



Name :

Roll No. :

Invigilator's Signature :

CS/B.TECH(N)/SEM-1/PH-101/2012-13

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 × 1 = 10

- i) The relaxation time (τ) of a damped harmonic oscillator with damping constant (K) is

- a) $\tau = 1/K$ b) $\tau = 1/2K$
c) $\tau = K$ d) $\tau = 2K$.

- ii) The resonant frequency of an electrical oscillator is given by

- a) $\nu = 2\pi \sqrt{LC}$ b) $\nu = \frac{1}{2\pi \sqrt{LC}}$
c) $\nu = \frac{2\pi}{\sqrt{LC}}$ d) $\nu = 2\pi \sqrt{\frac{L}{C}}$.



- iii) If ' α ' is the force constant of an oscillating body of mass ' m ' the Q -factor is
- a) $Q \propto \sqrt{\alpha m}$ b) $Q \propto \sqrt{\frac{m}{\alpha}}$
- c) $Q \propto \sqrt{\frac{\alpha}{m}}$ d) $Q \propto \frac{\alpha}{m}$.
- iv) If a thin mica sheet is placed between two interfering waves, then
- a) Fringe width increases
- b) Fringe width decreases
- c) Fringe pattern gets shifted
- d) No change in the fringe pattern.
- v) The emissive power of a black body kept at absolute temperature T which is very near to the temperature of surroundings (T_0) is proportional to
- a) $(T - T_0)^4$ b) $(T - T_0)$
- c) T^4 d) $T^{2/3}$.
- vi) The miller indices of a plane having intercepts 2, 3, 4 units along X, Y, Z axis respectively are
- a) (6, 4, 3) b) (4, 3, 6)
- c) (2, 3, 1) d) (2, 3, 4).
- vii) Compton shift $\Delta\lambda$ and Compton wavelength λ_c are equal if the angle of scattering is
- a) $\theta = 0^\circ$ b) $\theta = 90^\circ$
- c) $\theta = 180^\circ$ d) $\theta = 360^\circ$.



viii) The relativistic energy momentum relation is

- a) $p^2 = E^2 + m_0^2 c^2$
- b) $E^2 = p^2 + m_0^2 c^4$
- c) $E^2 = p^2 c^2 + m_0^2 c^4$
- d) $p^2 = E^2 c^2 + m_0^2 c^4$

ix) According to Wien's displacement law

- a) $\lambda_m T = \text{Constant}$
- b) $\frac{\lambda_m}{T} = \text{Constant}$
- c) $\lambda_m T^2 = \text{Constant}$
- d) $\frac{\lambda_m}{T^2} = \text{Constant}$

x) Volume of a unit cell in FCC structure is

- a) $16 \sqrt{2} r^3$
- b) $4 \sqrt{2} r^3$
- c) $\frac{16 \sqrt{2}}{r^3}$
- d) $2 \sqrt{2} r^3$

[r = mean radius of the constituent atoms]

xi) Polarization conclusively proves that light waves are

- a) longitudinal
- b) progressive
- c) stationary
- d) transverse.

xii) An α -particle is 4 times heavier than proton. If a proton and an α -particle are moving with the same velocity, their de-Broglie wavelengths are given by

- a) $\lambda_p = \lambda_a$
- b) $\lambda_p = 4\lambda_a$
- c) $\lambda_p = \lambda_{a/2}$
- d) $\lambda_p = \lambda_{a/4}$

xiii) For larger value of damping constant k the resonance curve will be

- a) Unchanged
- b) Flatter
- c) Sharper
- d) None of these.



xiv) In Ruby Laser, the host crystal is

- | | |
|----------------------------|-----------------------------|
| a) Al_2O_3 | b) MnO_2 |
| c) CaCO_3 | d) Al_2SO_4 |

xv) If we measure the energy of a particle accurately then the uncertainty of the measurement of time becomes

- | | |
|------|------------------|
| a) 0 | b) ∞ |
| c) 1 | d) $\frac{1}{2}$ |

GROUP - B

(Short Answer Type Questions)

