Physics 3305
Home Work # 3

Problem 12:

$$\lambda_{max} T = 2.898\ 10^{-3}\ m.K$$

$$T = 70°F = 21°C$$

$$T(°K) = T(°C) + 273 = 21 + 273 = 294$$

$$\lambda_{max} = \frac{2.898\ 10^{-3}\ m\cancel{K}}{294\ \cancel{K}} = 9.85\ 10^{-6}\ m$$ Infrared

Problem 18 $\lambda = 250$ nm

$$KE_{max} = hf - \phi = \frac{hc}{\lambda} - \phi$$

$$= \left(6.63\ 10^{-34} J.S\right)\left(\frac{3\ 10^{8} m/s}{250\ 10^{-9} m}\right) \frac{1}{1.6\ 10^{-19}} - \left(4.3\ eV\right)$$

$$= 4.97\ eV - 4.3\ eV$$

$$\boxed{KE_{max} = 0.67\ eV}$$

Problem 19: Find λ.? $\phi = 3.7\ eV$

$$KE_{max} = hf - \phi \qquad \text{and } KE_{max} = \frac{1}{2} m v^2 = \frac{1}{2}\left(9.11\ 10^{-31}\right)\left(2\times10^{6} m/s\right)^2$$

$$= \frac{hc}{\lambda} - \phi \qquad\qquad = 1.822\ 10^{-18}\ J$$

$$1.822\ 10^{-18} = \frac{6.63\ 10^{-34} \times 3\ 10^{8} m/s}{\lambda} - 3.7 \times 1.6\ 10^{-19}$$

$$\boxed{\lambda = 82.4\ nm}$$

Problem 20

$$\frac{\#\text{ of photons}}{\text{second}} = \frac{\text{energy}/s}{\text{energy}/\text{photon}}$$

$$6\times 10^{15}\,\frac{\text{photons}}{\cancel{s}} = \frac{0.002\,\cancel{J}/\cancel{s}}{\left(6.63\ 10^{-34}\,\cancel{J}\cancel{s}\right)\left(\frac{3\ 10^{8} m/\cancel{s}}{\lambda}\right)}$$

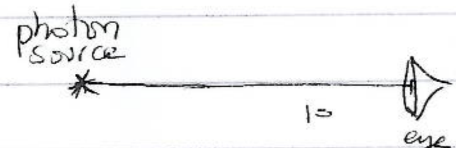
$$\boxed{\lambda = 597\,nm}$$

Problem 21

$$\frac{\#\text{of photons}}{\text{second}} = \frac{\text{energy}/\text{sec}}{\text{energy}/\text{photon}} = \frac{40\times 10^{3}\,J/s}{6.63\ 10^{-34}\,Js \times 940\ 10^{3}\left(\frac{1}{s}\right)}$$

$$= 6.62\ 10^{31} \text{ photons per second.}$$

Problem 26



By the time the photons reach the eye they are spread over a surface of radius $r = 10m$, thus a surface area $4\pi(10m)^2$

The fraction that enter you eye is the ratio of the area of the pupil to this total area.

$$\frac{\pi(0.002m)^2}{4\pi\,(10m)^2} = 10^{-8}$$

The total number per unit time

$$\frac{\text{energy}/\text{time}}{\text{energy}/\text{photon}} = \frac{\text{power}}{hf} = \frac{10J/s}{(6.63\,10^{-34})\left(\frac{3\,10^{8}}{589\,10^{-9}}\right)}$$

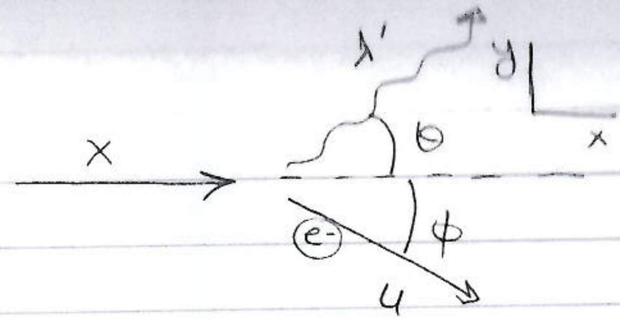
$$= 2.96\ 10^{19}\,\text{photon}/s$$

Thus, the rate at which they enter the eye is

$$10^{-8}\times 2.96\ 10^{19}\,\text{photons}/s = 3\times 10^{11}\,\text{photons}/s$$

