Modern Optics: Homework 15

Due: 14 October 2015

1 Double slit interference

Suppose light is incident on a double slit, whose slit separation is d, and the light on one slit is vertically polarized while the light on the other is polarized along the direction midway between vertical and horizontal. Also assume that there is no phase difference between the two slits.

a) Determine an expression for the intensity of the wave at a distant point as a function of the angle θ, used in class.

b) Determine expressions for the maximum and minimum intensities of the fringes and use these to determine the fringe visibility.

2 Bennett, *Principles of Physical Optics*, 5.4, page 206. Determine the visibility of the pattern.

3 Number of interference fringes

Double slits will only produce a finite number of bright interference fringes.

a) Describe how the number of maxima can be determined in general.

b) Suppose that $d < \lambda$. How many maxima are there in the interference pattern?

c) Suppose that $d = 0.010\,\mathrm{mm}$ and $\lambda = 650\,\mathrm{nm}$ How many maxima are there in the interference pattern?

4 Interference pattern in a different medium

Suppose that a double slit experiment can be performed using the same source and slits but with the entire apparatus in air (index of refraction 1.00) or water (index of refraction 1.33). If the angle from the central maximum to the first maximum when the apparatus in air is $2.5°$, then determine what it will be when the apparatus is in water.

5 Bennett, *Principles of Physical Optics*, 5.6, page 210.

6 Bennett, *Principles of Physical Optics*, 5.7, page 210.

7 General thin film interference

Consider a film of oil (index of refraction 1.52) on a body of water (index of refraction 1.33). Light is incident on the film from air (index of refraction 1.00).

a) Show that the phase shift for the two reflected rays, using the scheme presented in class, is

$$\delta = -\pi - \frac{4\pi l}{\lambda_0} \sqrt{n_{\text{oil}}^2 - n_{\text{air}}^2 \sin^2 \theta_i}$$

where λ_0 is the wavelength of the light in a vacuum.

b) If $l = \lambda_0$ determine the angles at which light of minimal intensity is reflected. How many dark fringes will appear in the interference pattern?

c) If $l = 5\lambda_0$ determine the angles at which light of minimal intensity is reflected. How many dark fringes will appear in the interference pattern?

d) *Extra credit: 10% of total assignment grade.* Show that in this case, the number of dark fringes is twice the number of integers between $\sqrt{n_{\text{oil}}^2 - n_{\text{air}}^2} 2l/\lambda_0$ and $n_{\text{oil}} 2l/\lambda_0$.