Predicting the location of interference fringes

Consider two narrow slits that are separated by a distance d, as shown in **Figure 7,** and through which two coherent, monochromatic light waves, l_1 and l_2, pass and are projected onto a screen. If the distance from the slits to the viewing screen is very large compared with the distance between the slits, then l_1 and l_2 are nearly parallel. As a result of this approximation, l_1 and l_2 make the same angle, θ, with the horizontal dotted lines that are perpendicular to the slits. The angle θ also indicates the position at which the waves combine with respect to the central point of the viewing screen.

The difference in the distance traveled by the two waves is called their **path difference.** Study the right triangle shown in **Figure 7,** and note that the path difference between the two waves is equal to $d \sin \theta$. Note carefully that the value for the path difference varies with angle θ and that each value of θ defines a specific position on the screen.

The value of the path difference determines whether the two waves are in or out of phase when they arrive at the viewing screen. If the path difference is either zero or some whole-number multiple of the wavelength, the two waves are in phase, and constructive interference results. The condition for bright fringes (constructive interference) is given by:

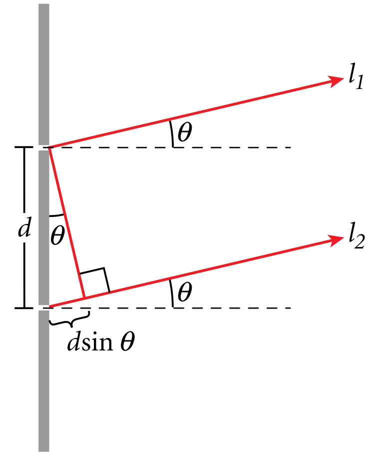

Figure 7
The path difference for two light waves equals $d \sin \theta$. In order to emphasize the path difference, the figure is not drawn to scale.

EQUATION FOR CONSTRUCTIVE INTERFERENCE

$$d \sin \theta = \pm m\lambda \quad m = 0, 1, 2, 3, \ldots$$

the path difference between two waves = an integer multiple of the wavelength

path difference
the difference in the distance traveled by two beams when they are scattered in the same direction from different points

In this equation, m is the **order number** of the fringe. The central bright fringe at $\theta = 0$ ($m = 0$) is called the *zeroth-order maximum,* or the *central maximum;* the first maximum on either side of the central maximum, which occurs when $m = 1$, is called the *first-order maximum,* and so forth.

order number
the number assigned to interference fringes with respect to the central bright fringe

Similarly, when the path difference is an odd multiple of $\frac{1}{2}\lambda$, the two waves arriving at the screen are 180° out of phase, giving rise to destructive interference. The condition for dark fringes, or destructive interference, is given by the following equation:

EQUATION FOR DESTRUCTIVE INTERFERENCE

$$d \sin \theta = \pm\left(m + \tfrac{1}{2}\right)\lambda \quad m = 0, 1, 2, 3, \ldots$$

the path difference between two waves = an odd number of half wavelengths

If $m = 0$ in this equation, the path difference is $\pm\frac{1}{2}\lambda$, which is the condition required for the first dark fringe on either side of the bright central maximum.