Chapter 18
Interference and Diffraction

The colors of the blue morpho butterfly are caused by interference of light waves. (see text p.664)

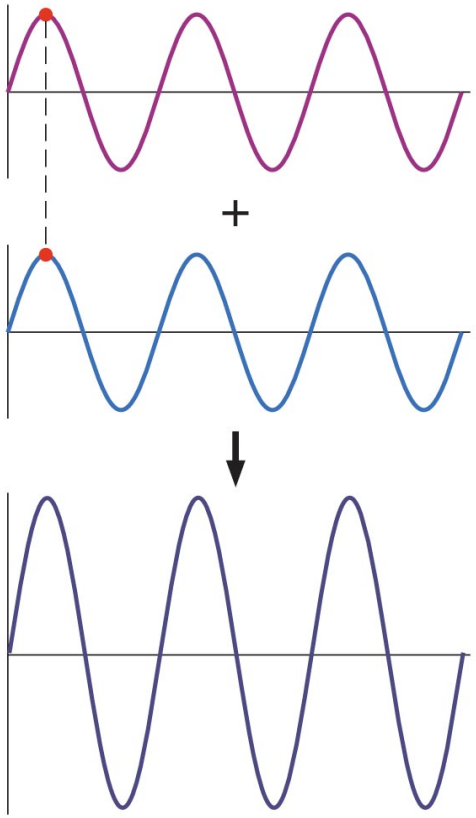
Revised 7.23.2020 Some diagrams from Pearson Physics by Walker. Used with permission

Preliminaries

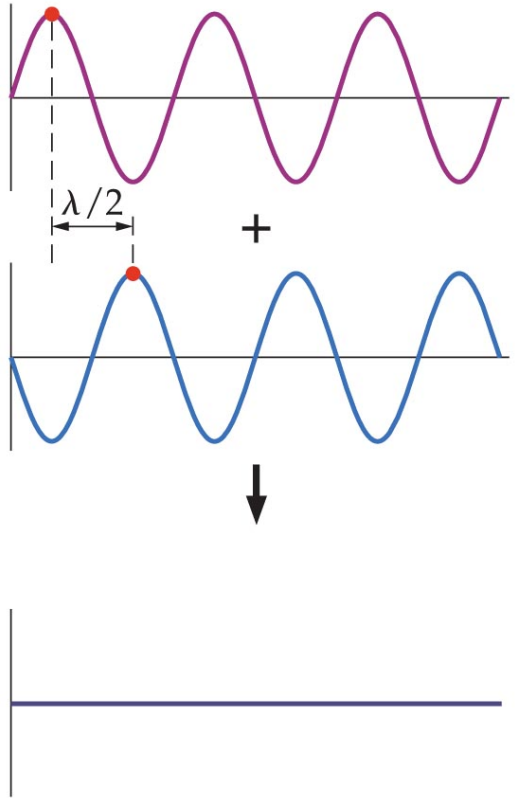
- Read ages 637 – 660
- You should know these words:

1. Coherent light (constant phase relationship among photons)
2. Incoherent light
3. Monochromatic light (a single color – or frequency, or wavelength)
4. Constructive Interference (Waves meet in phase and tend to reinforce each other)
5. Destructive Interference (waves meet out of phase and tend to cancel each other)

