Name : .....

Roll No. : .....

Invigilator's Signature : .....

CS/B.Tech(NEW)/SEM-1/PH-101/2010-11

2010-11

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) If a particle is executing simple harmonic motion with frequency ν then its potential energy

a) remains constant over time

b) is oscillating with a frequency ν

c) is oscillating with a frequency $\nu/2$

d) is oscillating with a frequency 2ν.

ii) The quality factor Q for an L-C-R circuit is

a) $\frac{\omega R}{L}$ b) $\frac{\omega L}{R}$

c) $\frac{\omega}{LR}$ d) $\frac{R}{\omega L}$.

iii) An external force $F = F_0 e^{i\omega x}$ is applied to a slightly damped oscillator of natural frequency ω_0, then in steady state it will oscillate with a frequency

a) ω_0 b) ω

c) $\omega_0 - \omega$ d) $\sqrt{\omega_2^0 - \omega^2}$.

iv) The intensity of principal maximum in the Fraunhofer diffraction spectrum produced by a grating with N number of lines is proportional to

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

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

v) In the propagation of lightwave the angle between the plan of polarization and plane of vibration is

a) 0° b) $\frac{\pi}{2}$

c) $\frac{\pi}{4}$ d) π.

vi) In case of simple cubic crystal the effective number of atoms per unit cell is

a) 2 b) 1

c) 3 d) none of these.

vii) In order to produce X-ray by striking electron beam on a metal target the kinetic energy of the electron should be

a) less than one eV b) of the order of eV

c) of the order of KeV d) of the order of GeV.

viii) If the energy of a particle is much higher than its rest energy then the energy is

a) independent of the momentum

b) proportional of the momentum

c) proportional to square of the momentum

d) proportional to the square root of the momentum.

ix) If a wave packet is described by

$\varphi\ (\ x\ ) = A\ exp\left(-\frac{x^2}{2\sigma^2}\right)$ then the momentum uncertainty is proportional to

a) $h\sigma$ b) $\frac{h}{\sigma}$

c) $h\sigma^2$ d) $\frac{h}{\sigma^2}$.

x) Given that the temperature of a younger star is higher than that of an older one

a) a blue star is younger than a red star

b) a blue star is older than a red star

c) both of them are same age

d) colour of the star cannot be correlated to the age of the star.

xi) In Ruby laser the active medium is

a) solid

b) liquid

c) gas

d) a solid and gas mixture.

xii) In a Nicol-prism the *O*-ray is totally internally reflected and the *E*-ray is transmitted. This statement is

a) true b) false

c) partly true d) partly false.

xiii) Two sources are said to be coherent when the waves produced by them hare

a) same wavelength

b) same wavelength and same phase

c) same wavelength and constant phase difference

d) same amplitude and constant phase difference.

xiv) In an arrangement for viewing Newton's ring, if the lens which rests on a glass plate were moved upwards by one wavelength, (of the viewing light), which of the following will be observed ?

a) The central spot becomes bright

b) No change of fringe pattern is observed

c) The rings shift towards the centre

d) The rings move out from the centre.

xv) Holography is based on

a) the interference of reference and object waves which are coherent

b) superposition of object and the reference waves which are of slightly different wavelengths

c) recording of superposed images of two different wavelengths

d) recording the phase information of the resultant of the reference and the object waves.

xvi) For a laser action to occur, the medium used must have at least

a) 4 energy levels b) 2 energy levels

c) 3 energy levels d) one energy level.

GROUP – B
(Short Answer Type Questions)

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

2. A vibrator of mass 10 gm is acted on by a restoring force of 5 dyne/cm and a damping force 2 dyne-sec/cm. Find whether the motion is overdamped or oscillatory. If at t = 0 the vibrator was at position x = 0, when a velocity 1 cm/sec is imparted to it then calculate the maximum deviation along positive x-axis. 2 + 3

3. a) In a Newton's ring experiment, the diameter of a dark ring is 0·32 cm, when the wavelength of monochromatic light be 6000 Å. What would be the diameter of that ring when the wavelength of light changes to 5000 Å ? 2

   b) Write down the expression for the intensity of light due to Fraunhoffer diffraction in a transmission grating and hence find the condition for secondary minima in the interference pattern. 1 + 2

