Physics 122 – Class #9 – Outline

- Announcements
- Interference
  - Of Sound Waves
  - Of light waves
    - Double slit
    - Single slit

Reading Assignment (next class)

Read Chapter 22 (Wave Optics)

Next week, Chapter 25 (Coulomb's Law)

Online Homework #5

Covers single and double slit diffraction and concepts of diffraction. It will be the last material included on the first test. It is due A WEEK FROM TODAY (Not Saturday).

Test topics:

Snell's law, Total internal reflection

Index of refraction

Ray tracing, lenses

Properties of waves, the wave equation, k, omega, f, Lambda, T, phi

Superposition of waves

Beats

Standing waves on strings and pipes/normal modes

Interference of sound and light waves

Double and single slit diffraction

Relations between sketches and equations … wavefronts, node diagrams etc...

Exam #1

Next THURSDAY 2/19/2014

… in CLASS

Covers Ch. 20, 21, 22, 23

Review Homework

Review Workbook (recitation questions)

One 3x5 card. One side. With equations only. No words / no pictures. Card submitted with exam.

Calculator Bonus

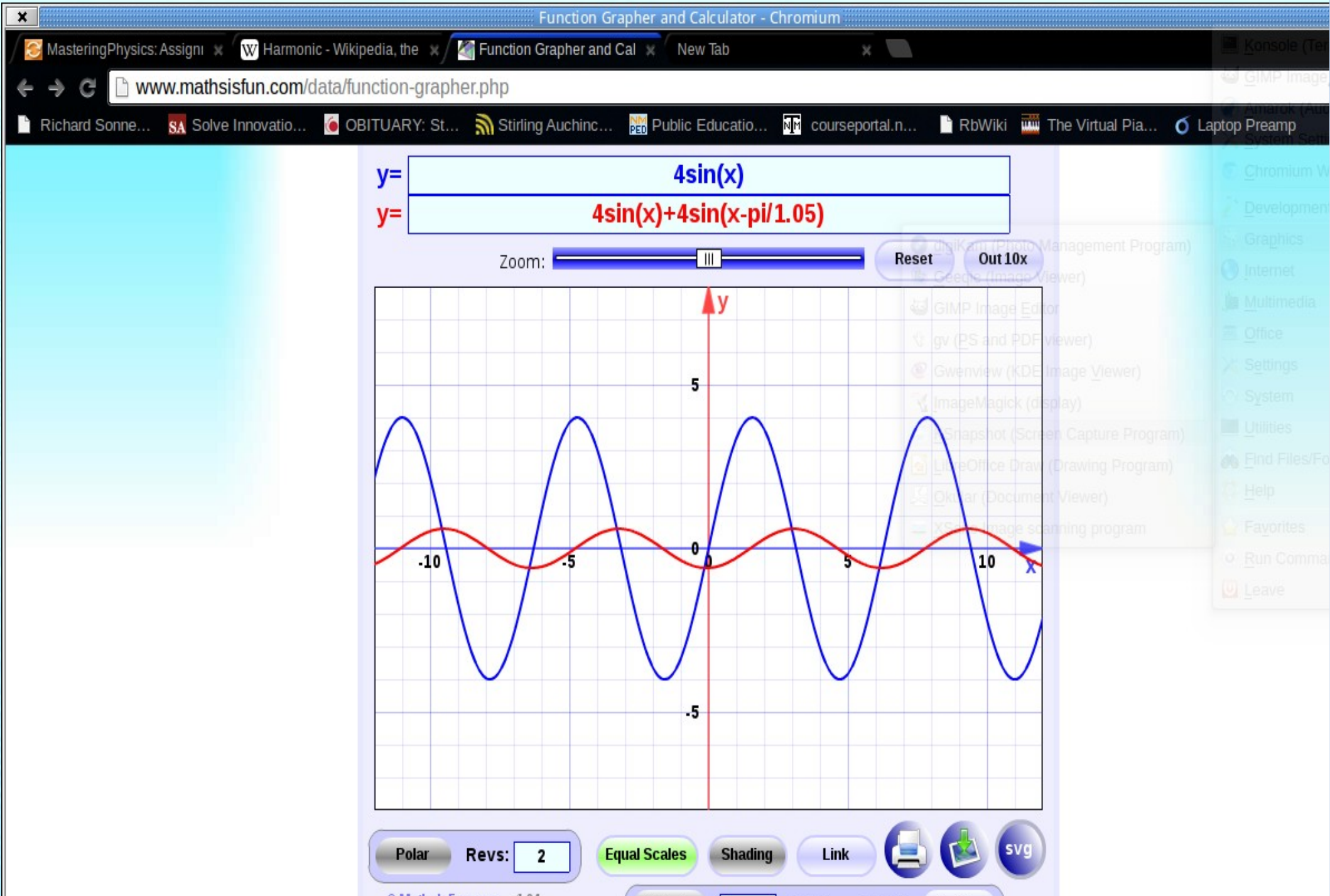
Four function calculator bonus +4.
(I have a few 4-function calculators)