Constructive and Destructive interference

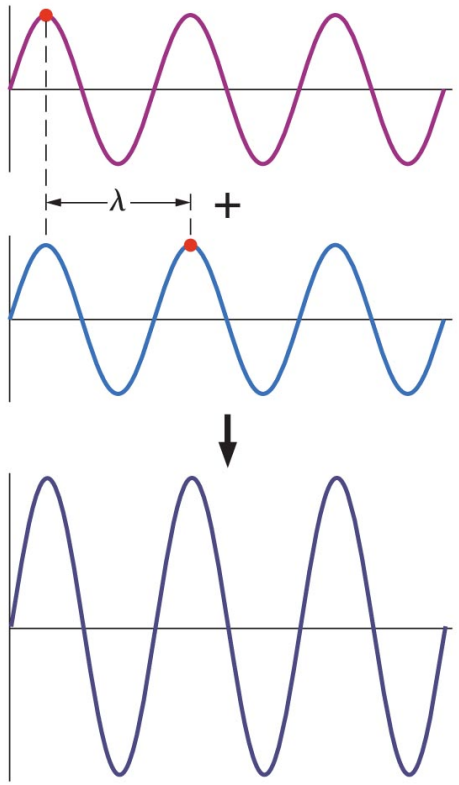


(a) In phase



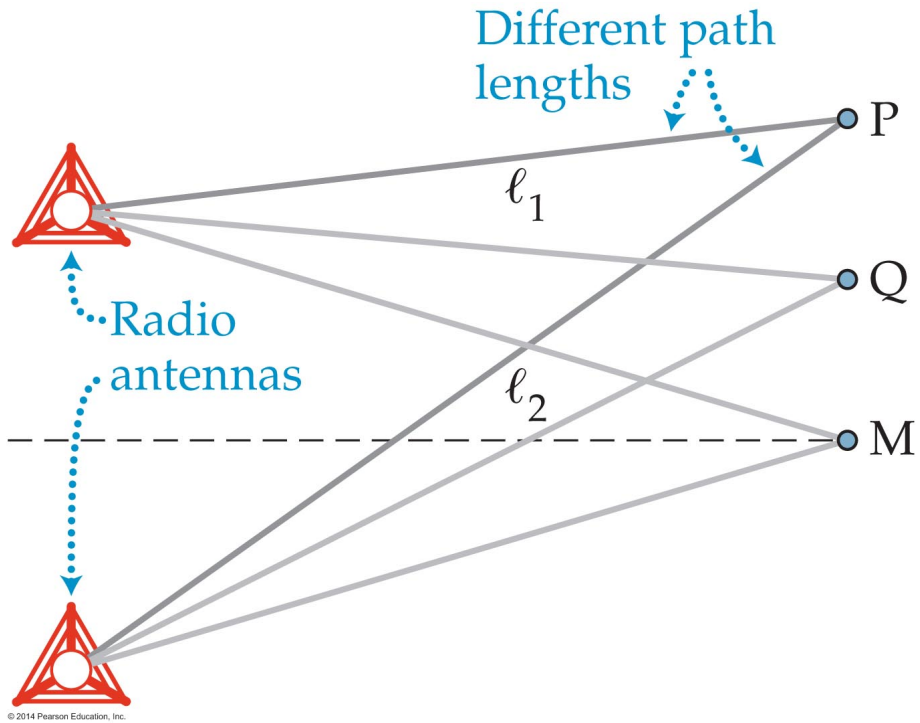
(b) Half a wavelength out of phase

Full wavelength out of phase = back in phase!



(c) Full wavelength out of phase

Two signals starting in phase can be out of phase when they meet depending upon the path difference.



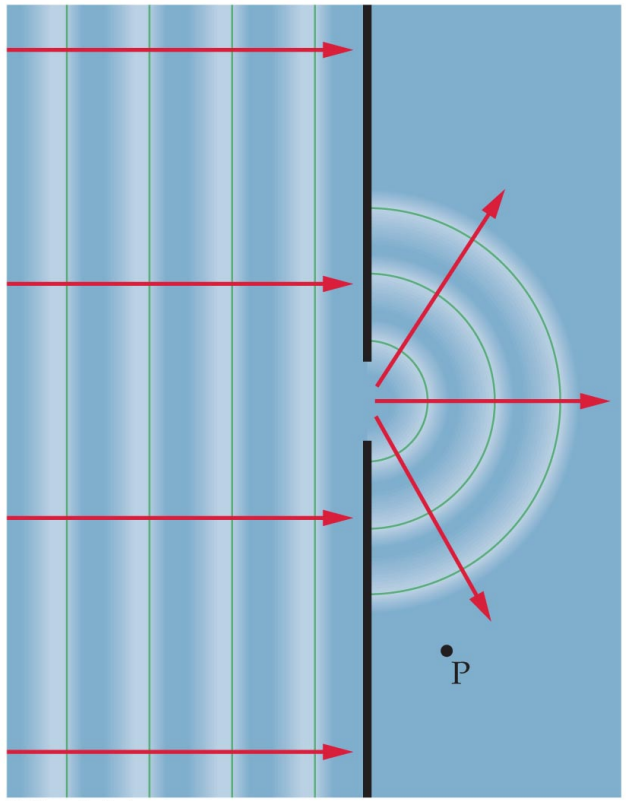
Summary of Constructive and Destructive interference

In terms of PHASE DIFFERENCE:
If two waves are “in step” with each other we say they are in phase with each other.
If they are in phase with each other they will interfere constructively.
If they are 180 degrees out of phase, they will interfere destructively.