4. a) Two polarizers are placed at crossed position — angle between the polarizing planes are 90° — a third polarizer with angle θ with the first one is placed between them. An unpolarised light of intensity I is incident on the first one and pass through all three polarisers. Find the intensity of the light that comes out. 3

   b) What is population inversion in the context of LASER ? Does it violate Maxwell Boltzmann distribution law ? 2

5. a) An electron is observed moving at 50% of the speed of light, $v = 1{\cdot}5 \infty 10^{8}$ m/s. What is the relativistic mass of the electron ? What is the kinetic energy of the electron ? 2

b) Write down the conservation laws in Compton scattering. Show that in Compton scattering while the photon can be scattered at any anlge between 0° to 180°, the recoil electron can only be emitted at angles between 0° and 90°. 2 + 1

6. a) The linear absorption coefficient of an element of *X*-rays having $\lambda = 0{\cdot}3$ Å is 135 m^{-1}. Find the half value thickness for that material. 2

b) Cs metal (atomic weight 130) has a cubic unit cell of lattice constant 0·6 nm. If the density of Cs is 2 g/cc, determine whether the unit cell is simple, body-centered or face-centered. 3

GROUP – C

(Long Answer Type Questions)

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

7. a) Starting from the equation of motion and after solving it show that, for a forced oscillator in the steady state, the displacement amplitude at low frequencies ($\omega \varnothing 0$), the velocity amplitude at velocity resonance $(\omega = \omega_0)$ are independent of the frequency of the driving force.

2 + 6 + 2 + 2

b) Explain the terms logarithmic decrement and quality factor of a damped oscillatory system. How are they related ? 1 + 1 + 1

8. a) Derive the intensity distribution of diffraction of Fraunhofer class of light due to a single slit. Sketch the intensity distribution. 7 + 2

b) A single slit forms diffraction pattern of Fraunhofer class with white light. The second maximum in the pattern for red light of wavelength 7000 Å coincides with the third maximum of an unknown wavelength. Calculate the unknown wavelength. 3

c) In Young's double slit experiment the distance between two slits is 0·5 mm. The wavelength of light is 5000 Å and the separation between the sources and the screen is 50 cm. Calculate the Fringe width in this case. 3

9. a) How can you get an elliptically polarized light from an linearly polarized light by using an optical device ?

A plane polarized light is incident on a piece of quartz cut parallel to the axis. Find the least thickness for which the ordinary and the extraordinary rays comine to form plane polarized light given that
$\mu_0 = 1{\cdot}5442$ and $\mu_e = 1{\cdot}5533$, $\lambda = 5 \infty 10^{-5}$ cm.
2 + 3

b) Define Einstein *A*, *B* coefficients of absorption and emission. Find out the relations among them.
1 + 1 + 1 + 3

c) Explain how holographic images one reconstructed from the holograms. 4

10. a) Describe the function of an optical resonator ? What is the use of such a device in the context of LASER generation ? 3 + 1

b) What is co-ordination number ? Determine the co-ordination number for *sc* and *bcc* structures. Draw necessary sketch. 'atomic packing factor' increases with co-ordination number. Justify the statement. 1 + 4 + 3

c) Find the short-wave limit of continous *X*-ray spectrum. Does it shift by 0·5 nm when the voltage applied to *X*-ray tube is doubled ? 2 + 1

11. a) State and explain de Broglie's hypothesis. Show that the relativistic de Broglie wavelength is given by

$$\lambda_{relativistic} = \frac{h}{\sqrt{E_k \left(E_k + 2 m_0 c^2 \right)}}$$

(The notations used have their usual significance)

2 + 3

b) Describe an experiment which verified de Broglie's hypothesis. 4

c) Write down the expressin of the number of possible modes of cavity waves of frequency υ to $\upsilon + d\upsilon$. Using Planck's hypothesis about the energy quantization of the cavity oscillators find out the average energy of an oscillator at a temperature T and the energy density within the frequency range υ to $d\upsilon$. Explain why the energy density decreases at very high values of the frequency at a finite temperature. 1 + 3 + 1 + 1