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

2. a) Show that for a particle executing SHM, the average kinetic energy is half of the corresponding maximum energy.
 b) Calculate the time period of the liquid column of length 1 in a U-tube, if it is depressed in one arm by x , d is the density of liquid and A is the cross-sectional area of each arm of the tube. 3 + 2
3. a) What do you mean by population inversion ?
 b) Draw the energy level diagram in helium and neon laser transition. 2 + 3
4. a) Determine the atomic packing fraction of FCC lattice.
 b) X-rays of wavelength 1.54 \AA are used for the calculation of the d_{100} plane of a cubic crystal, the Bragg's angle of 1st order reflection is 10° . What is the size of the unit cell ? 2 + 3



5. What is Einstein's A and B coefficient ? Relate Spontaneous and stimulated emission probabilities and hence find out the relation between field energy and A , B coefficient. 1 + 4
6. Define Black-Body ? Establish Wein's distribution law and Stefan's law from Plank's black body radiation law. 1 + 2 + 2

GROUP - C

(Long Answer Type Questions)

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

7. a) A cubical block of side L cm and density ρ is floating in water of density ρ_o ($\rho_o > \rho$). The block is slightly depressed and released. Show that it will execute simple harmonic motion. Determine the frequency and time period of oscillation. 3 + 1 + 1
- b) Write down the differences between standing and progressive wave and establish the differential equation of a progressive wave. 2 + 2
- c) Establish the differential equation of SHM from energy conservation principle. An oscillator executing SHM has zero displacement at time $t = 0$. If the displacements are 1 mm and 1.5 mm at instants 0.1 and 0.2 seconds, calculate the frequency and amplitude of oscillation. 2 + 2
- d) A body of mass 10 g is acted upon by a restoring force/unit displacement of 10^7 dyne/cm, a frictional force/unit velocity of 4×10^3 dyne/cm, s^{-1} and a driving force of $10^5 \cos \omega t$ dyne. Find the value of maximum amplitude. 2



8. a) Two independent sources of light of same wavelength can not produce interference. Justify. 3
- b) Plot the intensity distribution curve of Young's double-slit interference experiment and label it. 2
- c) Can you measure the refractive index of a liquid by Newton's ring experiment ? Explain. 3
- d) In Young's experiment the width of the fringe obtained with light of wavelength 6000 \AA is 2.0 mm . What will be the fringe width if the entire apparatus is immersed in a liquid of refractive index 1.33 . 3
- e) Newton's ring experiment is performed with reflected light of wavelength 5700 \AA using a plano-convex lens and a plane glass plate. What would be the observation when the glass plate is moved away from the lens along the axis of the lens by 10^{-5} m ? 4
9. a) Distinguish between Fresnel and Fraunhofer class of diffraction. 2
- b) Using the expression of single-slit diffraction intensity, show that the secondary maxima are given by the equation $\tan \alpha = d$, where $\alpha = \pi e \sin \theta / \lambda$, symbols have their usual meaning. 3
- c) Draw and explain the intensity distribution curve in case of Fraunhofer single slit diffraction phenomenon. 4
- d) State and explain Rayleigh criterion of resolution. 3
- e) An oil immersion microscope just resolves the rulings of a grating having 3900 lines/mm when light of wavelength 400 nm is employed. Find the numerical aperture of the lens. 3



10. 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". 5
- 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, find
- the number of electrons striking per second the target material
 - speed of electron
 - minimum wavelength of the X-ray produced
 - cut-off wavelength of the X-ray produced
 - energy of each striking electron. 5
11. a) What is holography ? Why is it called a wavefront reconstruction ? 4
- b) Explain with neat diagram, spontaneous emission, stimulated absorption and stimulated emission of radiation and deduce expressions relating various Einstein's coefficients. 6
- c) Write a short note on Nicol prism and its use as polarizer and analyser. 5



12. a) What is the origin of modified and unmodified lines in Compton effect ?
- b) Can you observe Compton effect if visible light is used instead of X-rays ?
- c) Prove that the maximum recoil energy of a free electron of rest mass m_0 when struck by a photon of wavelength λ is given by $E_{max} = \frac{2m_0 c^2 \lambda_c^2}{\lambda^2 + 2\lambda_c \lambda}$. Here λ_c is the Compton wavelength of the electron.
- d) Show that in Compton scattering while the photon can be scattered at any angle between 0° to 180° , the recoil electron can only be emitted at angles between 0° and 90° .

3 + 2 + 5 + 5

