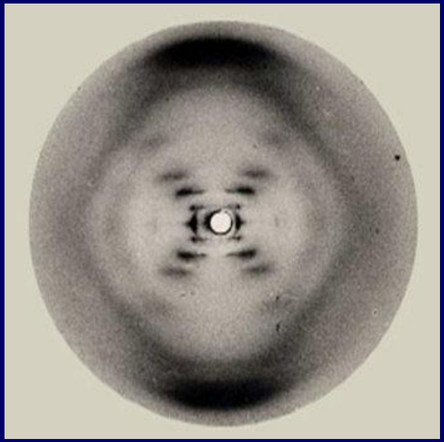
Physics 102: Lecture 20
Interference

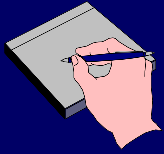
Phys 102 recent lectures

Light as a wave

- Lecture 14 – EM waves
- Lecture 15 – Polarization
- Lecture 20 & 21 – Interference & diffraction

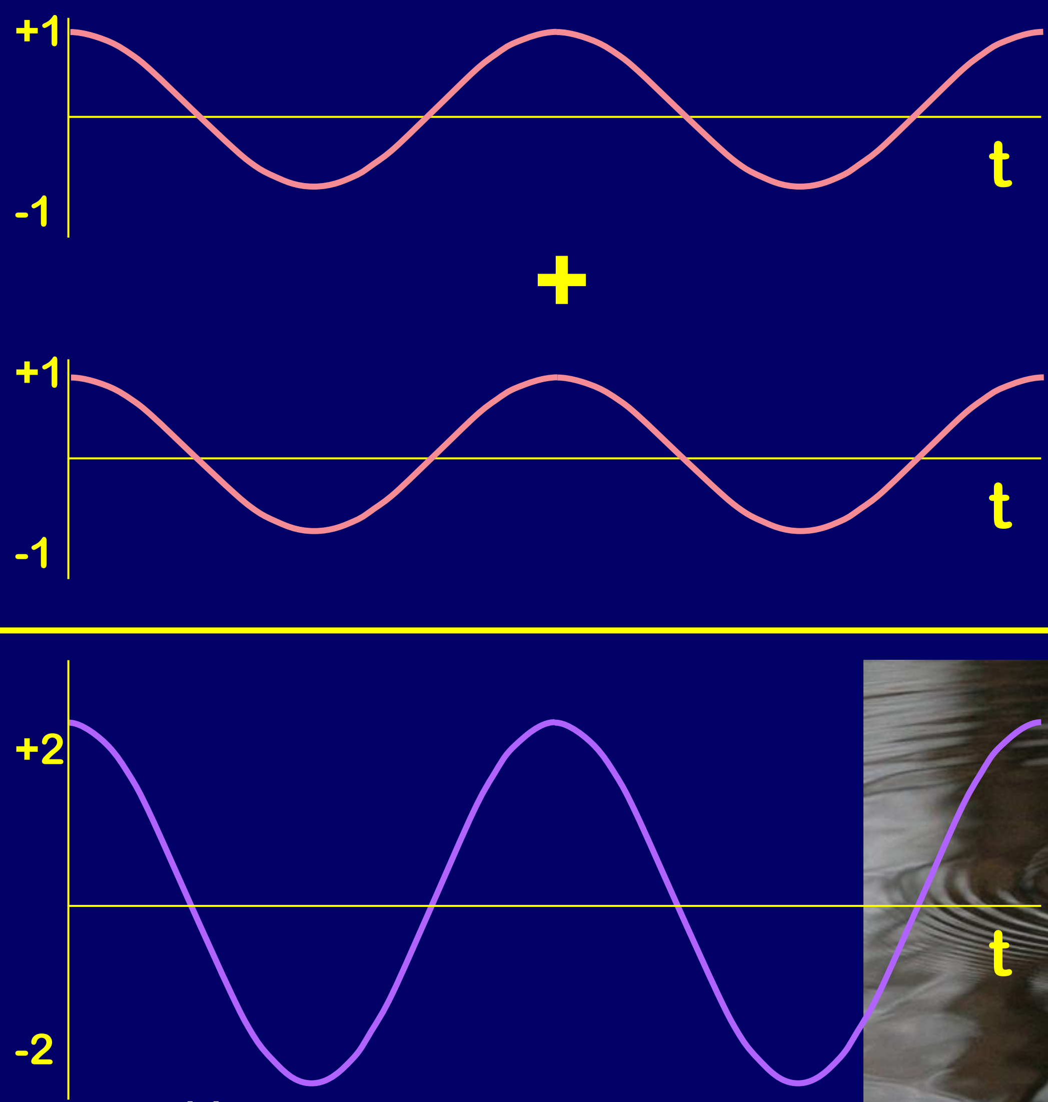
Light as a ray

- Lecture 16 – Reflection
- Lecture 17 – Spherical mirrors & refraction
- Lecture 18 – Refraction & lenses
- Lecture 19 – Lenses & your eye



