Name_____

Physics 111 Quiz #5, February 18, 2022

Please show all work, thoughts and/or reasoning in order to receive partial credit. The quiz is worth 10 points total.

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

_____

A blue laser pointer has a power output of $0.75mW$ and emits light with a wavelength $\lambda_{blue} = 460nm$. The laser is shone onto the board in the front of the room, and we find that it makes a circular spot of diameter $1.5mm$.

1. What is the intensity of the blue laser light?

$$S = \frac{P}{A} = \frac{0.75\times10^{-3}W}{\pi(0.75\times10^{-3}m)^2} = 424.4\frac{W}{m^2}$$

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

$$S = \tfrac{1}{2}c\varepsilon_0 E_{max}^2 \rightarrow E_{max} = \sqrt{\frac{2S}{c\varepsilon_0}} = \sqrt{\frac{2\times424.4\frac{W}{m^2}}{3\times10^8\frac{m}{s}\times8.85\times10^{-12}\frac{C^2}{Nm^2}}} = 565\frac{N}{C}$$

$$E_{max} = cB_{max} \rightarrow B_{max} = \frac{E_{max}}{c} = \frac{565\frac{N}{C}}{3\times10^8\frac{m}{s}} = 1.89\times10^{-6}T$$

3. Suppose that the output of the laser pointer was directed at a polarizing sheet with its transmission axis vertically oriented. Further, suppose that the laser light from the pointer were a source of unpolarized light. At what angle θ, measured with respect to the orientation of the 1st polarizer, would a 2nd polarizing sheet need to be oriented so that the transmitted intensity through both polarizing sheets reduces the output intensity of the laser pointer by 78%?

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

$$S_{out,2} = S_{in,2}\cos^2\theta = \frac{1}{2}S_0\cos^2\theta = 0.22S_0$$

$$\cos^2\theta = 0.44 \rightarrow \cos\theta = 0.6633 \rightarrow \theta = 48.5^0$$

These next two questions do not depend on the previous three.

4. Sunlight is a source of unpolarized light and the intensity of the sunlight that reaches the earth's surface (called the solar constant) is $1350\frac{W}{m^2}$. If the sunlight were incident on a sheet of aluminum foil held vertically, what magnitude of force would the sunlight exert on the sheet of aluminum foil? Assume the sunlight is incident parallel to the normal to the sheet and the sheet has dimensions, length $L = 0.22m$, width $W = 0.28m$, and thickness $t = 0.1mm$.

   $P = \frac{2S}{c} = \frac{F}{A} \rightarrow F = \frac{2SA}{c} = \frac{2\times1350\frac{W}{m^2}\times(0.22m\times0.28m)}{3\times10^8\frac{m}{s}} = 5.43 \times 10^{-7}N$

5. If the density of aluminum is $\rho_{Al} = 2700\frac{kg}{m^3}$, what is the magnitude of the acceleration of the sheet of aluminum foil due to the incident sunlight?

   $F = ma \rightarrow a = \frac{F}{m} = \frac{5.43 \times 10^{-7}N}{0.0166kg} = 3.27 \times 10^{-5}\frac{m}{s^2}$

   Where, $\rho_{Al} = \frac{m}{V} \rightarrow m = \rho_{Al}V = 2700\frac{kg}{m^3} \times (0.22m \times 0.28m \times 0.1 \times 0^{-3}m) = 0.0166kg$