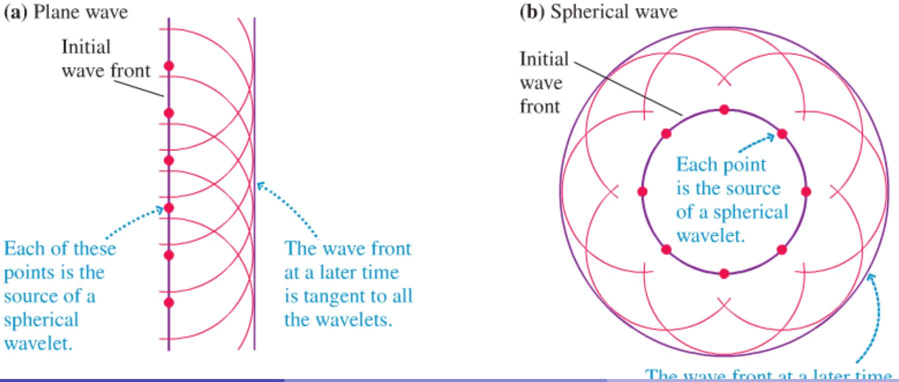
Chapter 22: Wave Optics

Now we go from general properties of waves to specifically studying the properties of light: optics. This chapter begins with an historical introduction to the particle and wave models of light (which we have covered already). Then we get to do all of the neat wave-like properties of light.

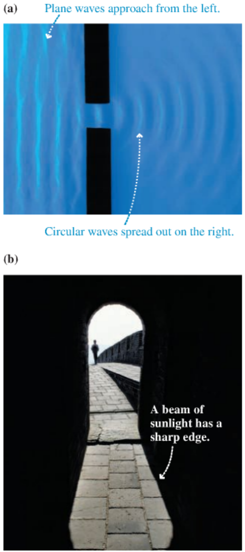
Diffraction - Huygen's Principle

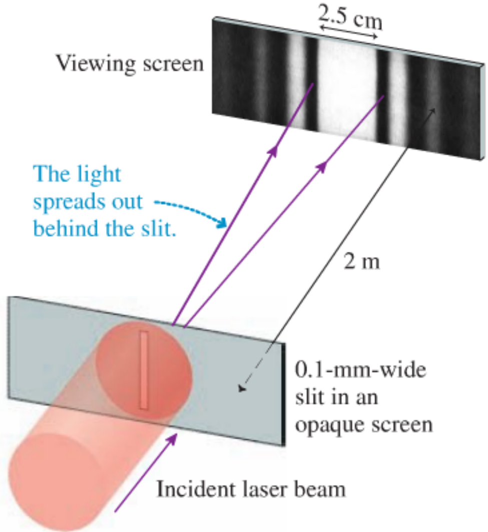
Huygen's Principle

1. Each point on a wave front is the source of a spherical wavelet that spreads out at the wave speed.
2. At a later time, the shape of the wavefront is the tangent line to all of the wavelets.

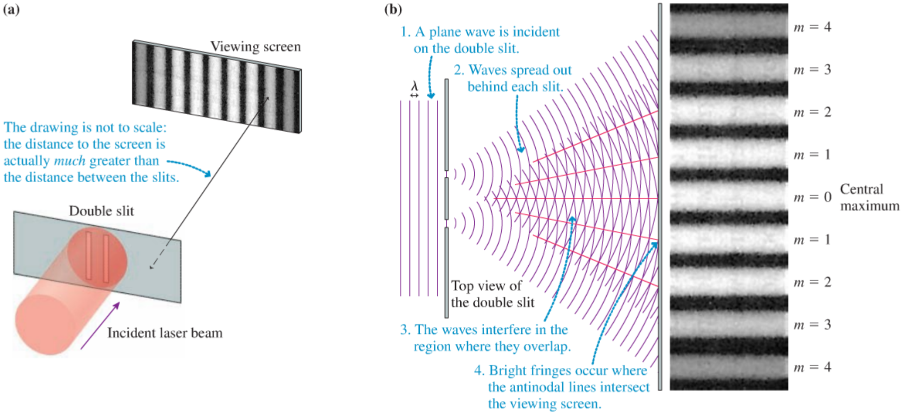


Diffraction - Single Slit





Young's Double-Slit Experiment

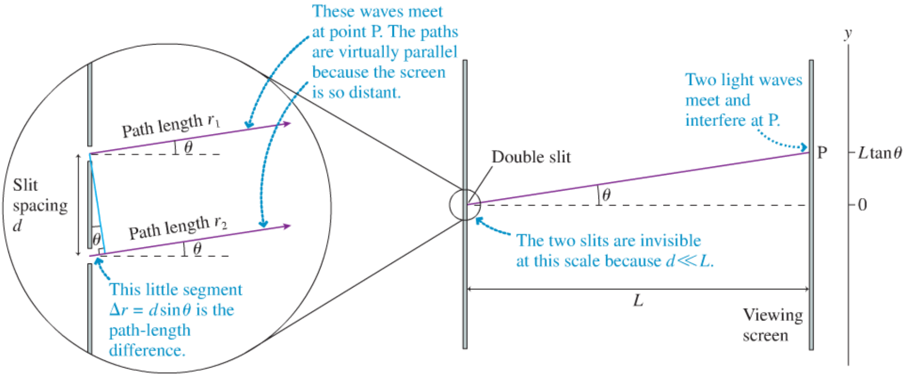


Young's Double-Slit Experiment

Notes

- The slit-width (*a*) and slit-separation (*d*) are similar in size to the wavelength of light (λ)
- The wave fronts arrive at the two slits from the same source in about the same time - they are in phase ($\Delta\phi = 0$).
- Each slit acts like a point-source by Huygen's principle.

