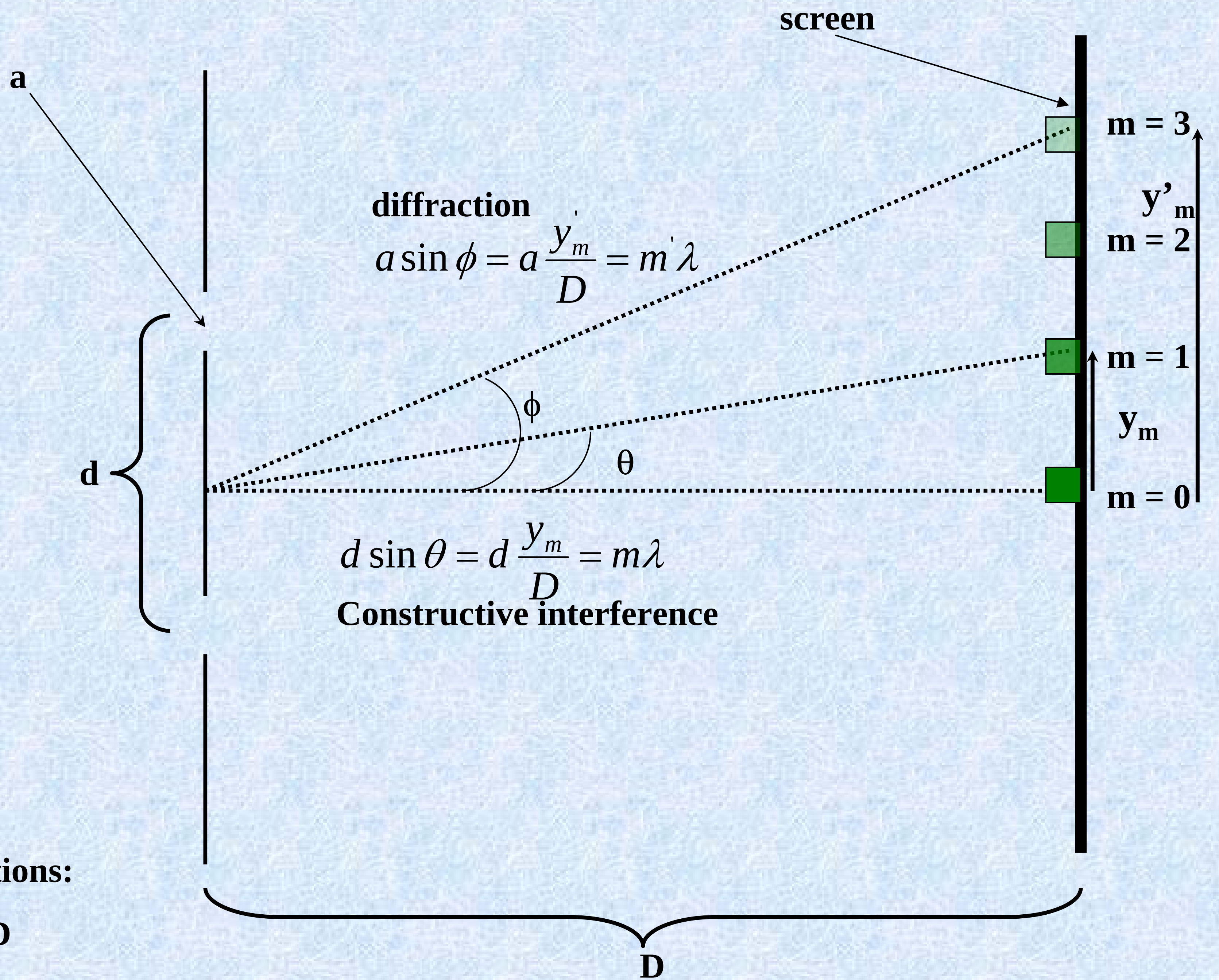
