PHYS143: Module III – Wave Optics

Constants:

$h = 6.63 \times 10^{-34}$ J.s $\qquad$ $c = 3.00 \times 10^{8}$ m/s

Formulas:

The energy of a photon: $E = hf$.

Images Formed by Refraction:

$$\frac{n_1}{p} + \frac{n_2}{q} = \frac{n_2 - n_1}{R}$$

Lens-makers' Equation:

$$\frac{1}{p_1} + \frac{1}{q_2} = (n-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) = \frac{1}{f}$$

Two Lenses in Contact:

$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}$$

Camera:

f-number $\equiv f / D$ $\qquad$ $P = 1/f$

Magnifier:

$$m \equiv \frac{\theta}{\theta_o} = \frac{\text{angle with lens}}{\text{angle without lens}} \qquad m_{\max} = 1 + \frac{25\text{ cm}}{f} \qquad m_{\min} = \frac{\theta}{\theta_o} = \frac{25\text{ cm}}{f} \qquad p = \frac{25f}{25+f}$$

Compound Microscope:

$$M_o = -L / f_o \qquad m_e = 25\ cm / f_e \qquad M = M_o\, m_e = -\frac{L}{f_o}\left(\frac{25\text{ cm}}{f_e}\right)$$

Angular Magnification of a Telescope:

$$m = \frac{\theta}{\theta_o} = -\frac{f_o}{f_e}$$

Light Intensity (Interference):

$$I = I_{\max}\cos^2\left(\frac{\pi d \sin\theta}{\lambda}\right) \qquad I = I_{\max}\cos^2\left(\frac{\pi d}{\lambda L}y\right) \quad \text{(small angles)}$$

Single-Slit Diffraction, Intensity: $I = I_{\max}\left[\frac{\sin(\pi a \sin\theta/\lambda)}{\pi a \sin\theta/\lambda}\right]^2$

Intensity of Two-Slit Diffraction Patterns: $I = I_{\max}\cos^2\left(\frac{\pi d \sin\theta}{\lambda}\right)\left[\frac{\sin(\pi a \sin\theta/\lambda)}{\pi a \sin\theta/\lambda}\right]^2$

Resolution:

$$\theta_{\min} = \lambda/a \quad \text{(vertical / horizontal slit)}$$

$$\theta_{\min} = 1.22\,\frac{\lambda}{D} \quad \text{(Spherical Aperture)}$$

Two-Slit Diffraction Patterns, Maxima and Minima:

$$\frac{d\sin\theta}{a\sin\theta} = \frac{m\lambda}{\lambda} \rightarrow \frac{d}{a} = m$$

Interference: Phase difference $\phi = \frac{2\pi}{\lambda} d\sin\theta$

Diffraction Grating:

$$d\sin\theta_{\text{bright}} = m\lambda$$

X-Ray Diffraction:

$$2d\sin\theta_{bright} = m\lambda$$

Polarization:

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

Law of Reflection: $\theta_1' = \theta_1$

$$\frac{\sin\theta_2}{\sin\theta_1} = \frac{v_2}{v_1}$$

$$n \equiv \frac{\text{speed of light in vacuum}}{\text{speed of light in a medium}} \equiv \frac{c}{v}$$

$$\lambda_1 n_1 = \lambda_2 n_2$$

$$n = \frac{\lambda}{\lambda_n} \quad \left(\frac{\lambda \text{ in vacuum}}{\lambda \text{ in a medium}}\right)$$

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

$$\frac{\lambda_1}{\lambda_2} = \frac{n_2}{n_1}$$

$$\sin\theta_C = \frac{n_2}{n_1} \quad (\text{for } n_1 > n_2)$$

****

$$M = \frac{\text{image height}}{\text{object height}} = \frac{h'}{h}$$

$$M = \frac{h'}{h} = -\frac{q}{p}$$

$$\frac{1}{p} + \frac{1}{q} = \frac{1}{f}$$

$$\frac{1}{p} + \frac{1}{q} = \frac{2}{R}$$

Interference Equations:

$$d\sin\theta_{\text{bright}} = m\lambda \qquad m = 0, \pm 1, \pm 2, \ldots$$

$$d\sin\theta_{\text{dark}} = (m + \tfrac{1}{2})\lambda \qquad m = 0, \pm 1, \pm 2, \ldots$$

$$y_{\text{bright}} = L\frac{m\lambda}{d} \text{ and } y_{\text{dark}} = L\frac{(m + 1/2)\lambda}{d}$$

$$\delta = \frac{yd}{L}$$

$$y = L\tan\theta \approx L\sin\theta$$

Single-Slit Diffraction:

$$\sin\theta_{\text{dark}} = m\frac{\lambda}{a} \qquad m = \pm 1, \pm 2, \pm 3, \ldots$$

Thin Films:

- $2nt = (m + \tfrac{1}{2})\lambda \qquad (m = 0, 1, 2 \ldots)$
- $2nt = m\lambda \qquad (m = 0, 1, 2 \ldots)$