B.Tech/BT/CE/CHE/EE/ME/1st 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 alternatives for the following : **[10×1=10]**

   i) For a particle executing SHM, the phase difference between displacement and velocity is

   (a) π (b) 0

   (c) $\pi/2$ (d) $-\pi/2$

   ii) The quality factor of a series LCR circuit is

   (a) $\frac{1}{R\sqrt{LC}}$ (b) $\frac{1}{R}\sqrt{\frac{L}{C}}$

   (c) $\sqrt{\frac{RL}{C}}$ (d) $\sqrt{RLC}$

   iii) Two coherent sources of different intensities interfere with each other. The ratio of maximum intensity to the minimum intensity is 25. The intensities of the sources are in the ratio

   (a) 25 : 1 (b) 5 : 1

   (c) 9 : 4 (d) 625 : 1

   iv) In Newton's rings experiment if an oil of refractive index μ (>1) is introduced in place of air in between the plano-convex lens and the glass plate then

   (a) the radius of a particular order of ring will increase

   (b) the radius of a particular order of ring will decrease

   (c) the radius of a particular order of ring will remain same

   (d) none of the above

   v) If the emergent light from a rotating polarizer shows maximum and minimum (not zero) intensities then the incident light is

   (a) partially plane polarized

   (b) unpolarized

   (c) circularly polarized

   (d) plane polarized

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

   (a) 0.5c (b) 2c

   (c) $\left(\sqrt{3}/2\right)c$ (d) 0.25c

   Where, c = the velocity of light in free space

   vii) Dimension of Planck's constant h is

   (a) $[ML^2T^{-1}]$ (b) $[MLT^{-1}]$

   (c) $[MLT^{-2}]$ (d) $[ML^2T^{-2}]$

viii) In Compton effect the scattered photon has frequency ν' and the incoming photon had frequency ν then (if the photon is scattered at an angle 45°)

(a) $\nu < \nu'$ (b) $\nu > \nu'$

(c) $\nu = \nu'$ (d) $\nu.\nu' = c^2$

ix) If a is the lattice constant of a FCC structure and 'r' is the atomic radius then the relation between them would be:

(a) $2r = \sqrt{2}\,a$ (b) $4r = \sqrt{3}\,a$

(c) $2r = \sqrt{3}\,a$ (d) $4r = \sqrt{2}\,a$

x) 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

GROUP - B

2. (a) Why are light waves from two different candles not seen to produce interference pattern?

(b) Prove that for Newton's Rings in reflected light the diameters of dark rings are proportional to square root of natural number.

(c) When the parallel waves of monochromatic light of wavelength 5790 Å fall normally on a granting 2.54 cm wide, the first order spectrum is produced at an angle of 19.994° to the normal. Calculate total number of lines of the grating.

(d) If the numerical aperture of an optical fibre is 0.39 and $n_1 - n_2 = 0.05$ then find the refractive index n_1 of the core, where n_2 is the r.i. of the cladding and $n_1 + n_2 \cong 2n_1$.

1+4+4+3 = 12

3. (a) Starting from the relation of the intensity distribution of Fraunhofer diffraction due to a single slit obtain the conditions for principal maximum and minimum. Draw the intensity distribution curve.

(b) A ray of light is incident on the surface of a glass plate of refractive index 1.6 at polarizing angle. Calculate the angle of refraction of the ray.

(c) Two polarising plates have polarising directions parallel so as to transmit maximum intensity of light. Through what angle must either plate be turned if the intensity of the transmitted beam is one third the intensity of the beam?

(4+2)+3+3 = 12

GROUP - C

4. (a) Show that the differential equation of motion for SHM is linear and homogeneous. Hence, prove that the principle of superposition holds for SHM.

(b) What are Lissajous figures? Two vibrations at right angles to each other are described by the equations

$x_1 = 10\cos(5\pi t)$, $y_1 = 10\cos\left(5\pi t - \frac{\pi}{4}\right)$.

Draw the Lissajous figure corresponding to the resulting motion.

(c) Show that the amplitude of a weakly damped oscillator reduces to half of its initial value in time $t = \tau \ln 2$, where τ is the relaxation time.

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

5. (a) Establish the equation of motion of a damped harmonic oscillator subjected to a resistive force that is proportional to the first power of its velocity. If the damping is less than critical, show that the motion of the system is oscillatory with its amplitude decaying exponentially with time.

(b) Draw the variation of velocity amplitude against the applied frequency for different damping constants for forced vibration.

(c) A radio station "radio A" wants to have a broadcast frequency (ν) 101.9 MHz. An input voltage $V_0 \cos 2\pi\nu t$ is fed to a LCR. If L is already chosen to be 0.1 μH then what should be the value of C such that the LCR resonates with this broadcast frequency?
[C = Capacitance]

(2+3)+4+3 = 12

Group - D

6. (a) What are the characteristics of black body radiation? Show it graphically. Clarify the basic difference in the approach made by Rayleigh-Jeans and Planck to explain blackbody radiation.

(b) Estimate the ratio of temperatures of two bulb filaments if they predominantly emit light of wave length 6000 Å and 5000 Å, respectively. Approximate them to be black bodies.

(c) "In Compton effect, recoil electron cannot be ejected at an angle greater than 90° with the direction of incident radiation" — Justify.

(d) The observed Compton shift $\Delta\lambda$ at a particular scattering angle for electron-photon scattering is 0.02 Å. If we replace the electron by a proton what will be the value of Compton shift at the same scattering angle λ? Assume that the mass of a proton is 2000 times the mass of an electron.

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

7. (a) State de-Broglie's hypothesis. If an electron is accelerated by potential V then what will be the wavelength of the matter wave corresponding to the electron (non-relativistic).?

(b) Show that the phase velocity of de Broglie waves of a particle of rest mass m_0 and de Broglie wavelength λ is given by $v_p = c\sqrt{1+\left(\frac{m_0 c\lambda}{h}\right)^2}$,
where h = Planck's constant and c = the velocity of light in free space.

(c) The uncertainty in the velocity of a particle is equal to its velocity. Calculate the minimum uncertainty in the position of the particle in terms of its de Broglie wavelength.

(d) Show that the uncertainty principle can be used to derive an expression for the radius of the first orbit of the Hydrogen atom.

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

GROUP - E

8. (a) What is meant by primitive and non-primitive unit cells?

   (b) Find the Miller Indices for a plane with the set of intercepts (a/2, b, ∞). Draw the plane for the same.

   (c) Ni has FCC structure. Its lattice constant is 3.52 $\mathring{A}$; atomic weight of Ni is 58.71. Calculate its radius, atomic packing fraction and density.

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

9. (a) What is the basis of dividing the crystal systems into different types and how many different Bravais lattices are shown in crystal structure?

   (b) For a metal if the distance between (100) planes is 2.32 $\mathring{A}$ and if it has a BCC structure, then what is the size of the unit cell? What is the radius of the atom?

   (c) Derive Bragg's law of X-ray diffraction.

   (d) Show that FCC structure is more closely packed than BCC structure.

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