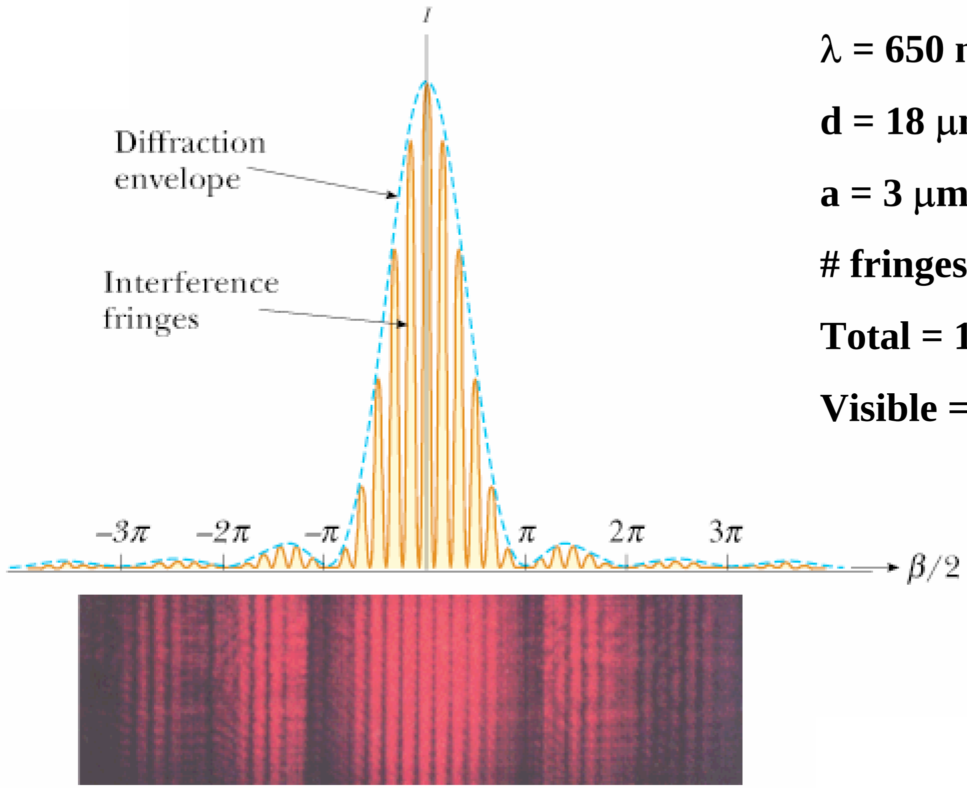


