# Physics 201 - Homework 3

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February 19, 2011

## 32.5

### (a)

$$f = \frac{c}{\lambda} = \frac{3 \times 10^8}{432 \times 10^{-9}} = 6.944 \times 10^{14}\,\text{Hz}$$

### (b)

$$E_{max} = cB_{max} = 3 \times 10^8 \times 1.25 \times 10^{-6} = 375\,\text{V/m}$$

### (c)

First find the wavenumber and angular frequency

$$k = \frac{2\pi}{\lambda} = 1.45 \times 10^7\,\text{m}^{-1}$$

$$\omega = 2\pi f = 4.363 \times 10^{15}\,\text{s}^{-1}$$

Then substitute these values and the amplitudes from part (a) into the wave equations

$$\vec{\mathbf{E}} = 375\,\text{V/m}\,\hat{\jmath}\cos(1.45 \times 10^7\,\text{m}^{-1}x - 4.36 \times 10^{15}\,\text{s}^{-1}t)$$

$$\vec{\mathbf{B}} = 1.25\,\mu\text{T}\,\hat{\mathbf{k}}\cos(1.45 \times 10^7\,\text{m}^{-1}x - 4.36 \times 10^{15}\,\text{s}^{-1}t)$$

## 32.14

### (a)

$$v = \frac{c}{\sqrt{KK_m}} = \frac{3 \times 10^8}{\sqrt{3.64 \times 5.18}} = 6.909 \times 10^7\,\text{ms}^{-1}$$

### (b)

$$\lambda = \frac{v}{f} = \frac{6.909 \times 10^7}{65} = 1.063 \times 10^6\,\mathrm{m}$$

### (c)

$$B_{max} = \frac{E_{max}}{v} = \frac{7.2 \times 10^{-3}}{6.909 \times 10^7} = 1.04 \times 10^{-10}\,\mathrm{T}$$

### (d)

$$I = S_{av} = \frac{E_{max}B_{max}}{2\mu} = \frac{E_{max}B_{max}}{2K_m\mu_0} = 5.76 \times 10^{-8}\,\mathrm{W/m^2}$$

## 32.43

### (a)

$$I_R = \frac{P}{4\pi R^2} = \frac{3.9 \times 10^{26}}{4\pi \times (6.96 \times 10^8)^2} = 6.41 \times 10^7\,\mathrm{W/m^2}$$

For an absorbing surface the radiation pressure is given by,

$$p_{rad} = \frac{I_R}{c} = \frac{6.41 \times 10^7}{3 \times 10^8} = 0.214\,\mathrm{Pa}$$

For $r = R/2$,

$$I_{R/2} = \frac{P}{4\pi(R/2)^2} = 4\left(\frac{P}{4\pi R^2}\right) = 4I_R = 2.56 \times 10^8\,\mathrm{W/m^2}$$

$$p_{rad} = \frac{I_{R/2}}{c} = \frac{4I_R}{c} = 4 \times 0.214 = 0.85\,\mathrm{Pa}$$

These values are about a million times larger than at the Earth's atmosphere.

### (b)

No because the radiation pressure only accounts for a tiny fraction of the Sun's pressure.

## 35.18

### (a)

$$d \sin\theta = m\lambda$$

$$\sin\theta = \frac{m\lambda}{d} = m\left(\frac{c}{fd}\right) = m\left(\frac{3 \times 10^8}{12 \times 107.9 \times 10^6}\right) = 0.232m$$

Note that $m_{max} = 4$. This means there are four angles for which constructive interference occurs outside of the central maximum. These angles are,

$$\theta_1 = \pm 13.41^\circ$$
$$\theta_2 = \pm 27.65^\circ$$
$$\theta_3 = \pm 44.11^\circ$$
$$\theta_3 = \pm 68.13^\circ$$

### (b)

$$d \sin\theta = \left(m + \frac{1}{2}\right)\lambda$$
$$\Rightarrow \sin\theta = 0.232\left(m + \frac{1}{2}\right)$$

This time we have $m_{max} = 3$ so there are four angles for which destructive interference occurs, since $m$ starts from zero. These angles are,

$$\theta_0 = \pm 6.66^\circ$$
$$\theta_1 = \pm 20.37^\circ$$
$$\theta_2 = \pm 35.45^\circ$$
$$\theta_3 = \pm 54.29^\circ$$

## 35.46

$n_{film} > n_{air} \Rightarrow$ No phase change
$n_{glass} > n_{film} \Rightarrow$ No phase change

Therefore, the condition for constructive interference is,

$$2nt_c = m\lambda$$

and for destructive interference,

$$2nt_d = \left(m' + \frac{1}{2}\right)\lambda$$

where $t_c$ and $t_d$ are the thickness for constructive and destructive interference respectively; $n$ is the refractive index of the film; $m$ and $m'$ are integers; $\lambda$ is the wavelength in air. The difference in thickness is given by,

$$t_d - t_c = \frac{\lambda}{2n}\left(m' + \frac{1}{2} - m\right)$$

Since we require the minimum amount of time we have $m' = m$ which leads to,

$$t_d - t_c = \frac{\lambda}{2n}\left(\frac{1}{2}\right) = \frac{\lambda}{4n}$$

$$\Delta t = \frac{525}{4 \times 1.4} = 93.75\,\mathrm{nm}$$

$$\mathrm{Time} = \frac{93.75}{4.2} = 22.3\,\mathrm{years} \approx 22\,\mathrm{years}$$