# SWAMI RAMANAND TEERTH MARATHWADA UNIVERSITY, NANDED

## Ph. D. ENTRANCE TEST (PET) SYLLABUS FOR PHYSICS

## Section-B

**Unit I: Mechanics and Properties of Matter:**

Newton's law of Gravitation, Keplar's laws of Planetary Motion ,Newton's deduction from Keplar's laws, Gravitational Field, Gravitational Intensity, Gravitational Potential, Gravitational Potential energy ,Potential and field Intensity due to uniform Solid Sphere at a point (Point inside and outside), Three types of Elastic stress and Strains, Deformation of cube ( Bulk Modulus),Modulus of Rigidity and Young's modulus, Relation connecting elastic constants, Twisting couple on a cylinder or a (wire), Tensional pendulum, Bending of Beam, Bending Moment, Cantilever (Weight of the beam is ineffective, Weight of the beam is effective), Depression of a Beam supported at the ends and loaded at the centre, Surface Tension, Curvature pressure and Surface Tension, Difference of pressure on two sides of Spherical drop, Expression for Excess Pressure inside a Spherical Drop and spherical Soap Bubble, Surface,Coefficient of Viscosity , Streamline flow, Reynolds number, Bernoullie's theorem, (Kinetic energy, Potential energy, Pressure energy) Poiseuille's equation for the flow of liquid through a tube.

**Unit II: Waves and Oscillations:**

**Free and damped oscillations**: differential equation of undamped vibration (SHM) and its solution (exponential form), Damped vibrations, differential equation of damped harmonic oscillator and its solution. energy equation of damped oscillation.

**Forced oscillation**: differential equation of forced vibration and its solution, resonance; amplitude and velocity resonance; sharpness of resonance, energy of forced oscillation, quality factor, and bandwidth.

**Wave motion**: Wave velocity and particle velocity, Differential equation of wave motion, Energy of a plane progressive wave, Equation of motion of a vibrating string, Velocity of transverse waves along a string, Frequency and period of vibration of a string. Distribution of Energy in a stationary wave, Energy is not transferred in a stationary wave. Noise and Musical sounds, Loudness, pitch, Quality, Intensity of Sound, The Decibel, The Phon , Bel, Reverberation, Reverberation time, Absorption coefficient, Sabine's formula,. Transducers and their characteristics, pressure microphone, moving coil loud speaker, process of recording and reproduction of sound in compact disc. Ultrasonics, properties of ultrasonic waves, Piezo-electric & magnetostriction effect, production of ultrasonic waves by Piezo electric & magnetostriction oscillator, acoustic grating, Application of ultrasonic waves.

**Unit III: Heat and Thermodynamics and Statistical Physics:**

Mean free path, Transport Phenomena, Viscosity of Gases, Thermal Conductivity of Gases, Diffusion, Inter relation between three transport coefficients, Zeroth Law of Thermodynamics, First Law of Thermodynamics, Relation connecting P,V and T in an Adiabatic Process, Second Law of Thermodynamics ,Carnot's cycle, Carnot's Engine and its efficiency, Carnot's Theorem, Entropy changes of a Closed System during an Irreversible Process, Entropy, Third Law of Thermodynamics, Maxwell's Thermodynamical Relations, T-ds equations, Clausius- Clapeyron latent heat equations, Internal energy, Helmholtz' function, Enthalpy, Gibb's function.

