B.Tech/AEIE/CSE/ECE/IT/2nd Sem/PHYS-1001/2015

2015

PHYSICS–I

(PHYS 1001)

Time Alloted : 3 Hours ***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 : **[10×1=10]**

   i) To see wave aspect of a base ball moving with a speed 10m/sec, we need an instrument having characteristic dimension of the order of

   (a) 10^{-25} °A or less (b) 10^{-25} °A or more

   (c) any value (d) 1°A

   ii) How fast a particle must travel so that its mass becomes twice its rest mass?

   (a) 0.5C (b) 2C

   (c) $\frac{\sqrt{3}}{2}$C (d) 0.25C

iii) The threshold wave length of a photon for pair production is

(a) 1.02°A (b) 0.012°A

(c) 0.12°A (d) 1.12°A

iv) In case of X-ray production the cut off wave length of continuous spectra depends on

(a) target material as well as on electron accelerating potential.

(b) target material only.

(c) electron accelerating potential only.

(d) neither on target element nor on the electron accelerating potential

v) w_1 and w_2 are two half power frequencies on either side of the resonant frequency w_o in case of a forced harmonic oscillator of mass m. The product $w_1 w_2$ is

(a) $w_0^2 - b^2$ (b) b^2

(c) w_0^2 (d) $\frac{b^2}{m^2}$

vi) I_0 is the intensity produced by each source of an interference phenomenon and the phase difference φ between the two sources varies in a random manner with time which is small compared with time of average, then the resultant intensity will be

(a) I_0 (b) $2I_0$

(c) $2I_0 (I + \cos\phi)$ (d) $4I_0$

vii) When does the O-ray and E-ray travel along the optic axis of an uniaxial crystal?

(a) $\mu_e > \mu_0$ (b) $\mu_e < \mu_0$

(c) $\mu_e = \mu_0$ (d) $\mu_e > \frac{1}{\mu_0}$

viii) The amount of void space in fcc crystal is

(a) 48% (b) 74%

(c) 26% (d) 32%

ix) If a be the width of the opaque space and b that of the slit then if 2a = b, the number of interference maxima enclosed by central maximum is

(a) 3 (b) 6

(c) 5 (d) 7

x) If n_1 and n_2 be the refractive indices of the core and cladding respectively then

(a) $n_1 = n_2$ (b) $n_1 < n_2$

(c) $n_1 > n_2$ (d) $n_1 = \frac{1}{n_2}$

GROUP - B

2. (a) A quartz plate with thickness of 0.1436 mm is used as phase retardation plate. For what wavelengths in the visible region (450 - 800 nm) will it act as a quarter wave plate? (μ_0 = 1.5443, μ_e = 1.5533)

(b) Newton's rings are formed with reflected light of wavelength 5895×10^{-8} cm with a liquid between the plane surface of the plate and curved surface of a convex lens. The diameter of the 5th dark ring is 0.3 cm and the radius of curvature of the curved surface of the lens is 100 cm. Calculate the refractive index of the liquid.

(c) Find the relation between Einstein's A and B coefficients in connection with laser transition.

(d) Light reflected from a smooth ice surface is found to be completely polarized. Find the angle of the incident light if the refractive index of ice is 1.739.

(2+1)+3+4+2 = 12

3. (a) Show that in case of interference the average intensity is equal to the sum of the individual intensities of two coherent sources.

   (b) Show that the resultant intensity distribution in the Fraunhofer diffraction pattern produced by two parallel slits each of width b and separated by a distance d is a product of the single-slit (width b) diffraction pattern and the interference pattern produced by two point sources separatedby a distance d.

   (c) Draw the intensity distribution graph for single and double slit Fraunhofer diffraction.

   (d) Calculate the NA, acceptance angle and the critical angle of a fibre having refractive index of core 1.5 and that of cladding 1.45. **3+5+2+2 = 12**

GROUP - C

4. (a) Obtain the condition of amplitude resonance of a harmonic oscillator under forced vibration. Draw the amplitude resonance graph for a particular damping medium showing amplitude resonant frequency, damped oscillatory frequency and the natural frequency of the oscillator.

