Name_____

Physics 111 Quiz #5, October 21, 2024

Please show all work, thoughts and/or reasoning to receive partial credit. The quiz is worth 10 points total, and all parts may not be of equal weight.

I affirm that I have carried out my academic endeavors with full academic honesty.

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1. A $100mW$ beam of red laser light with wavelength $\lambda_{red} = 632nm$ is incident on a $1\mu m$ thick sheet of aluminum foil that has been cut into a square of sides of length $L = 10cm$. The aluminum foil is suspended from a support and hangs vertically at rest and the laser beam strikes the aluminum foil perpendicular to its surface. The laser beam makes a circular spot of radius $r = 1mm$ on the aluminum foil's surface. If the density of aluminum is $\rho = 2700\frac{kg}{m^3}$, what is the mass of the aluminum foil?

$$\rho = \frac{m}{V} \rightarrow m = \rho V = 2700\frac{kg}{m^3} \times (10 \times 10^{-2}m)^2 \times 1 \times 10^{-6}m = 2.7 \times 10^{-5}kg$$

2. If the red laser light is completely reflected from the surface of the aluminum foil, with what magnitude of acceleration does the aluminum foil recoil?

$$P_{ref} = \frac{2S}{c} = \frac{2P}{Ac} = \frac{F}{A} = \frac{ma}{A} \rightarrow a = \frac{2P}{mc}$$

$$a = \frac{2 \times 100 \times 10^{-3}W}{2.7 \times 10^{-5}kg \times 3 \times 10^{8}\frac{m}{s}} = 2.5 \times 10^{-5}\frac{m}{s^2}$$

3. What is the intensity of the red laser light on the aluminum foil?

$$S = \frac{P}{A} = \frac{100 \times 10^{-3} W}{\pi(1 \times 10^{-3} m)^2} = 31831 \frac{W}{m^2}$$

4. What are the maximum values of the electric and magnetic fields in the red laser light?

$$S = \frac{1}{2} c\epsilon_0 E_{max}^2 \rightarrow E_{max} = \sqrt{\frac{2S}{c\epsilon_0}} = \sqrt{\frac{2 \times 31831 \frac{W}{m^2}}{3 \times 10^8 \frac{m}{s} \times 8.85 \times 10^{-12} \frac{C^2}{Nm^2}}} = 4897 \frac{N}{C}$$

$$E_{max} = cB_{max} \rightarrow B_{max} = \frac{E_{max}}{c} = \frac{4897 \frac{N}{C}}{3 \times 10^8 \frac{m}{s}} = 1.6 \times 10^{-5} T$$

Or

$$S = \frac{c}{2\mu_0} B_{max}^2 \rightarrow B_{max} = \sqrt{\frac{2\mu_0 S}{c}} = \sqrt{\frac{2 \times 4\pi \times 10^{-7} \frac{Tm}{A} \times 31831 \frac{W}{m^2}}{3 \times 10^8 \frac{m}{s}}} = 1.6 \times 10^{-5} T$$

5. Suppose that the red laser light is a source of polarized light, and that the direction of polarization was not known. Suppose that the laser light is incident on a polarizer with the transmission axis of the polarizer horizontal. If the intensity of the light that emerges from the polarizer was found to be reduced by 60% from the incident intensity, at what angle was the laser light originally incident on the polarizer? Express your answer as measured counterclockwise from the horizontal.

$$S_{out} = S_{in} \cos^2 \theta \rightarrow \cos \theta = \sqrt{\frac{S_{out}}{S_{in}}} = \sqrt{\frac{0.4 S_{in}}{S_{in}}} = 0.6325 \rightarrow \theta = \cos^{-1} 0.6325 = 50.8^0$$