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PH2101: Final exam

Full marks: 50

1. Choose the correct answer(s): [2x5]

i) A string of length L fixed at both ends is plucked vertically by a distance d at the centre $(L/2)$. The solution for the resultant vertical displacement along the string would be of the form (with A as a constant, and n - an integer from 1 to ∞):

(a). $A\ \mathrm{Sin}(n\pi)$. (b). $A\ \mathrm{Cos}(n\pi)$. (c). $A\ \mathrm{Sin}(n\pi) + A\ \mathrm{Cos}(n\pi)$. (d). $A\ \mathrm{Sin}(n\pi) - A\ \mathrm{Cos}(n\pi)$.

ii) Of the following statements regarding the interference of light which are true:

(a). Fringes will be always observed if two beams of light obtained from a coherent source interfere.

(b). Fringes will be observed only if two light beams are coherent and have similar intensities.

(c). A tube light cannot produce interference effects.

(d). Every light source has a finite coherence length and time.

iii) A laser beam is incident on a transparent optical element, a linear polarizer, and a detector - in that order. When the linear polarizer is rotated by 360 degrees around its axis, the power measured on the detector does not change. Which of the following can be definitively concluded from this?

(a). The incident laser beam was linearly polarized and the optical element is a half-wave plate.

(b). The incident laser beam was linearly polarized with its polarization axis at 45 degrees with the axis of the optical element, and the optical element is a quarter wave plate.

(c). The incident laser beam was elliptically polarized and the optical element is a half-wave plate.

(d). The incident laser beam was unpolarized and the optical element is a polarizer.

iv) A simple pendulum of length 'l' is suspended from the roof of a trolley which moves in a horizontal direction with an acceleration a. Then, the time period is given by, $T = 2\pi\sqrt{\frac{l}{g'}}$, where g' is given by (g is the acceleration due to gravity):

(a). $g - a$. (b). $g + a$. (c). ga. (d). $\sqrt{(g^2 + a^2)}$

v. In a double slit diffraction experiment, if the individual slit widths are decreased, but the slit separation is increased, then which of the following are true:

(a). The width of the central diffraction maximum will increase.

(b). The number of interference maxima inside the central maximum will in-

crease.

(c). The width of the central diffraction maximum will reduce.

(d). The number of interference maxima inside the central maximum will reduce.

2. For a damped oscillator (not driven by any external force) find the time T^* after which the amplitude of oscillations drops to half its value in terms of the damping coefficient γ and mass m. [3]

b) For the following figure, find the normal mode frequencies and amplitudes if the lower mass is given a small displacement vertically downwards. [4]

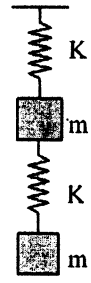

Figure 1.

3. a) Two strings whose linear densities are in the ratio of 1:4 are stretched and joined together. A transverse wave is incident at the boundary from the lower density side. Calculate the reflection and transmission amplitude coefficients. [3]

b) A string of length l fixed at two ends and initially at rest is plucked at a distance $x = l/3$ by a vertical distance d. Find the total displacement of the string in terms of its normal modes. [5]

4. a) Show that the expression $\psi(z,t) = A\exp -(2z + 3t)^2$ is a progressive wave. Find the velocity of the wave and verify that $\psi(z,t)$ is a solution of the wave equation. [2+2]

b) The speed of propagation of a surface wave in a liquid of depth much greater than λ is given by $v = \sqrt{\frac{g\lambda}{2\pi} + \frac{2\pi Y}{\rho\lambda}}$ where g = acceleration of gravity, λ = wavelength, ρ = density, Y = surface tension. Compute the group velocity of a pulse in the long wavelength limit (i.e. when λ is very large). [3]

5. Consider the diagram given below. Explain the phase response of the reflected field amplitudes r with respect to the incident electric field for each case (Figures (a) - (c)). Describe the polarization of each incident field. [6]

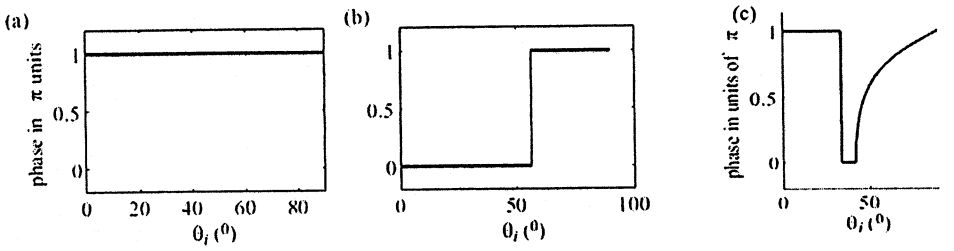

Figure 2.

6. a) Find the Jones matrix for an optical element that will act as a left circular polarizer for an x-polarized input wave. [3]
   b) A wave travels in a medium of refractive index n_1 and enters a second medium having refractive index n_2 where $n_1 > n_2$. Show that beyond a certain angle of incidence, there can be no energy propagating in the direction of the incident wave. What is then the direction of propagating energy? [4+1]

7. Consider Fig. 3, where a field E_0 is incident on a Fabry Perot interferometer with the given incident and transmitted angles. The refractive index of the incident medium (air) is n_i, while that of the other (glass) is n_t. Given that the path difference Λ between adjacent reflected rays is $\Lambda = (m + 1/2)\lambda$ where λ is the wavelength of the light field inside the interferometer, and m is an integer, find out the total reflected field E_r in this circumstance considering a very large number of reflections. Give reasons for your answer. [4]

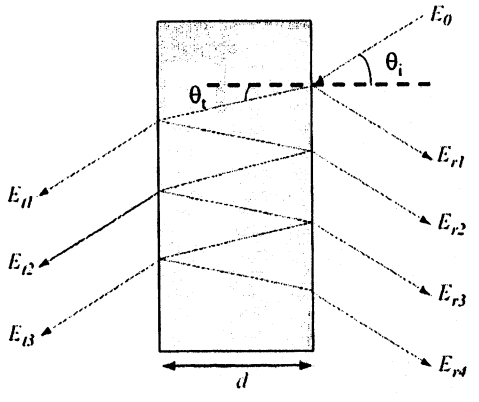

Figure 3.