Interference

- **Two sine waves of the same frequency and nearly the same phase add.**
  - The waves are said to be “in phase” and they “constructively interfere” with one another
- **Two sine waves of the same frequency and nearly a phase difference of “pi” cancel eachother.**

The waves are said to be “out of phase” and they “destructively interfere” with one another

Destructive Interference



Wave terminology

$D(x,t)=A\sin(kx-\omega t+\Phi_0)$

Φ_0 Is "initial phase"

$kx-\omega t+\Phi_0$ Is just "phase" and it varies with time and position

Condition for constructive interference is that phase differs by 2*pi*n

Condition for destructive interference is that phase differs by 2*pi*n + pi

Ways interference can happen

Two waves can travel the same distance and start “out of phase” (different phi0).

Two waves can start “in phase” and Travel different distances

Two waves can start in phase but have slightly different frequencies and go in and out of phase (beats)

Thinking of interference in terms of distance traveled.

Since waves repeat every “lambda”
Meters, waves that travel a

Distance Difference = m lambda
will be in phase.

Distance Difference = m lambda+ lambda/2
will be out of phase.

Thinking of interference in terms of distance traveled – the math works

$$D(x,t)=A\sin(kx-\omega t+\Phi_0)$$

Ch. 22: Interference and Diffraction

$d \sin\theta = m\lambda$

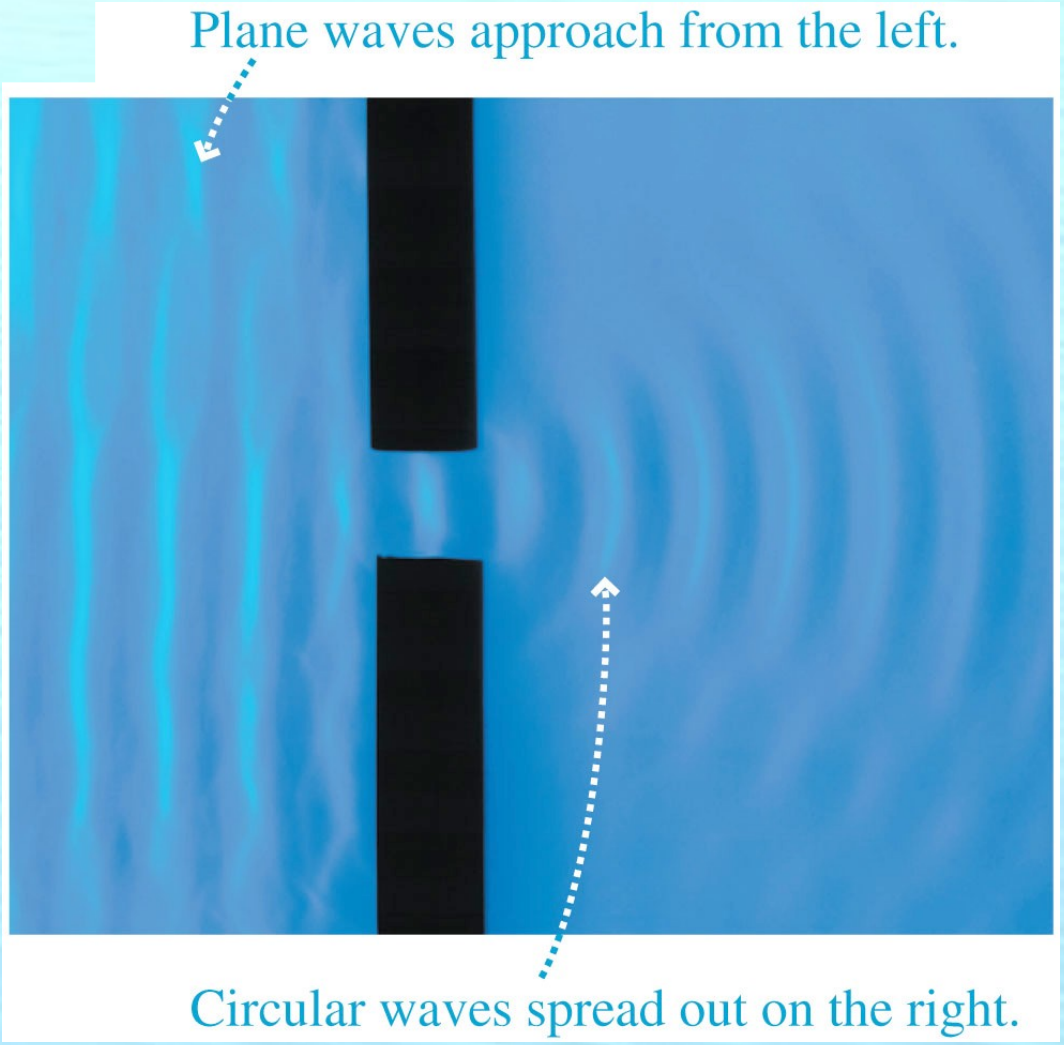
Condition for constructive interference between slits separated by "d".