**Statistical Physics**: Phase space, Micro and Macro states, Ensemble, Thermodynamic probability, Maxwell-Boltzmann statistics and Distribution law, Bose- Einstein statistics and Distribution law, Fermi- Dirac statistics and Distribution law. Application of quantum Statistics to photon gas and electron gas ,

**Unit IV: Electrostatics:** Polarization, field outside a dielectric media, Gauss's law in a dielectric-the electric displacement, Electric susceptibility and dielectric constant, Clausius-Mossotti equation, Induced dipoles. Applications of Biot and Savart's law for long straight conductor and circular coil Generalization of Ampere's law-displacement current, Maxwell's equations and their derivations. Electromagnetic Energy, Wave equations for electric (**E**) and magnetic (**H**) field

**Unit V: Optics:**

Cardinal Points of an Optical System(six points), Newton's formula , Nodal slide, Coaxial Lens System (equivalent focal length and cardinal points), Huygens Eyepiece, Ramsden Eyepiece and their cardinal points. Newton's Rings, Determination of wavelength of Sodiumlight, Michelson Interferometer, Determination of wavelength of monochromatic light, Difference in wavelength between two neighboring spectral lines. Fresnel and Fraunhofer diffraction, Fraunhofer's diffraction due to single and double slit, Plane diffraction grating, Determination of wavelength of Sodium light, Rayleigh criterion, Resolving power of grating, Resolving power of Prism. Polarization by Reflection, Brewster's law, Malus law, Double refraction, Nicol prism, Nicol prism as an analyzer, Huygen's explanation of double Refraction in Uniaxial crystals , Optic axis in the plane and inclined to the crystal surface, Elliptically and Circularly polarized light, Quarter wave plate, Half wave plate, Optical Activity , Specific rotation, Laurent's half shade polarimeter.

**Unit VI: Mathetical Methods in Physics**

**Vector Analysis**

Vector triple product, Scalar triple product, Vector identity, Scalar and vector field , Gradient of a scalar field , Divergence of a vector field and Curl of a vector field and their Physical interpretation , Laplacian Operator ($\nabla^2$), Line integral, Surface integral,

Volume integral, Gauss's divergence theorem, Stoke's theorem, Green's theorem Vector Identities ,

complex algebra (Addition, Subtraction, Multiplication, Division, conjugate complex number), Argand diagram, Graphical representation of Sum, Difference, product and Quotient of complex number, Extraction of Roots, Properties of moduli ,arguments and geometry of complex numbers, , Rectangular, polar and exponential form of complex numbers,

Definition of Partial Differentiation, Successive Differentiation, total Differentiation , Exact Differentiation, Chain rule, Theorem of Differentiation, Change of variables from Cartesian to Polar Co-ordinates, Implicit and explicit functions, Condition for maxima and minima ( without proof), Definition, Evaluation of the coefficients of Fourier series, Cosine series, Sine series, Dirichlet's Theorem, Graphical representations of even and odd functions, Physical applications of Fourier series analysis, Square wave, Half wave Rectifier

**Unit VII: Solid State Physics and electronics**

Bravais lattices, Reciprocal lattice, diffraction and the structure factor; Drude-Lorentz theory, Thermal conductivity, Electrical conductivity, Widemann- Franz relation, Summerfeld Model, Fermi dirac Distribution, Quantum theory of free electron in a box, Free electron concentration, Electronic specific Heat, Explanation of Diamagnetism, Para magnetism, ferromagnetism, Anti ferromagnetism, Specific heat of solids, Classical theory of Lattice heat Capacity, Einstein's theory of heat Capacity , Limitations, Debye's theory of specific heat of solids, Debye contimum Model, Limitations of Debye model.

Energy bands in solids, Intrinsic and Extrinsic Semiconductor, improved model of an insulator and Intrinsic Semiconductors, Model for impurity semiconductors, n-type semiconductors, P- type semiconductors. Donor Level, Acceptor level, P-N junction theory,

**Unit VIII : Atomic Molecular Physics**

**Atomic and Molecular Physics;** The Vector Atom Model, Quantum numbers associated with the vector atom model, LS and J-J coupling, The Pauli's exclusion Principle, Selection rules, Intensity rules, Interval rule, Normal Zeeman effect, Anomalous Zeeman effect, Stark effect.

Electromagnetic Spectra, Classification of Molecular Spectra, Theory of pure rotational spectra, Theory of rotation-vibration spectra, Raman Effect, Experimental study, Raman Effect in solids, liquids and gases.

