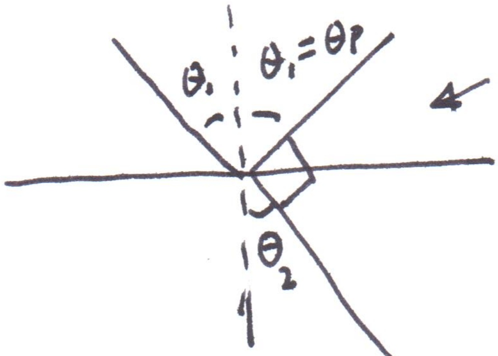
1. When the reflected and refracted light

(a) is 90°, the reflection angle is $\theta_2 = \theta_P$

θ_P is called Brewster angle

(b)



At this condition $\theta_2 \equiv \theta_P \equiv$ Brewster angle

(c) From the above diagram

$$\theta_p + 90° + \theta_2 = 180°$$

Use Snell's law.

$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$

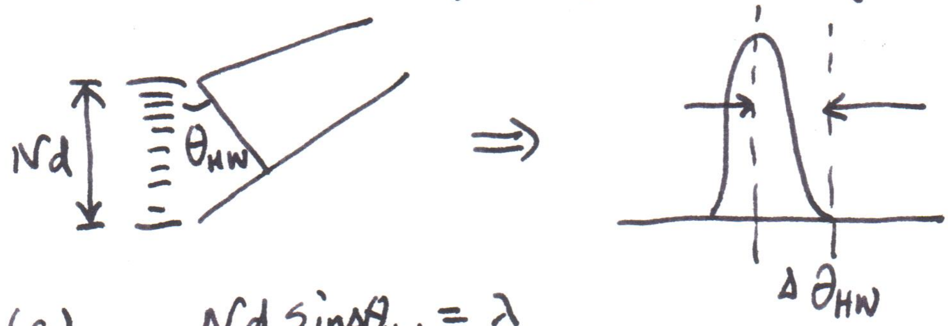
$$\frac{n_2}{n_1} = \frac{\sin\theta_1}{\sin\theta_2} = \frac{\sin\theta_p}{\sin(90° - \theta_p)}$$

$$\therefore \tan\theta_p = \frac{n_2}{n_1}$$

(d) if $n_1 =$ air $= 1$. then $\tan p = n_2$

this is the easiest way to find out the index of refraction of medium 2.

2. In a diffraction grating of ruling N, spacing d



(a) $Nd \sin\Delta\theta_{HW} = \lambda$

if $\Delta\theta_{HW}$ is small, $\sin\Delta\theta_{HW} = \Delta\theta_{HW}$

$\therefore \ \Delta\theta_{HW} = \dfrac{\lambda}{Nd}$

(b) $\cancel{N\theta} \sin\theta_{HW} = \dfrac{y}{D} = \dfrac{\lambda}{Nd} \Rightarrow y = D\dfrac{\lambda}{Nd}$

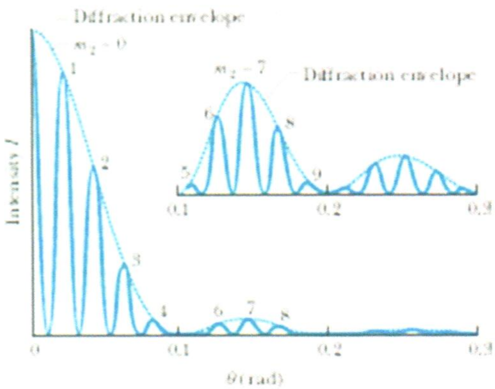
3

(a) For single slit diffraction, $a\sin\theta = \lambda$, *for* $m_1=1$ center bright

For double slit (Yang's), $d\sin\theta = m_2\lambda$, *for* $m_2=0, 1, 2, ..$

Therefore, $m_2 = \dfrac{d}{a} = \dfrac{19.44\,\mu m}{4.050\,\mu m} = 4.8$

For the center bright, there are **9** interference fringes



(b) At the second diffraction minimum, $a\sin\theta = 2\lambda$

$$m_2 = \frac{2d}{a} = \frac{(2)(19.44\,\mu m)}{4.050\,\mu m} = 9.6$$

As shown in the right figure, there are only **4** bright interference fringes in either side band. There are total **8** bright fringes on the first side bands on both sides.

4.

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

$\Delta V_{out} = IX_C = \dfrac{I}{\omega C}$. The gain ratio is

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

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

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

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

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

5. In an AC circuit $\Delta V = \Delta V_{max} \sin \omega t$

$$i = \frac{\Delta V}{R} = \frac{\Delta V_{max}}{R} \sin \omega t = I_{max} \sin \omega t$$

$$i_{rms} = \sqrt{\overline{i^2}}$$

$$\therefore \overline{i^2} = \frac{1}{2} I_{max}^2$$

$$i_{rms} = \sqrt{\overline{i^2}} = \frac{1}{\sqrt{2}} I_{max}$$

$$P_{AV} = I_{rms}^2 R$$

$$= \frac{1}{2} I_{max}^2 R$$

$$i^2 = I_{max}^2 \sin^2 \omega t$$

$$\overline{i^2} = \frac{1}{T} \int I_{max}^2 \sin^2 \omega t \, dt$$

$$= I_{max}^2 \frac{1}{T} \int_0^T \sin^2 \omega t$$

$$= I_{max}^2 \frac{1}{T} \int_0^T \left[\frac{1 - \sin(\frac{\omega}{2} t)}{2} \right] dt$$

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