In terms of PATH DIFFERENCE:
If two waves start off in phase and travel the same distance, they will meet in phase.
If the path difference is an even number of half-wavelengths, they will meet in phase.
If the path difference is an odd number of half-wavelengths, they will meet out of phase.

DIFFRACTION

- Diffraction is the bending of a wave around a small obstruction, or as it passes through a small opening. (Small compared to the wavelength.)

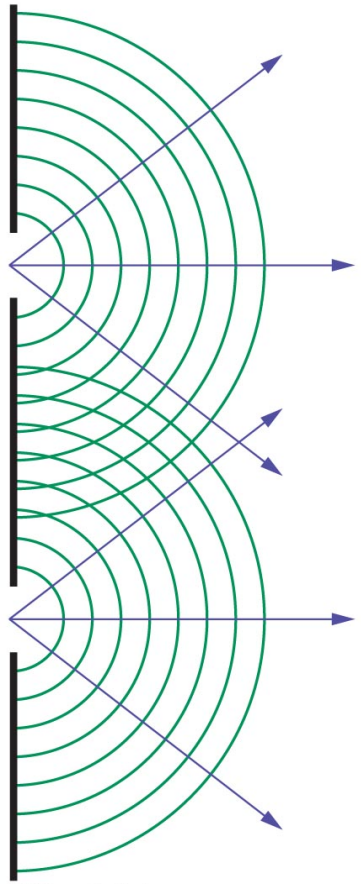


Ripple Tank Simulation:

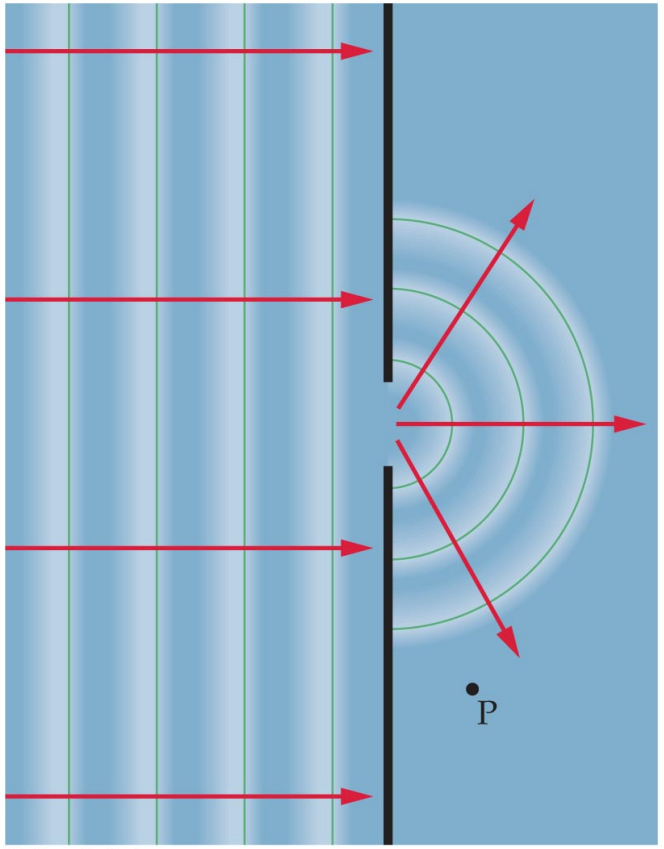
- Click the link (or copy it and paste it into your browser)