**Unit IX: Nuclear Physics:**

Proton Electron Hypothesis, Nuclear transmutation and Discovery of Neutron, Proton-neutron hypothesis to Nuclear forces, Nuclear Binding energy, Shell model, Liquid Drop Model and Semi-Empirical Binding energy formula, Geiger Muller counter, Proportional counter, Wilson Cloud Chamber, Ionization chamber, Linear accelerator, Cyclotron. Synchrocyclotron, principal of phase stability.

**Unit X: Quantum Mechanics:**

Introduction, Photoelectric Effect, X-rays, X-ray diffraction , Quantum Theory of Light, The Compton Effect, de Broglie waves, Wave function, de Broglie Wave Velocity, Wave and Group velocities, G. P. Thomsons experiment, The Uncertainty principle and its applications, The Wave Particle Duality, Schrödinger's Equation: Time dependent form, Probability current, Expectation Values, Operators, Schrödinger's Equation: Steady-state form, Eigen values and Eigen functions,

**Applications of Quantum Mechanics:** The particle in a box :energy quantization, The particle in a box :wave functions, The particle in a box : Momentum Quantization, The Harmonic Oscillator, The Harmonic Oscillator-Energy level, The particle in a three dimensional box, Schrödinger's equation for the Hydrogen Atom, Quantum numbers – Total quantum number, Orbital quantum number, Magnetic quantum number.

**UNIT I: Maxwell's equations and Electromagnetic waves:** Maxwell's equations and their physical significance. Equation of continuity and relaxation time, Vector and scalar potentials, Lorentz and Coulomb gauge, electromagnetic energy and Poynting's theorem, electromagnetic wave equations in free space, their plane wave solutions, waves in conducting medium: skin depth, waves in ionized medium (ionospheric propagation) polarization of EM waves. Concept of radiation pressure, Reflection and refraction of plane electromagnetic waves at a plane interface: normal incidence, oblique incidence, Fressnel's equations, and Brewster's angle. Total internal reflection. Reflection and refraction from metallic surfaces, Electromagnetic wave propagation between two parallel conducting plates, waves in hollow conductors, Rectangular wave guides – TE and TM modes.

**Unit II: Radiations from moving charges:** Concept of retarded potential, The Lienard-Wiechert potentials, Fields produced by moving charges, radiations from an accelerated charged particle at low velocities, radiations from a charged particles with co-linear velocity and acceleration, Radiations from an accelerated charged particle at low velocities in circular orbits-Larmor formula, Radiations from an accelerated charged particle at relativistic velocities in circular orbits relativistic generalization of Larmor Formula. Multipole expansion of EM fields, Electric dipole radiations, field due to oscillating electric dipole, magnetic dipole radiations, electric quadrupole radiation, fields due to linear, centre-fed antenna, simple array of antennas. electromagnetic field tensor, covariance of electrodynamics, Lorentz force and equation of motion of a charged particle in an electromagnetic field, Covariance of Maxwell's equations, transformation of EM fields and field tensor. Electromagnetic wave equation and plane wave solution in 4-vector form.

**Unit III: Nuclear Physics and Particle Physics**

Nuclear size & its determination, nuclear radii by Rutherford scattering, electron scattering & mirror nuclei method, nuclear quantum numbers, angular Momentum, nuclear dipole moment, electric quadruple moment, Interaction of charged particles & em rays with matter, range, straggling, stopping power, scintillation detector, semiconductor detector. Elements of two body problem, charge independence & charge symmetry of

nuclear forces, Meson theory of nuclear forces, collective model, collective model, Fermi gas model. Radioactive decay, laws of successive transformation, dosemetry nuclear reactions, fission & fusion, B – decay, three forms of B- decay, Fermi theory of B- decay, kurie plot, selection rule, non conservation of parity in B- decay. Weak, strong & electromagnetic interaction, classification of elementary particles, conservation laws, quark theory.

