Maulana Abul Kalam Azad University
of Technology, West Bengal

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MAULANA ABUL KALAM AZAD UNIVERSITY OF TECHNOLOGY, WEST BENGAL

Paper Code : PH-101
PUID : 01005 (To be mentioned in the main answer script)
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 : $10 \times 1 = 10$

i) If a particle is executing simple harmonic motion with frequency ν then its potential energy

   a) remains constant over time

   b) is oscillating with a frequency ν

   c) is oscillating with a frequency ν/2

   d) is oscillating with a frequency 2 ν.

ii) If two SHMs of the similar amplitude, time period and phase act at right angle to each other then the resultant vibration is

   a) circular   b) elliptical

   c) linear   d) parabolic.

iii) According to Wien's displacement law

   a) $\lambda_m T$ = Constant   b) λ_m / T = Constant

   c) $\lambda_m T^2$ = Constant   d) λ_m / T^2 = Constant.

iv) Velocity resonance of the forced oscillator occurs at

   a) $\omega = 2\omega_0$ b) $\omega = \omega_0$

   c) $\omega = \dfrac{\omega_0}{2}$ d) none of these.

v) At resonance, the phase difference between displacement and velocity of a forced oscillator is

   a) π b) $\dfrac{2\pi}{3}$

   c) $\dfrac{3\pi}{4}$ d) 0.

vi) The quality factor Q for an LCR circuit is

   a) $\dfrac{\omega L}{R}$ b) $\dfrac{\omega R}{L}$

   c) $\dfrac{\omega}{LR}$ d) $\dfrac{R}{\omega L}$.

vii) In holography we obtain image, which is

   a) 2 dimensional   b) 1 dimensional

   c) 3 dimensional   d) none of these.

viii) In Biprism's experiment, coherent sources are produced by means of

    a)   division of wavelength

    b)   division of amplitude

    c)   division of wave front

    d)   division of colour.

ix) Polarization of light confirms that

    a)   light is a transverse wave

    b)   light is a longitudinal wave

    c)   light bends when passes by the edge of a sharp object

    d)   light consists of photons.

x) Nicol prism can be used as

    a)   a polarizer only

    b)   an analyzer only

    c)   a polarizer and an analyzer

    d)   a spectrum analyzer.

xi) In Ruby lasing system, Al_2O_3 is doped with

    a)   carbon   b)   chromium

    c)   calcium   d)   chlorine.

xii) The resolving power of a grating having N no. of lines exposed, in n-th order is

    a) $\dfrac{N}{n}$ b) $\dfrac{n}{N}$

    c) $n + N$ d) nN.

xiii) Compton wavelength is given by

    a) $\lambda = \dfrac{h}{m_0 c^2}$ b) $\lambda = \dfrac{h}{m^0}$

    c) $\lambda = \dfrac{h}{m_0 c}$ d) $\lambda = \dfrac{m_0}{hc}$.

xiv) Heisenberg position momentum uncertainty relation is given by

    a) $\Delta x \Delta p_x = h$ b) $\Delta x \Delta p_x \geq \hbar/2$

    c) $\Delta x \Delta p_x \leq \hbar/2$ d) $\Delta x \Delta p_x = 1$.

xv) The de-Broglie wavelength of a moving particle of mass m and kinetic energy E is

    a) $\lambda = h/(2m\,E)^{1/2}$ b) $\lambda = h/2mE$

    c) $\lambda = (2m\,E)^{1/2}/h$ d) $\lambda = \lambda^2 (2mE)^{1/2}$.

GROUP – B

(Short Answer Type Questions)

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

2. Show that the total energy of an oscillator exhibiting simple harmonic motion is constant. Show that in an LC circuit charge q undergoes an Simple harmonic oscillation with time. $3 + 2$

3. a) In a Young's double slit experiment the fringes are formed at a distance of 1 m from the double-slit of separation 0.12 mm. Calculate the distance of 3rd dark band from the centre of the screen. Given wavelength of light is 6000 Å.   2

    b) Write down the expression for the intensity of light due to Fraunhofer diffraction in a transmission grating and hence find the condition for secondary minima in the interference pattern. $1 + 2$

4. a) Describe with energy level diagram, the working principle of lasing action. 3

   b) The refractive index of E-ray and o-ray are respectively 1.65 and 1.45. Then find the thickness of the material required to make a quarter wave plate for light of wavelength 5000 Å. 2

5. What is Compton effect ? Calculate the Compton shift in wavelength for a photon scatters from a free electron at an angle θ ? 1 + 4

6. Deduce the relation between the lattice constant and density of a material of simple cubic crystal. In a crystal a lattice plane cuts intercepts of $2a$, $3b$ and $6c$ along the axes, where a, b and c are the primitive vectors of the unit cell. Determine the Miller indices of the plane. 3 + 2

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GROUP – C

(Long Answer Type Questions)

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

7. a) Starting from the equation of motion and after solving it show that, for a forced oscillator in the steady state, the displacement amplitude at low frequencies ($\omega \to 0$), the velocity amplitude at velocity resonance ($\omega = \omega_0$) are independent of the frequency of the driving force.

   b) Explain the term logarithmic decrement and quality factor of a damped oscillatory system. How are they related ? (2 + 6 + 2 + 2) + (1 + 1 + 1)

8. a) Derive the expression for the intensity distribution for Fraunhofer diffraction due to single slit. Describe the intensity pattern graphically.

   b) How will the radius of the Newton's ring change if air is replaced by oil between the lens and the glass plate ? Explain it. A film of oil of refractive index 1.70 is placed between a plate and an equi-convex lens. The focal length of the lens is 1 metre. Determine the radius of the 10th dark ring when the wavelength of the light used is 6000 Å.

   (7 + 2) + (2 + 4)

9. a) State Brewster's law and hence prove that the angle between the reflected and refracted ray is 90°. Describe the construction of Nicol prism and hence state how the polarized light can be obtained by the help of a Nicol prism.

   b) Obtain a relation between the Einstein's A and B coefficients. In a He-Ne laser transition from E_3 to E_2 level gives a lser emission of wavelength 632.8 nm. If the energy of the E_2 level is 15.2×10^{19} J, how much pumping energy is required ? Consider no energy loss.

   c) What is holography ? [(1 + 3) + 4] + (3 + 3 + 1)

10. a) Assume that an electron is inside a nucleus of radius 10^{-15}m. Calculate from the uncertainty principle the minimum kinetic energy of the electron.

    b) A 5 kW radio transmitter operates at a frequency of 500 kHz. Find the number of photons it emits.

c) What is de Broglie hypothesis ? Describe an experiment to verify the de Broglie hypothesis.

d) Show that the relativistic momentum, $p = \dfrac{\sqrt{k(k+2E_0)}}{c}$, where k is the kinetic energy, E_0 is the rest mass energy of the electron and c is the velocity of light. $4 + 2 + (1 + 4) + 4$

11. a) Calculate the interplaner spacing 'd' of planes (111) in a simple cubic lattice of side 'a'.

b) Show that in a cubic crystal of side a, the interplaner spacing between consecutive parallel planes of Miller indices (hkl) is

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

c) Molybdenum has a BCC structure and its atomic radius is 0.1653 nm. What is the interplaner spacing for (220) plane ?

d) Prove that the intensity of x-rays decreases exponentially with the thickness of the material. Show the variation graphically. $2 + 4 + 3 + (4 + 2)$

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