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 : $10 \times 1 = 10$

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 haing 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) $\lambda_m T$ = Constant b) $\frac{\lambda_m}{T}$ = Constant

c) $\lambda_m T^2$ = Constant d) $\frac{\lambda_m}{T^2}$ = 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 and 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 $\mathring{A}$ 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 Å 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 Å 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 m A, find

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

ii) speed of electron

iii) minimum wavelength of the *X*-ray produced

iv) cut-off wavelength of the *X*-ray produced

v) energy of each stricking 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 of 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