Name : ....

Roll No. : ....

Invigilator's Signature : ....

CS/B.Tech(Old)/SEM-2/PH-201/2011

2011

ENGINEERING PHYSICS

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 × 1 = 10

i) A ray of light is incident on the surface of a glass plate at an angle of incidence equal to the Brewster's anlge φ. If μ represents the refractive index of glass with respect to air, then the angle between reflected and refracted rays is

a) $90° + \varphi$ b) $\sin^{-1}(\mu \cos\varphi)$

c) $90°$ d) $90° - \sin^{-1}(\mu \sin\varphi)$.

ii) The first minimum due to a Fraunhofer diffraction using light of wave length 500 nm and a slit width of 0·5 mm will be formed at an angle

a) 0·084° b) 0·057°

c) 0·001° d) 3·42°.

iii) Two waves having amplitudes 5 : 1 produce interference. The ratio of the maximum to minimum intensity in the interference pattern is

a) 25 : 1 b) 6 : 4

c) 3 : 1 d) 9 : 4.

iv) A grating has 5000 lines/cm. The maximum order of diffraction visible with light of wavelength 600 nm is

a) 4 b) 3

c) 2 d) 1.

v) In a ruby laser population inversion is achieved by

a) chemical reactions

b) inelastic collision between atoms

c) optical pumping

d) applying strong electric field.

vi) The coordination number in a *fcc* lattice is

a) 4 b) 6

c) 8 d) 12.

vii) Velocity of a particle when its mass become twice its rest mass is

a) 0·5c b) 0·72c

c) 0·866c d) c.

viii) The resolving power of a grating having N number of lines exposed to nth order is

a) N/n b) n/N

c) $n + N$ d) nN.

ix) The wave length λ at which a black body emits maximum amount of radiation is proportional to

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

c) T^4 d) e^T.

x) The maximum velocity of an electron emitted by light of wavelength λ incident on the surface of a metal of work function ϕ is

a) $\sqrt{\frac{2(hc + \lambda\phi)}{m\lambda}}$ b) $\sqrt{\frac{2(hc - \lambda\phi)}{m\lambda}}$

c) $\sqrt{\frac{2(h\lambda - \phi)}{m}}$ d) $\frac{2(hc + \lambda\phi)}{m\lambda}$.

xi) Electron of masss m, when accelerated through a potential difference V has a de-Broglie wavelength λ. The de-Broglie wavelength associated with a proton of mass M accelerated through the same potential difference will be

a) $\lambda \frac{m}{M}$ b) $\lambda \frac{M}{m}$

c) $\lambda \sqrt{\frac{m}{M}}$ d) $\lambda \sqrt{\frac{M}{m}}$.

xii) The commutation relation $[x^2, p_x]$, where x and p_x are respectively the quantum mechanical position and momentum operators along x-axis, is equal to

a) $2i\hbar x$ b) $i\hbar$

c) $2i\hbar$ d) $2i\hbar x^2$.

xiii) For a particle in a potential the two lowest states have energies ε_1 and ε_2 and the corresponding eigenfunctions are ψ_1 and ψ_2 respectively. At one instant the wave function is represented by

$\psi = \frac{\sqrt{3}}{2}\psi_1 + \frac{1}{2}\psi_2$. The expectation value of the total energy corresponding to the wave function ψ is

a) $\frac{\sqrt{3}}{2}\varepsilon_1 + \frac{1}{2}\varepsilon_2$ b) $\frac{3}{2}\varepsilon_1 + \frac{1}{2}\varepsilon_2$

c) $\frac{3}{4}\varepsilon_1 + \frac{1}{2}\varepsilon_2$ d) $\varepsilon_1 + \varepsilon_2$.

xiv) In the X-ray spectrum emitted from a tungsten anode, if I_α and I_β be the intensities and λ_α and λ_β are the wave lengths of the K_α and K_β lines respectively, then

a) $I_\alpha > I_\beta$ and $\lambda_\alpha > \lambda_\beta$ b) $I_\alpha > I_\beta$ and $\lambda_\alpha < \lambda_\beta$

c) $I_\alpha < I_\beta$ and $\lambda_\alpha < \lambda_\beta$ d) $I_\alpha < I_\beta$ and $\lambda_\alpha > \lambda_\beta$.

xv) The number of ways in which four identical bosons can be distributed in three different energy states is

a) 15 b) 6

c) 144 d) 24.