Problem 34

$\phi = 60$



Momentum Conservation

$\boxed{x}$ $$\frac{h}{\lambda} = \frac{h}{\lambda'}\cos\theta + \gamma_u m u \cos\phi$$

$\boxed{y}$ $$0 = \frac{h}{\lambda'}\sin\theta - \gamma_u m_e u \sin\phi$$

$$\left(\frac{h}{\lambda'}\sin\theta\right)^2 = \left(\gamma_u m_e u \sin\phi\right)^2 \;\&\; \left(\frac{h}{\lambda} - \gamma_u m u \cos\phi\right)^2 = \left(\frac{h}{\lambda'}\cos\theta\right)^2$$

$$\left(\frac{h}{\lambda} - \gamma_u m u \cos\phi\right)^2 + \left(\gamma_u m_e u \sin\phi\right)^2 = \frac{h^2}{\lambda'^2}$$

$$\frac{h^2}{\lambda^2} - \frac{2h}{\lambda}\gamma_u m u \cos\phi + \gamma_u^2 m^2 u^2 \cos^2\phi + \gamma^2 m^2 u^2 \sin^2\phi = \frac{h^2}{\lambda'^2}$$

(1) $$\boxed{\frac{h^2}{\lambda^2} - \frac{2h}{\lambda}\gamma_u m u \cos\phi + (\gamma m u)^2 = \frac{h^2}{\lambda'^2}}$$

we have:

$$\Delta KE_e = (\gamma_u - 1)mc^2 = \frac{hc}{\lambda} - \frac{hc}{\lambda'} \Rightarrow \boxed{\left((\gamma - 1)mc - \frac{h}{\lambda}\right)^2 = \frac{h^2}{\lambda'^2}}$$

(1) = (2) $\Rightarrow$ $$\cancel{\frac{h^2}{\lambda^2}} - 2\frac{h}{\lambda}\gamma_u m u \cos\phi + (\gamma_u m u)^2 = (\gamma-1)^2 m^2 c^2 - 2\frac{h}{\lambda}(\gamma - 1)mc + \cancel{\frac{h^2}{\lambda^2}}$$ (2)

$$-2\frac{h}{\lambda}\gamma_u \cancel{m} u \cos\phi + \gamma_u^2 m^{\cancel{2}} u^2 = (\gamma-1)^2 m^{\cancel{2}} c^2 - 2\frac{h}{\lambda}(\gamma-1)\cancel{m}c$$

$$\frac{1}{\lambda}\, 2h\left(c(\gamma_u - 1) - \gamma_u u \cos\phi\right) = (\gamma - 1)^2 mc^2 - \gamma_u^2 m u^2$$

$$\frac{1}{\lambda} = \frac{(\gamma-1)^2 mc^2 - \gamma_u^2 m u^2}{2h\left(c(\gamma_u - 1) - \gamma_u u \cos\phi\right)}$$

$$\boxed{\lambda = \frac{2h\left(c(\gamma_u - 1) - \gamma_u u \cos\phi\right)}{(\gamma - 1)^2 mc^2 - \gamma_u^2 m u^2}}$$

Problem 4.5

$$2d\sin\theta = n\lambda$$

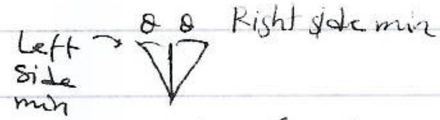
$$d = \frac{a}{2}$$

$$2\frac{a}{2}\sin\theta = n\lambda$$

$n = 1$

$$a\sin\theta = \lambda \qquad \sin\theta = \frac{\lambda}{a}$$

$$\boxed{\theta = \sin^{-1}(\lambda/a)}$$



The angle from the first min on one side to the first min on the other side is:

$$\boxed{\Delta\theta = 2\sin^{-1}(\lambda/a)}$$

(a) $\lambda = 500\,nm$

$$\Delta\theta = 2\sin^{-1}\left(\frac{500\ 10^{-9}\,m}{10^{-6}\,m}\right) = 60^\circ$$

(b) $\lambda = 0.05\,nm$

$$\Delta\theta = 2\sin^{-1}\left(\frac{0.05\ 10^{-9}\,\cancel{m}}{10^{-6}\,\cancel{m}}\right) = 5.73\ 10^{-3\,\circ}$$

(c) Diffraction, a wave phenomenon, is more pronounced for the long wavelength, the visible light, a particle (moving in a straight line, not diffracting) nature is more evident when the wavelength is very small compared to dimensions of the apparatus: $\lambda_{X\text{-ray}} \ll a$.