**Unit IV: Basics of Laser and Devices**

Properties of Lasers,Intensity,Monochromaticity,Directionality and coherence, Einstein's coefficients, Momentum transfer, Life time and possibility of amplification. Concepts of waves and interference, Temporal and spatial coherence, Coherence of the field and size of the source, Coherence and monochromaticity, Shape and width of spectral lines, Line broadening mechanism, Intrinsic broadening, collision broadening, Doppler broadening. Basic principles of lasers, population inversion, Laser pumping, Two level and three level pumping, Vibrational modes and mode density of resonator, Open and confocal resonator. **Ruby laser**, Three level system and its pumping power, Nd:YAG and Nd:Glass laser ,its energy level diagram and salient features. **He-Ne lasers:** Energy level diagram, construction and salient features of theHe-Ne laser device, **He-Cd and He-Sc laser:** Energy level description and salient features, Molecular gas laser-CO2 gas laser, Energy level scheme and general features. Nonlinear optics, Harmonic generation, Phase matching, Optical mixing parametric generation of light and self focusing. **Applications of Lasers:** Applications of lasers in (i) Communication (ii) Industry (iii) Medicine (iv) Biology (v) Astronomy.

**Unit V: Thin Film and Nano Physics**

Introduction to Thin Films, Physical Methods - Thermal evaporation methods: Resistive heating, Flash evaporation, Laser evaporation, Electron bombardment, heating, Arc evaporation, Sputtering process: Glow discharge, DC sputtering, Radio frequency sputtering, Magnetron sputtering, Ion beam sputtec Common CVD reactions, Methods of film, preparation, laser CVD, Photochemical CVD, Plasma enhanced CVD, Chemical bath deposition: ionic and solubility products, preparation of binary semiconductors,

**Electrode position:** Deposition mechanism and preparation of compound thin film **Spray pyrolysis**: Deposition mechanism and preparation of compound thin Films **Nanoscience and nanotechnology** Introduction, Nanoscience and nanotechnology, Quantum structures, Nanoclusters, organic nanocrystals. **Synthesis of Nanomaterials:** metal colloids, Nanoclusters, nanotubes, nanowires, nano rods, nanocrystalline materials, oxide nanoparticles. **Application of Nanotechnology**: Nanobiology, nanocatalysis, nanoelectrodes,
nanoswitches, nanocomputers.

**Unit VI: Atomic & Molecular Mathematical Physics:**

Quantum states of an electron in an atom; Electron spin; Stern-Gerlach experiment; Spectrum of Hydrogen, helium and alkali atoms; Relativistic corrections for energy levels of hydrogen; Hyperfine structure and isotopic shift; width of spectral lines; LS & JJ coupling; Paschen Back & Stark effect; Electron spin resonance, Nuclear magnetic resonance, chemical shift; Rotational, vibration, electronic, and Raman spectra and diatomic molecules; Frank – Condon principle and selection rules.

**Matrices and Vector space**Definitions, Algebra and Properties Rank of matrix, special matrix with their properties, Transformation, Inverse of matrix, Trace of matrix, characteristic roots and characteristic vectors, Digonalization of matrix.

**Special function of Mathematical Physics**

Legendre's equation, Rodrigues formula For $P_n(X)$, The generating function for $P_n(X)$, Orthogouality of Legendre polynomials, the associated legendre functions its orthogonality, Hermit's equation, Rodrigues formula for Hermit polynomial, Recurrence relation, Generating function, Orthogonal Hermit's function, Laguerre's equation, generating function for Laguerre's polynomial $L_n(X)$, Rodrigues formula and orthogonality, Associated Laguerre polynomials $L_n^m(X)$,

**Integral Transforms (L.T)** Laplace transform, First and Second shifting theorem, Inverse L.T. by partial function, Laplace transform of derivative and integral of a function. Fourier integral and transforms and its properties.