$a \sin\theta = m\lambda$

Condition for destructive interference for single slit of width "a".

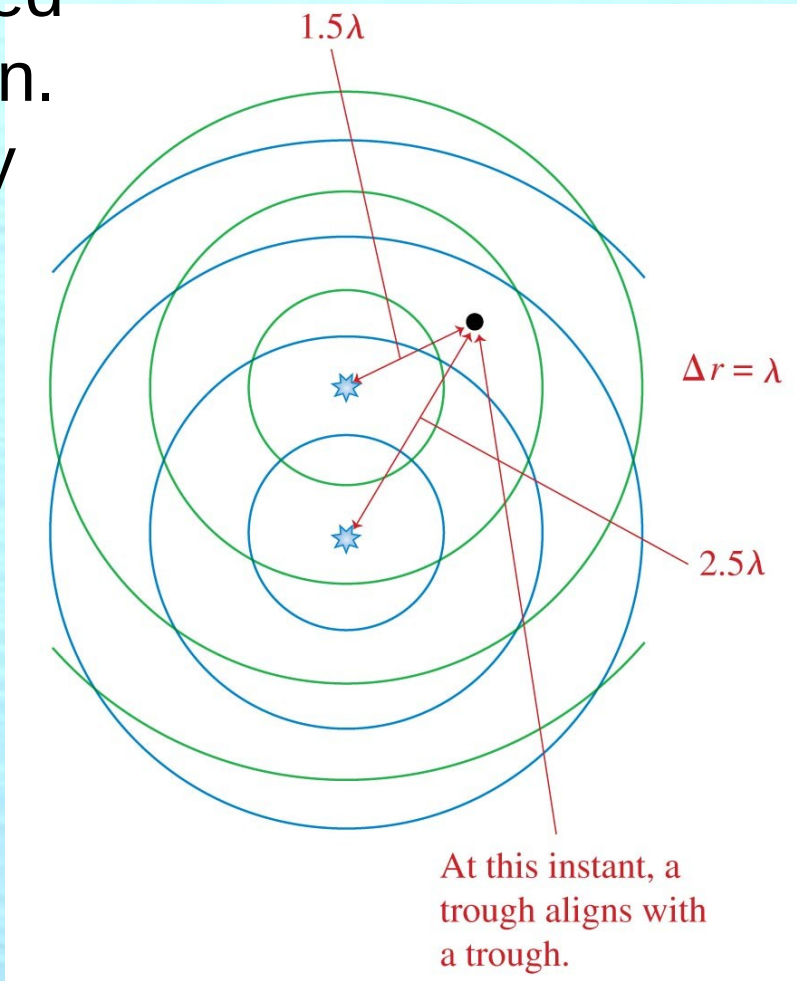
Diffraction of Water Waves

- A water wave, after passing through an opening, *spreads out* to fill the space behind the opening.
- This well-known spreading of waves is called **diffraction**.



Clicker

Two rocks are simultaneously dropped into a pond, creating the ripples shown. The lines are the wave crests. As they overlap, the ripples interfere.
At the point marked with a dot,



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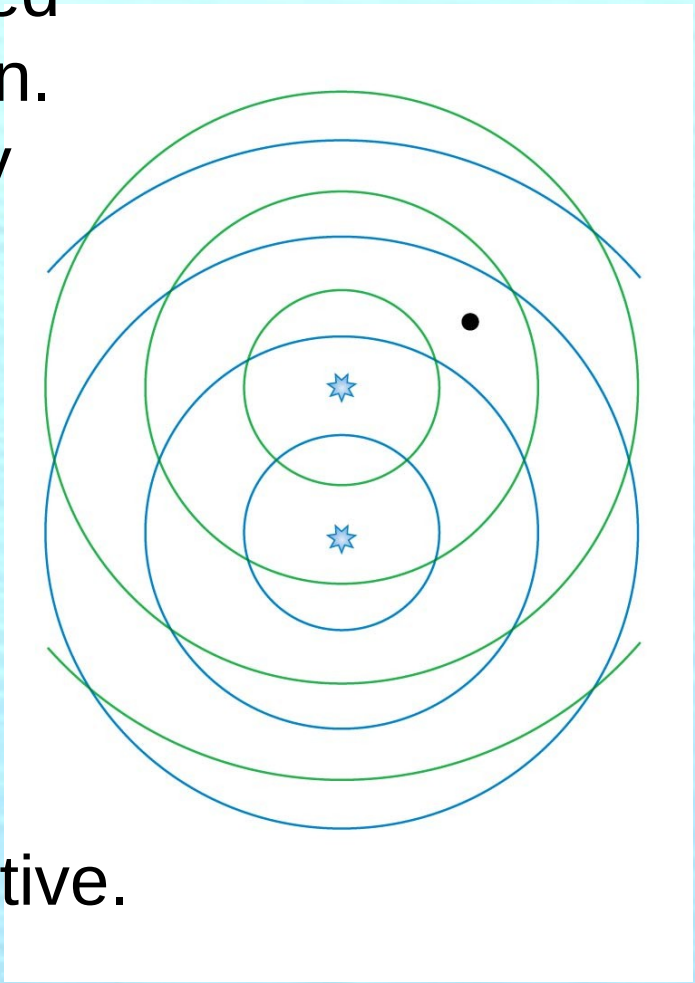