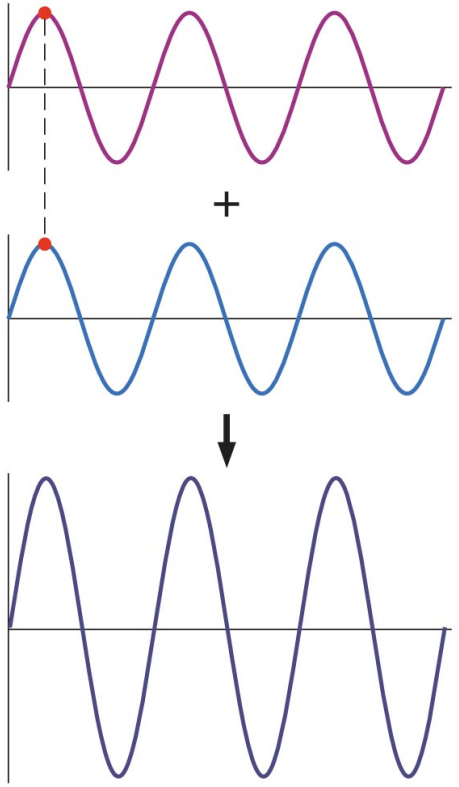
- https://www.falstad.com/ripple/

Diffraction at two narrow openings. The Diffracted waves can interfere when they meet on the right.



Put Diffraction and Interference together and you get





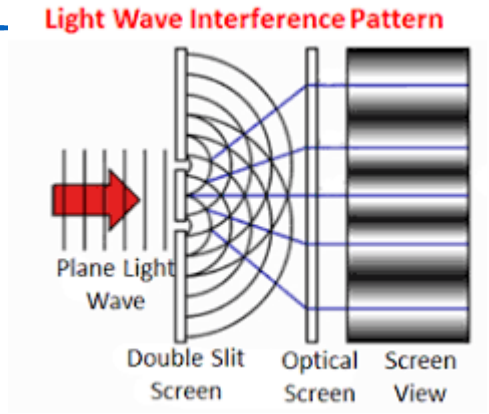
(a) In phase

Young's Double Slit Experiment

Link

https://www.youtube.com/watch?v=8GIwQ_

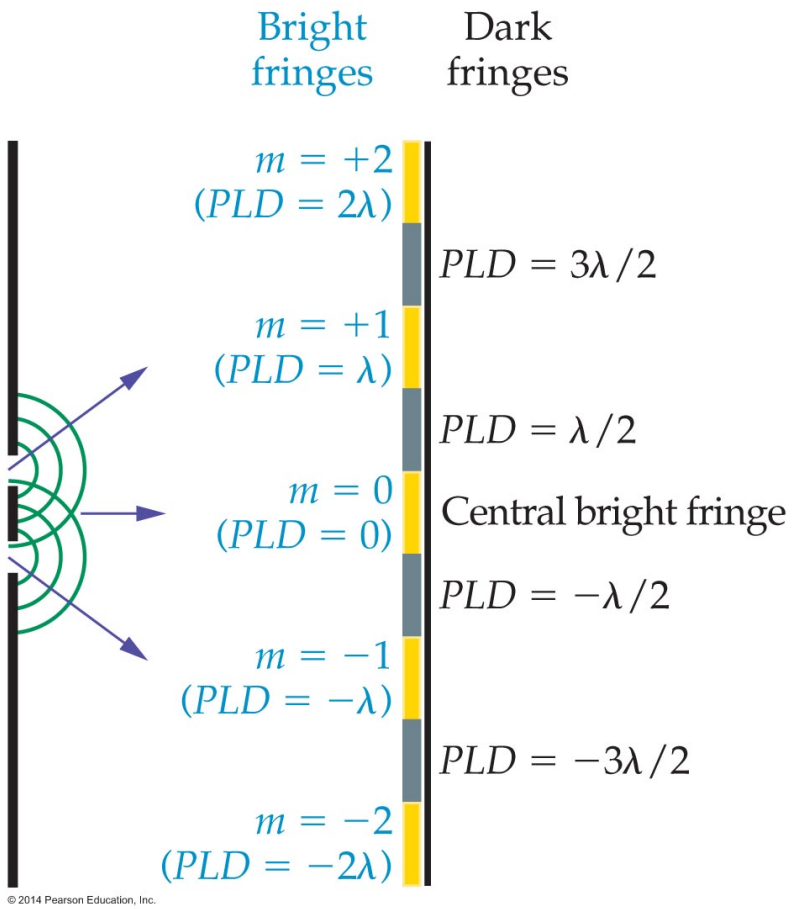
Light enters from the left and passes through two slits, diffracting and interferes on the screen. You get constructive interference when the path difference is $n\lambda/2$, when n = 0,2,4,6,…
Destructive interference occurs when n= 1,3,5,…



Another, more detailed diagram of same experiment

PLD = Path Length Difference

Light entering from the left passes through two narrow slits, Diffracts, and interferes on the screen at the right. Dark fringes have path difference nλ/2, where n = 1,3,5,… Bright fringes have path difference nλ/2, where n= 2,4,6,…



With careful measurements you can find the wavelength of the light.

