# PHYSICS - I
# (PHYS 1001)

**Time Allotted: 3 hrs** **Full Marks: 70**

***Figures out of the right margin indicate full marks.***

***Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.***

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

## Group – A
## (Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

(i) The centre of the Newton's ring for the reflected system of a monochromatic source of light is
(a) bright (b) dark (c) white (d) red.

(ii) The fringe width βin Young's double slit experiment with light of wavelength λ=400 nm is 0.4 mm. If λ = 600 nm, then β will be
(a) 0.66 mm (b) 0.6 mm (c) 0.4 mm (d) 0.12 mm

(iii) Which of the following is the phase (φ) relationship between the displacement Y of the forced oscillator and the applied force F
(a) Y lags behind F by φ (b) Y leads F by φ
(c) Y lags behind F by φ/2 (d) Y leads F by φ/2.

(iv) The effective number of atoms per unit cell of FCC crystal is
(a) 4 (b) 3 (c) 2 (d) 1.

(v) If the wavelength of the light used in single slit diffraction is increased then the width of the central maximum
(a) decreases (b) increases (c) remains same (d)none of these

(vi) An electron being accelerated through a potential difference 100 volt, is associated with de Broglie wavelength
(a) 1.227 A° (b) 0.1227 A° (c) 122.7 A° (d) 12.27 A°

(vii) How fast a particle must travel so that its mass becomes twice its rest mass
(a) 0.5C (b) 2c (c) (√3/2)C (d)0.25C
Where, C= the velocity of light in free space

(viii) The amplitude of a weakly damped oscillator reduces to half its initial value in time,
(a) $t = \tau \ln 2$

(b) $t = \tau \ln[0.2]$
(c) $t = \tau / \ln 2$
(d) $1/t = \tau \ln 2$, where $\tau$ is the relaxation time of the oscillator.

(ix) If the refractive index of water is 1.33, the angle of polarization of light reflected from water is
(a) $\text{Cos}^{-1}(1.33)$ (b) 53.1° (c) 36.9° (d) 1.33°

(x) In the process of Laser, Spontaneous emission rate depends on
(a) the number of atoms in excited state
(b) intensity of the exciting radiation
(c) both (a) and (b)
(d) the number of atoms in the ground state.

## Group – B

2. (a) When a Newton's ring apparatus is immersed in a liquid, the diameter of the eighth dark ring decreases from 2.92 cm to 2.54 cm. what is the refractive index of the liquid?

(b) How do diffraction spectra differ from interference spectra?

(c) Describe the state of polarization of wave represented by the following set of equations:
$E_x = E_0 \sin(\omega t + kz)$, $E_y = E_0 \cos(\omega t + kz)$

(d) Find the ratio of spontaneous emission to stimulated emission by an incandescent bulb at 2500 K. The frequency in the optical range is $5.9 \times 10^{14}$ Hz.

(e) In a plane diffraction grating the width of each slit is equal to the width of the opaque space between the two adjacent slits. Find the missing order of spectra.

**3 + 2 + 3 + 2 + 2 = 12**

3. (a) Two polaroids are crossed to each other. Now one of them is rotated 60°. What percentage of incident unpolarised light will pass through the system?

(b) Obtain the intensity expression for Fraunhofer diffraction pattern of a single slit and also write down the expression of intensity distribution for Fraunhofer diffraction pattern of a double slit.

(c) Light waves can be polarized but sound waves cannot. Why?
A ray of light is incident on a liquid of refractive index 1.40. Find the angle of refraction of the beam when the reflected ray is completely polarized.

**3 + (3 + 2) + (2 + 2) = 12**

## Group – C

4. (a) A wave with the equation $\Psi(x, t) = A \exp i(ax - bt)$ (a, b being constant) has frequency $\nu$. Assuming the wave to satisfy classical wave equation. Find its wavelength?

