Name_____

Physics 111 Quiz #6, October February 21, 2025

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 beam of laser light (with wavelength $\lambda = 410nm$) has a power output of $P = 12.6W$. The laser beam makes a circular spot with diameter $4mm$ when it is shone onto a surface. What is the intensity of the laser beam on the surface?

$$S = \frac{P}{A} = \frac{12.6W}{\pi(2 \times 10^{-3}m)^2} = 1 \times 10^6 \frac{W}{m^2} = 1\frac{MW}{m^2}$$

2. With what magnitude of force does the light exert on the surface if the light is completely reflected?

$$P = \frac{2S}{c} = \frac{F}{A} \rightarrow F = \frac{2AS}{c} = \frac{2 \times \pi(2 \times 10^{-3}m)^2 \times 1 \times 10^6 \frac{W}{m^2}}{3 \times 10^8 \frac{m}{s}} = 8.4 \times 10^{-8}N$$

3. What are the maximum values for the electric and magnetic fields in the light?

$$S = \frac{1}{2}c\epsilon_0 E_{max}^2 \rightarrow E_{max} = \sqrt{\frac{2S}{c\epsilon_0}} = \sqrt{\frac{2 \times 1 \times 10^6 \frac{W}{m^2}}{3 \times 10^8 \frac{m}{s} \times 8.85 \times 10^{-12} \frac{C^2}{Nm^2}}} = 2.7 \times 10^4 \frac{N}{C}$$

$$E_{max} = cB_{max} \rightarrow B_{max} = \frac{E_{max}}{c} = \frac{2.7 \times 10^4 \frac{N}{C}}{3 \times 10^8 \frac{m}{s}} = 9.2 \times 10^{-5}T$$

4. Suppose the laser light is shone onto a polarizer with the transmission axis of the polarizer vertical. The laser light emerges from the first polarizer and is incident on a second polarizer whose transmission axis is oriented at an angle θ to the first. The intensity of the laser light that emerges from the second polarizer is measured to be 12% of the incident intensity. At what angle was the second polarizer oriented if the laser light was initially unpolarized?

$$S_{out,1} = \frac{1}{2}S_0$$

$$S_{out,2} = S_{in,2}\cos^2\theta \rightarrow 0.12S_o = \frac{1}{2}S_0\cos^2\theta \rightarrow \theta = \cos^{-1}\left(\sqrt{2 \times 0.12}\right) = 60.7^0$$

5. Suppose that the laser light was incident on the left edge of a tank of water at an angle θ_{air} measured with respect to the normal to the water's surface. The beam of laser light is seen to strike the lower right edge of the tank a horizontal distance $x = 0.5m$ from where the beam enters the water on the left edge. If the tank is $D = 0.5m$ deep, at what angle θ_{air} was the light incident on the water from the air?

From the geometry:

$$\tan\theta_{water} = \frac{x}{D} = \frac{0.5m}{0.5m} = 1 \rightarrow \theta_{water} = 45^0$$

The law of refraction at the air/water interface:

$$n_{air}\sin\theta_{air} = n_{water}\sin\theta_{water} \rightarrow \sin\theta_{aiir} = \frac{n_{water}}{n_{air}}\sin\theta_{water} = \frac{1.33}{1.00}\sin 45 = 0.9405$$

$$\theta_{air} = \sin^{-1}(0.9405) = 70.1^0$$