632.

Problem 45.13 (RHK)

In the front of a lecture hall, a coherent beam of monochromatic light from a helium-neon laser $(\lambda = 632.8 \text{ nm})$ *illuminates a double slit. From there it travels a distance of* 20.0 m *to a mirror at the back of the hall, and returns the same direction to a screen.* (a) *We have to fix the distance between the two slits in order that the distance between the interference maxima is observed to be* 10.0 cm. (b) *We have to state the change in interference pattern if the lecturer inserts in front of one of the slits a cellophane that contains* 2.5 *more waves than a path through air of the same geometric thickness.*

Solution:

(a)

A mirror has been kept at a distance of 20.0 m from the double slit. Thus image of the slits is formed at a distance of 20.0 m behind the mirror. As the interference pattern is observed on a screen facing the mirror, the effective distance of the screen from the virtual images is 40.0 m. The distance between the interference maxima will be given by the double-slit condition

$$d\,\frac{\Delta y}{D} = \lambda \ ,$$

where d is the distance between the slits, and D is the distance from the slits to the screen. As we have stated above, in the experimental set up described in the problem $D = 40.0\ \text{m}$. We want $\Delta y = 10.0\ \text{cm}$ for laser light of wavelength $\lambda = 632.8\ \text{nm}$. We thus find that

$$d = \frac{\lambda D}{\Delta y} = \frac{632.8\times10^{-9}\times 40}{10\times10^{-2}}\ \text{m}$$

$$= 0.253\ \text{mm.}$$

(b)

When cellophane that contains 2.5 more waves than a path through air of the same geometric thickness is inserted in front of one of the slits, the phase difference between the rays changes by 5π. As a result in the interference pattern maxima and minima get interchanged.