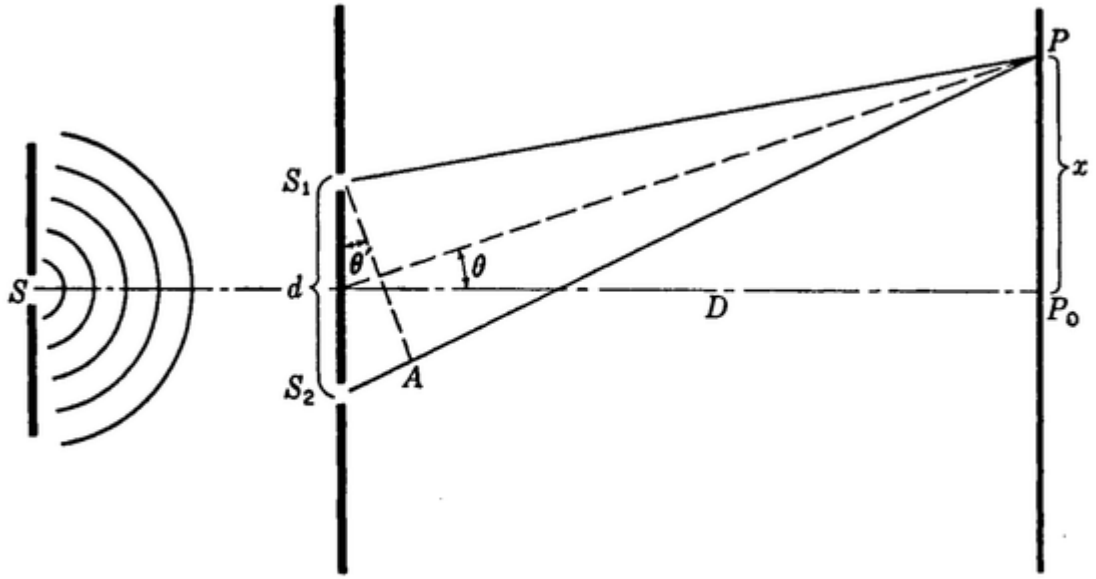


FIGURE 13F
Path difference in Young's experiment.