Assumptions:

$a << d << D$



λ = 650 nm

d = 18 μm

a = 3 μm

fringes = d/a = 6

Total = 13

Visible = 11

Intensity of interference and diffraction patterns for a double slit. The Diffraction envelope is a modified Sine function (due to single slit diffraction), while the interference fringes obeys a square Cosine function (due to double slit constructive and destructive interference).

Example:

What is the spacing between adjacent interference maxima?

What is the spacing between adjacent diffraction minima?

How does the number of fringes on one side of the central interference maximum relate to d and a?

Example:

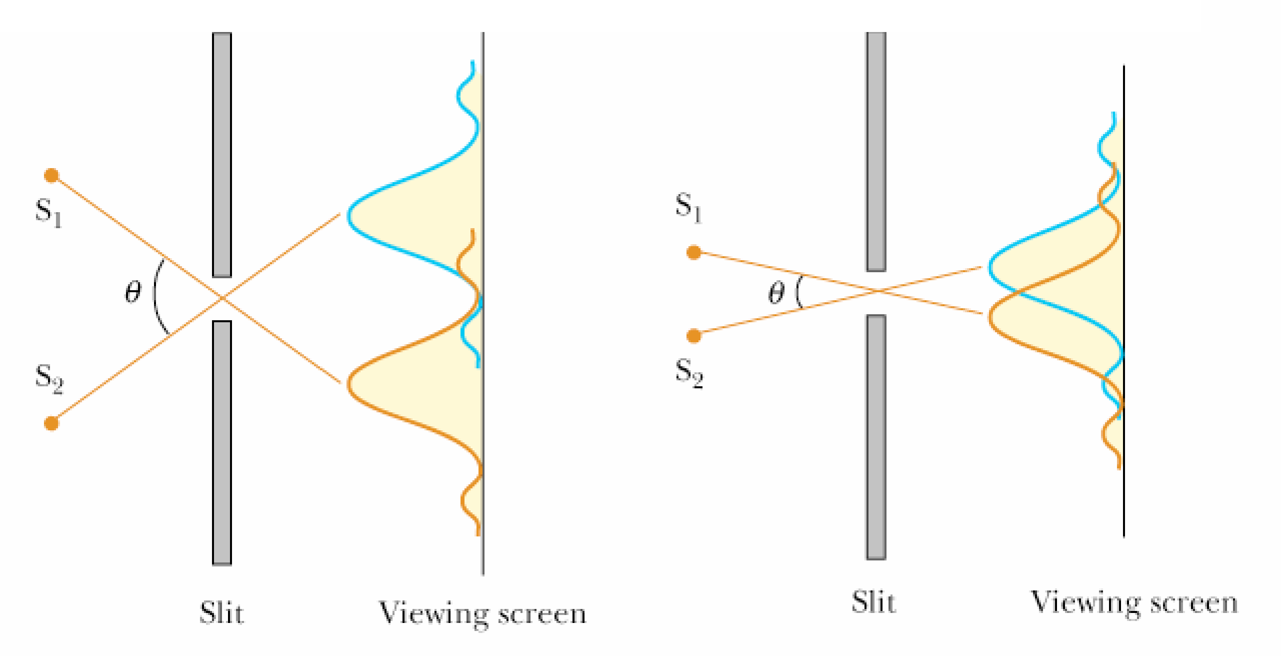
Suppose that a double slit pattern observed on a screen 4 m away from a pair of slits separated by 0.05 mm. What is the wavelength of light used if the 1st bright maximum is 4.6 cm from the central maximum?

If the slit width a = 0.01 mm, at what angle, ϕ, will the 1st order diffraction minimum lie?

What distance from the center interference maximum does the 1st diffraction minimum occur?

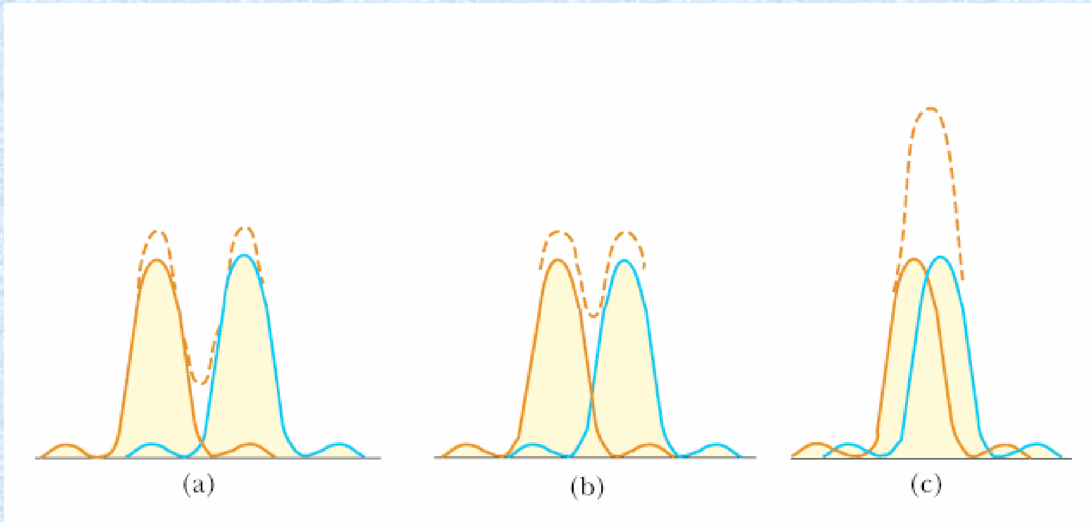
How many total fringes are in the diffraction envelope?

