hamiltonian formalism and equations of motion. Conservation laws and cyclic coordinates.				
Unit 2:	Electrostatics and quantum theory: Gauss's law and its applications, Laplace and Poisson equations, boundary value problems. Magnetostatics: Biot-Savart law, Ampere's theorem. Electromagnetic induction. Maxwell's equations in free space and linear isotropic media; boundary conditions on the fields at interfaces. Electromagnetic waves in free space. Dielectrics and conductors. Reflection and refraction, polarization, Fresnel's law, interference, coherence, and diffraction. Quantum Mechanics: Wave-particle duality. Schrödinger equation (time-dependent and time-independent). Eigenvalue problems (particle in a box, harmonic oscillator, etc.). Tunneling through a barrier. Wave-function in coordinate and momentum representations. Commutators and Heisenberg uncertainty principle. Motion in a central potential: orbital angular momentum, angular momentum algebra, spin, addition of angular momenta; Hydrogen atom. Identical particles, Pauli Exclusion Principle.				

Unit 3:	Thermodynamic and Statistical Physics: Laws of thermodynamics and their consequences. Thermodynamic potentials, Maxwell relations, chemical potential, phase equilibria. Phase space, micro- and macro-states. Micro-canonical, canonical and grand-canonical ensembles and partition functions. Free energy and its connection with thermodynamic quantities. Classical and quantum statistics. Ideal Bose and Fermi gases. Principle of detailed balance. Blackbody radiation and Planck's distribution law. First- and second-order phase transitions. Diamagnetism, paramagnetism, and ferromagnetism. Bose-Einstein condensation. Diffusion equation. Random walk and Brownian motion.
Unit 4:	Atomic & Molecular Physics: Quantum states of an electron in an atom. Electron spin. Spectrum of helium and alkali atom. LS & JJ couplings. Zeeman, Paschen-Bach & Stark effects. Electron spin resonance. Nuclear magnetic resonance, chemical shift. Electronic, rotational, vibrational and Raman spectra of diatomic molecules, selection rules. Lasers: spontaneous and stimulated emission, Einstein A & B coefficients. Optical pumping, population inversion, rate equation. Modes of resonators and coherence length. Semiconductor devices (diodes, junctions, transistors, field effect devices, homo- and hetero-junction devices), device structure, device characteristics, frequency dependence and applications. Opto-electronic devices (solar cells, photo-detectors, LEDs).
Unit 5:	Condensed Matter and Nuclear Physics:Bravais lattices. Reciprocal lattice. Diffraction and the structure factor. Phonons, lattice specific heat. Free electron theory and electronic specific heat. Response and relaxation phenomena. Drude model of electrical and thermal conductivity. Hall effect and thermoelectric power. Electron motion in a periodic potential, band theory of solids: metals, insulators and semiconductors. Superconductivity: type-I and type-II superconductors. Josephson junctions. Nuclear and Particle Physics 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. Deuteron problem. Evidence of shell structure, single-particle shell model, its validity and limitations. Rotational spectra. Elementary ideas of alpha, beta and gamma decays and their selection rules. Fission and fusion. Nuclear reactions, reaction mechanism, compound nuclei and direct reactions. Classification of fundamental forces. Elementary particles and their quantum numbers (charge, spin, parity, isospin, strangeness, etc.). Gellmann-Nishijima formula. Quark model, baryons and mesons. C, P, and T invariance.
Textbooks:	1. Concepts of Modern Physics by Arthur Beiser (McGraw-Hill Book Company. 2. Introduction to Electromagnetic Theory, T.L. Chow, Jones & Bartlett Learning Fundamentals of Electromagnetics, M.A.W. Miah, Tata McGraw Hill. 3. Quantum Physics of Atoms, Molecules, Nuclei and Solids: R. M. Eisberg and R. Resnick.
Reference Books:	1. Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. Bence, Cambridge University Press. 2. Introduction to Solid State Physics, Charles Kittel, Wiley India Pvt. Ltd. 3. Statistical Physics: Berkeley Physics Course by F Reif (Tata McGraw-Hill Company Ltd. 4. Fundamentals of Nuclear Physics: B. B. Srivastava.
Additional Electronic Reference Material:	1. https://www.youtube.com/watch?v=y3ARLfm-52w 2. https://www.youtube.com/watch?v=SZbNx4VfMzg 3.https://www.youtube.com/watch?v=zy9aLwWtGDU&list=PL3V8X5qWC1MRmSvEMZUjTU3BisDsi2KqV&index=24 4.https://www.youtube.com/watch?v=jVAoBWy8VE&list=PL_uaeekrhGzL9fDd1Mohm9Llzah1yFYem