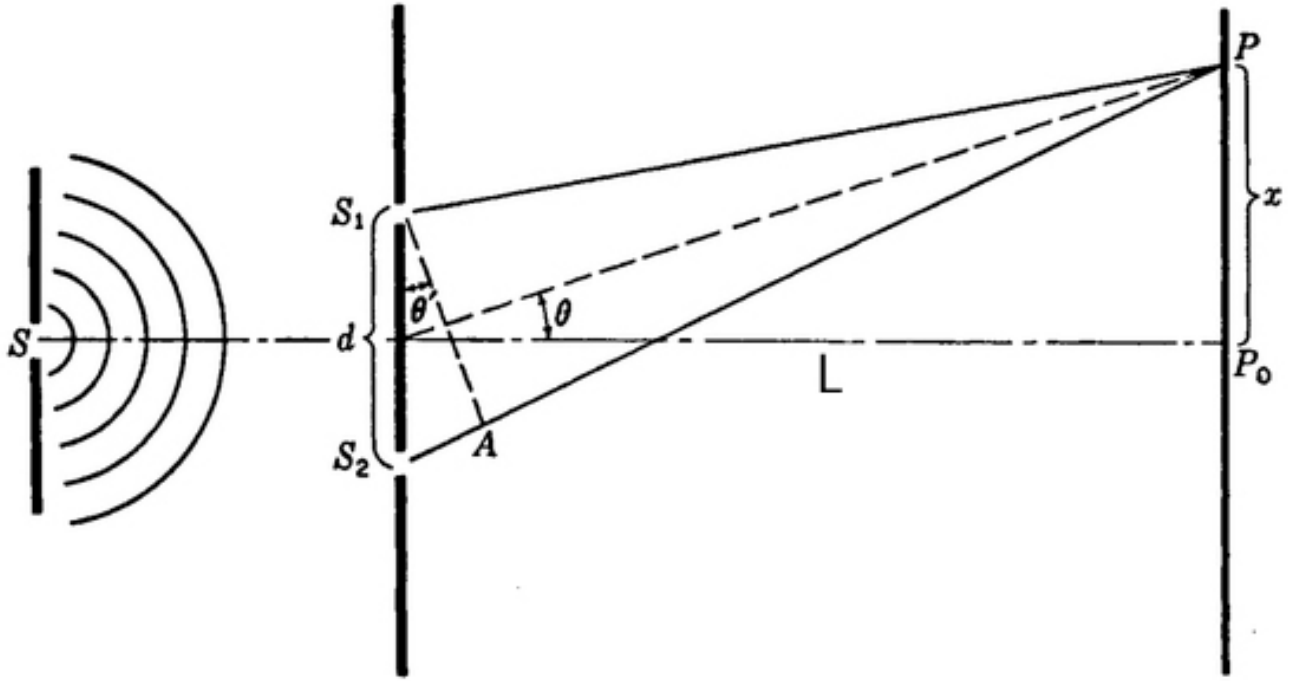


FIGURE 13F
Path difference in Young's experiment.

λ = wavelength of the light
d = separation of the slits
X = distance from central to first maximum
L = distance from slits to screen

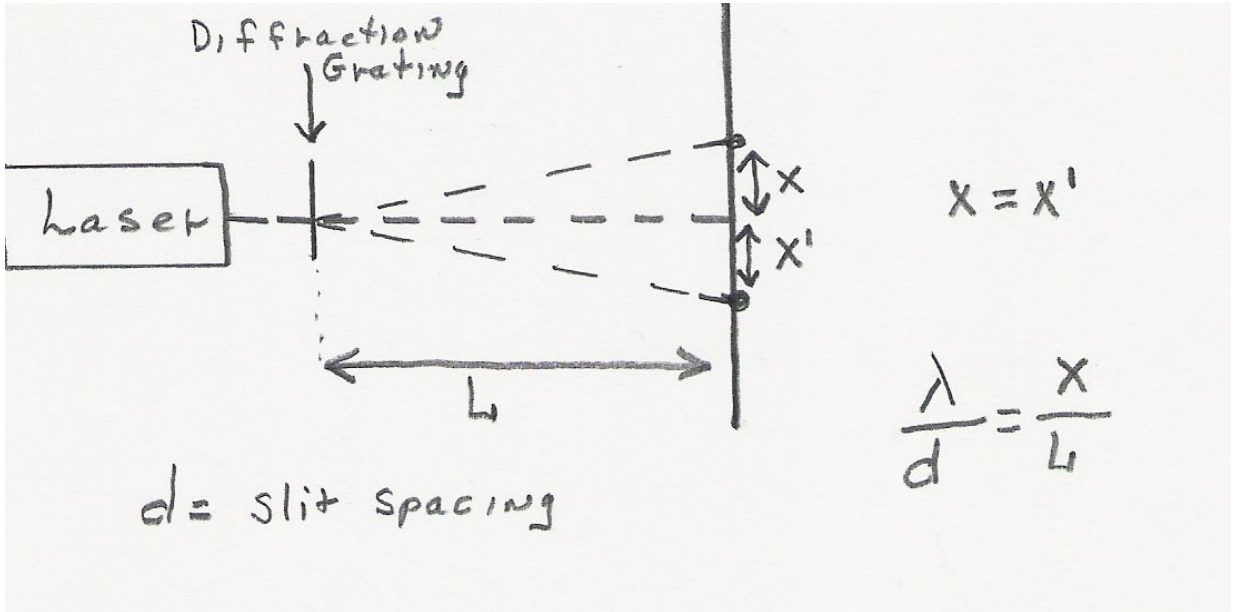
In triangle S1,S2,A
The Path difference = length of S2-A
Length of S2-A = d sin Θ

