Name____

Physics 111 Quiz #6, February 26, 2021

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.

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1. Light from a laser pointer rated at $0.5mW$ and wavelength $\lambda = 510nm$ is directed onto a piece of paper held vertically in front of the laser. The laser pointer makes a spot on the paper $1mm$ in diameter. What is the intensity of the light on the paper?

$$S = \frac{Energy}{time \cdot Area} = \frac{Power}{Area} = \frac{P}{\pi r^2} = \frac{0.5\times10^{-3}W}{\pi(0.5\times10^{-3}m)^2} = 636.6\frac{W}{m^2}$$

2. If the paper has a mass of $1\mu g$, what magnitude of the acceleration would the paper experience? Assume that the light is completely reflected from the paper.

$$P = \frac{2S}{c} = \frac{F}{A} = \frac{ma}{A} \rightarrow a = \frac{2SA}{mc} = \frac{2 \times 636.6\frac{W}{m^2} \times \pi(0.5 \times 10^{-3}m)^2}{1 \times 10^{-6}g \times \frac{1kg}{1000g} \times 3 \times 10^8\frac{m}{s}} = 0.0033\frac{m}{s^2}$$

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

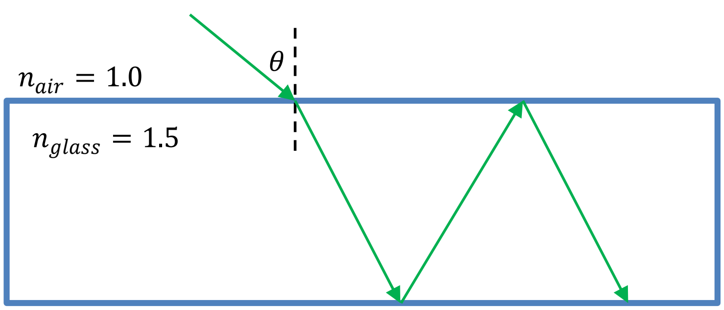
$$S = \frac{1}{2}c\varepsilon_0 E_{max}^2 \rightarrow E_{max} = \sqrt{\frac{2S}{c\varepsilon_0}} = \sqrt{\frac{2 \times 636.6\frac{W}{m^2}}{3 \times 10^8\frac{m}{s} \times 8.85 \times 10^{-12}\frac{C^2}{Nm^2}}} = 692.5\frac{N}{C}$$

$$E_{max} = cB_{max} \rightarrow B_{max} = \frac{E_{max}}{c} = \frac{692.5\frac{N}{C}}{3\times10^8\frac{m}{s}} = 2.3 \times 10^{-6}T = 2.3\mu T$$

4. Suppose instead of a piece of paper, that the laser light is shown onto a polarizer with its transmission axis vertical. If the electric field of the laser light makes an angle of 27^0 with respect to the horizontal, what is the intensity of the laser light that emerges from the polarizer? Assume that light from the laser light is a source of polarized light.

$$S_{out} = S_{in}\cos^2\theta = 636.6\frac{W}{m^2}\cos^2(90-27) = 131.2\frac{W}{m^2}$$

5. The laser light that emerges from the polarizer is directed onto a block of glass surrounded on all sides by air. The upper and lower surfaces of the glass are parallel, and the laser light makes an angle of θ measured with respect to the normal to the glass' upper surface. If the light is to be totally internally reflected from interior of the glass as shown below, at what angle θ does the light have to be incident at on the upper surface of the glass?



$$n_{air}\sin\theta = n_{glass}\sin\theta_c \rightarrow \sin\theta = \frac{n_{glass}}{n_{air}}\sin\theta_c = \frac{1.5}{1.0}\sin 41.8 \rightarrow \theta = 88.9^0$$

$$n_{glass}\sin\theta_c = n_{air}\sin 90 \rightarrow \theta_c = \sin^{-1}\left(\frac{n_{air}}{n_{glass}}\right) = \sin^{-1}\left(\frac{1.0}{1.5}\right) = 41.8^0$$

Physics 111 Equation Sheet

Electric Forces, Fields and Potentials

$$\vec{F} = k\frac{Q_1 Q_2}{r^2}\hat{r}$$

$$\vec{E} = \frac{\vec{F}}{q}$$

$$\vec{E}_Q = k\frac{Q}{r^2}\hat{r}$$

$$PE = k\frac{Q_1 Q_2}{r}$$

$$V(r) = k\frac{Q}{r}$$

$$E_x = -\frac{\Delta V}{\Delta x}$$

$$W = -q\Delta V_{f,i}$$

Magnetic Forces and Fields

$$F = qvB\sin\theta$$

$$F = IlB\sin\theta$$

$$\tau = NIAB\sin\theta = \mu B\sin\theta$$

$$PE = -\mu B\cos\theta$$

$$B = \frac{\mu_0 I}{2\pi r}$$

$$\varepsilon_{induced} = -N\frac{\Delta\phi_B}{\Delta t} = -N\frac{\Delta(BA\cos\theta)}{\Delta t}$$

