Unit 28 - Homework Solutions

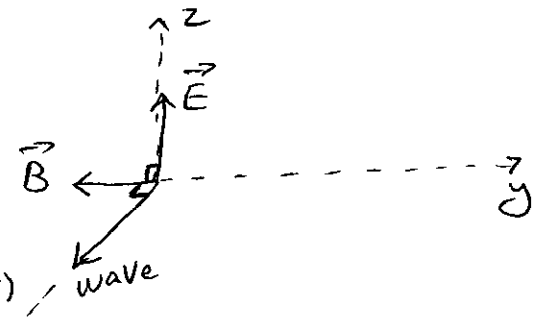
34 - 3 $\quad E_x = 0\ ,\ E_y = 0\ ,\ E_z = 2\cos\left[(\pi \times 10^{15})\left(t - \frac{x}{c}\right)\right]$

$B_z = 0$

$B_x = 0$

$B_y = -B^{max}\cos\left[(\pi \times 10^{15})\left(t - \frac{x}{c}\right)\right]$

$$B^{max} = \frac{E^{max}}{c} = \frac{2}{3\times 10^8} = 0.7\times 10^{-8} = 7\times 10^{-9}\ (T)$$



$$B_y = -7.0\times 10^{-9}\ (T)\cos\left[(\pi \times 10^{15})\left(t - \frac{x}{c}\right)\right]$$

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34 - 11 $\quad E^{max} = 2.0\ V/m$

a) $$B^{max} = \frac{E^{max}}{c} = \frac{2.0}{3.0\times 10^8} = 0.7\times 10^{-8}\ (T) = 7\times 10^{-9}\ (T)$$

b) $$I = \frac{1}{c\mu_0}(E^{rms})^2 \qquad E^{rms} = \frac{E^{max}}{\sqrt{2}}$$

$$I = \frac{1}{c\mu_0}\frac{(E^{max})^2}{2} = \frac{4.0}{3\times 10^8 \times 4\pi\times 10^{-7}\times 2} = 5.3\times 10^{-3}\ \frac{W}{m^2}$$

c) $$P = IA = I(4\pi r^2) = 5.3\times 10^{-3}\times 4\pi\times 10^2 = 6.7\ W$$

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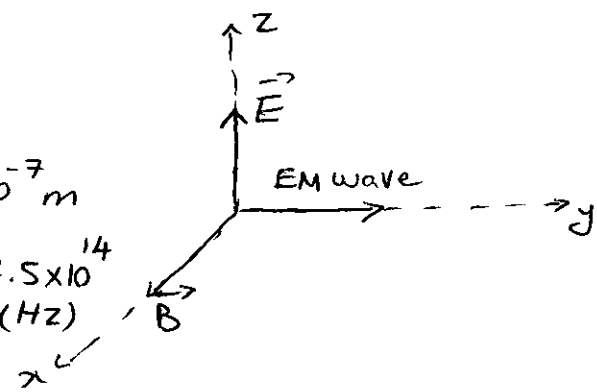
34 - 17 $\quad B_x = (4.0\times 10^{-6})\sin\left[(1.57\times 10^7)y + \omega t\right]$

a) The direction of electric field shows the polarization direction of light.

positive - z direction

b) $$k = \frac{2\pi}{\lambda} = 1.57\times 10^7 \Rightarrow \lambda = 4.0\times 10^{-7}\ m$$

$$\lambda = cT = \frac{c}{f} \Rightarrow f = \frac{c}{\lambda} = \frac{3.0\times 10^8}{4.0\times 10^{-7}} = 7.5\times 10^{14}\ (Hz)$$



c) $I = \frac{1}{c\mu_0}(E^{rms})^2$ $\qquad E^{rms} = cB^{rms} = \frac{cB^{max}}{\sqrt{2}}$

$$I = \frac{1}{c\mu_0}\frac{c^2(B^{max})^2}{2} = \frac{c(B^{max})^2}{2\mu_0} = \frac{3\times10^8 \times (4\times10^{-6})^2}{2\times4\pi\times10^{-7}}$$

$$= 1.9\times10^3 \ W/m^2$$

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34 - 19

$I = 100 \ W/m^2$

$$I_{heater} = \frac{P_{heater}}{4\pi r^2} \rightarrow 100 = \frac{10^3}{4\pi r^2} \Rightarrow r = \sqrt{\frac{10}{4\pi}} = 0.89 \ m$$