**Unit VII: Condensed Matter Physics:**

Interaction of X – rays with matter, X – ray diffraction according to Braggs law, Reciprocal lattice, Properties of reciprocal Lattice to 1) Simple cubic (SC) lattice, 2) Body centered cubic (BCC) lattice, 3) Face centered cubic (FCC) lattice, The Bragg condition and Ewald construction, Brillouin zones for 1) One dimensional lattice, 2) Two dimensional square lattice, 3) Simple cubic lattice, 4) Body centered cubic (BCC) lattice, 5) Face centered cubic (FCC) lattice, atomic scattering factor, Geometrical structure factor, Laue method, Rotating crystal method powered method.

Electron motion in crystal ( oe dimensional), Bloch theorem, Kroning – penny model, the concept of effective mass, concept of hole, metals insulators and semiconductor, The nearly free electron model, Tight binding approximation, Wingewr-seiz cellular method, Orthogonalised plane wave (opw) method, Pseudo potential method, Fermi surface. Diamagnetism, paramagnetism, and ferromagnetism; Electron motion in a periodic potential, Superconductivity, Type – I and Type – II superconductors

**Unit VIII: Classical Mechanics and Quantum Mechanics**

Constraints classification of constrains, Principle of virtual, De'Abembert's principle and its application, Generalized coordinates, Newtonian mechanics for many particle system, conservation laws, work energy theorem,

Lagrangian equation of motion, Variation techniques, Kinetic energy in terms of generalized coordinates, Theorem on total energy, Generalized momentum cyclic coordinates, Integrals of motions, Concept of symmetry, Invariance under Galilean transformation, Variational principal., Two boby problem, The equation of motion and first integral, Equation of orbit, Kepler's laws, Kepler's problem and general analysis of orbits, stability of orbits, Rutherford scattering, Differentials scattering cross section, Rutherford's formula viral theorem, Principal of least actions, derivation of equations of motions, variation and end points, Hamilton's principle, and characteristic, Hamlton Jacobii equation Canonical transformation, generating function condition for canonical transformation problems.

Postulates of quantum Mechanics, representation of states and dynamical variations, self adjionts, operations, eigen values and eigen functions, degerency, Approximation Methods Time independent perturbation theory, application to Zeeman and stark effect,

Time dependent perturbation theory, transition amplitude, constant perturbation, Fermi golden rule, sudden and adiabatic approximations, Variational method, basic principle and application to hydrogen atom and He atom WKB approximation condition for validity, connection formulae, application to tunneling.

**Unit IX: Statistical Physics**

Fundamentals :- Macroscopic and microscopic state; phase space; Ensemble and ensemble ,Average; Liouville's theorem; Density matrix, Micro canonical Ensemble – Microcanonical distribution; equal a priori probability; Entropy; Entropy of a perfect gas in a microcanonical ensemble; Gibbs paradox; Thermodynamic quantities in a microcanonical ensemble; Sackur – Tetrode formula, Canonical Ensemble – Canonical distribution; canonical partition function; Maxwell distribution of velocities; Thermodynamic quantities in a canonical ensemble; classical system in canonical ensemble; Gibbs paradox. Grand Canonical Ensemble – Grand canonical distribution; Grand canonical partition function ;Thermodynamic quantities in a grand canonical ensemble; Classical system in a grand canonical ensemble; Density and energy fluctuations a grand canonical ensemble, Phase Transitions – First-order phase transitions; Equilibrium between two phases; Clapeyron-Clausius equation; Scaling hypothesis; Critical indices; Second-order phase transition; Ising model; Landau theory.

Kinetic and Dynamical Theories of Gases :- Boltzmann transport equation; Mean free path; Transport properties; Fluctuations and thermodynamics properties; Brownian motion; Langevin theory .

**UNIT X: Electronics,:**

Semiconductor device physics, including diodes, junctions, transistors, field effect devices, Optoelectronic devices, including solar cells, photo detectors and LEDs; Operational amplifiers and their applications; Digital techniques, Logic gates, NAND,NOR gates building block, X-OR gate, Half and full adders, registers, counters, comparators, A/D and D/A converters; Microprocessor and microcontroller basics.