   (b) Write the equation for the resultant vibration of a particle under the action of the two mutually perpendicular vibrations,

   $x = \cos\omega t$ and $y = 2\cos\left(\omega t + \frac{\pi}{2}\right)$ and hence construct Lissajous figure described by it.

   (c) Show that in case of forced vibration under steady state, at velocity resonance the periodic force and velocity are in same phase.

(d) A mass of 0.01 kg suspended from a spring oscillates freely with a time period of 1 seconds. When it is immersed in oil and allowed to oscillate the time period is increased by 0.2 seconds. Calculate the damping constant due to the oil medium. **(2+2)+3+3+2 = 12**

5. (a) To avoid the decay in damped oscillation some oscillating external force must be applied to the system. If we apply a periodic force in the form of $F_0\cos\omega t$, we get a sustained oscillation. Show that the average power input is equal to average power dissipated per unit cycle. For which value of ω average power input per unit cycle is maximum (which is known as power resonance) and what is that maximum value?

(b) A spring of negligible mass is extended by 2.5 cm when a mass of 2 kg is attached to it. If the mass is displaced from its equilibrium position it is observed that the amplitude of oscillation decays to e^{-1} times the initial amplitude in 20s. To avoid this decay it is then subjected to a periodic force.

If the frequency of the driving force is varied then at which frequency (ω_r) the average power input is maximum?

If the amplitude of sustained oscillation for power resonance condition is 1 cm then calculate the average input power.

How is the value of this maximum average input power is going to change is the mass of the oscillator is doubled.

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

Group - D

6. (a) Show graphically how the energy density vs frequency plot of black body radiation is changed if the temperature of the body increased.

(b) Show that the temperature dependence in Stefan's law can be derived from Planck's black body radiation law.

(c) What is Compton effect? Explain why an unmodified line is always present with the modified line. Do you observe Compton effect with visible light? Give reasons for your answer.

(d) A photon of energy 110 keV suffers 10% change in wavelength on being scattered by a stationary free electron. Find the kinetic energy of the recoil electron.

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

7. (a) State the de-Broglie hypothesis of matter waves. Show that the de-Broglie wave length of a particle is equal to its Compton wavelength when its velocity is 0.707c, where c is the velocity of light in free space.

(b) Show the particle velocity is equal to the group velocity of the associated wave packet.

(c) State the Heisenberg Uncertainty principle. An electron is confined to a nucleus of radius 10^{-4} m. Calculate the uncertainty in the momentum of an electron if it is in the nucleus.

(d) What is pair production? Show that pair production cannot occur in empty space.

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

GROUP - E

8. (a) Show that the density of crystalline material is proportional to the inverse volume of the unit cell in case of cubic crystal.

(b) Define Miller indices. Draw the plane in a cubic unit cell for Miller indices (102) and $(1\bar{1}0)$.

P

(c) Cs metal (atomic weight 130) has a cubic unit cell of lattice constant 0.6 nm. If the density of Cs is 2gm/cc, determine whether the unit cell is simple, bcc or fcc.

(d) Atomic packing factor increases with co-ordination number. Justify the statement. **3+(1+3)+3+2 = 12**

9. (a) KBr crystal has a cubic structure. If its density is 2.75×10^3 kg/m^3 and molecular weight is 119.01. Calculate its lattice constant.

(b) Draw the <110> and <111> planes and the (110) and (111) direction in a simple cubical crystal.

(c) Determine unit cell dimension when Bragg's angle of 45° is observed during first order reflection in a cubic crystal having Miller indices (100). Given the wavelength of the X-ray used is 2 Å.

(d) Show that for a simple cubic lattice

$d_{100} : d_{110} : d_{111} = \sqrt{6} : \sqrt{3} : \sqrt{2}$

3+4+2+3 = 12