A. The interference is constructive.
B. The interference is destructive.
C. The interference is somewhere between constructive and destructive.
D. There's not enough information to tell about the interference.

Clickers

Given f=343 Hz and v=343 m/s and two sound waves of equal amplitude emitted in phase by two speakers. at what possible distance differences between the speakers will you get destructive interference?

A. 0.5 m, 1.5 m, 2.5 m

B. 0.5 m, 1.0 m, 1.5 m

C. 1.5 m, 2.0 m, 2.5 m

D. 0.25 m, 0.75 m, 1.25 m

Clicker Question

Light sources 1 and 2 are oscillating in phase emit sinusoidal waves. Point P is 7.3 wavelengths from source 1 and 4.3 from source 2.

As a result, at P there is

(A) Constructive interference.

(B) Destructive interference.

(C) Neither constructive nor destructive interference.

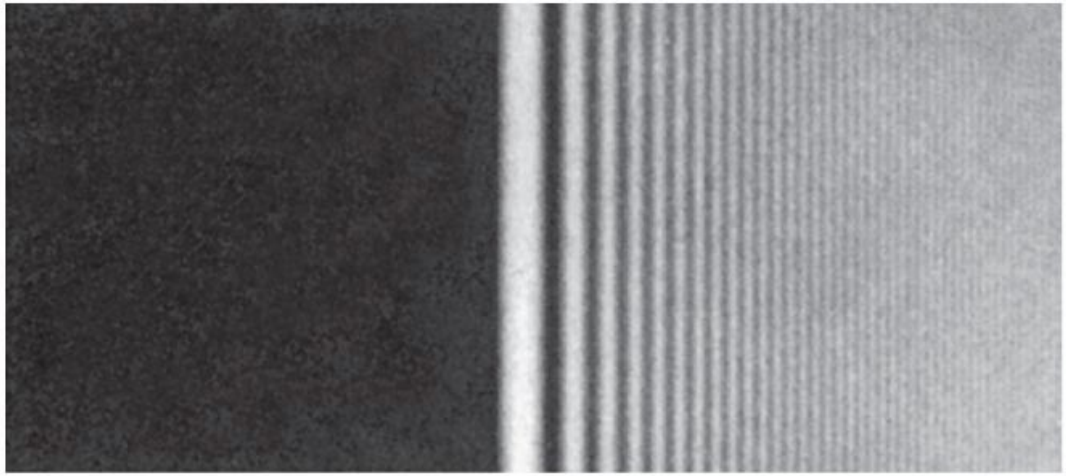
(D) Not enough information give to decide.

