B.Tech/ BT/CE/CHE/EE/ME/ 1st Sem/PHYS-1001/2016

2016

PHYSICS I

(PHYS 1001)

Time Allotted : 3 hrs *Full Marks : 70*

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

Candidates are required to give answer in their own words as far as practicable.

GROUP - A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **[10 x 1=10]**

i) The fringe width β with light of wavelength λ=400 nm is 0.4 mm. If λ = 600 nm, then β will be
a) 0.66 mm b) 0.6 mm c) 0.4 mm d) 0.12 mm

ii) The nearest neighbour distance in case of BCC structure is
a) $\frac{a\sqrt{3}}{2}$ b) $\frac{2a}{\sqrt{3}}$ c) $\frac{a\sqrt{3}}{4}$ d) a

iii) If b and a be the slit width and the separation of the slits respectively, then the number of lines/length N is given by
a) N = (a+b) b) N = $\frac{1}{(a+b)}$ c) N = ab d) N = $\frac{1}{ab}$

iv) If λ_L and λ_K are the wavelength of L and K X-rays respectively, then
a) $\lambda_L > \lambda_K$ b) $\lambda_L < \lambda_K$ c) $\lambda_L = \lambda_K$ d) $\lambda_L = 2\lambda_K$

v) Interference fringes in Newton's rings are example of
a) equal inclination, coherence is obtained by amplitude division
b) equal thickness, coherence is obtained by amplitude division
c) equal thickness, coherence is obtained by wave-front division
d) equal inclination, coherence is obtained by wave-front division

vi) Number of oscillation modes for the electromagnetic standing waves of frequency γ for the cavity radiation is proportional to

a) $\sqrt{\gamma}$ b) γ c) γ^4 d) γ^2

where γ is the frequency of the wave.

vii) If visible light is used to study the Compton scattering then the Compton shift will be

a) negative (wave length of the scattered light will be lesser)
b) more positive than what is observed with x-ray
c) zero
d) positive but not detectable in the visible window

viii) A proton, electron and a helium nuclei move with equal velocity. Rank their de- Broglie wavelengths from longest to shortest.

a) Helium nucleus, proton, electron
b) Proton, electron, helium nucleus
c) Helium nucleus, electron, proton
d) Electron, proton, helium nucleus

ix) The angle between the crystal planes (100) and (010) of a simple cubic structure is

a) zero b) 45° c) 90° d) 135°

x) What is the phase difference between driving force and velocity of forced oscillator?

a) ϕ b) $\phi + \frac{\pi}{2}$ c) $\phi - \frac{\pi}{2}$ d) $\frac{\pi}{2} - \phi$

GROUP - B

2 a) When a Newton's ring apparatus is immersed in a liquid, the diameter of the eighth dark ring decreases from 2.92 cm to 2.54 cm. What is the refractive index of the liquid?

b) Describe the state of polarization of wave represented by the following set of equations:

(i) $E_x = E_o \sin(\omega t + kz)$ (ii) $E_y = E_o \cos(\omega t + kz)$

c) What are the differences between single-slit and double-slit diffraction pattern?

d) An optical fibre has NA of 0.22 and a refractive index of 1.6. Determine the acceptance angle for the fibre in water which has a refractive index of 1.33.

3+3+4+2=12

3 a) Prove that the angle between the reflected and refracted rays for complete polarization of the reflected ray is 90°.

b) Deduce the missing orders for a double-slit Fraunhofer diffraction pattern if the slit widths are 0.18 mm and they are 0.72 mm apart.

c) Obtain the conditions for principal maximum and minimum in Fraunhofer diffraction due to a single slit. Draw the intensity distribution curve.

3+3+(4+2)=12

GROUP - C

4 a) Write down the differential equation of damped harmonic motion. Under what condition will the motion be critically damped? Find the solution of the differential equation for critically damped motion.

b) Find the amplitude, phase and instantaneous velocity of the vibrational motion represented by

$$x = a\cos\omega t + \frac{a}{2}\cos\left(\omega t + \frac{\pi}{2}\right) + \frac{a}{4}\cos(\omega t + \pi) + \frac{a}{8}\cos\left(\omega t + \frac{3\pi}{2}\right)$$

(2+2+3)+(2+2+1)=12

5 a) (i) Write down the differential equation of a series L-C-R circuit driven by a sinusoidal voltage.

(ii) Identify the natural frequency of this circuit.

(iii) Find out the condition that this circuit will show an oscillatory decay and find out the relaxation time.

b) A wave with the equation $\Psi(x, t) = A \exp i(ax-bt)$ (a, b being constant) has frequency ϑ. Assuming the wave to satisfy classical wave equation, find its wavelength.

2+2+(2+2)+4=12

GROUP - D

6 a) What is Compton effect? From the expression of Compton shift calculate the Compton wavelength for an electron.

b) Show graphically, how the energy density varies with frequency (or the wave length) of black body radiation for different temperatures.

c) The phase velocity of ripples on a liquid surface is $\sqrt{\frac{2\pi S}{\lambda\rho}}$, where S is the surface tension and ρ the density of the liquid. Find the group velocity of the ripples.

(2+2)+4+4=12

7 a) A beam of X-rays is scattered by free electrons. At 45° from the beam direction the scattered X rays have a wavelength of 0.022 Å. What is the wavelength of the X rays in the direct beam?

b) Using Heisenberg's uncertainty relation prove that electrons cannot exist within the nucleus of an atom.

c) Deduce Wien's displacement law from Planck's law of black body radiation.

4+4+4=12

GROUP - E

8 a) In a NaCl structure, calculate the number of atoms per unit cell and atomic packing factor. Assuming radius of Na^+ is 0.98Å and radius of Cl^- is 1.81 Å.

b) Ni has FCC structure. Its lattice constant is 3.52 Å; atomic weight of Ni is 58.71. Calculate its radius, atomic packing factor and density.

(3+3)+(2+2+2)=12

9 a) Define packing fraction. Show that the packing fraction of FCC is greater than BCC.

b) Calculate the inter-planar spacing d of a plane (hkl) in a tetragonal lattice of side $a = b \neq c$.

c) Plot the Miller plane and directions denoted by (101), (020) in a unit cell of a cubic structure.

(2+3)+5+(1+1)=12