Name : .....

Roll No. : .....

Invigilator's Signature : .....

CS/B.Tech(New)/SEM-2/PH-201/2012

2012

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 deBroglie wavelength of a moving electron subjected to a potential V is

   a) $\frac{1{\cdot}26}{\sqrt{V}}$ b) $\frac{12{\cdot}26}{\sqrt{V}}$

   c) $\frac{122{\cdot}6}{\sqrt{V}}$ d) $\frac{1226}{\sqrt{V}}$

   (consider the appropriate units).

   ii) For Laser action to occur, the medium used must have at least

   a) 2 energy levels b) 4 energy levels

   c) 3 energy levels d) one energy level.

iii) The Miller indices of a plane holding the intercepts $\frac{a}{2}$, b, 3c is

a) (361) b) (611)

c) (631) d) (321).

iv) The intensity of principal maxima in the spectrum of grating with N number of lines is proportional to

a) $\frac{1}{N}$ b) N

c) N^2 d) $\frac{1}{N^2}$.

v) To get a circular Lissajous figure, the phase difference (ϕ) and the amplitude (a and b) of two superimposing, mutually perpendicular SHMs are respectively

a) $\phi = 0, a = b$ b) $\phi = \frac{\pi}{2}, a = b$

c) $\phi = \frac{\pi}{2}, a \neq b$ d) $\phi = \frac{\pi}{4}, a \neq b$.

vi) X-ray is suitable for crystallography because

a) X-ray is electromagnetic

b) X-ray is neutral

c) X-ray wavelength is in same order of interatomic spacing of Crystal

d) X-ray is hard penetrating.

vii) In Fraunhofer diffraction, the wave front is

a) Cylindrical b) Spherical

c) Plane d) Circular.

viii) The refractive indices of *E*-ray and *O*-ray are respectively 1·65 and 1·45. Then, the thickness of the material required for a quarterwave plate for light of wavelength 500 nm is

a) 250 nm b) 125 nm

c) 625 nm d) 740 nm.

ix) If a spring of force constant K is cut into three equal parts, then the force constant of each part is

a) $\frac{K}{3}$ b) $3K$

c) 1 d) K.

x) Davisson-Germer experiment is related with

a) Interference b) Thermionic emission

c) Phosphorescence d) Electron diffraction.

xi) The velocity of a particle when its mass becomes twice its rest mass is

a) 0·5c b) 0·72c

c) 0·866c d) c

(where c is the speed of light in vacuum).

xii) Which of the following pairs cannot be simultaneously measured ?

a) p_x, p_y b) y, p_y

c) p_x, z d) p_x, p_z .

xiii) The Compton shift $\Delta\lambda$ and Compton wavelength λ_c of a particle are equal if the angle of scattering is

a) 0° b) 90°

c) 180° d) 45°.

xiv) For holography system, the exposure time is of the order of

a) 5 seconds and depends on the colour of the object

b) nearly 2 seconds

c) 1 second

d) 50 seconds.

xv) The emissive power of a black body kept at an absolute temperature T is proportional to

a) T^4 b) T^3

c) T^{-1} d) T.

GROUP – B

(Short Answer Type Questions)

Answer any *three* of the following. $3 \times 5 = 15$

2. The displacement of any particle at any instant t is given by $x = 3\cos\omega t + 4\sin\omega t$. Show that the motion is simple harmonic. What is the amplitude of this oscillation ? Show that its kinetic energy oscillates with angular frequency 2ω.

2 + 1 + 2

3. a) What is diffraction of light ?

   b) Draw the intensity distribution pattern of diffraction grating.

   c) Two slits in Young's double slit experiment are 1·3 mm apart from each other and the screen is placed 1·6 m away from the slits. Calculate the distance of the 4th bright fringe. The wavelength of the light used is 6000 Å. 1 + 1 + 3

4. a) State Bragg's law.

   b) Cs metal (atomic weight 130) has a cubic unit cell of lattice constant 0·6 nm. If the density of Cs is 2 gm/cc, determine whether the unit cell is SC, BCC or FCC. 1 + 4

5. a) Explain Brewster's law.