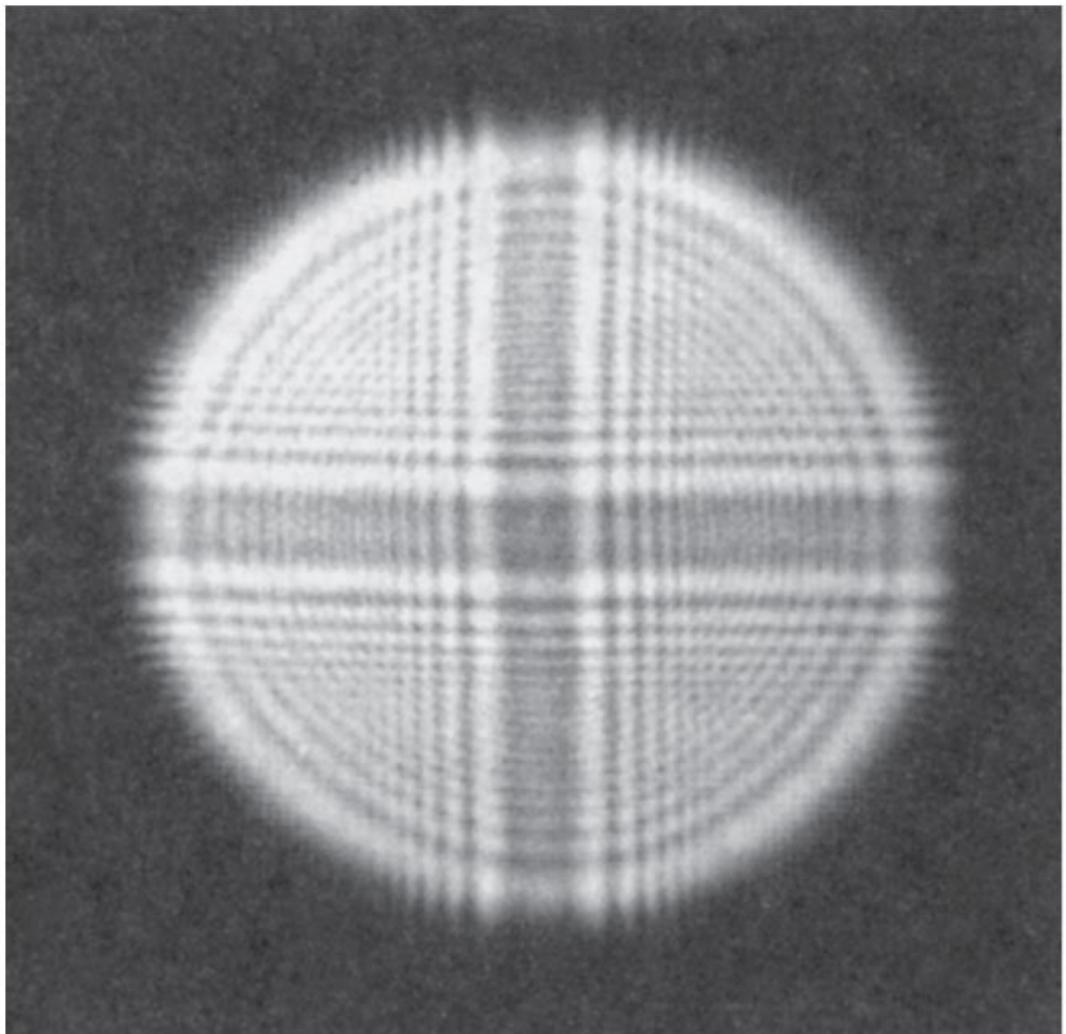
When a hole or slot is large compared
To wavelength of light, you have “ray optics”.

Light could be a particle.
It travels in straight lines.
Shadows are sharp.

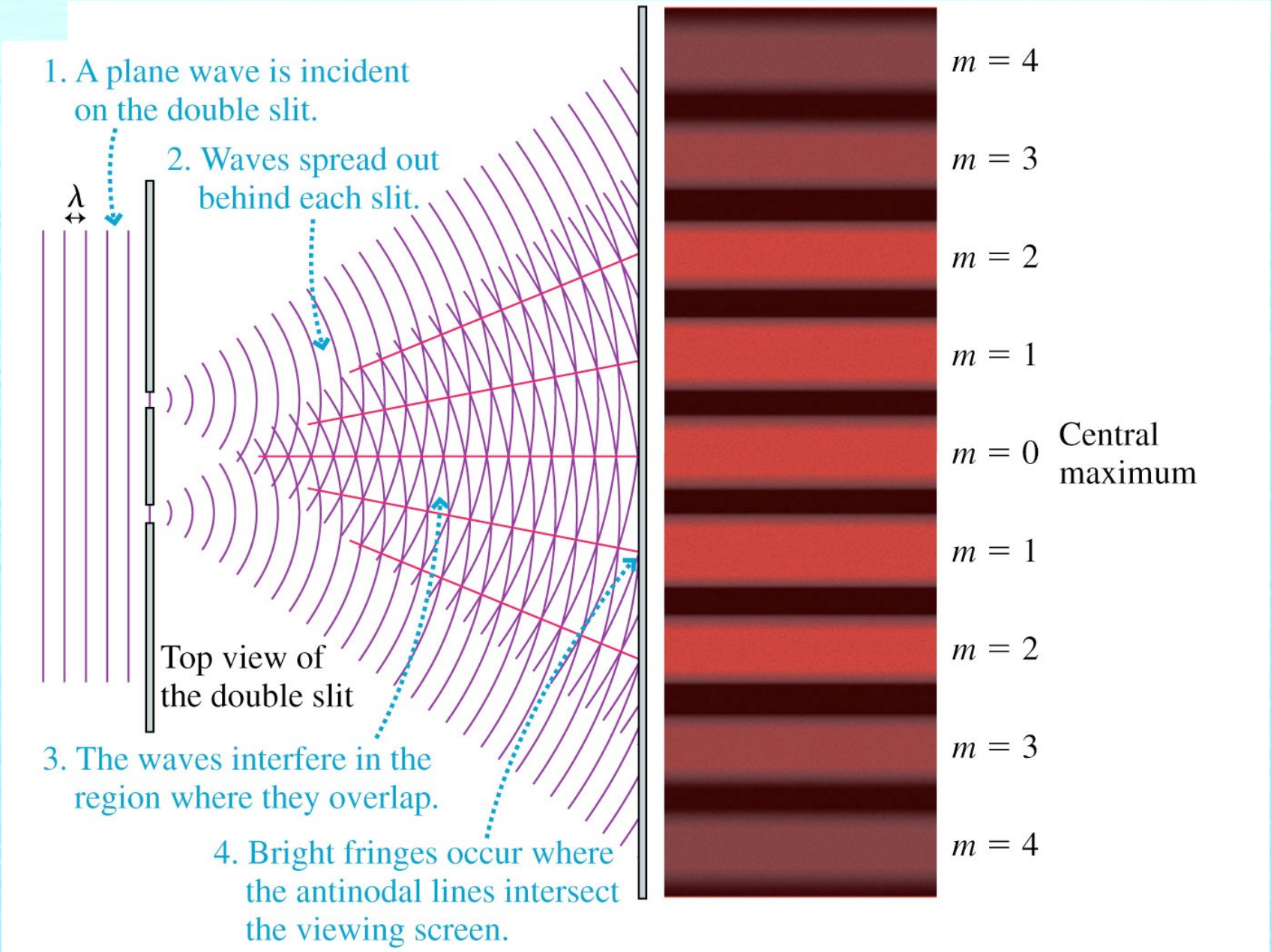
When the slot is comparable to wavelength
Of light, you see diffraction effects.

