330 HW #2 25 points

(3.3)

$E_K = 5.0 \times 10^4\ eV$

$\frac{1}{2} m v^2 = E_K$

$\frac{1}{2}\left(0.511\ \frac{MeV}{c^2}\right) v^2 = .050\ MeV$

$v^2 = c^2 \left(\frac{.050\ MeV}{0.511\ MeV}\right) 2$

$v = 0.63\ c$ ← this is a relativistic velocity so better use relativistic E_K

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

$\gamma = \frac{E_K}{mc^2} + 1$

$\frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} = \frac{E_K}{mc^2} + 1$

$1 - \frac{v^2}{c^2} = \frac{mc^2}{E_K + mc^2}$

$v = c\left(1 - \frac{mc^2}{E_K + mc^2}\right)^{1/2} = 0.30\ c = 9.0 \times 10^7\ m/s$

$B = \frac{E}{v} = \frac{2.0 \times 10^5\ V/m}{9.0 \times 10^7\ m/s} = 2.2 \times 10^{-3}\ \frac{Vs}{m^2} = 2.2 \times 10^{-3}\ T$

3.11 Using values from problem

$$\rho_{oil} = 0.75\ g/cm^3 = 750\ kg/m^3$$

$$\eta = 1.80 \times 10^{-5}\ N{\cdot}s/m^2$$

$$\rho_{air} = 1.35 \times 10^{-3}\ g/cm^3 = 1.35\ kg/m^3$$

Stokes's Law

$b = 6\pi\eta a$ a – Radius of oil drop

$V_f = \frac{mg}{b}$ - terminal velocity

a.)

$$V_f = \frac{mg}{6\pi\eta a} = \frac{\frac{4}{3}\pi a^3 \rho g}{6\pi\eta a}$$

$$a = \left(\frac{9 V_f \eta}{2 \rho g}\right)^{1/2}$$

$$= \left[\frac{9(2.5 \times 10^{-4}\ m/s)(1.80 \times 10^{-5}\ N{\cdot}s/m^2)}{2(750\ kg/m^3)(9.8\ m/s)}\right]^{1/2}$$

$$a = 1.7 \times 10^{-6}\ m$$

$$m = \frac{4}{3}\pi a^3 = 1.9 \times 10^{-17}\ kg$$

b.)

$F_E = qE$

$F_g = mg$

$$\frac{2(1.60 \times 10^{-19}\ C)(2.5 \times 10^3\ V/m)}{(1.9 \times 10^{-17}\ kg)(9.8\ m/s)} = 430$$

seems larger than needed for this experiment

3.15

a.) Using Weins displacement law

$$\lambda_m T = 2.898 \times 10^{-3}\ m.k$$

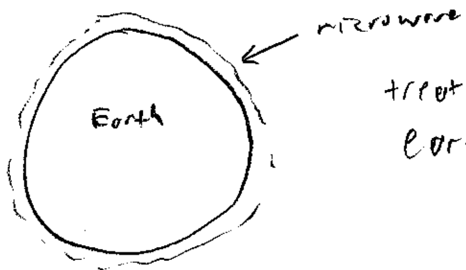
$$T = 2.7\ K$$

$$\lambda_m = 1.1 \times 10^{-3}\ m = 1.1\ mm$$

b.) $$f = \frac{c}{\lambda} = 2.8 \times 10^{11}\ Hz$$

c.) Stefan-Boltzman law

$$R = \sigma T^4$$ Power radiated per unit area.



treat as a spherical shell at earth's surface, all power radiated hits the earth.

$$P = (4\pi R_e^2)(\sigma T^4) = 4\pi (6.38 \times 10^6\ m)^2 (5.67 \times 10^{-8}\ J.s^{-1} m^{-2} K^{-4}) \times (2.7\ K)^4$$

$$= 1.54 \times 10^9\ J/s = 1.54\ GW$$

3.26

$$hf = \frac{hc}{\lambda} = 1.9 \cdot eV$$

a.)

$$\frac{1240 \text{ eV}\cdot\text{nm}}{\lambda} = 1.9 \text{ eV}$$

$$\lambda = 650 \text{ nm}$$

$$f = \frac{c}{\lambda} = 4.6 \times 10^{14} \text{ Hz}$$

b.)