Superposition

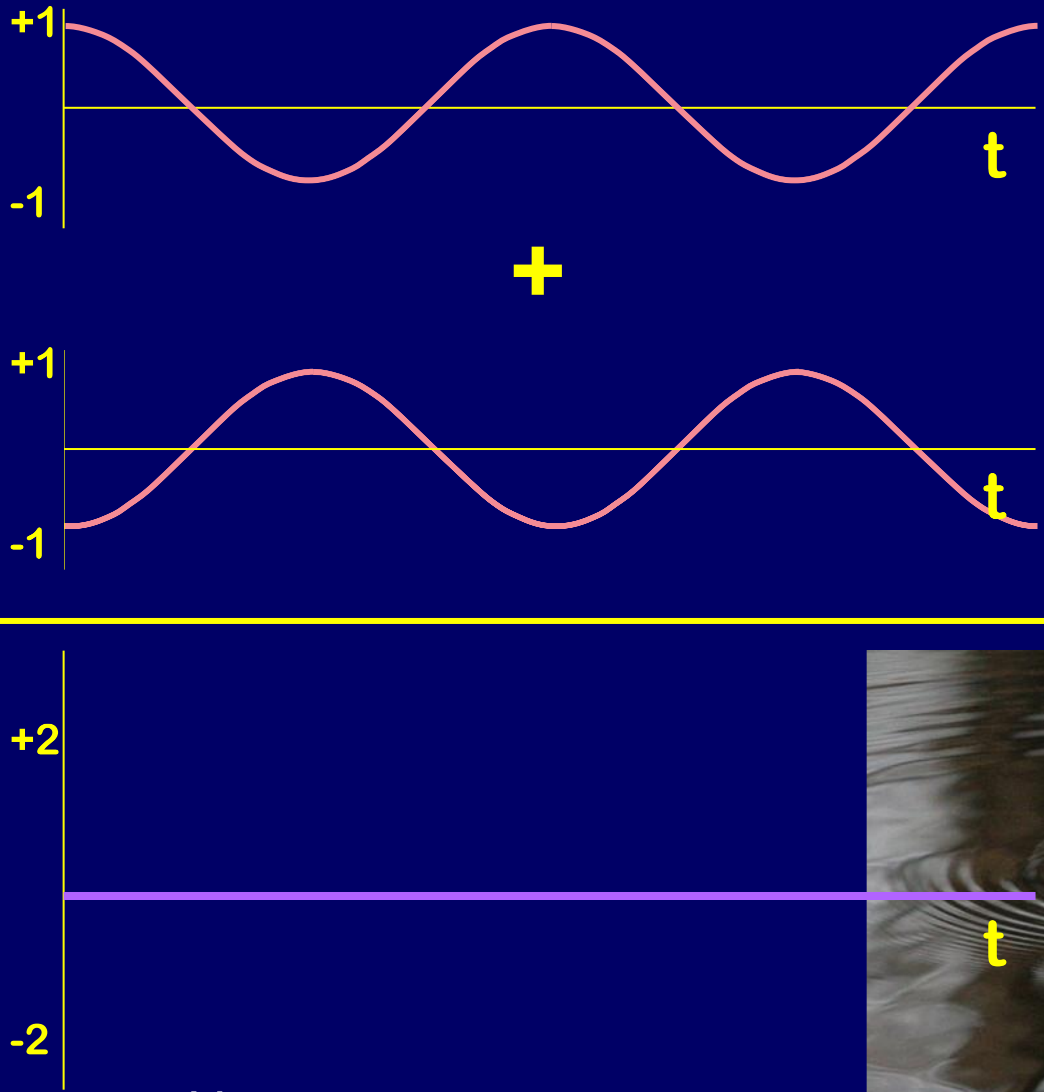
Constructive Interference



In Phase

Superposition

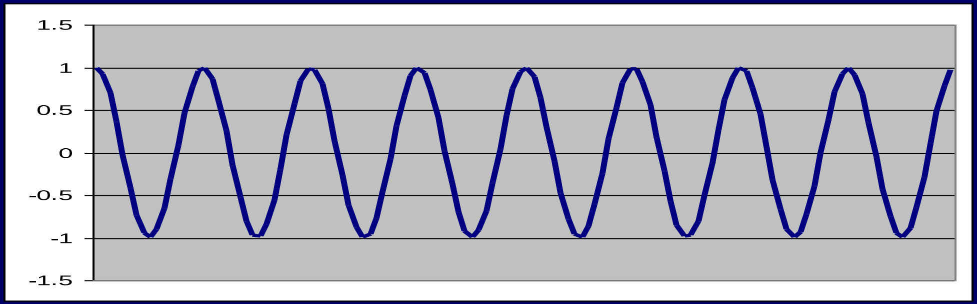
Destructive Interference



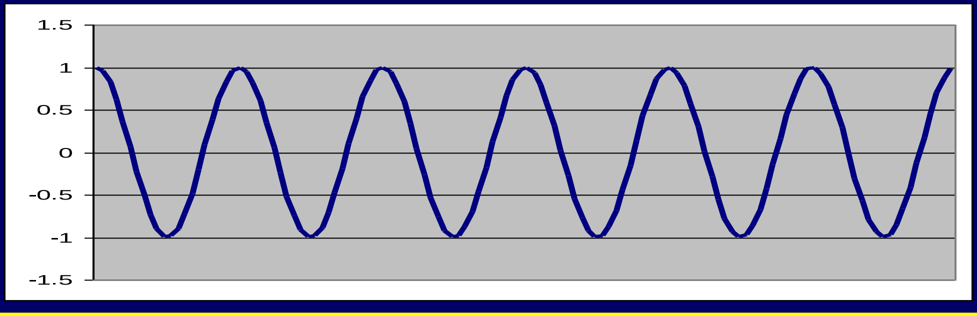
Out of Phase

180 degrees

ACT: Superposition



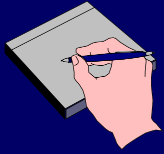
+



Different f

1) Constructive 2) Destructive 3) Neither

Constructive/Destructive Interference Requirements



- Need two (or more) waves
- Must have same frequency
- Must be coherent (i.e. waves must have definite phase relation)

Destructive interference:

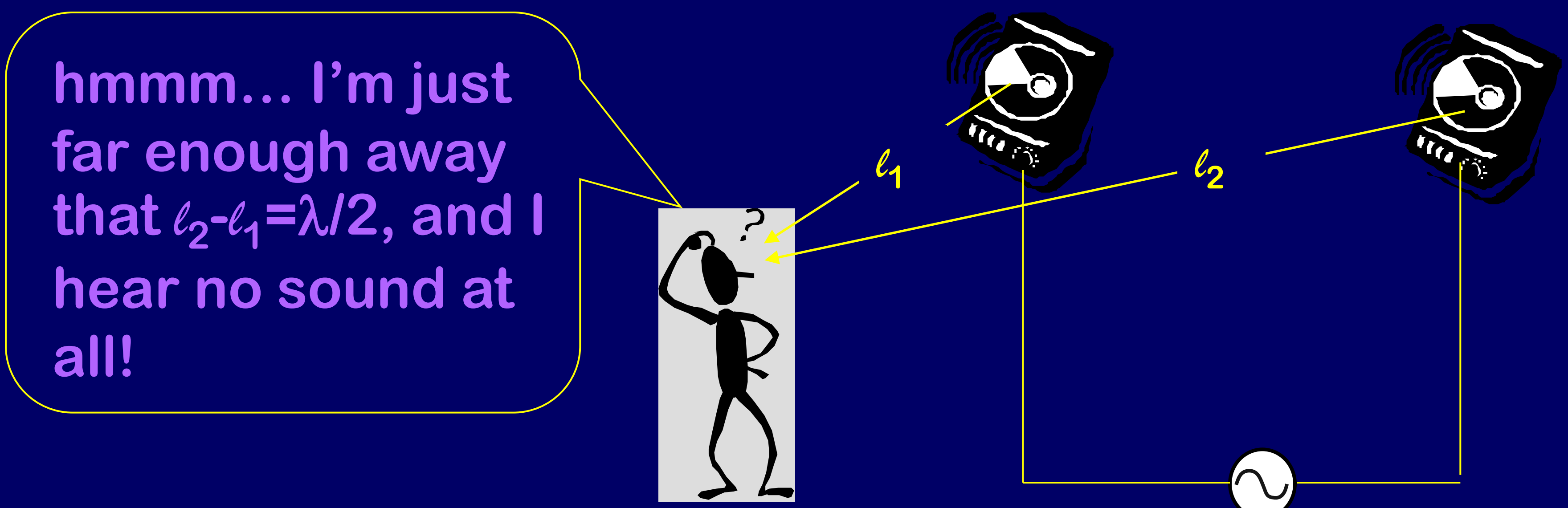
- **Waves are out of phase by 180°**
- **Path difference between waves=** $\lambda/2$, $3\lambda/2$, $5\lambda/2$, …
- $d/\lambda = \delta = 1/2, 3/2, 5/2, \ldots$

Constructive interference

- **Waves are in phase**
- **Path difference between waves=0,** λ, 2λ, 3λ, …
- $d/\lambda = \delta = 0, 1, 2, \ldots$

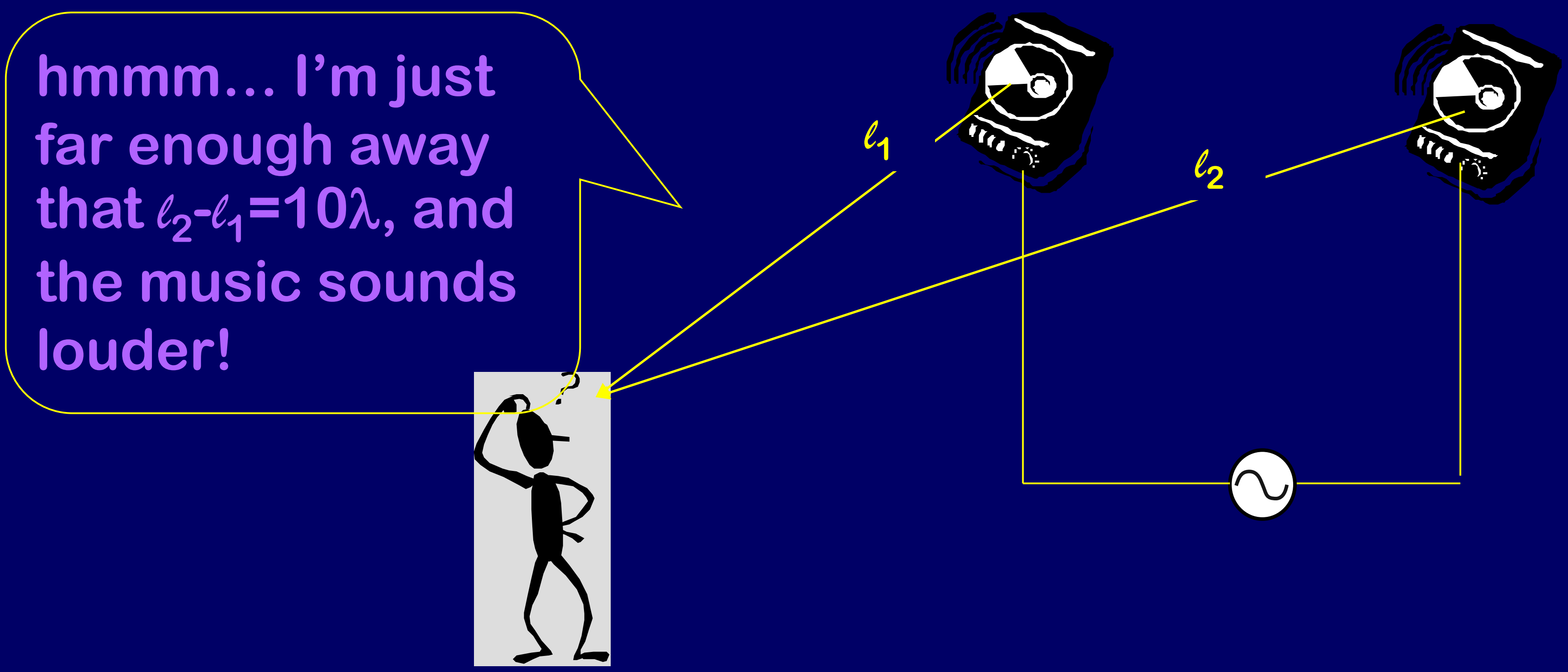
Demo: Interference for Sound …

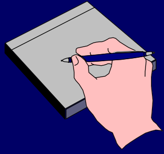
For example, a pair of speakers, driven in phase, producing a tone of a single f and λ:



Demo: Interference for Sound …

For example, a pair of speakers, driven in phase, producing a tone of a single f and λ:





Interference for Light …

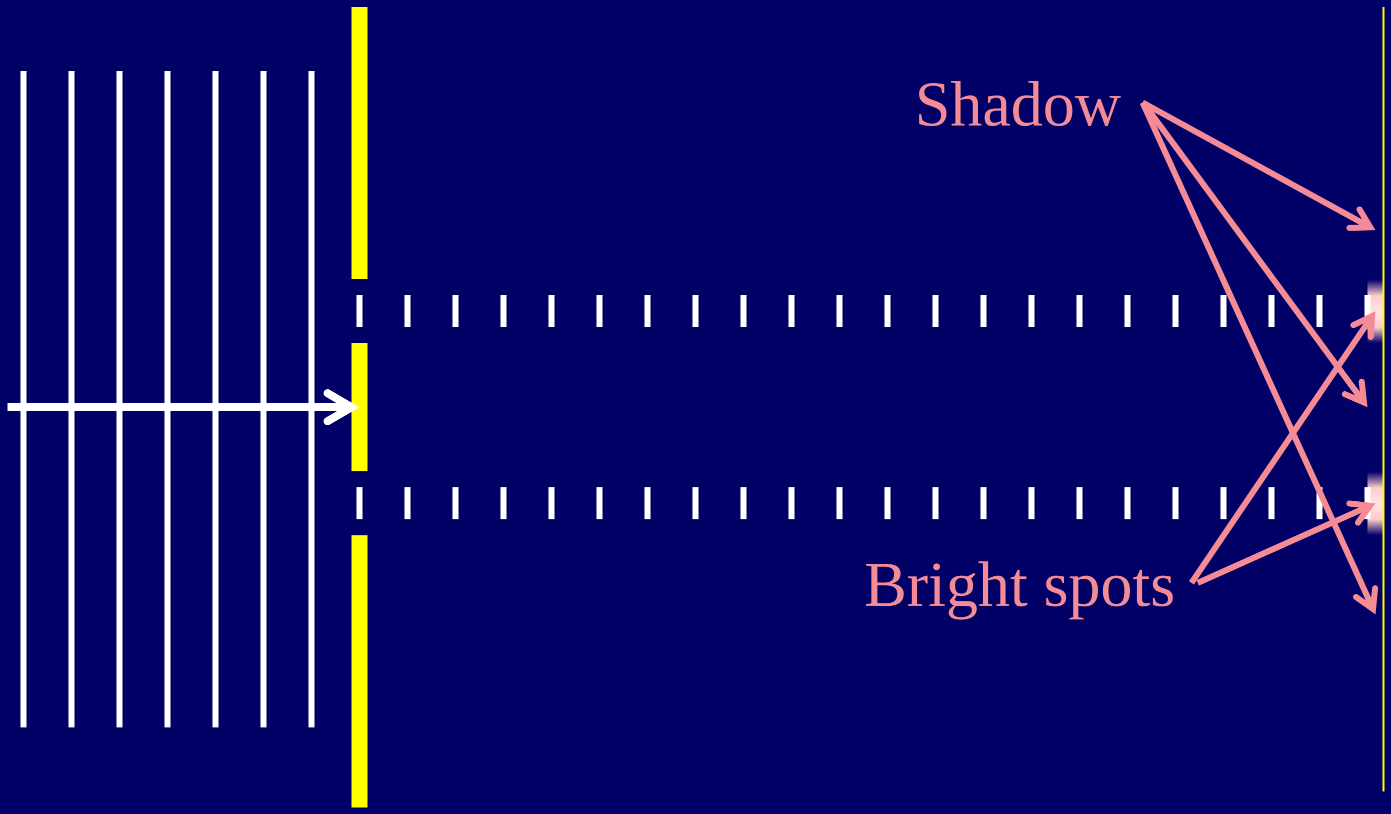
- Either use single-frequency lasers, or…
- Or microwave / radio-frequency sources, or…
- Need two waves from single source taking two different paths
  - Two slits
  - Reflection (thin films)
  - Diffraction

Today's lecture (Two slits)

Next lecture (Reflection (thin films), Diffraction)

Young's double slit/rays

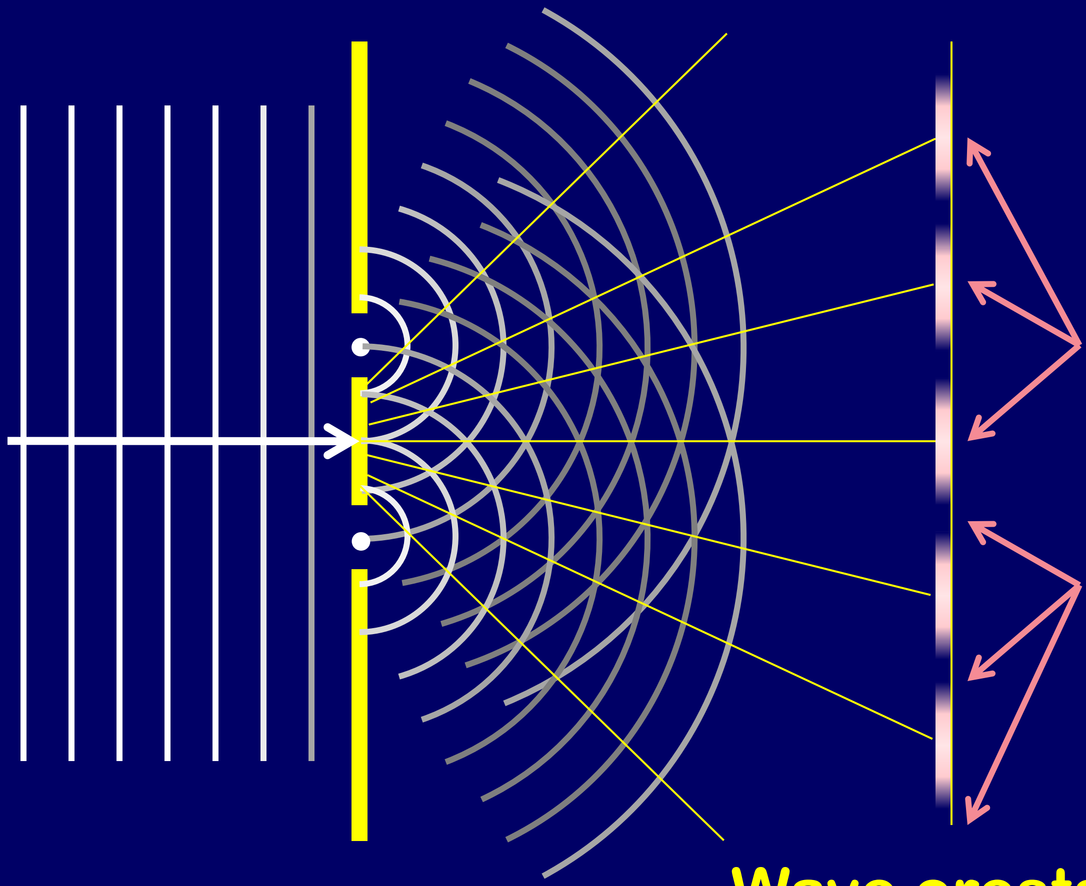
Monochromatic light travels through 2 slits onto a screen
What pattern emerges on the screen?



