# PHYSICS I
## (PHYS1001)

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

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

*Candidates are required to answer Group A and*
*<u>any 5 (five)</u> from Group B to E, taking <u>at least one</u> 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)    In a damped motion, if the natural frequency of mass m be $\omega$ and the damping
          constant be K, then the quality factor (Q value) is defined as
          (a) $\frac{\omega}{2K}$          (b) $\frac{\omega}{K}$          (c) $\frac{K}{2\omega}$          (d) $\frac{K}{\omega}$

   (ii)   Malus law in polarization is defined by
          (a) $I = I_0 cos^2\theta$     (b) $I = I_0 cos\theta$     (c) $I = I_0 cos^2\frac{\theta}{2}$    (d) $I = I_0 cos\frac{\theta}{2}$

   (iii)  The phase velocity ($v_p$) of a monochromatic de Broglie wave is
          $v_p = \frac{C^2}{v}$                                    (b) $v_p = Cv$
          (c) $v_p = C^2v$                                         (d) $v_p = v$ , v is the particle velocity

   (iv)   Two coherent sources of different amplitudes interfere with each other. The
          ratio of amplitude is 3:2. Calculate the ratio of maximum intensity to the
          minimum intensity.
          (a) 25:1          (b) 5:1          (c) 9:4          (d) 625:1

   (v)    The plane along which the electric vector vibrations are lying is known as
          (a) plane of polarization                     (b) plane of vibration
          (c) principal plane                           (d) symmetric plane.

   (vi)   In $N_1$ and $N_2$ are populations of energy state $E_1$ and $E_2$ respectively in a system
          and $E_2 > E_1$ then condition for population inversion will be
          (a) $N_1 = N_2$                              (b) $N_1 > N_2$
          (c) $N_1 < N_2$                              (d) independent of $N_1$ and $N_2$

   (vii)  Two photons approach each other with velocity C. One photon's relative velocity
          with respect to other will be
          (a) 0.5C          (b) C          (c) ($\sqrt{3}/2$)C          (d) 0.25C
          Where, C= the velocity of light in free space

(viii)  In Compton effect photon can transfer
(a) negligible energy to the electron  (b) whole of its energy to the electron
(c) less than its energy to the electron  (d) none of these.

(ix)  An electron, neutron and a proton have the same de-Broglie wave length. Which particle has greater velocity?
(a) Electron  (b) Neutron  (c) Proton  (d) All have the same velocity.

(x)  The packing factor of the FCC structure is
(a)  52%  (b)  68%  (c)  84%  (d) none of these.

## Group – B

2.  (a)  What are the essential conditions for sustained interference?

(b)  In a Young's double slit experiment, the slits are separated by 1.15 mm and the screen is placed 1 m from the slits. The slits are illuminated by yellow light ($\lambda$ = 5896Å). Calculate the fringe width that would be observed on a screen.

(c)  What happened to the Newton's ring if air film is replaced by oil film in the space between the plano convex lens and the glass plate?

(d)  Define the term diffraction of light. How is diffraction different from interference of light?

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

3.  (a)  Differentiate between positive and negative crystal. What is quarter wave plate?
(b)  Critical angle for refraction for glass to air is 40°. Calculate the polarizing angle for glass.
(c)  Two polaroids are adjusted so as to obtain maximum intensity. Through what angle one should rotate one polaroid to reduce the intensity to one third of the original one.
(d)  In Laser, what do you mean by stimulated emission of light?

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

## Group – C

4.  (a)  Established the differential equation of motion of a damped harmonic motion subjected to a resistive force proportional to velocity. Write down the condition for overdamped and critical damped motion.
(b)  What is relaxation time in weakly damped motion and how does it vary with damping coefficient of the damped oscillator? Show that the amplitude of a weakly damped oscillator reduces to half its initial value in time $t = \tau ln2$, where $\tau$ is the relaxation time.

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

5.  (a)  What is resonance in forced vibration? Draw the plots of the displacement amplitude and velocity amplitude against the frequency of the sinusoidal force driving a mechanical oscillator for different values of damping.

(b)    Show that in the steady state the time-averaged input power equals the time-averaged power dissipated through friction in forced vibration.

(c)    In a L-C-R circuit, current is driven by an e.m.f $E = E_0 e^{-i\omega t}$. Write down the differential equation for charge flowing through the circuit.

**(2 + 2 + 2) + 4 + 2 = 12**

# Group – D

6.   (a)    Write down the expression of Planck's black body radiation law and explain all the term. Derive the Stefan's law from Planck's black body radiation law.

    (b)    Write down an expression for the Compton shift in wavelength for a photon scattered from a free electron at an angle θ. An X-ray photon is found to have doubled its wavelength on being scattered by 90°. Find the energy of incident photon.

**(2 + 4) + (2 + 4) = 12**

7.   (a)    State the de-Broglie hypothesis of matter waves. Find the de-Broglie wavelength of an electron moving with velocity $10^6$ m/s.

    (b)    State Heisenberg's uncertainty principle. Using uncertainty principle show that electron cannot exist within the nucleus.

    (c)    An electron of mass $9.1 \times 10^{-31}$ kg has a speed of 1 kms$^{-1}$ with an accuracy of 0.01%. Calculate the uncertainty with which the position of the electron can be located.

**(2 + 2) + (2 + 4) + 2 = 12**

# Group – E

8.   (a)    What are Miller indices? Show that in a cubic crystal of side 'a' the inter-planar spacing between consecutive parallel planes of Miller indices (hkl) is

$$d_{hkl} = \frac{a}{\sqrt{h^2 + k^2 + l^2}}$$

    (b)    Copper has an FCC structure having atomic radius 0.1278 nm. Calculate its cell length and inter-planar spacing for (111) planes.

    (c)    A beam of X-rays of wavelength 0.842 Å is incident on a crystal at a glancing angle of 8°35' when first order Bragg's reflection occurs. Calculate the glancing angle for the thirds order reflection.

**(1 + 4) + (2 + 2) + 3 = 12**

9.   (a)    Define atomic packing factor. Find out the packing factor for BCC structure.

    (b)    Find the ratio of intercepts on the crystal axes by a plane (231) in simple cubic lattice.

    (c)    A cubic crystal has lattice constant 4.3Å and density 963 kg/m$^3$. If its atomic weight is 45, then what type of cubic unit cell does it form?

    (d)    Draw the following miller planes (i) (100), (ii) (110) in the case of cubic crystal

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