B.Tech/AEIE/CSE/ECE/IT/2nd Sem/PHYS-1001/2016

2016

PHYSICS – I

(PHYS 1001)

Time Alloted : 3 Hours ***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 alternatives for the following : **[10×1=10]**

   i) In the process of Laser, Spontaneous emission rate depends upon

   (a) the number of atoms in excited state

   (b) intensity of the exciting radiation

   (c) both (a) and (b)

   (d) the number of atom in the ground state

   ii) If the refractive index of water is 1.33, the angle of polarization of light reflected from water is

   (a) $Cos^{-1}(1.33)$ (b) 53.1°

   (c) 36.9° (d) 1.33°

iii) If n_1 and n_2 be the refractive indices of the core and cladding respectively, then

(a) $n_1 = n_2$ (b) $n_1 > n_2$

(c) $n_1 < n_2$ (d) $n_1 \leq n_2$

iv) If the wavelength of the light used in single slit diffraction is increased, the width of the central maximum

(a) decreases (b) increases

(c) remains same (d) none of these

v) A vibrator of mass 10 gm is acted upon by a restoring force of 5 dyne/cm and a damping force 2 dyne-sec/cm. Comment on the motion of the vibrator.

(a) Crtically damped

(b) Overdamped

(c) Oscillatory

(d) Data insufficient to comment

vi) A particle executes simple harmonic motion with an amplitude 'a'. 50% of the energy of the particle is kinetic and the rest is potential, when the displacement is

(a) $\frac{a}{3}$ (b) $\frac{a}{2}$ (c) $\frac{a}{\sqrt{2}}$ (d) $\frac{a}{2\sqrt{2}}$

vii) A stone is dropped from the top of a building. What happens to the de-Broglie wavelength of the stone as it falls?

(a) It increases

(b) It decreases

(c) Remains constant

(d) de-Broglie wavelength cannot be defined

viii) How fast a particle must travel so that its mass becomes twice its rest mass

(a) 0.5c (b) 2c

(c) $\left(\sqrt{3}/2\right)c$ (d) 0.25 c

ix) Miller indices of a plane which cut intercepts of 2,3 and 4 units along the three axes are

(a) (2, 3, 2) (b) (6, 4, 3)

(c) (2, 3, 4) (d) (3, 4, 6)

x) 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 $\phi/2$ (d) Y leads F by $\phi/2$

GROUP - B

2. (a) Explain with necessary theory how you can determine the refractive index of a liquid by Newton's ring apparatus.

(b) Light waves can be polarized but not sound waves, why?

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

(d) In Newton's ring experiment, the diameter of a dark ring is 0.32 cm, when the wavelength of monochromatic light is 6000 Å. What will be the diameter of that ring when the wavelength of light changes to 5000 Å?

4+2+2+4 = 12

3. (a) 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 double slit.

(b) Define stimulated radiation in connection to Laser

(c) Two linearly polarised light waves are in phase but have different amplitudes. They are represented as

$\vec{E}_1(z,t) = \hat{i}A\ \cos(kz - \omega t) + \hat{j}B\ \cos(kz - \omega t)$ &

$\vec{E}_2(z,t) = \hat{i}A_2\ \cos(kz - \omega t) + \hat{j}B_2\ \cos(kz - \omega t)$.

Show that $\vec{E}_1 + \vec{E}_2 = \vec{E}$ is also linearly polarised. Find its polarisation direction.

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

GROUP - C

4. (a) Two simple harmonic motions having the same period but differing in phase and amplitude are acting in the same direction on a particle. Deduce the expression for the amplitude and phase of the resulting motion. Discuss the special cases when the phase difference is 0 and $\pi/2$ respectively.

(b) Write down the differential equation of a forced vibration explaining each term.

Show graphically how amplitude varies with frequency for different damping cases in a system undergoing forced vibration.

(c) The displacement of a simple harmonic oscillator is given by $x = a\sin(\omega t + \phi)$. If the oscillations started at time $t = 0$ from a position x_0 with velocity $V = v_0$ show that

$$\tan\phi = \frac{\omega x_0}{v_0} \text{ and } a = \left(x_0^2 + \frac{v_0^2}{\omega^2}\right)$$

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

5. (a) In damped harmonic motion, calculate the time by which the energy of the system falls to $\frac{1}{e}$ times of its initial value.

   (b) Explain the meaning of relaxation time and logarithmic decrement of a system undergoing damped harmonic motion.

   (c) Verify that u(x,t) = (Ax + B) (Ct + D) + (EsinKx + FcosKr) (GsinKct + HcosKct), is a solution of the one dimensional wave equation. (Where A, B, C, H, K and C are constants).

3+(2+2)+5 = 12

Group - D

6. (a) Show that Stefan's law can be derived from Planck's radiation law.

   (b) What is Compton effect? Write down equations for energy and momentum conserved in compton scattering (Diagram is mandatery).

   (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.

4+(2+3)+3 = 12

7. (a) Explain de Broglie hypothesis for matter waves.

   (b) What do you mean by group velocity and phase velocity? Show that the relation between group velocity (v_g) and phase velocity (v_p) is given by $v_g = v_p - \lambda \frac{dv_p}{d\lambda}$

   (c) Show that the rest mass m_0 of a particle of momentum P and kinetic energy T are related by $m_0 = \frac{P^2c^2 - T^2}{2Tc^2}$, where c is velocity of light in vaccum.

   (d) State Heisenberg's uncertainty principle.

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

GROUP - E

8. (a) Define coordination number. By drawing a neat diagram of a lattice network of SCC structure find the coordination number of a SCC.

   (b) Explain space lattice and crystal lattice.

   (c) Plot the Miller plane and directions denoted by [110], [102] in a unit cell of a cubic structure.

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

9. (a) What is the difference between a primitive cell and a unit cell? Show that all primitive cells are unit cells but all unit cells are not primitive cells.

   (b) Find the Miller indices of a plane having intercepts of 8a, 4b and 2c on the X, Y, Z axes respectively where a, b, c are primitive vectors of the unit cell.

   (c) A diffraction pattern of a cubic crystal of lattice parameter $a = 3.16\,\text{Å}$ is observed with a monochromatic x-ray beam of wavelength $1.54\,\text{Å}$. The first line on this pattern is observed to have $\theta = 20.3°$. Calculate interplanar spacing and Miller indices of the crystal plane.

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