Shadows are not sharp, they
Show “fringes”

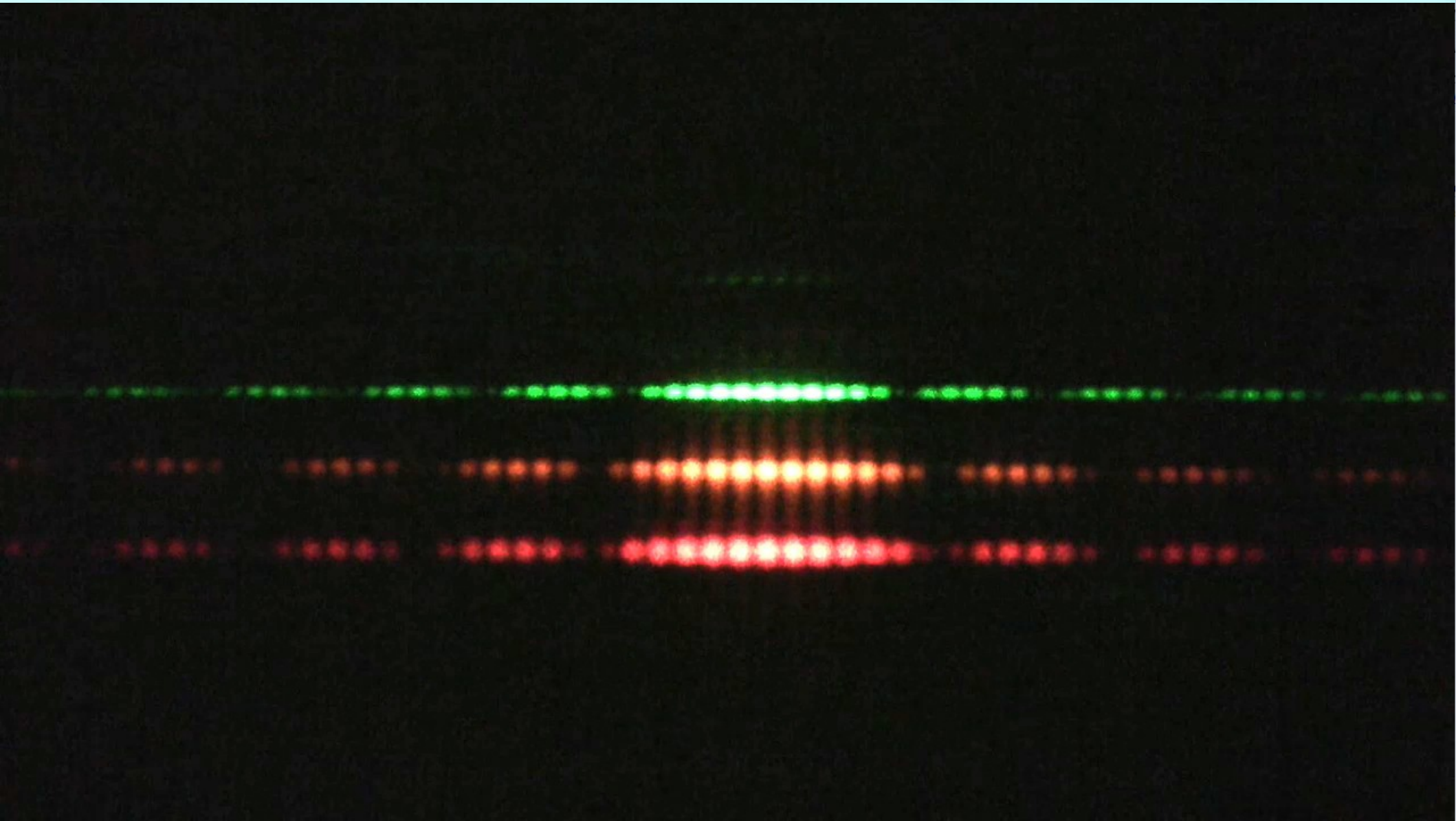




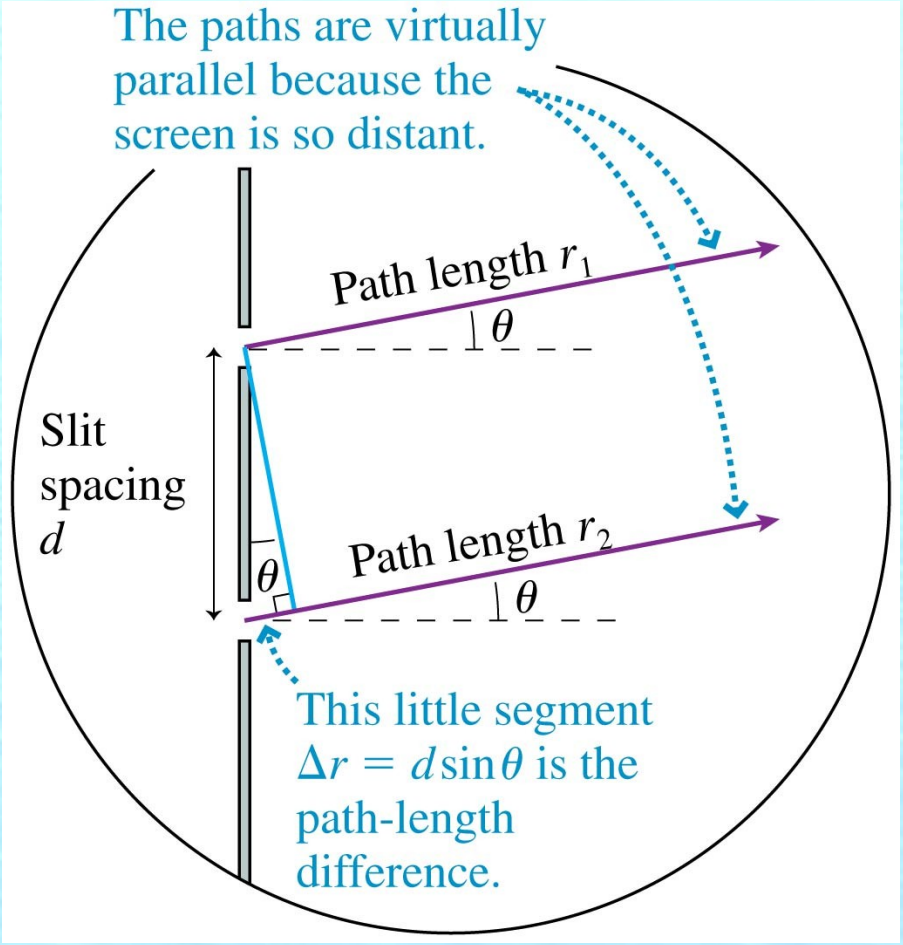
