PH-214 Homework 3

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Problem 1

$$\text{Mass of Electron: } 9.11 * 10^{-31} \text{ kg} \qquad \text{Mass of Proton: } 1.67 * 10^{-27} \text{ kg}$$

$$r_e = \frac{q^2}{4\pi\epsilon_0 m_e c^2} = \frac{(1.6 * 10^{-19})^2}{4\pi * (8.85 * 10^{-12}) * (9.11 * 10^{-31}) * (3 * 10^8)^2} = 2.81 * 10^{-15}$$

$$\sigma_{\text{Th}} = \frac{8\pi}{3}(r_e)^2 = \boxed{6.6 * 10^{-29} \text{ m}^2}$$

$$r_p = \frac{q^2}{4\pi\epsilon_0 m_p c^2} = \frac{(1.6 * 10^{-19})^2}{4\pi * (8.85 * 10^{-12}) * (1.67 * 10^{-27}) * (3 * 10^8)^2} = 1.53 * 10^{-18}$$

$$\sigma_{\text{Th}} = \frac{8\pi}{3}(r_p)^2 = \boxed{1.97 * 10^{-15} \text{ m}^2}$$

Problem 2

$$\epsilon_0 = \frac{\text{C}^2}{\text{N} \cdot \text{m}^2} \qquad q = \text{C} \qquad c = \frac{\text{m}}{\text{s}} \qquad m = \text{kg}$$

$$\sigma_{\text{Th}} = \frac{8\pi}{3}\left(\frac{q^2}{4\pi\epsilon_0 m c^2}\right)^2 = \left(\frac{\text{C}^2}{\frac{\text{C}^2}{\text{N}\cdot\text{m}^2} * \text{kg} * \frac{\text{m}^2}{\text{s}^2}}\right)^2 = \left(\frac{\text{C}^2}{\frac{\text{C}^2}{\text{kg}\cdot\frac{\text{m}}{\text{s}^2}\cdot\text{m}^2} * \text{kg} * \frac{\text{m}^2}{\text{s}^2}}\right)^2 = \boxed{\text{m}^2}$$

Problem 3

$$\left|\overrightarrow{S}\right| = \epsilon_0 * c * \left|\overrightarrow{E_0}\right|^2$$

$$1.38 * 10^3 = 8.85 * 10^{-12} * 3 * 10^8 * \left|\overrightarrow{E_0}\right|^2$$

$$\overrightarrow{E_0} = \sqrt{\frac{1.38 * 10^3}{8.85 * 10^{-12} * 3 * 10^8}} = \boxed{720.95 \text{ V/m}}$$

$$\overrightarrow{B_0} = \frac{\overrightarrow{E_0}}{c} = \boxed{2.4 * 10^{-6} \text{ T}}$$

Problem 4

$$\left|\overrightarrow{S}\right| = \epsilon_0 * c * \left|\overrightarrow{E_0}\right|^2$$

$$14 * 10^6 = 8.85 * 10^{-12} * 3 * 10^8 \left|\overrightarrow{E_0}\right|^2$$

$$\overrightarrow{E_0} = \sqrt{\frac{14 * 10^6}{8.85 * 10^{-12} * 3 * 10^8}} = \boxed{7.26 * 10^4 \text{ V/m}}$$

$$\overrightarrow{B_0} = 0.75 * \frac{\overrightarrow{E_0}}{c} = \boxed{1.81 * 10^{-8} \text{ T}}$$