



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.*

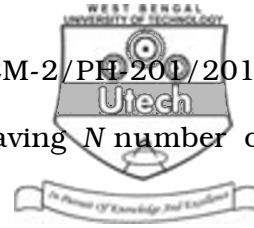
*Candidates are required to give their answers in their own words  
as far as practicable.*

**GROUP – A**  
**( Multiple Choice Type Questions )**

1. Choose the correct alternatives for any *ten* of the following :  
 $10 \times 1 = 10$
- i) A ray of light is incident on the surface of a glass plate at an angle of incidence equal to the Brewster's angle  $\phi$ . If  $\mu$  represents the refractive index of glass with respect to air, then the angle between reflected and refracted rays is
- a)  $90^\circ + \phi$                                       b)  $\sin^{-1}(\mu \cos \phi)$   
c)  $90^\circ$     d)  $90^\circ - \sin^{-1}(\mu \sin \phi)$
- 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)  $0.084^\circ$     b)  $0.057^\circ$   
c)  $0.001^\circ$     d)  $3.42^\circ$



- 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  $n$ th order is

- a)  $N/n$                                       b)  $n/N$   
c)  $n + N$                                       d)  $nN$ .

ix) The wave length  $\lambda$  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  $\lambda$  incident on the surface of a metal of work function  $\phi$  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 mass  $m$ , when accelerated through a potential difference  $V$  has a de-Broglie wavelength  $\lambda$ . 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  $\epsilon_1$  and  $\epsilon_2$  and the corresponding eigenfunctions are  $\psi_1$  and  $\psi_2$  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  $\psi$  is

- a)  $\frac{\sqrt{3}}{2} \epsilon_1 + \frac{1}{2} \epsilon_2$                                       b)  $\frac{3}{2} \epsilon_1 + \frac{1}{2} \epsilon_2$   
 c)  $\frac{3}{4} \epsilon_1 + \frac{1}{2} \epsilon_2$                                       d)  $\epsilon_1 + \epsilon_2$ .

xiv) In the X-ray spectrum emitted from a tungsten anode, if  $I_\alpha$  and  $I_\beta$  be the intensities and  $\lambda_\alpha$  and  $\lambda_\beta$  are the wave lengths of the  $K_\alpha$  and  $K_\beta$  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.



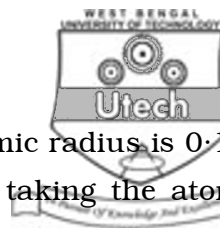
**GROUP – B**

**( Short Answer Type Questions )**

Answer any *three* of the following.

3 × 5 = 15

2. a) Write the basic difference between Fresnel and Fraunhofer type of diffraction.
- b) In a two-slit Fraunhofer diffraction pattern, with equal slit width  $b = 8.8 \times 10^{-3}$  cm and the slit separation  $d = 7.0 \times 10^{-2}$  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  $\lambda = 6328 \text{ \AA}$ . 2 + 3
3. Assuming that the oscillators can have only discrete energy values  $\epsilon = nh\nu$ , where,  $n = 0, 1, 2, 3, \dots$  ( all positive integer values ) and follow the Boltzman distribution function show that the average energy of each oscillator at temperature  $T$  is  $\bar{\epsilon} = \frac{h\nu}{e^{h\nu/kT} - 1}$ .
4. a) An electron is inside an atom of radius  $5 \times 10^{-11}$  m. Calculate from uncertainty principle the minimum kinetic energy of the electron. 2
- b) Using the relations  $\epsilon^2 = p^2 c^2 + m_0^2 c^4$  ;  $\epsilon = mc^2$  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  $0.128 \text{ nm}$ . Calculate the density of copper taking the atomic weight of copper as  $63.5$ . 2
- c) Calculate the glancing angles on the set of parallel planes  $(110)$  of cubic crystal with lattice constant  $a = 2.814 \text{ \AA}$  corresponding to second order diffraction maximum for X-rays of wavelength  $0.710 \text{ \AA}$ . 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.  $3 \times 15 = 45$

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  $45^\circ$  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  $\varphi$  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 :
- $$V(x) = \begin{cases} 0 & \text{for } 0 \leq x \leq L \\ \infty & \text{for } x < 0 \text{ and } x > L \end{cases}$$
- 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  $L = 1.0 \text{ \AA}$ , 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 Fermi energy 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  $\bar{\epsilon} = 0.6 \epsilon_F$ . 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