Young's Double-Slit Experiment

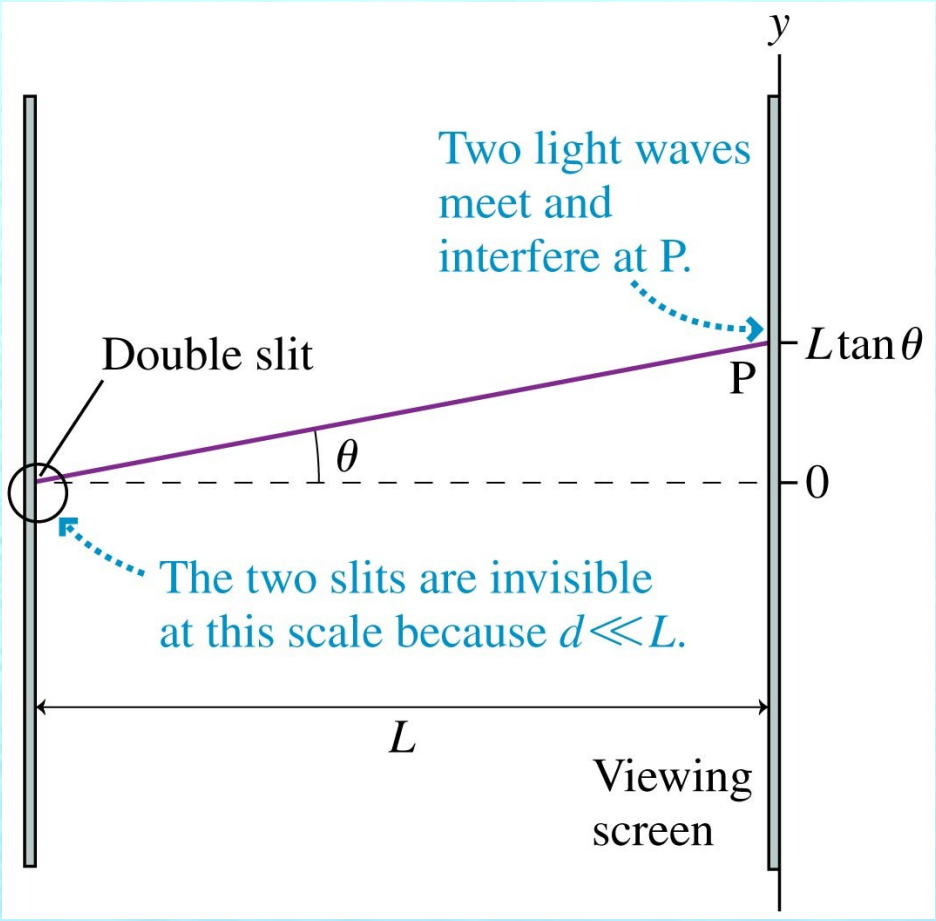


Doubles slit diffraction