GROUP – B

(Short Answer Type Questions)

Answer any *three* of the following. $3 \times 5 = 15$

2. a) Write the basic difference between Fresnel and Fraunhofer type of diffraction.

   b) In a two-slit Fraunhoer diffraction pattern, with equal slit width $b = 8.8 \infty 10^{-3}$ cm and the slit separation $d = 7.0 \infty 10^{-2}$ cm, find the number of interference minima occurring between the two diffraction minima occurring on either side of the central maximum. The wave length of light used is $\lambda = 6328$ Å. 2 + 3

3. Assuming that the oscillators can have only discrete energy values $\varepsilon = nhv$, where, $n = 0, 1, 2, 3, \ldots\ldots$ (all positive integer values) and follow the Boltzman distribution function show that the average energy of each oscillator at temperature T is $\bar{\varepsilon} = \dfrac{hv}{e^{hv/kT} - 1}$.

4. a) An electron is inside an atom of radius $5 \infty 10^{-11}$ m. Calculate from uncertainty principle the minimum kinetic energy of the electron. 2

   b) Using the relations $\varepsilon^2 = p^2 c^2 + m_0^2 c^4$; $\varepsilon = mc^2$ for a relativistic particle, show that group velocity is equal to particle velocity. Also find the phase velocity of the particle. 2 + 1

5. a) Find the miller indices of a crystal plane which intercepts the a-axis at $3a$, b-axis at $4b$ and is parallel to c-axis ; a, b and c being primitive vectors of the lattice. 1

b) Copper has *fcc* structure and the atomic radius is 0·128 nm. Calculate the density of copper taking the atomic weight of copper as 63·5. 2

c) Calculate the glacing angles on the set of parallel planes (110) of cubic crystal with lattice constant a = 2·814 Å corresponding to second order diffraction maximum for X-rays of wavelength 0·710 Å. 2

6. What are the essential requirements for the construction of an optical fiber ? Calculate the numerical aperture of an optical fiber in which the refractive index of core and cladding are 1·58 and 1·5 respectively. Find the maximum acceptance angle if the fiber is placed in a medium of refractive index 1·33.

GROUP – C

(Long Answer Type Questions)

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

7. a) State and explain Malus' law. 3

b) What are half wave and quarter wave plates ? 2

c) How can you convert plane polarized light to circularly polarized light ? 4

d) A beam of unpolarized light of intensity I is passed first through a Tourmaline crystal A and then through another Tourmaline crystal B oriented such that its principal plane is parallel to that of A. If A is now rotated by 45° in a plane parallel to the direction of incident ray, find the intensity of the emergent light. 3

e) The critical angle for a particular pair of medium is $\sin^{-1}(3/5)$. Find the polarizing angle for the pair of mediums. 3

8. a) Explain the terms spatial coherence and temporal coherence. 2

b) Find an expression for the intensity distribution when two sinusoidal coherent waves with amplitudes A_1 and A_2 and phase difference φ superpose to produce interference. 5

c) Find an expression for the fringe width in the interference pattern of Young's double slit experiment. 5

d) A thin sheet of glass of thickness 6 micron (refractive index 1.5) is introduced in the path of one of the interfering beams in a double slit experiment. The shift pattern shifts by 5 fringes. Find the wavelength of light used in the experiment. 3

9. Consider a particle of mass m that can move along X-axis in a region between $x = 0$ and $x = L$ in a potential given as :

$$V(x) = \begin{cases} 0 \text{ for } 0 \bullet x \bullet L \\ \bullet \text{ for } x \bullet 0 \text{ and } x \text{ ® } L \end{cases}$$

a) Write the time-independent Schrödinger equation for both regions and derive expressions for the energy eigenvalues and corresponding normalized wave functions.

b) Draw the wave functions corresponding to lowest two states.

c) Find the expectation value of the position operator in the ground state.

d) An electron is confined in the infinite potential box with length $L = 1{\cdot}0$ Å, Calculate energy of the ground state. 7 + 2 + 3 + 3

10. a) Explain Compton effect. Derive an expression for the Compton shift. 8

b) For which angle of scattering the Compton shift is maximum ? 2

c) Can we study Compton effect with visible light ? Give explanation. 2

d) Explain the significance of Compton effect in the development of quantum theory. 3

11. a) Compare MB, BE and FD statistics mentioning at least three characteristics. 5

b) Sketch the Fermi distribution function at temperature $T = 0$ and $T > 0\ K$. 2

c) Express Fermienergy at 0 K in a metal in terms of free electron density. 5

d) Show that the average energy of a free electron in the metal $\bar{\varepsilon} = 0{\cdot}6\ \varepsilon_F$. 3

12. a) Define Einstein's A and B coefficients and deduce their mutual relations. 5

b) Show that the ratio of spontaneous and stimulated emission is proportional to cube of frequency. 3

c) What do you mean by population inversion and why is it necessary in a LASER ? 2

d) Explain the working principle of He-Ne LASER with energy level diagram. 5