2ND SEMESTER EXAMINATION, APRIL – 2005

PHYSICS – I

Full Marks – 70

Time – 3 Hours

The figures in the right hand margin indicate full marks for the questions.

*Answer Question No. 1 which is compulsory and any **five** questions from the rest.*

(Given : $h = 6.62 \times 10^{-34}$ J.s, $e = 1.6 \times 10^{-19}$ C, $m_e = 9.1 \times 10^{-31}$ kg.)

1. Answer **all** questions : 2×10

(a) The natural angular frequency of a simple harmonic oscillator of mass 2 gram is 0.8 rad/s. It undergoes critically damped

motion when taken to a viscous medium. Find the damping force on the oscillator when its speed is 0.2 cm/s.

(b) Twenty sinusoidal waves of equal amplitude superpose incoherently to produce a resultant wave of intensity 0.5 watt/m^2. What would be the resultant intensity if the waves superpose coherently ?

(c) In a Newton's ring experiment performed in air, the diameter of a given ring is 0.2 mm. When a liquid is introduced between the lens and the plane glass plate below it, the diameter of the ring shrinks to 0.17 mm. Find the refractive index of the liquid.

(d) The primary focal length of a Fresnel zone plate is 8 cm with monochromatic red light ($\lambda = 6000$ Å). What would be the focal length if a monochromatic light with $\lambda = 4800$ Å is used ?

(e) A light beam is allowed to pass through a Nicol prism. As the prism is rotated about an axis parallel to the incident beam, the intensity of the emergent beam undergoes variation and becomes zero at one position. What is the state of polarization of the incident light beam ?

(f) Write the Maxwell electromagnetic equation which follows from the non-existence of isolated magnetic pole.

(g) A plane electromagnetic wave travels vertically upward. If the magnetic field of the e.m. wave is eastward, what is the direction of the associated electric field ?

(h) In an experiment demonstrating photoelectric effect, the maximum kinetic energy of the emitted photoelectrons 1.6 eV. The source of monochromatic light is moved away from the photocell so that the intensity of light incident on the photocell decreased by 10%. How is the maximum kinetic energy of the photoelectrons affected ?

(i) Transition between which energy levels of hydrogen atom produces the most intense spectral line of the Balmer series ?

(j) A particle is in one-dimensional infinitely deep potential well. If its ground state energy is 0.8 eV, what is the energy of the second excited state ?

2. (a) Starting from the differential equation of a damped oscillator, write the solution for under-damped oscillatory motion. Graphically show the variation of amplitude with time. Mention the condition for critical damping. 5

(b) Write the wave equation for a one-dimensional wave propagating along the (+) ve Y-axis in an elastic medium of density ρ and bulk modulus B. 2

(c) Find the speed of a longitudinal wave propagating in a medium of density 6×10^3 kg/m^3 and bulk modulus 1.2×10^8 N/m^2. 3

3. (a) Two harmonic waves of the same amplitude and frequency, but different phase superpose. Obtain expression for amplitude and phase of the resultant wave. 5

(b) In Young's double slit experiment, the screen is 1 m away from the slits. The separation between the slits is 1 mm and the distance between the 1st and 4th fringe is 1.2 mm. Determine the wavelength of light used. 3

(c) In a Newton's ring system, the center is bright. Is the ring system observed in reflected or transmitted light ? Justify your answer. 2

4. (a) Mention the similarities and differences between a zone plate and a converging lens. 4

(b) A plane diffraction grating of width 2.5 cm has 12500 rulings on it. What is the maximum order of grating spectrum observable for incident light of wavelength 5500 Å ? 3

(c) In Fraunhofer diffraction due to single slit, the first order minimum is observed at angle 30° with the incident beam. What is the width of the slit if wavelength of incident light is 6000 Å ? 3

5. (a) Give the construction of Nicol prism. Explain how it produces polarized light. 7

(b) The refractive indices of a double refracting crystal for ordinary and extra-ordinary rays are 1.584 and 1.592 respectively for wave-length 5600 Å. Determine the thickness of the crystal required to produce a quarter wave plate. 3

6. (a) Evaluate the divergence of the vector field $\vec{F} = \hat{i}\,2xy + \hat{j}\,y^2 + \hat{k}\,3xz$ at (1, 1, 0). 3

(b) State Ampere's circuital law and obtain its differential form. 4

(c) Distinguish between displacement current and conduction current. 3

7. (a) Starting from Maxwell's electromagnetic equations in free space, obtain Poynting theorem. 7

(b) Write the electromagnetic wave equation in free space, in absence of charges and currents, in terms of scalar and vector potential. 3

8. (a) Write the time-dependent Schrodinger equation for a free particle moving along the Z-axis. 3

(b) Evaluate the de Broglie wavelength of a particle of mass 6.62×10^{-30} kg moving with speed 10 cm/s. 4

(c) Write the boundary conditions satisfied by the quantum mechanical wave function at the boundary between two regions. 3