Constants

$g = 9.8\,\frac{m}{s^2}$

$1e = 1.6\times10^{-19}\,C$

$k = \frac{1}{4\pi\varepsilon_o} = 9\times10^{9}\ \frac{Nm^2}{C^2}$

$\varepsilon_o = 8.85\times10^{-12}\ \frac{C^2}{Nm^2}$

$1eV = 1.6\times10^{-19}\,J$

$\mu_o = 4\pi\times10^{-7}\ \frac{Tm}{A}$

$c = 3\times10^{8}\ \frac{m}{s}$

$h = 6.63\times10^{-34}\,Js$

$m_e = 9.11\times10^{-31}\,kg = \frac{0.511MeV}{c^2}$

$m_p = 1.67\times10^{-27}\,kg = \frac{937.1MeV}{c^2}$

$m_n = 1.69\times10^{-27}\,kg = \frac{948.3MeV}{c^2}$

$1amu = 1.66\times10^{-27}\,kg = \frac{931.5MeV}{c^2}$

$N_A = 6.02\times10^{23}$

$Ax^2 + Bx + C = 0 \rightarrow x = \frac{-B\pm\sqrt{B^2-4AC}}{2A}$

Electric Circuits

$$I = \frac{\Delta Q}{\Delta t}$$

$$V = IR = I\left(\frac{\rho L}{A}\right)$$

$$R_{series} = \sum_{i=1}^{N} R_i$$

$$\frac{1}{R_{parallel}} = \sum_{i=1}^{N}\frac{1}{R_i}$$

$$P = IV = I^2R = \frac{V^2}{R}$$

$$Q = CV = \left(\frac{\kappa\varepsilon_0 A}{d}\right)V = (\kappa C_0)V$$

$$PE = \tfrac{1}{2}QV = \tfrac{1}{2}CV^2 = \frac{Q^2}{2C}$$

$$Q_{\text{charge}}(t) = Q_{\max}\left(1 - e^{-\frac{t}{RC}}\right)$$

$$Q_{\text{discharge}}(t) = Q_{\max}e^{-\frac{t}{RC}}$$

$$C_{parallel} = \sum_{i=1}^{N} C_i$$

$$\frac{1}{C_{series}} = \sum_{i=1}^{N}\frac{1}{C_i}$$

Ligh as a Particle & Relativity

$$E = hf = \frac{hc}{\lambda} = pc$$

$$KE_{\max} = hf - \phi = eV_{stop}$$

$$\Delta\lambda = \frac{h}{m_e c}(1-\cos\phi)$$

$$\gamma = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}}$$

$$p = \gamma mv$$

$$E_{total} = KE + E_{rest} = \gamma mc^2$$

$$E_{total}^2 = p^2c^2 + m^2c^4$$

$$E_{rest} = mc^2$$

$$KE = (\gamma - 1)mc^2$$

Geometry

Circles $C = 2\pi r = \pi D \qquad A = \pi r^2$

Triangles $A = \tfrac{1}{2}bh$

Spheres $A = 4\pi r^2 \qquad V = \tfrac{4}{3}\pi r^3$

Light as a Wave

$$c = f\lambda = \frac{1}{\sqrt{\varepsilon_o\mu_0}}$$

$$S(t) = \frac{energy}{time \times area} = c\varepsilon_o E^2(t) = c\frac{B^2(t)}{\mu_0}$$

$$I = S_{avg} = \tfrac{1}{2}c\varepsilon_o E_{\max}^2 = c\frac{B_{\max}^2}{2\mu_0}$$

$$P = \frac{S}{c} = \frac{Force}{Area} \qquad P = \frac{2S}{c}$$

$$S = S_o\cos^2\theta$$

$$v = \frac{1}{\sqrt{\varepsilon\mu}} = \frac{c}{n}$$

$$\theta_{inc} = \theta_{refl}$$

$$n_1\sin\theta_1 = n_2\sin\theta_2$$

$$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$$

$$M = \frac{h_i}{h_o} = -\frac{d_i}{d_o}$$

$$M_{total} = \prod_{i=1}^{N} M_i$$

$$S_{out} = S_{in}e^{-\sum_i \mu x_i}$$

$$HU = \frac{\mu_w - \mu_n}{\mu_w}$$

Nuclear Physics

$$E_{binding} = (Zm_p + Nm_n - m_{rest})c^2$$

$$\frac{\Delta N}{\Delta t} = -\lambda N_o \rightarrow N(t) = N_o e^{-\lambda t}$$

$$A(t) = A_o e^{-\lambda t}$$

$$m(t) = m_o e^{-\lambda t}$$

$$t_{\frac{1}{2}} = \frac{\ln 2}{\lambda}$$

Misc. Physics 110 Formulae

$$\vec{F} = \frac{\Delta\vec{p}}{\Delta t} = \frac{\Delta(mv)}{\Delta t} = m\vec{a}$$

$$\vec{F} = -k\vec{y}$$

$$\vec{F}_C = m\frac{v^2}{R}\hat{r}$$

$$W = \Delta KE = \tfrac{1}{2}m\left(v_f^2 - v_i^2\right) = -\Delta PE$$

$$PE_{gravity} = mgy$$

$$PE_{spring} = \tfrac{1}{2}ky^2$$

$$|\vec{A}| = \sqrt{A_x^2 + A_y^2}$$

$$\phi = \tan^{-1}\left(\frac{A_y}{A_x}\right)$$

$$\vec{v}_f = \vec{v}_i + \vec{a}t$$

$$v_f^2 = v_i^2 + 2a\Delta x$$

$$\vec{x}_f = \vec{x}_i + \vec{v}_i t + \tfrac{1}{2}\vec{a}t^2$$