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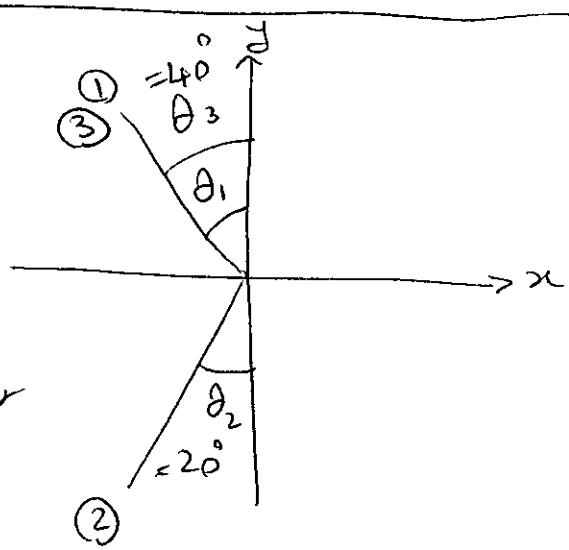
34 - 39



I_0 : Intensity of unpolarized light

After passing through the first polarizer, I becomes half no matter what the angle is:

$$I_1 = \frac{1}{2}I_0$$

$$I_2 = I\cos^2(\theta_{21}) = \left(\frac{1}{2}I_0\right)\cos^2(120^\circ)$$

θ_{21}: angle between 2 and 1

$$I_3 = I_2\cos^2\theta_{32} = \left(\frac{1}{2}I_0\right)\cos^2(120^\circ)\cos^2(120^\circ) = 0.03\,I_0$$

$$\frac{I_3}{I_0} = 0.03 = 3\%$$

34 - 49

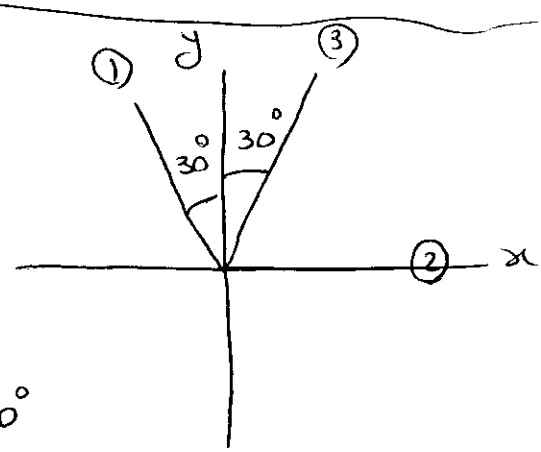
$I_1 = \frac{1}{2} I_0$, $I_2 = I_1 \cos^2\theta_{12} = \frac{1}{2} I_0 \cos^2\theta_{12}$

I_1: Intensity after the first polarizer

$$\frac{I_2}{I_0} = \frac{1}{2}\cos^2\theta_{12} = \frac{1}{3}$$

$$\Rightarrow \cos^2\theta_{12} = \frac{2}{3} \Rightarrow \boxed{\theta_{12} = 35.3^\circ}$$

34 - 51



$I_1 = \frac{1}{2} I_0$ $\quad I_2 = I_1 \cos^2\theta_{12}$

$$I_2 = \frac{1}{2} I_0 \cos^2 120^\circ$$

$$I_3 = I_2 \cos^2\theta_{23} = \left(\frac{1}{2} I_0 \cos^2 120^\circ\right)\cos^2 60^\circ$$

$$= \frac{1}{2} I_0 \cos^2 120^\circ \cos^2 60^\circ = 0.031\, I_0$$

$$\boxed{\frac{I_3}{I_0} = 3.1}$$

34 - 55

a) speed $c = 3\times10^8$ m/s $\quad d = 150\times10^3$ m

$$t = \frac{d}{c} = \frac{150\times10^3}{3\times10^8} = 5\times10^{-4}\ s$$

b) $t = \dfrac{\text{Earth-sun distance}}{c} = \dfrac{1.5\times10^8\times10^3}{3\times10^8} = 500\ s = 8.3\ min$

c) $t = \dfrac{2\times 1.3\times10^9\times10^3}{3\times10^8} = 8.7\times10^3\ s = 2.4\ h$

d) $t = \dfrac{d}{c} = \dfrac{(6500)\times c}{c} = 6500$ years

$1054 - 6500 = -5446 \rightarrow 5446$ B.C.