   b) Show that when light is incident on a transparent substance at the polarizing angle, the reflected and the refracted rays are perpendicular to each other. 2 + 3

6. a) Deduce Stefan's law from Planck's radiation law.

   b) What is population inversion ? Why is it needed for lasing action ? 3 + 1 + 1

GROUP – C

(Long Answer Type Questions)

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

7. a) State Heisenberg's uncertainty principle. 2

   b) Using this principle, prove that a free electron cannot exist in an atomic nucleus. 4

   c) Write down the uncertainty relation for energy and time. 1

   d) Find the wavelength spread of a 1 nano-second pulse from a ruby LASER with a wavelength of 630 nm. 3

e) Show that the group velocity of the wave packet representing a particle is equal to the velocity of the particle itself. 2

f) Calculate the de Broglie wavelength of a baseball of mass 1 kg moving at a speed of 10 m/sec. Discuss the reason why its wave nature connot be observed. 3

8. a) State Malus law. A beam of polarized light makes an angle of 60° with the axis of the polaroid sheet. How much intensity of light is transmitted through the sheet ? 2 + 4

b) What is a retardation plate ? How can you distinguish between circularly polarized light and unpolarized light with the help of a quarter wave plate and a Nicol prism ? 2 + 4

c) The critical angle of glass with respect to air is 41°. Find the refractive index of the medium and the angle of refraction of the light incident on the glass plate at the polarizing angle. 3

9. a) What are the differences between LASER and normal visible light ? 2

b) Derive the relation between Einstein's *A* and *B* coefficients. 4

c) Calculate the ratio of stimulated to the spontaneous emission at a temperature 300 K for sodium D-line (λ = 5890 Å). 2

d) With the help of a neat diagram, briefly describe the construction of a Ruby LASER. 5

e) Why is optical pumping not generally employed in case of a gas LASER ? 2

10. a) Distinguish between interference and diffraction. Is energy conserved in interference phenomenon ? Explain. 3 + (1 + 2)

b) In a Newton's ring arrangement, the diameter of the 5th dark ring is 0·3 cm and the diameter of 25th dark ring is 0·8 cm. If the radius of curvature of the plano-convex lens is 100 cm, find the wavelength of the light used. 4

c) What are the conditions to get sustained interference pattern ? 2

d) Show that the intensity of the 1st secondary maxima formed by a single slit Fraunhofer diffraction process is nearly 4·5% of the principal maxima. 3

11. a) Show that the fractional change in the natural frequency of a damped simple harmonic oscillator is $\frac{1}{8Q^2}$, where Q is the quality factor of the oscillator. 3

b) The displacement of a simple harmonic oscillator is given by $x = a \sin(\omega t + \theta)$. If the oscillations started at time $t = 0$ from a position x_0 with velocity $\dot{x} = \upsilon_0$, show that $\tan\theta = \frac{\omega x_0}{\upsilon_0}$ and $a = \left(x_0^2 + \frac{\upsilon_0^2}{\omega^2} \right)^{1/2}$. 3

c) A particle of mass 2 kg is subjected to an elastic force per unit displacement 0·03 Nm^{-1} and frictional force per unit velocity 0·005 $Nm^{-1}s$. If if is displaced through 2 cm and then released, find whether the resulting motion is oscillatory or not. 3

d) The forced harmonic oscillators have displacement amplitude at frequencies ω_1 = 400 sec^{-1} and ω_2 = 600 sec^{-1}.

Find the resonant frequency at which the displacement amplitude is maximum. 4

e) Differentiate between amplitude resonance and velocity resononce for a forced harmonic oscillator. 2

12. a) In the continuous *X*-ray spectra, λ_{min} values are obtained for higher potential. Explain. 2

b) What do you mean by the terms "atoms per unit cell", "cordination number" and "atomic packing factor" ? 3

c) Show that the packing fraction of FCC is greater than BCC. 4

d) The density of BCC iron is 7·9 gm/cc and its atomic weight is 56. Calculate the length of the side of the cubic unit cell and nearest neighbouring distance. 3

e) The spacing of planes in a crystal is 1·2 Å and the angle for the 1st order Bragg's reflection is 30°. Determine the energy of the *X*-rays beam in eV. 3