Problem 3.49 m is constant

$$F = ma = m\frac{dv}{dt} = \frac{d(mv)}{dt} = \frac{dP}{dt} = \frac{\Delta P}{\Delta t}$$

$$F = \frac{\Delta P}{\Delta t} = \frac{\Delta P}{\text{photon}}\ \frac{\text{photons}}{\text{Second}} = (\Delta p \text{ of a photon})\ \frac{\text{energy of photons/time}}{\text{energy of one photon}}$$

$$\text{power} = \frac{\text{Energy}}{\text{time}}$$

$$F = \frac{h}{\lambda}\ \frac{\text{Power}}{\frac{hc}{\lambda}} = \frac{\text{Power}}{c}$$

(a) $$\text{Pressure} = \frac{\text{Force}}{\text{Area}} = \frac{\text{power}/c}{\text{Area}} = \frac{\text{power/area}}{c}$$

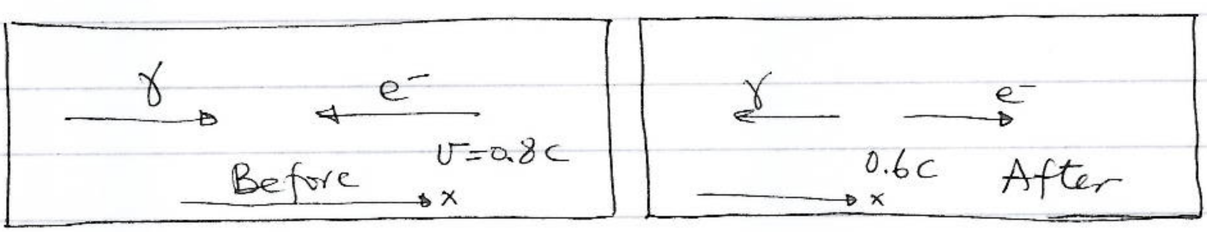
$$= \frac{1.5\ 10^{3}\ W/m^2}{3\ 10^{8}\ m/s} = 5 \times 10^{-6}\ Pa$$

(b) Total force experienced by Earth

$$= 5 \cdot 10^{-6} \times 4\pi\left(6.37\ 10^{6}\ m\right)^2$$

$$= -$$

Problem 3.53



Conservation of momentum

① $$\boxed{\frac{h}{\lambda} + \gamma_{0.8}\, m(-0.8c) = \gamma_{0.6}\, m(0.6c) - \frac{h}{\lambda'}}$$

Conservation of Energy:

$$\frac{hc}{\lambda} + \gamma_{0.8}\, mc^2 = \gamma_{0.6}\, mc^2 + \frac{hc}{\lambda'}$$

Divide by c: ② $$\boxed{\frac{h}{\lambda} + \gamma_{0.8}\, mc = \gamma_{0.6}\, mc + \frac{h}{\lambda'}}$$

① + ② $\Rightarrow$

$$\frac{2h}{\lambda} + \gamma_{0.8} m (0.2c) = \gamma_{0.6} m (1.6c)$$

$$\frac{1}{\lambda} = \frac{1}{2h}\left(\gamma_{0.6}(1.6c) - \gamma_{0.8}(0.2c)\right) m$$

$$= \frac{1}{2h}\left(\frac{5}{4}\, 1.6c - \frac{5}{3}\, 0.2c\right) m$$

$$= \frac{1}{2 \times 6.63\ 10^{-34} Js} (1.667c)\,(9.11\ 10^{-31} kg)$$

$$= 3.44\ 10^{-11} m^{-1}$$

$$\boxed{\lambda = 2.91\ 10^{-12} m}$$