$$eV_0 = \frac{hc}{\lambda} - \phi$$

$$V_0 = \frac{1}{e}\left(\frac{hc}{\lambda} - \phi\right)$$

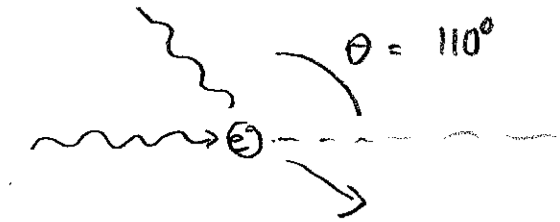
400 nm

$$V_0 = \frac{1}{\cancel{e}}\left(\frac{1240 \cancel{e}\text{V}\cdot\text{nm}}{400 \text{ nm}} - 1.9 \cancel{e}\text{V}\right)$$

$$= 1.2 \text{ V}$$

c.) $V_0 = 2.2 \text{ V}$

3.36



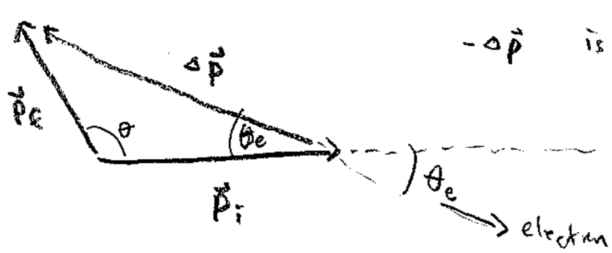
$$\lambda_f - \lambda_i = \frac{h}{mc}\left(1 - \cos\theta\right)$$

$$\lambda = \frac{hc}{E} \quad \text{- photon}$$

$$p = \frac{h}{\lambda}$$

use momentum conservation

photon momentum



$-\Delta\vec{p}$ is given to electron

$$p_i = \frac{E_i}{c} = mc$$

$$p_f = \frac{h}{\lambda_f} = h\left[\lambda_i + \frac{h}{mc}\left(1 - \cos\theta\right)\right]^{-1}$$

$$\boxed{\text{use } E_i = mc^2}$$

$$\Delta p^2 = p_i^2 + p_f^2 - 2p_i p_f \cos\theta$$

$$=$$

$$p_f = \left[\frac{c}{E_i} + \frac{1}{mc}\left(1 - \cos\theta\right)\right]^{-1}$$

$$= \left[\frac{1}{mc} + \frac{1}{mc}\left(1 - \cos\theta\right)\right]^{-1} = \left[\frac{1 + (1 - \cos\theta)}{mc}\right]^{-1}$$

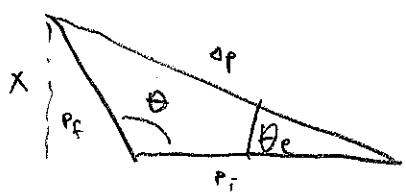
$$p_f = \frac{mc}{2 - \cos\theta}$$

$$\Delta p^2 = p_i^2 + p_f^2 - 2 p_i p_f \cos\theta$$

$$= mc^2 \left[1 + \frac{1}{(2-\cos\theta)^2} - \frac{2}{(2-\cos\theta)} \right]$$

$$= \frac{mc^2}{(2-\cos\theta)} \left[1 + \cos^2\theta - 2\cos\theta \right] = \frac{mc^2}{(2-\cos\theta)} \left[(1-\cos\theta)^2 \right]$$

$$\Delta p = mc \left(\frac{1-\cos\theta}{2-\cos\theta} \right)$$



$$\Delta p \sin\theta_e = X$$

$$p_f \sin\theta = X$$

$$\Delta p \sin\theta_e = p_f \sin\theta$$

$$\theta_e = \sin^{-1} \left[\frac{p_f}{\Delta p} \sin\theta \right]$$

$$= \sin^{-1} \left[\frac{\sin\theta}{1-\cos\theta} \right] = 0.77 \text{ rad}$$

$$= 44^\circ$$