Department of Physics
National Dong Hwa University, 1, Sec. 2,
Da Hsueh Rd., Shou-Feng, Hualien, 974, Taiwan

General Physics II, Final 2
PHYS10400, Class year 98
06-24-2010

Solutions

1. Let d is the diameter of the aperture, then $d\sin\theta = \lambda$ is the first minimum of the central bright diffraction pattern. θ=1°, sinθ ≅ θ = 1° = π/180

So, $d = \dfrac{420\times10^{-9}m}{\sin(\frac{\pi}{180})} = \dfrac{420\times10^{-9}}{3.14/180} = 24\mu m$

2. (This is the derivation in page 1057 of the textbook)

(a) $E_p = E_1 + E_2 = E_0[\sin\omega t + \sin(\omega t + \phi)]$ Then using

$SinA + SinB = 2Sin(\dfrac{A+B}{2})Cos(\dfrac{A-B}{2})$, We get, $E_p = 2E_0 Cos(\dfrac{\phi}{2})Sin(\omega t + \dfrac{\phi}{2})$

$I \propto E_P^2 = 4E_0^2 Cos^2(\dfrac{\phi}{2})Sin^2(\omega t + \dfrac{\phi}{2})$, but the time average of the term $Sin^2(\omega t + \dfrac{\phi}{2}) = \dfrac{1}{2}$

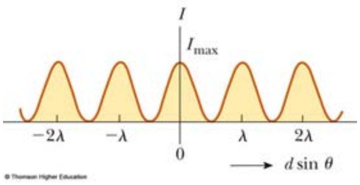
Therefore, $I = 2E_0^2 Cos^2(\dfrac{\phi}{2}) = I_{\max} Cos^2(\dfrac{\phi}{2})$, with $I_{\max} = 2E_0^2$

(b) The slit separation is d, using equation (37.9),

$\phi = \dfrac{2\pi}{\lambda}\delta = \dfrac{2\pi}{\lambda} dSin\theta$

(c) The interference intensity is $I == I_{\max} Cos^2(\dfrac{\phi}{2})$

If we plot I against dSinθ, the figure is shown on the right.



3. (a) The input voltage is $\Delta V_{\text{in}} = IZ = I\sqrt{R^2 + X_C^2} = I\sqrt{R^2 + (1/\omega C)^2}$. The output voltage is $\Delta V_{\text{out}} = IX_C = \dfrac{I}{\omega C}$. The gain ratio is

$$\frac{\Delta V_{\text{out}}}{\Delta V_{\text{in}}} = \frac{I/\omega C}{I\sqrt{R^2 + (1/\omega C)^2}} = \frac{1/\omega C}{\sqrt{R^2 + (1/\omega C)^2}}.$$

(b, c) As $\omega \to 0$, $\dfrac{1}{\omega C} \to \infty$ and R becomes negligible in comparison. Then

$\dfrac{\Delta V_{\text{out}}}{\Delta V_{\text{in}}} \to \dfrac{1/\omega C}{1/\omega C} = \boxed{1}$. As $\omega \to \infty$, $\dfrac{1}{\omega C} \to 0$ and $\dfrac{\Delta V_{\text{out}}}{\Delta V_{\text{in}}} \to \boxed{0}$.

(d) $\dfrac{1}{2} = \dfrac{1/\omega C}{\sqrt{R^2 + (1/\omega C)^2}}$ $\quad R^2 + \left(\dfrac{1}{\omega C}\right)^2 = \dfrac{4}{\omega^2 C^2}$ $\quad R^2\omega^2C^2 = 3$ $\quad \omega = 2\pi f = \dfrac{\sqrt{3}}{RC}$

$$\boxed{f = \frac{\sqrt{3}}{2\pi RC}}$$

4.

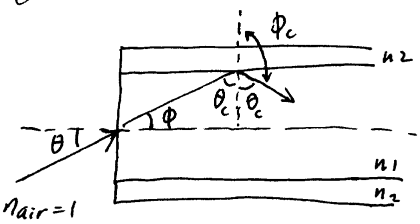
As shown on the diagram on the right

when light, $n_{air}=1$

Snell's law:

$n_{air} \sin\theta = n_1 \sin\phi$

$\rightarrow \sin\theta = n_1 \sin\phi$ — ①



Inside the fiber, light hits the surrounding materials for the largest incident angle θ, ϕ_c is 90° for total reflection

But $\theta_c = 90° - \phi$

$\therefore\ n_1 \sin(90° - \phi) = n_2 \sin\phi_c$, $\phi_c = 90°$

$n_1 \cos\phi = n_2 . \rightarrow \cos\phi = \frac{n_2}{n_1}$ — ②

① $\sin\theta = n_1 \sin\phi$ $\Rightarrow$ $\sin\phi = \sqrt{1-\cos^2\phi}$

$\sin\theta = n_1\sqrt{1-\cos^2\phi}$ $\Rightarrow$

$= n_1\sqrt{1-(\frac{n_2}{n_1})^2}$

$\therefore\ \theta = \sin^{-1}\left(n_1\sqrt{1-(\frac{n_2}{n_1})^2}\right)$

5. The magnitude of the poynting vector S_{av} is

$$S_{av} = \frac{P_{av}}{A} = \frac{P_{av}}{\pi r^2} = \frac{3.0\times10^{-3}W}{\pi(\frac{2.0\times10^{-3}m}{2})^2} = 955\,W/m^2\ ,\quad P_{av} = 2\frac{S_{av}}{c} = \frac{2\times955\,W/m^2}{3\times10^8\ m/s} = 6.36\times10^{-6}\ N/m^2$$

6. Page 955. Equations (34.4-7)