(b) Write down the differential equation of a series LCR circuit driven by a sinusoidal voltage. Identify the natural frequency of the circuit. Find out the condition that this circuit will show an oscillatory decay and find out the relaxation time.

(c) Draw the variation of velocity amplitude of the forced vibration with the applied frequency for different damping constant. Distinguish between the amplitude resonance and velocity resonance.

**3 + (2 + 2 + 2) + (1 + 2) = 12**

5. (a) The damped frequency of vibration of a body is 200 Hz. The amplitude of vibration becomes $\frac{1}{e}$ of the initial amplitude after 1 second. Calculate the frequency of free vibration.

(b) Consider the equation of motion for a damped harmonic motion
$d^2x/dt^2 + 2\gamma\, dx/dt + \omega_0^2 = 0$
Where, $\gamma$ = damping factor and $\omega_0$ = natural frequency of vibration.
A damped oscillator represented by the above equation has frequency $\omega_0 = 10\pi$/sec. If the amplitude of oscillation reduces to half of its initial value in 30 sec, calculate (i) damping factor (ii) Relaxation time (iii) quality factor.

(c) Write down the equation of forced vibration. In the steady state forced vibration describe how the phase of driven system changes with frequency of the driving force.

**2 + (2 + 2 + 2) + (1 + 3) = 12**

## Group – D

6. (a) State the characteristics of black body radiations. Show graphically, how the energy density versus wavelength plots of black body radiations are changed if the temperature is increased and also discusses the important conclusions from the curve.

(b) What is Compton effect? Why Compton effect cannot be observed with visible light but can be observed due to X-rays? Calculate the Compton wavelength in Å for an electron.

(c) Show that if a particle moves with velocity $C/\sqrt{2}$, where C is the velocity of light in vacuum then its de Broglie wavelength and Compton wavelength become equal.

**(2 + 1 + 2) + (1 + 2 + 2) + 2 = 12**

7. (a) Explain the de Broglie hypothesis for matter waves. If an electron is subjected to a potential difference of V volts then prove that the corresponding de Broglie wavelength $\lambda = \frac{12.27}{\sqrt{V}} \mathring{A}$.

(b) Derive the relation between phase velocity and group velocity of a wave packet in terms of wavelength of the matter waves.

(c) State Hisenberg's uncertainty principle and justify that the electron cannot exist in an atomic nucleus.

**(2 + 2) + 3 + (2 + 3) = 12**

## Group – E

8. (a) The distance between (1, 0, 0) plane in a simple cubic structure is 0.125nm. What is the size of the unit cell? What is the radius of the atom?

(b) Ni has FCC structure. Its lattice constant is 3.52 Å; atomic weight of Ni is 58.71. Calculate its radius, Atomic packing factor and density.

(c) Find the Miller Indices of a plane having intercepts of 4a, -2b and 6c on the X,Y,Z axes respectively where a, b, c are primitive vectors of the unit cell.

(d) If the lattice constant for a BCC crystal is 3.57Å and the density of the material of the crystal is 8575 kg/m$^3$, find its atomic mass [given, Avagadro's number=6.02×10$^{26}$ atom/kg-mole].

**(2 + 2) + 3 + 2 + 3 = 12**

9. (a) Show that all primitive cells are unit cell but all unit cells may or may not be primitive cell.

(b) Find the distance between adjacent planes of Miller indices (*hkl*) in cubic crystal of side 'a'.

(c) Aluminium is FCC crystal with lattice constant a = 0.405 nm. How many unit cells are there in aluminium foil 0.005 cm thick and side 25 cm square? If its weight is 0.0085 kg, then how many atoms are present? [atomic weight of the Aluminium is 26.98 gm/mol.]

(d) What is the basis of dividing the crystal systems into different types and how many different Bravais lattices are shown in crystal structure?

(e) Sketch the direction of [102].

**2 + 3 + 3 + (1 + 1) + 2 = 12**

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