

Name :

Roll No. :

Invigilator's Signature :

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

2011

PHYSICS – I

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

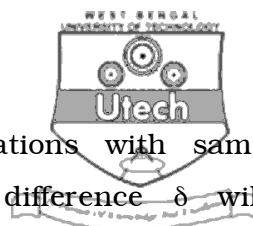
- i) If the damping force on an one-dimensional harmonic oscillator of natural frequency ω_0 , is $2bmv$, where m is the mass and v is the instantaneous velocity of the oscillator then the frequency of oscillation (when $b \ll \omega_0$) is

a) ω_0

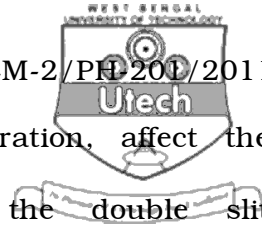
b) b

c) $\omega_0 \left(1 - \frac{b^2}{2\omega_0^2} \right)$

d) $\omega_0 \left(1 + \frac{b^2}{2\omega_0^2} \right)$.



- ii) Two mutually perpendicular oscillations with same frequency, amplitude but phase difference δ will produce closed curve with non-zero area enclosed
- a) for all values of δ except $\delta = 0$
 - b) only for $\delta = \frac{\pi}{2}$
 - c) for all values of δ except $\delta = 0$ and $\delta = \pi$
 - d) for all values of $\delta > \frac{\pi}{2}$.
- iii) Example of weakly damped harmonic oscillator is
- a) Dead-beat galvanometer
 - b) Tangent galvanometer
 - c) Ballistic galvanometer
 - d) Discharge of a charged capacitor through a resistance.
- iv) Missing orders are found in case of double slit diffraction patterns due to
- a) unequal value of two slit widths
 - b) superposition of diffraction minima and interference maxima
 - c) superposition of diffraction maxima and interference minima
 - d) oblique incidence of light.



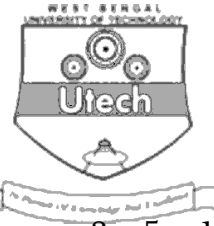
v) How does reducing the slit separation, affect the appearance of the fringes in the double slit interference ?

- a) The fringe width increases and the fringes are brighter
- b) The fringe width increases but the brightness remains unchanged
- c) The fringe width decreases and the fringes are brighter
- d) The fringe width is unchanged but the fringes are less bright.

vi) Resolving power of microscope objective placed in air with light of wavelength λ_1 is the same when immersed in oil of refractive index μ and wavelength λ_2 . Assuming the semivertical angle to be the same in these two cases then

- a) $\lambda_1 = \mu \lambda_2$
- b) $\lambda_2 = \mu \lambda_1$
- c) $\lambda_1 \lambda_2 = \mu (\lambda_1 + \lambda_2)$
- d) $\lambda_1 + \lambda_2 = \mu \lambda_1 \lambda_2$.

- where γ is the frequency of the wave.



GROUP – B
(Short Answer Type Questions)

Answer any *three* of the following.

3 × 5 = 15

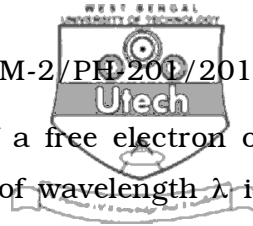
2. If a damped harmonic oscillator, with natural frequency ω_0 and damping force $2mbV$ (V = velocity, m = mass, b = a constant) is driven by a periodic force $Fe^{i\omega t}$ then the steady state displacement is given by

$$x = \frac{F}{m} \frac{e^{i\omega t}}{\sqrt{(\omega_0^2 - \omega^2)^2 + 4b^2\omega^2}}$$

Use this fact to show that at the velocity resonance the phase of the periodic force and the velocity is the same.

3. A mica sheet of thickness t and refractive index μ is introduced in the path of one of the interfering beams in Young's double slit experiment. Find out the linear displacement of the n th bright fringes in terms of ' μ ' and ' t '.
4. a) What is polaroid ? Give instances of its practical application.
- b) A quartz plate with thickness of 0.1436 mm is used as phase retardation plate. For what wavelengths in the visible region (450 – 800 nm) will it act as a quarter wave plate ($\mu_o = 1.5443$, $\mu_e = 1.55333$).

