Name : .....

Roll No. : .....

Invigilator's Signature : .....

CS/B.Tech (NEW)/SEM-2/PH-201/2013

2013
PHYSICS - I

Time Allotted : 3 Hours *Full Marks :* 70

The figures in the margin indicate full marks.

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

GROUP – A

(Multiple Choice Type Questions)

1. Choose the correct alternatives for any *ten* of the following : $10 \times 1 = 10$

   i) The time period of a simple pendulum of infinite length is given by

      a) finite b) zero

      c) infinite d) none of these.

   ii) The velocity with which a wave advances in a medium is called

      a) phase velocity b) group velocity

      c) wave velocity d) none of these.

iii) If v_g be the group velocity of the wave group representing a particle moving with velocity v, then

a) $v_g > v$ b) $v > v_g$

c) $v_g = v$ d) $v_g = \frac{1}{v}$.

iv) For SC structure atomic packing factor is

a) 74% b) 52%

c) 68% d) 47%.

v) Which one of the following is a biaxial crystal ?

a) Calcite b) Quartz

c) Argonite d) None of these.

vi) Young's double slit experiment is based on

a) division of wavefront

b) division of amplitude

c) division of both amplitude and wavefront

d) none of these.

vii) When interference takes place at some region, light energy is

a) created b) destroyed

c) redistributed d) none of these.

viii) The central spot of a Newton's ring experiment with a monochromatic light is

a) bright b) dark

c) white d) none of these.

ix) The angle between the planes of vibration and polarization of a beam of plane polarized light is

a) 90° b) 45°

c) 0° d) 180°.

x) How fast a particle must travel so that its mass becomes thrice its rest mass ?

a) 0·5 c b) 2 c

c) $\frac{\sqrt{3}}{2}$c d) $\frac{2\sqrt{2}}{3}$c.

xi) The rest mass of photon is

a) p/c b) $h\nu/c^2$

c) E/c^2 d) 0

xii) The colour of the laser output in case of ruby laser is

a) violet b) blue

c) red d) green.

xiii) *X*-rays are

a) elastic waves b) electromagnetic waves

c) stationary waves d) radio waves.

xiv) Origin of continuous *X*-ray is due to the process of

a) ionization b) inner orbital transition

c) bremsstrahling d) none of these.

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

a) negative

b) more positive than what is observed with *X*-rays

c) zero

d) positive but not detectable in the visible window.

GROUP – B

(Short Answer Type Questions)

Answer any *three* of the following. 3 × 5 = 15

2. a) What are the characteristics of S.H.M. ? Define time period and frequency.

   b) Establish the differential equation of harmonic motion and solve it. 2 + 3

3. a) Find the atomic packing factor for an FCC and BCC lattice.

   b) Describe the origin of characteristic *X*-ray. 2 + 3

4. Explain the nature of change in the fringe in Newton's ring experiment when

   i) some oil is placed between the glass plate and the plano-convex lens, and

   ii) the plano-convex lens is gradually moved away from the glass plate. 2 + 3

5. a) Why is *X*-ray diffraction used for crystal structure analysis and not common visible light ?

   b) Why in case of moving electrons quantum mechanics is used while for moving cars we use Newtonian mechanics ?

   c) What features of photoelectric effect cannot be explained from wave theory of light ? 1 + 2 + 2

6. a) What is Compton effect ?

   b) Calculate the Compton wavelength for an electron.

   c) Why does the unmodified line appear in Compton scattering ? 1 + 2 + 2

GROUP – C

(Long Answer Type Questions)

Answer any *three* of the following. 3 × 15 = 45

7. a) Write down the differential equation of damped oscillation. Solve it for underdamped motion. 1 + 3

   b) The equation for displacement of a point of a damped oscillator is given by $X = 5e^{-0.25t} \sin(\pi/2)t$ metre. Find the velocity of the oscillating point at $t = T/4$ and T, where T is the time period of oscillation. 2 + 2

   c) Define logarithmic decrement λ and relaxation time τ. Find expression for these terms. 2 + 2

   d) Give a graphical comparison among underdamped, overdamped and critically damped harmonic motion. 3

8. a) Calculate the distance between the adjacent parallel planes of the type [100], [110] and [111] in an FCC lattice of lattice constant a. Check the validity of the statement "The most closely packed planes are the most widely spaced". 3 + 3

   b) Establish the relation between lattice constant and density of a material of a simple cubic crystal. 5

   c) If an *X*-ray tube is subjected to a potential difference of 50 kV and the corresponding current is 8 mA, then find out

      i) the number of electrons striking per second the target material,

      ii) minimum wavelength of the *X*-ray produced. 2 + 2

9. a) What is missing order in case of double slit diffraction pattern ? 2

b) A diffraction grating, 2 cm wide is just able to resolve sodium *D*-lines (having wavelengths 589 nm and 589·6 nm) in second order. Find the number of rulings per mm. 3

c) Obtain an expression for resultant intensity and hence find the conditions for maxima and minima in a single-slit Fraunhofer diffraction process. 5

d) What is retardation plate ? A plane polarized light of wavelength 600 nm changes to a circularly polarized light on passing through a quartz crystal cut parallel to optic axis. Calculate the minimum thickness to produce such effect. Given $\left(\mu_e - \mu_0\right) = 0 \cdot 005$. 1 + 2

e) Find the state of polarization when the x and y components of the electric field are given by $E_x = E_0 \sin(\omega t + kz)$ and $E_y = E_0 \cos(\omega t + kz)$. 2

10. a) What are positive and negative crystals ? Describe the construction of Nicol prism. 4

b) Explain Fraunhofer diffraction by a single-slit with necessary theory. Point out also the graphical representation of intensity distribution. 7

c) The diameter of the *n*th Newton's ring changes from 1·2 to 1 cm, when the air space between the lens and the plate is replaced by a transparent liquid. Find the refractive index of the liquid. 4

11. a) Define plane of vibration and plane of polarization. 3

b) Describe an experiment to prove that light waves are transverse. 3

c) The displacement of a particle of mass 0·2 kg executing S.H.M. is indicated by $y = 10 \sin\left(\frac{\pi}{3}t - \frac{\pi}{12}\right)m$.

Calculate

i) amplitude

ii) the angular velocity

iii) the time period

iv) the maximum velocity

v) maximum acceleration. 5

d) Calculate the atomic packing fraction and atoms per unit cell in crystals having body centred cubic structure considering the atoms as hard sphere. 4

12. a) Illustrate spontaneous emission and stimulated emission. Describe in brief why stimulated emission generates highly intense coherent beam. 3 + 2

b) A beam of *X*-rays of wavelength 0·842 Å is incident on a crystal at a glancing angle of 8° 35′ when first order Bragg's reflection occurs. Calculate the distance between two consecutive crystal planes. 2

c) Derive an expression for lattice constant of a crystal in terms of its molecular weight, density and number of atoms per unit cell. 3

d) Find out the number of photons required to be emitted per second to give output power 2 mW corresponding to wavelength 632·8 nm. 3

e) The primitives of a crystal are 1·2 Å, 1·8 Å, 2 Å along the three axes. A plane with Miller indices (231) cuts intercepts 1·2 Å along *X*-axis. What will be the lengths of intercepts along *Y* and *Z*-axes ? 2