This is <u>not</u> what is actually seen!

Young's double slit/Huygens

Recall Huygens' principle: Every point on a wave front acts as a source of tiny wavelets that move forward.



Bright and dark spots on screen!

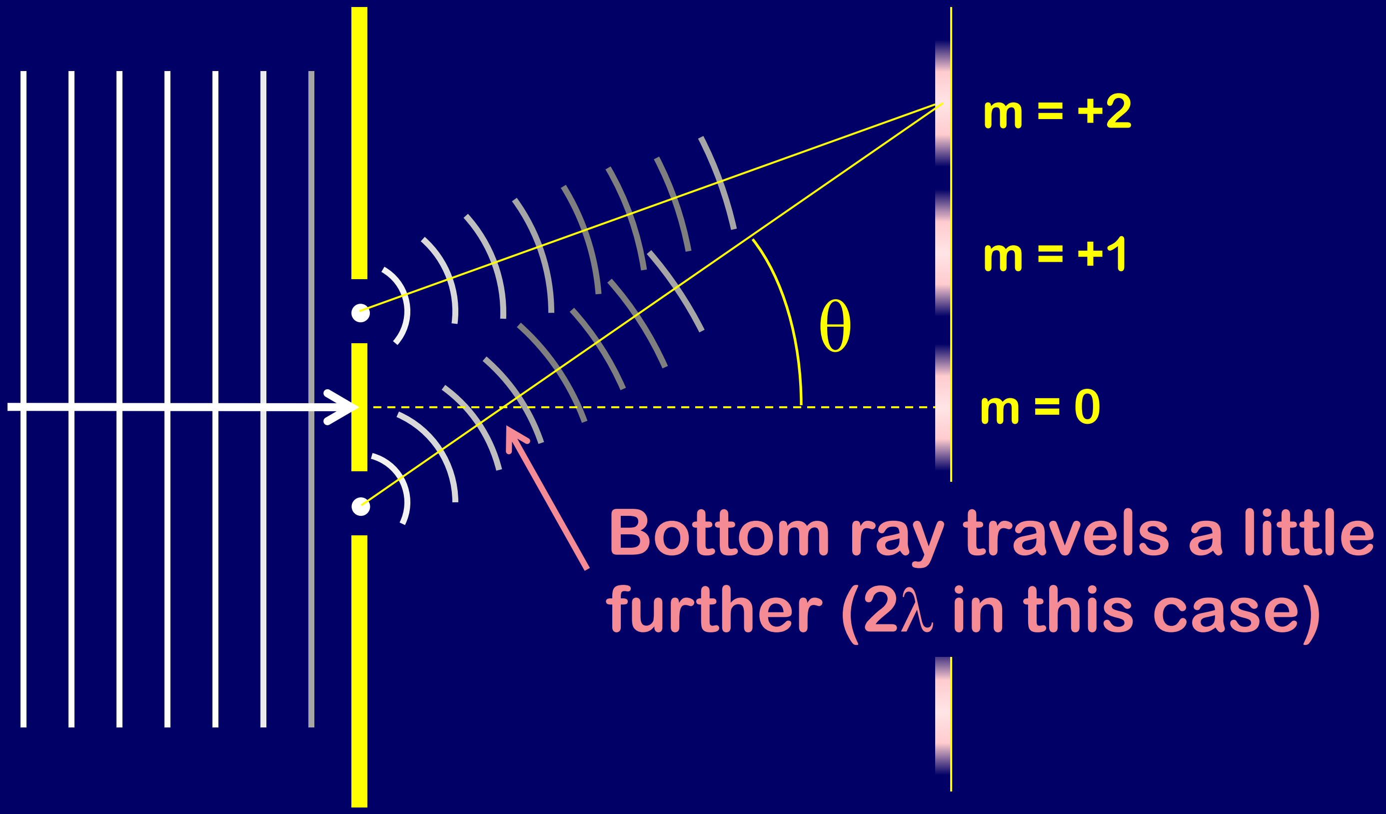
Constructive = bright

Destructive = dark

Wave crests in phase = constructive interference

Young's double slit: Key idea

Consider two rays traveling at an angle θ:

