Department of Physics
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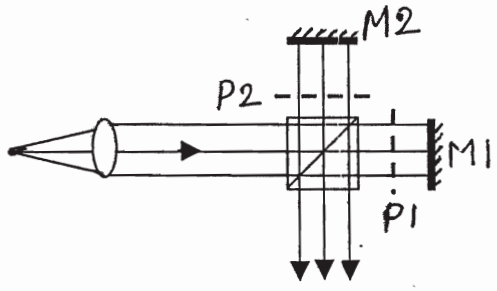
PHL110: Fields and Waves, Major, (07 May 2007), Max.Marks: 50, Time: 2hrs
This question paper contains two pages. Answer all the 12 questions.

1. State with appropriate reasons if the following statements are true or false.
   (a) Ultraviolet catastrophe was explained by Rayleigh-Jeans formula.
   (b) Electrostatic energy obeys the superposition principle.
   (c) A single charge Q located at $(1,-1,0)$ does have a dipole moment.
   (d) A conducting wire carrys a current I along its length. The direction of Poynting vector for this configuration is circumferential. (6)

2. A collimated monochromatic beam $(\lambda = 0.6\mu m)$ is used in a Michelson interferometer as shown in the figure given below. When the path difference between two arms is zero, no fringes are observed. Now, two crossed polarizers (P1 and P2 shown by dashed lines in the figure) one in each of the arms are introduced. One of the mirrors is moved (a) by $0.05\mu m$ and (b) by $0.075\mu m$ from its initial position. What will be the phase shifts and the state of polarization of the output beam in each case? (4)



3. The eighth interference order in a Young's two-slit experiment is missing and this occurs at the third diffraction minimum. If the separation between the two identical slits is $4\mu m$, what is the width of the slit? (4)

4. A grating of width *L*, slit width *s* and spacing *d* is illuminated normally by a plane monochromatic wave. Obtain the intensity distribution at the diffraction pattern (i) when alternate slits are blocked. (ii) When alternate slits are covered with transparent material, which retards the wave, by π radians. (5)

5. A particle confined in an infinite potential well of width L. Write an expression for the energy states corresponding to quantum number $n = 1 \& 2$. Sketch the wavefunction ψ and the probability density for each of these states. (5)

6. For a wavefunction given by $\psi(x) = Ae^{-\left(\frac{x^2}{2\sigma^2}\right)}e^{ik_0 x}$, find out the probability density and the expectation value of x. (4)

7. Calculate the group velocity of an electron with a de-Broglie wavelength of $1.5X10^{-2}$ nm. (3)

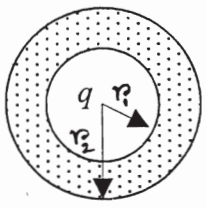
8. The emitter of a photoelectric tube has a threshold wavelength of 600nm. Determine the wavelength of light incident on the tube if the stopping potential for this light is 2.5 V. (3)

9. If sea water has permittivity $\varepsilon = 81\varepsilon_0$, permeability $\mu = \mu_0$ and resistivity $\rho = 0.23\Omega m$ at frequency 0.4 GHz, find the ratio of conduction current to the displacement current. (4)

10. Given that $\vec{E} = E_0 \sin(\omega t - \beta z)\hat{y}$ for an electromagnetic wave in free space, find the corresponding $\vec{H}$. What are the speed of the wave and the corresponding Poynting vector? (4)

11. An infinitely long solenoid is carrying a constant current I. What is the vector potential $\vec{A}$ in the region where $\vec{B} = 0$? (3)

12. A spherical conductor of radius r_1 carries a charge q as shown in the figure below. It is surrounded by a linear dielectric material of susceptibility χ out to radius r_2. Find the energy of this configuration. (5)



$$\int_{-\infty}^{\infty} e^{-px^2}\,dx = \sqrt{\frac{\pi}{p}}$$