Physics 2C Quiz 5 Solutions Winter 2018

Problem 1

$E_m = 3\,V/m$

$B = B_m \sin(kx - \omega t)$ $\omega = 2\pi f = 2\pi \frac{c}{\lambda}$

$\omega t = \frac{2\pi c}{\lambda} t = \frac{2\pi \times 3 \times 10^8}{3} \cdot 1.25 \cdot 10^{-9} = 0.25\pi = \frac{\pi}{4}$

$\Rightarrow B = B_m \sin\frac{\pi}{4}$, $\frac{E_m}{B_m} = c \Rightarrow B_m = \frac{E_m}{c} \Rightarrow$

$\Rightarrow B = \frac{E_m}{c} \sin\frac{\pi}{4} = \frac{3}{3\times 10^8} \cdot \frac{1}{\sqrt{2}} T = \frac{10^{-8}}{\sqrt{2}} T = \frac{10}{\sqrt{2}} nT = \boxed{7.07nT}$

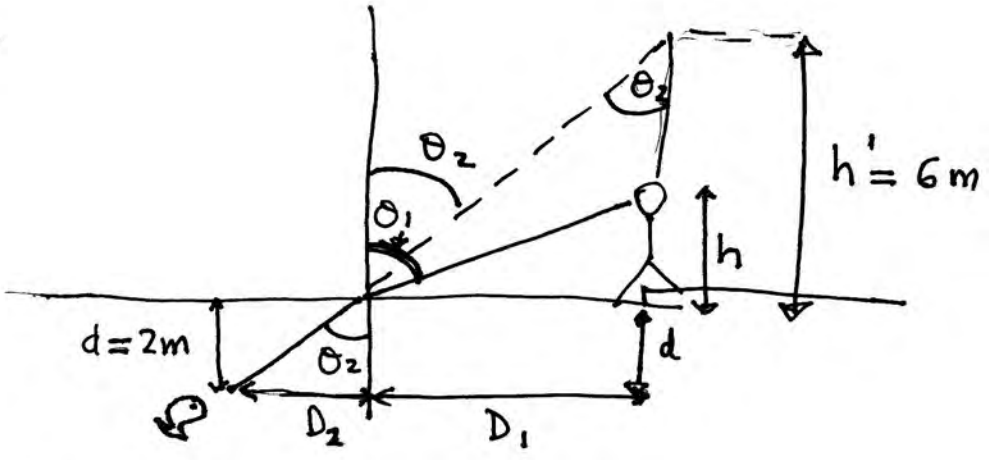
Problem 2

$S_{av} = \frac{1}{c\mu_0} E_{rms}^2 = \frac{P_s}{4\pi r^2} \Rightarrow P_s = \frac{4\pi r^2}{c\mu_0} E_{rms}^2$

$E_{rms} = \frac{E_m}{\sqrt{2}} \Rightarrow P_s = \frac{4\pi r^2}{c\mu_0} \frac{E_m^2}{2} \Rightarrow$

$\Rightarrow P_s = \frac{4\pi \times 4^3}{3\times 10^8 \times 4\pi \times 10^{-7}} \times \frac{200}{2} W = \boxed{60W}$

Problem 3



$D = D_1 + D_2 = 8m$

$\tan\theta_2 = \frac{D}{h'+d} = \frac{8m}{6m+2m} = 1 \Rightarrow \boxed{\theta_2 = 45°}$

$n_1 \sin\theta_1 = n_2 \sin\theta_2, \quad n_1 = 1, n_2 = 1.33 \Rightarrow$

$\Rightarrow \theta_1 = 70.13°. \quad \tan\theta_2 = \frac{D_1}{h'} \Rightarrow \boxed{D_1 = h' = 6m}$

$\tan\theta_1 = \frac{D_1}{h} \Rightarrow h = \frac{D_1}{\tan\theta_1} = \frac{6m}{2.766} = 2.17m$

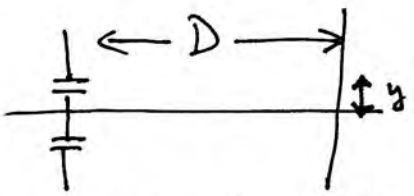
$\boxed{h = 2.2m}$

Problem 4

$\frac{1}{p} + \frac{1}{i} = \frac{1}{f}, \quad p = \frac{3}{4}f \Rightarrow \frac{1}{i} = \frac{1}{f} - \frac{4}{3f} = -\frac{1}{3f}$

$\Rightarrow \boxed{i = -3f} \qquad m = -\frac{i}{p} = \frac{3f}{\frac{3}{4}f} = 4 \Rightarrow \boxed{4h, U}$

Problem 5



$I = 4 I_0 \cos^2 \phi/2$

When one slit is closed, $I = I_0$. When both slits are open, if

$I = I_0 \Rightarrow 4\cos^2\frac{\phi}{2} = 1 \Rightarrow \cos\frac{\phi}{2} = \frac{1}{2} \Rightarrow \frac{\phi}{2} = \frac{\pi}{3} \Rightarrow \boxed{\phi = \frac{2\pi}{3}}$

$\phi = 2\pi\frac{\Delta L}{\lambda}$, $\Delta L = d\sin\theta \Rightarrow \phi = 2\pi\frac{d\sin\theta}{\lambda} \Rightarrow$

$\Rightarrow \sin\theta = \frac{\lambda}{2\pi d}\phi$, $\sin\theta \sim \tan\theta \sim \frac{y}{D} \Rightarrow$

$\Rightarrow y = \frac{\lambda}{2\pi d} D\phi = \frac{\lambda}{2\pi d}\frac{2\pi}{3} D = \frac{\lambda D}{3d} = \frac{600\times10^{-9}\times 10}{3\times10^{-3}}$ m

$\Rightarrow y = 2.10^{-3}$ m $\Rightarrow \boxed{y = 2\text{ mm}}$

Problem 6

bright: $(m+\frac{1}{2})\frac{\lambda}{n} = 2L$. $L = 900$ nm, $\lambda = 680$ nm, $n = 1.33$

$\Rightarrow m = \frac{2L}{\lambda} n - \frac{1}{2} = \frac{1800}{680}\cdot 1.33 - \frac{1}{2} = \boxed{3}$

dark: $m\frac{\lambda}{n} = 2L \Rightarrow \lambda = \frac{2L}{m} n = \frac{2394}{m}$ nm

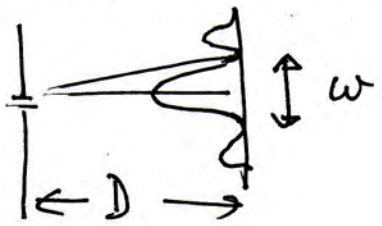
closest smaller wavelength is for $m = 4 \Rightarrow$

$\Rightarrow \boxed{\lambda = 598.5\text{ nm}}$

Problem 7

$a \sin\theta = m\lambda$ gives minima. So first minima is $m=1 \Rightarrow$

$\Rightarrow \sin\theta \sim \theta = \frac{\lambda}{a}$



$\theta = \frac{w}{2D} = \frac{\lambda}{a} \Rightarrow$

$w = 2\frac{\lambda}{a} D = \frac{2 \cdot 500\,nm}{10^{-3}m} \times 10m = 10^{7}\,nm = 10^{-2}m$

$\Rightarrow \boxed{w = 1\,cm}$