1 + 1 + 3



5. Prove that the maximum recoil energy of a free electron of rest mass m_0 when struck by a photon of wavelength λ is given by $E_{\max} = \frac{2m_0 c^2 \lambda_c^2}{\lambda^2 + 2\lambda_c \lambda}$. Here λ_c is the Compton wavelength of the electron.
6. a) The spacing between principal planes of NaCl crystal is 2.82 \AA . It is assumed that the first order Bragg reflection occurs at an angle 10° . Calculate the wavelength of X-rays.
- b) Find the atomic packing fraction of a B.C.C. structure. 2 + 3

GROUP – C

(Long Answer Type Questions)

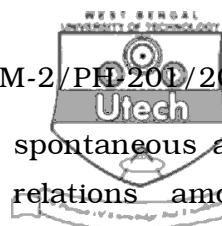
Answer any *three* of the following. 3 × 15 = 45

7. a) A cubical block of side L cm and density d is floating in water of density ρ ($\rho > d$). The block is slightly depressed and released. Show that it will execute simple harmonic motion. Determine the frequency and time period of oscillation. 5
- b) Find the displacement as a function of time of a particle of mass m which is subjected to overdamped harmonic motion with natural frequency ω_0 and damping force γV (V being the instantaneous velocity), given that the displacement is zero initially and the initial velocity is V_0 . Sketch the displacement as a function of time. 7 + 3



8. a) Newton's ring arrangement is used with a source emitting two wavelengths $\lambda_1 = 600 \text{ nm}$ and $\lambda_2 = 590 \text{ nm}$. It was found that the n th dark ring due to λ_1 coincides with the $(n + 1)$ th dark ring due to λ_2 . If radius of curvature of the lens is 0.9 m then find out the value of n and the diameter of the n th dark ring due to λ_2 . 5
- b) A plane transmission grating having 1500 lines/inch is being used under normal incidence of light.
- What is the longest wavelength of light for which a spectrum can be seen ?
 - What is the highest order spectrum that can be seen for the light of 589.3 nm wavelength ?
 - The spectral line of 589.3 nm in the second order spectrum overlaps with another spectral line in the next order. Find wavelength of the other spectral line.
 - Find the expression of the dispersive power for a given order.
 - If 90% of the width of the grating is covered, how the width of the spectral lines are changed ?

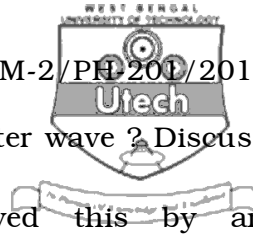
2 + 2 + 2 + 2 + 2



9. a) Define Einstein's A , B coefficient for spontaneous and stimulated emission. Derive the relations among them. 3 + 4
- b) At what angle should light be incident on a glass plate of refractive index $\mu = 1.5697$ to get a plane polarized light by reflection. 3
- c) An analyzing nicol examines two adjacent plane polarized beams A and B whose planes of polarization are mutually perpendicular. In one position of the analyzer the beam B shows zero intensity. From this position, a rotation of 30° shows the two beams as of equal intensity. Deduce the ratio of two intensities I_A/I_B of the two beams. 3
- d) Why is it necessary that the object beam and reference beam in holography are highly coherent ? 2
10. a) Discuss the action of optical resonator in a Baser device. What is the relation of the length of the resonator with the frequency of the laser beam ? 3 + 1
- b) A ruby laser emits light of 693.95 nm wavelength. If 1 mole of Cr^{3+} ions are involved in population inversion process in a pulse, calculate the pulse energy in eV. 3
- c) Calculate average energy of a cavity oscillator with frequency γ . How does this average energy vary with frequency in the high frequency limit ? 4 + 1
- d) Derive Wien's displacement law from Planck's law of Black body radiation. 3



11. a) What voltage must be applied to an X-ray tube for it to emit X-ray with a minimum wavelength 30 pm. Deduce the formula that you use $\left[\frac{hc}{e} = 1.24 \times 10^{-4} \text{ Vm} \right]$. 3 + 1
- b) What are characteristic X-rays ? How are they produced ? 1 + 2
- c) Describe the relation between the lattice constants and the angles between them in any one Bravais lattice other than cubic crystal system. 3
- d) Find the Miller indices of all the principal planes of a cubic crystal system. 3
- e) Aluminium is an fcc crystal with lattice constant $a = 0.405 \text{ nm}$. Calculate the number of unit cells present in an aluminium foil of 0.005 cm thickness and two sides of 25 cm length. 2



12. a) What is de Broglie hypothesis of matter wave ? Discuss how Davisson and Germer proved this by an experiment. 1 + 4
- b) If a particle of charge e and rest mass m_0 is accelerated by a potential V then what is the de Broglie wavelength of the particle viewing the relativistic energy momentum relation. 4
- c) The atoms in a solid possess a certain minimum zero point energy even at 0K while no such restriction holds for the molecules in an ideal gas. Use uncertainty principle to explain this statement. 2
- d) An electron has de Broglie wavelength 2 pm. Find the phase and group velocities of its de Broglie wave given that the rest energy of an electron is 511 eV. 4

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