Young's Equation

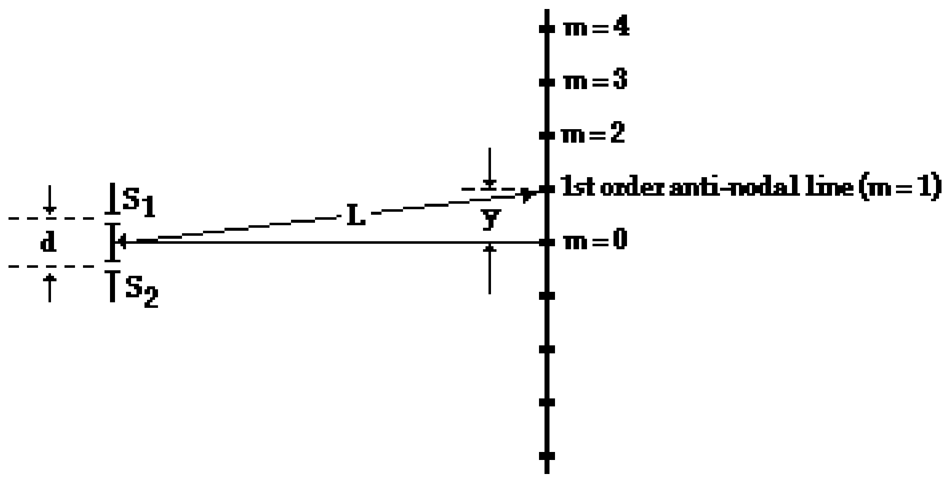
Thomas Young performed experiments in which a beam of monochromatic light was diffracted by a double-slit and produced an interference pattern. The pattern consisted of alternating bright (anti-nodal lines) and dark (nodal lines) regions. Young used the interference pattern in order to calculate the wavelength of the monochromatic light. From his studies, he discovered the following important equations which relate various distances on the pattern to the wavelength of light:

$$\mathbf{PD = m\,\lambda} \qquad\qquad \lambda = \frac{\mathbf{y\,d}}{\mathbf{m\,L}}$$

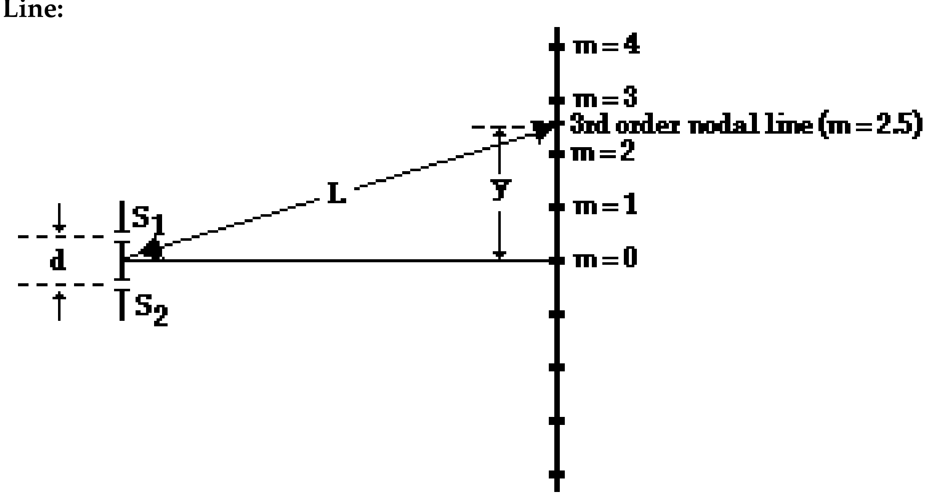
For anti-nodal lines (bright): m = 0 , 1, 2, 3, 4, ... For nodal lines (dark): m = 0.5, 1.5, 2.5, ...

The meaning of the variables in the above equation can be understood by studying the following diagrams. Note that the numbering system used here for the variable **m** is different than that used in our textbook. The results of both systems are the same. The numbering system used here allows us to have one **PD** equation and one **λ** equation (as opposed to separate equations for nodal and anti-nodal lines). The nodal points are assigned half-number values for **m**. For instance, the first nodal line to the left or right of the central anti-nodal line is assigned an **m** value of 0.5. The second nodal line to the left or right of the central anti-nodal line is assigned an **m** value of 1.5. Choose a system and use it consistently. Finally, note that since the bright lines (anti-nodal lines) are equally spaced, the **y** value for an m=2 line will be twice as big as the **y** value for an m=1 line.

First Anti-nodal Line:



Third Nodal Line:



Apply your understanding of the meaning of m, y, d and L by interpretting the following statements and identifying the values.

1. Two slits separated by 0.250 mm produces an interference pattern in which the fifth dark band is located 12.8 cm fron the central anti-node when the screen is placed a distance of 8.2 meters away.

   y = ________________ d = ________________ m = ________________ L = ________________

2. An interference pattern is produced when light is incident upon two slits which are 50.0 micrometers apart. The perpendicular distance from the midpoint between the slits to the screen is 7.65 m. The distance between the two third-order anti-nodes on opposite sides of the pattern is 32.9 cm.

   y = ________________ d = ________________ m = ________________ L = ________________

3. The fourth nodal line on an interference pattern is 8.4 cm from the first anti-nodal line when the screen is placed 235 cm from the slits. The slits are separated by 0.25 mm.

   y = ________________ d = ________________ m = ________________ L = ________________

4. Two sources separated by 0.500 mm produce an interference pattern 525 cm away. The fifth and the second anti-nodal line on the same side of the pattern are separated by 98 mm.

   y = ________________ d = ________________ m = ________________ L = ________________

5. Two slits that are 0.200 mm apart produce an interference pattern on a screen such that the central maximum and the 10th bright band are distanced by an amount equal to one-tenth the distance from the slits to the screen.

   y = ________________ d = ________________ m = ________________ L = ________________

6. The fifth anti-nodal line and the second nodal line on the opposite side of an interference pattern are separated by a distance of 32.1 cm when the slits are 6.5 m from the screen. The slits are separated by 25.0 micrometers.

   y = ________________ d = ________________ m = ________________ L = ________________

7. If two slits 0.100 mm apart are separated from a screen by a distance of 300 mm, then the first-order minimum will be 1 cm from the central maximum.

   y = ________________ d = ________________ m = ________________ L = ________________

8. Consecutive bright bands on an interference pattern are 3.5 cm apart when the slide containing the slits are 10.0 m from the screen. The slit separation distance is 0.050 mm.

   y = ________________ d = ________________ m = ________________ L = ________________