Analyzing Young's Double-Slit Experiment



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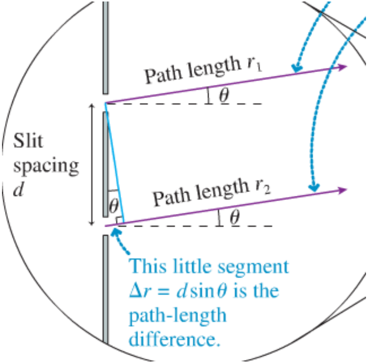
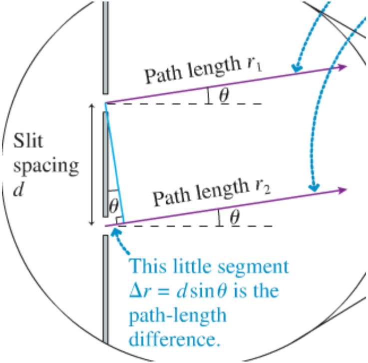


- Constructive interference occurs when

$$\Delta r = d \sin\theta_m = m\lambda, m = 0, 1, 2, 3, \ldots$$

Analyzing Young's Double-Slit Experiment



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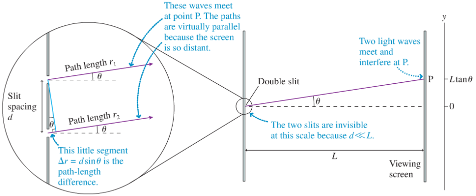
$$\Delta r = d \sin\theta_m = m\lambda, m = 0, 1, 2, 3, \ldots$$

- In practice, the angle is small and $\sin\theta \approx \theta$

$$\theta_m = m\frac{\lambda}{d}$$

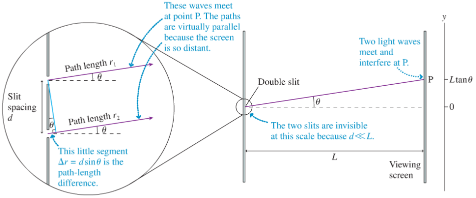
Analyzing Young's Double-Slit Experiment



- Using some simple trigonometry:

$$y_m = \frac{m\lambda L}{d}, m = 0, 1, 2, 3, \ldots$$

Analyzing Young's Double-Slit Experiment



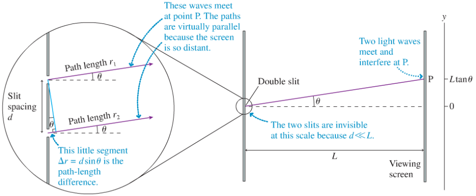
- Using some simple trigonometry:

$$y_m = \frac{m\lambda L}{d}, m = 0, 1, 2, 3, \ldots$$

- Similarly, we can get the dark fringe positions:

$$y'_m = \left(m + \frac{1}{2}\right)\frac{\lambda L}{d}, m = 0, 1, 2, \ldots$$

Analyzing Young's Double-Slit Experiment



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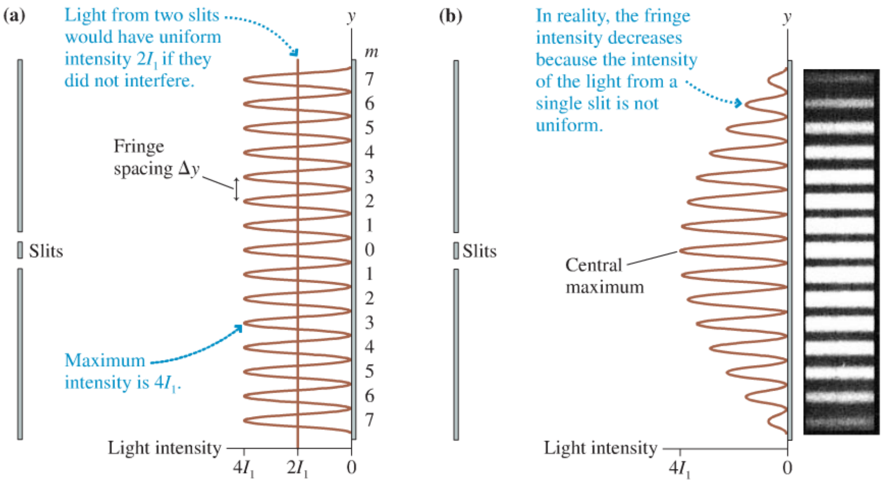
- And we can get the fringe spacing

$$\Delta y = y_{m+1} - y_m = \frac{(m+1)\lambda L}{d} - \frac{m\lambda L}{d} = \frac{\lambda L}{d}$$

Young's Double-Slit Fringe Intensity



$$I_{double} = 4I_1 \cos^2\left(\frac{\pi d}{\lambda L} y\right)$$