So for constructive interference at P
path difference = λ
λ = d sin Θ

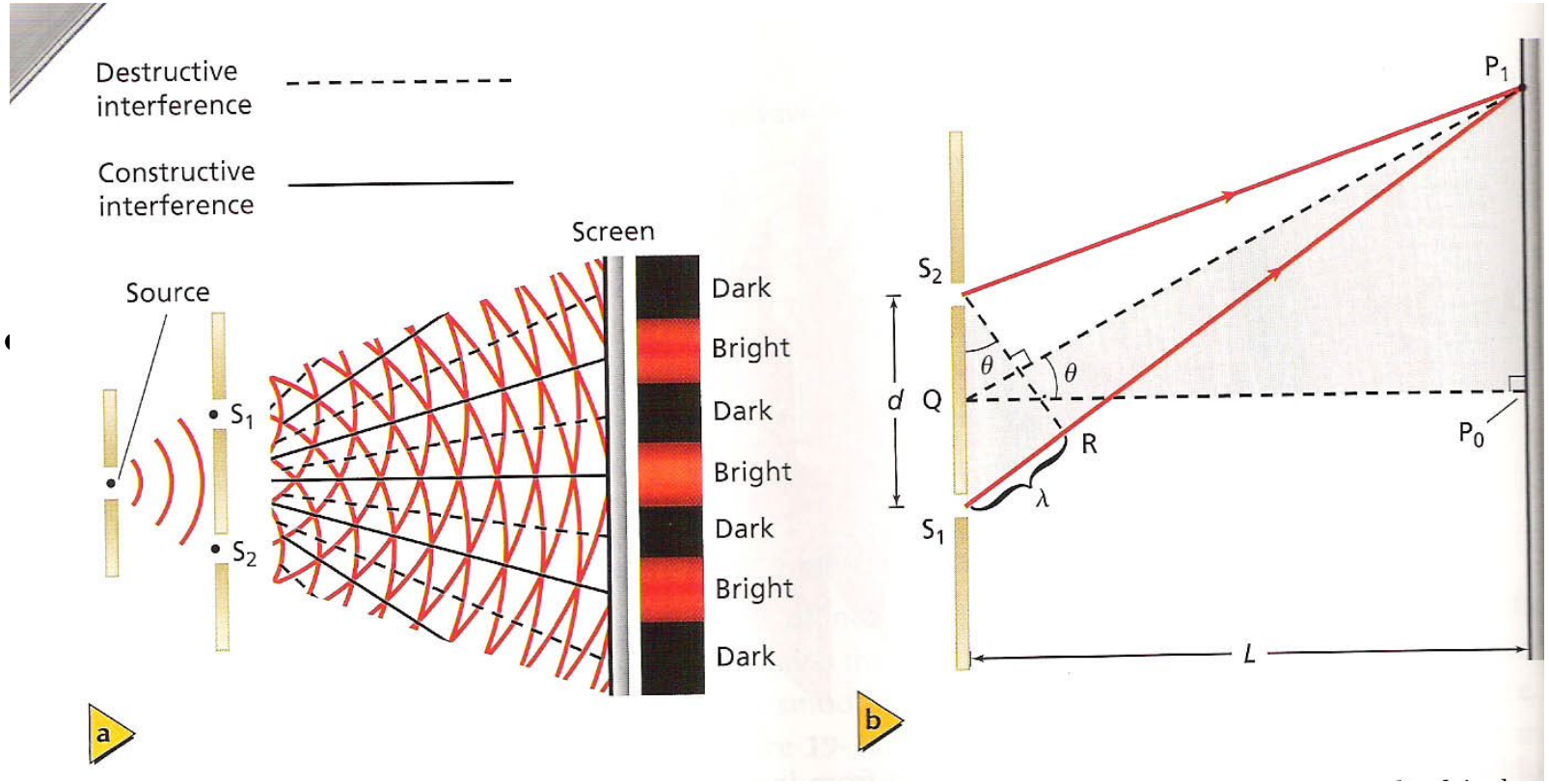
Then looking at triangle S1,A,P
Sin Θ = x/L

Combining them gives us
λ = d x/L

Which can be rearranged
λ/d = x/L



Data Table: d=1.75x10^-6 m Measure x in meters Measure L in meters
Calculate λ in meters using λ=dx/L



For constructive interference, path length difference = nλ where n = 0,1,2,…