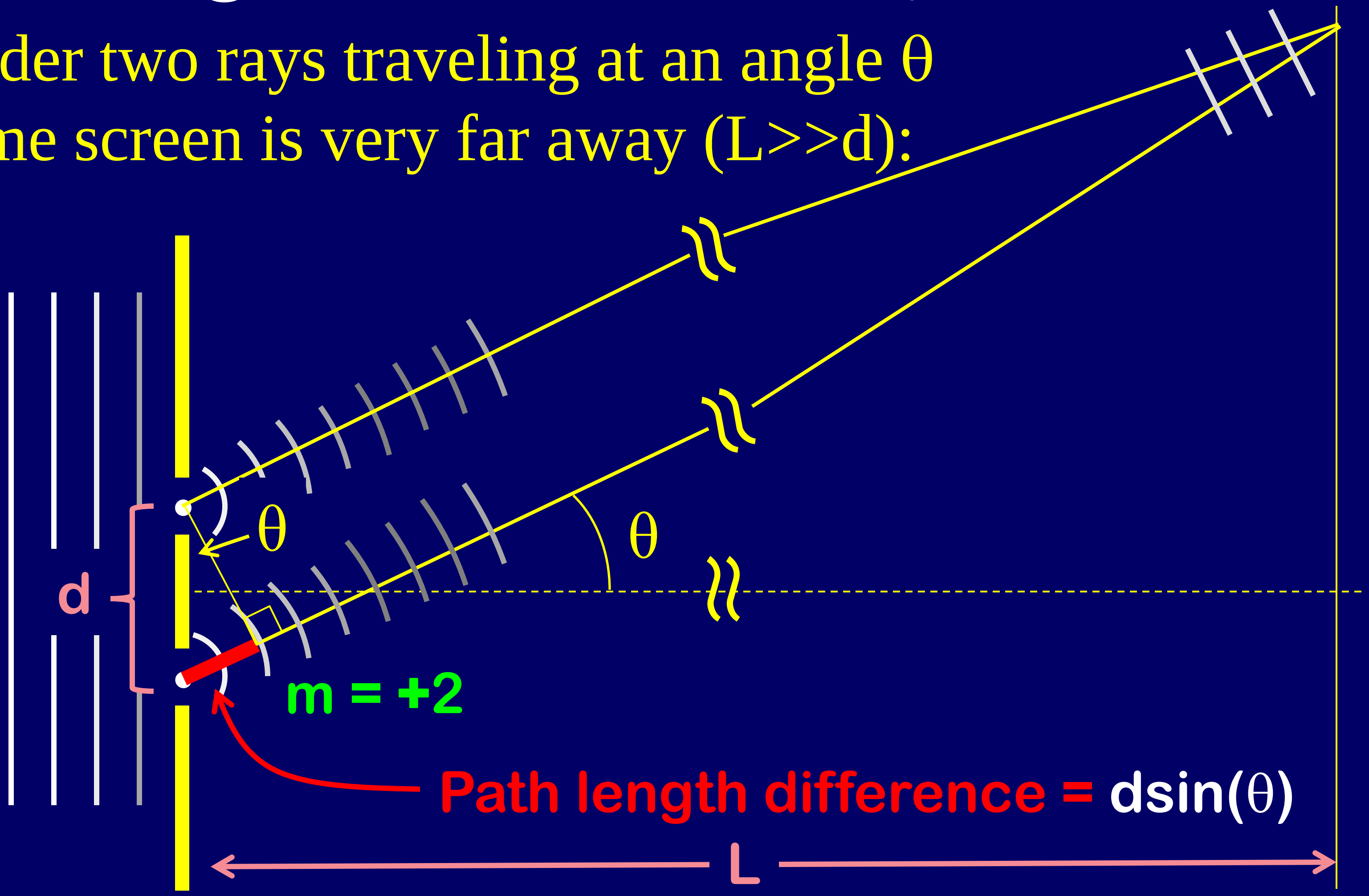


Key for interference is this small extra distance.

Young's double slit: Quantitative

Consider two rays traveling at an angle θ

Assume screen is very far away (L>>d):



Constructive: $d\sin(\theta) = m\lambda$

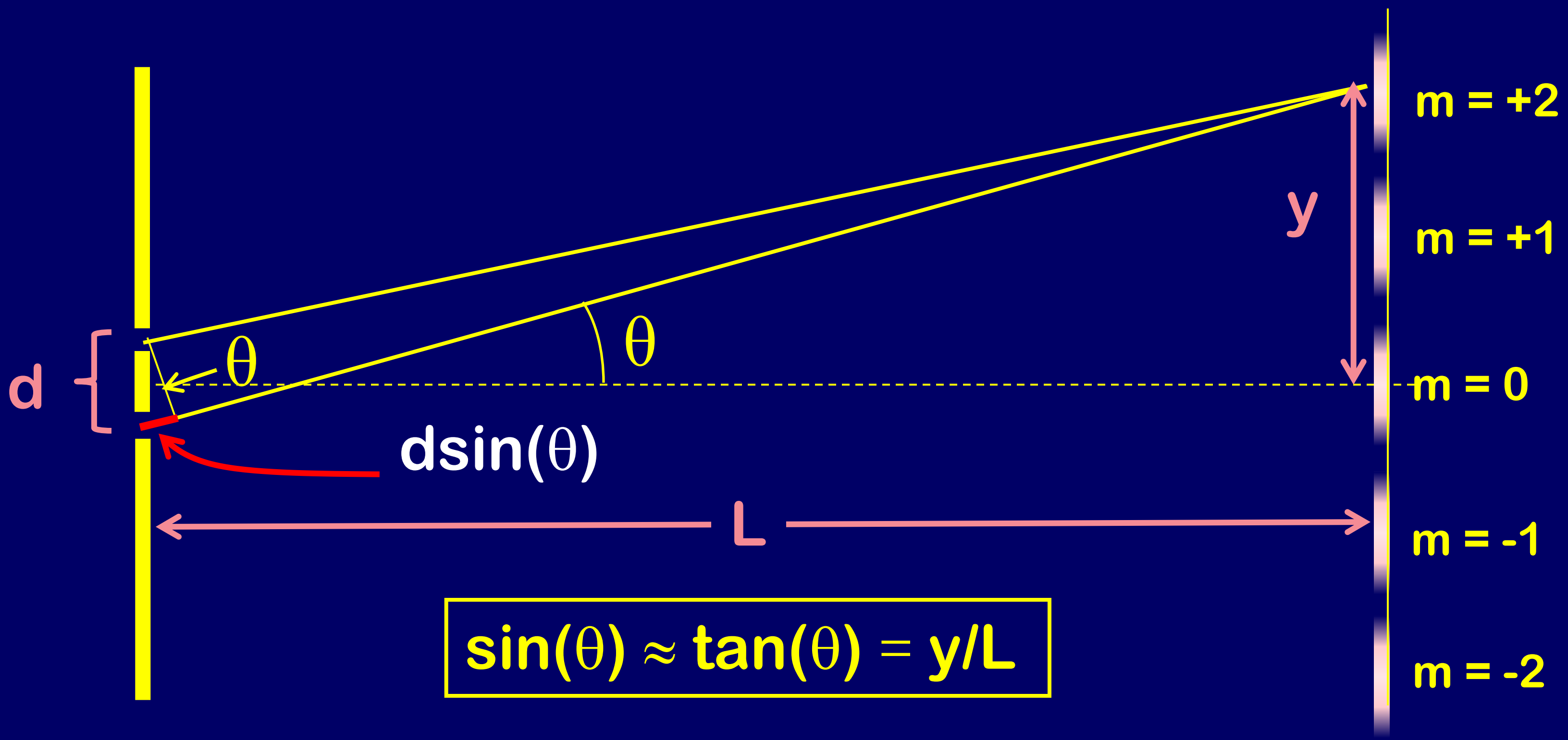
Destructive: $d\sin(\theta) = (m+1/2)\lambda$