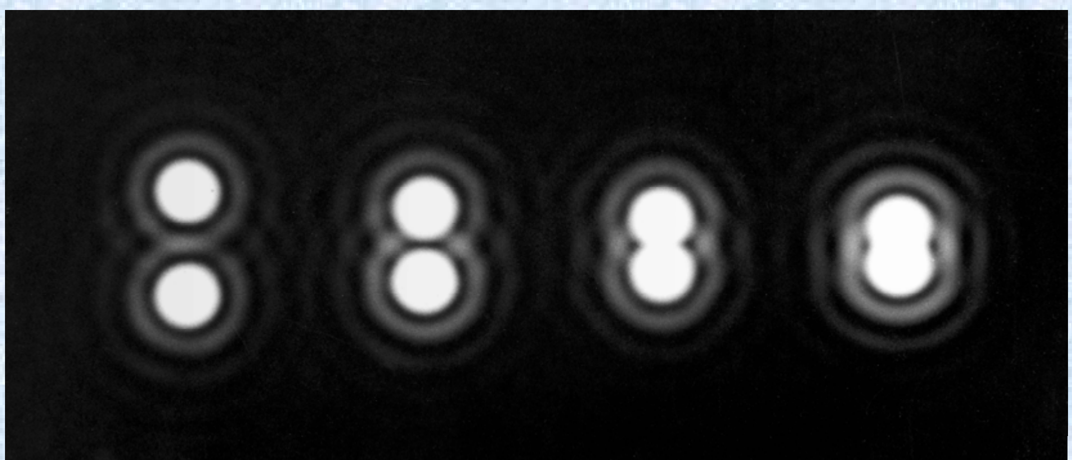
How many fringes are visible in the diffraction envelope?



Two individual point sources S_1 and S_2 each produce a diffraction pattern on a viewing screen. If θ is large then the diffraction patterns are distinct. If θ is small then the diffraction patterns overlap.

When the central maximum of the diffraction pattern of one source falls on the first minimum of the diffraction pattern of the other source, the sources are just resolved. (You can tell them apart, barely, as in picture b.) This is called Rayleigh's criterion.





For a single slit, of width a, the first minimum in the diffraction pattern occurs at the angle that satisfies:

$$\mathbf{Sin}\ \theta = \lambda/a$$

which for small θ, gives:

$$\theta_{min} = \lambda / a.$$

However in optical systems, like waveguides, the aperture is not a slit, but rather a circular disk. In this case,

$$\theta_{min} = 1.22 * (\lambda / D),$$

where D is the diameter of the disk and 1.22 is a zero of a Bessel function.

Example: A spy satellite

A spy camera in a satellite is located 160 km above the Earth's surface is capable of "reading" numbers on as car's license plate. What diameter lens aperture is needed to "read" two numbers on a license plate if λ = 550 nm and the numbers are separated by 5 cm?

Example: Astronomy

Binary star systems are composed of two stars in orbit about a common center. Suppose that a binary star system is 20 light years away and are the two stars that make it up are just barely resolved by a 12 inch diameter mirror. How far apart are the stars in space?

Example: Interference and Diffraction revisited

Suppose that a double slit pattern is produced under water (n_{water} = 1.33) observed on a screen 4 m away from a pair of slits separated by 0.05 mm. What is the spacing between interference fringes if the laser has a wavelength of 623.8 nm?

If the slit width a = 0.01 mm, at what angle, ϕ, will the 1st order diffraction minimum lie?

What distance from the center interference maximum does the 1st diffraction minimum occur and what is the width of the diffraction envelope?

How many total fringes are in the diffraction envelope?

How many fringes are visible in the diffraction envelope?

Now, redo the above calculations this time for the laser in *air* and determine what happens to the pattern of interference maxima and minima.