where m = 0, ±1, ±2

Need $\lambda < d$

Young's double slit: Quantitative

Assume screen is very far away (L>>d), angles θ are small:



$\sin(\theta) \approx \tan(\theta) = y/L$

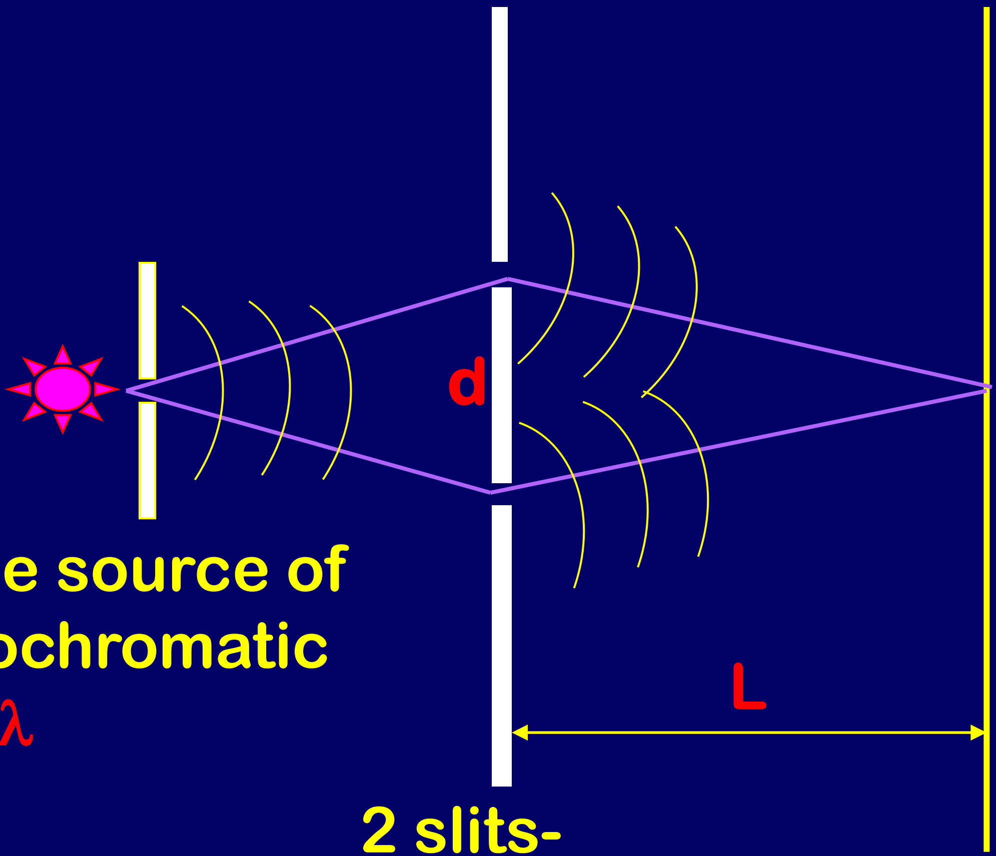
Constructive: $d\sin(\theta) = m\lambda$ $\quad y \approx m\lambda L/d$

Destructive: $d\sin(\theta) = (m+1/2)\lambda$ $\quad y \approx (m+1/2)\lambda L/d$

$m = 0, \pm 1, \pm 2$

ACT: Young's Double Slit

Light waves from a single source travel through 2 slits before meeting on a screen. The interference will be:



Single source of monochromatic light λ

2 slits- separated by d

Screen a distance L from slits

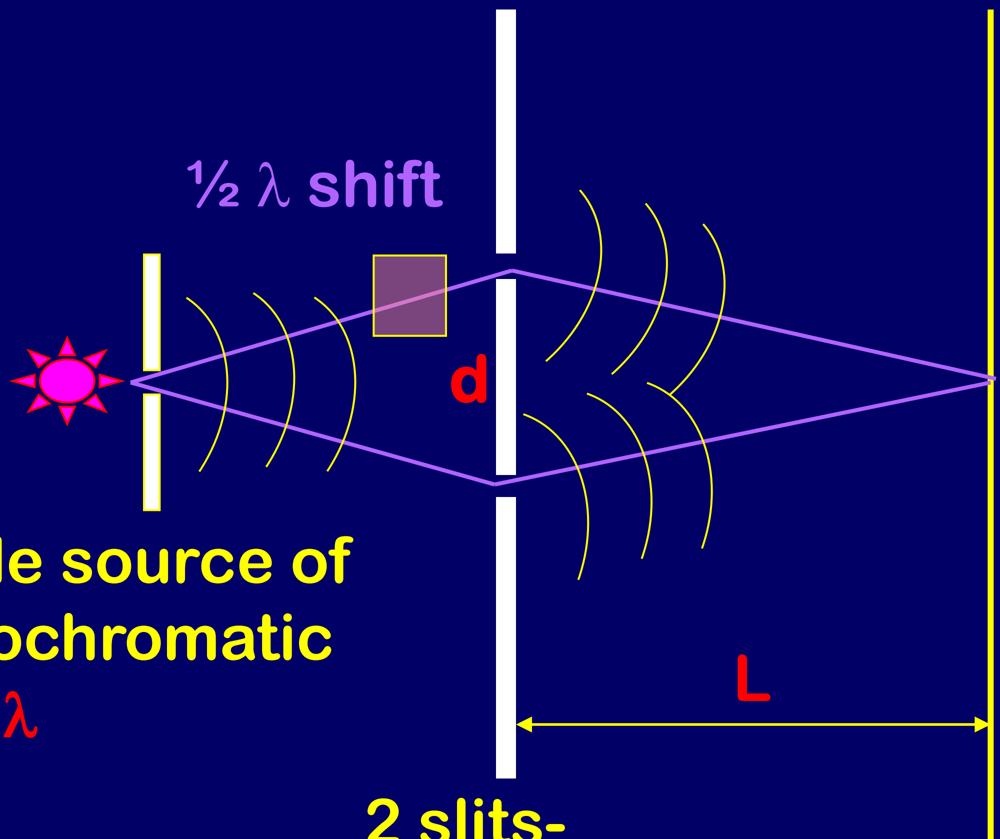
A. Constructive

B. Destructive

C. Depends on L

ACT/Checkpoint 1.1

The experiment is modified so that one of the waves has its phase shifted by ½ λ. Now, the interference will be:



A. Constructive

B. Destructive

C. Depends on L

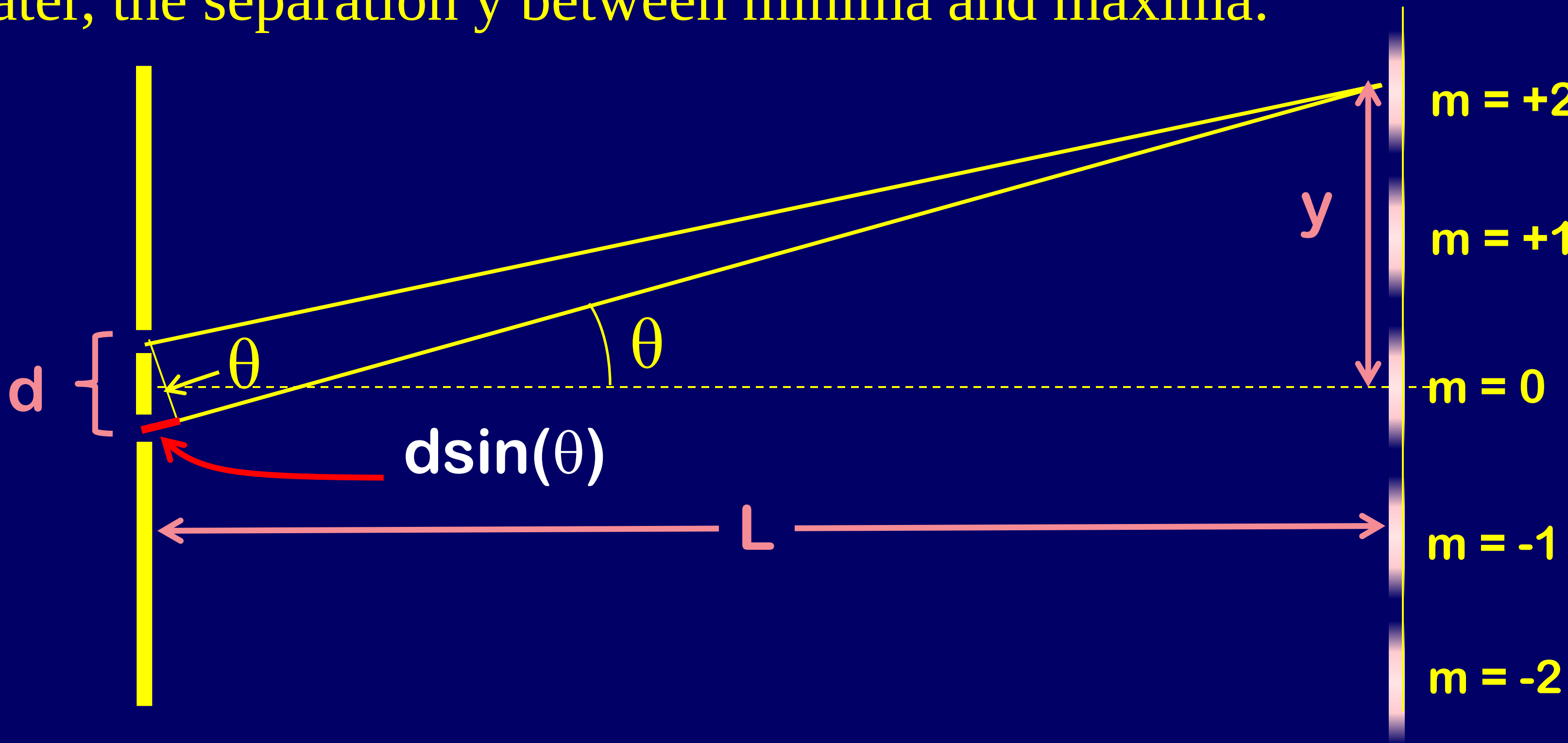
Single source of monochromatic light λ

2 slits-separated by d

Screen a distance L from slits

ACT: Checkpoint 2

When this Young's double slit experiment is placed under water, the separation y between minima and maxima:



A) increases **B) same** **C)**
decreases

Checkpoint 1.2

In the Young double slit experiment, is it possible to see interference maxima when the distance between slits is smaller than the wavelength of light?

1) Yes **2) No**