is superposition of single and double slit

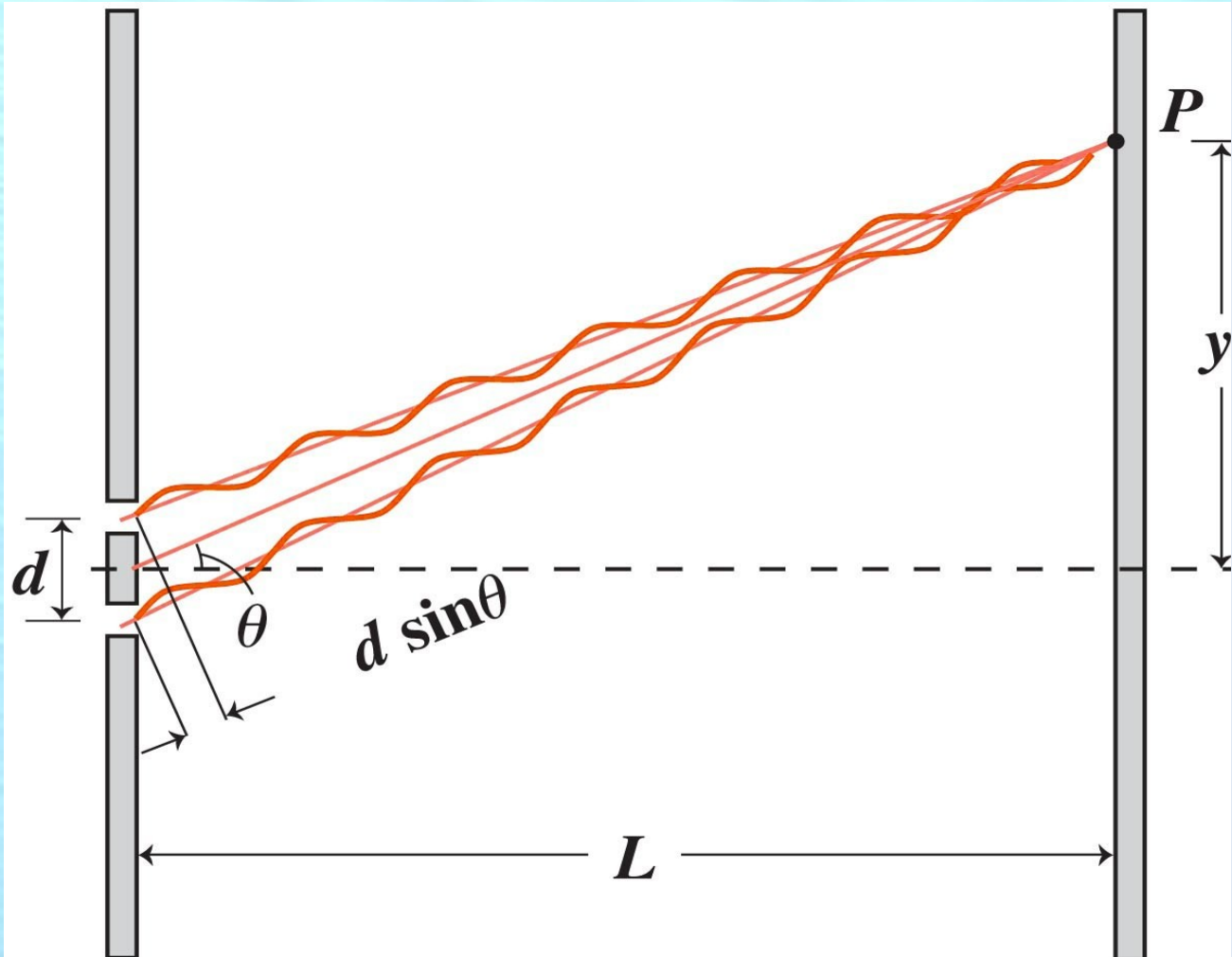


Double slit interference



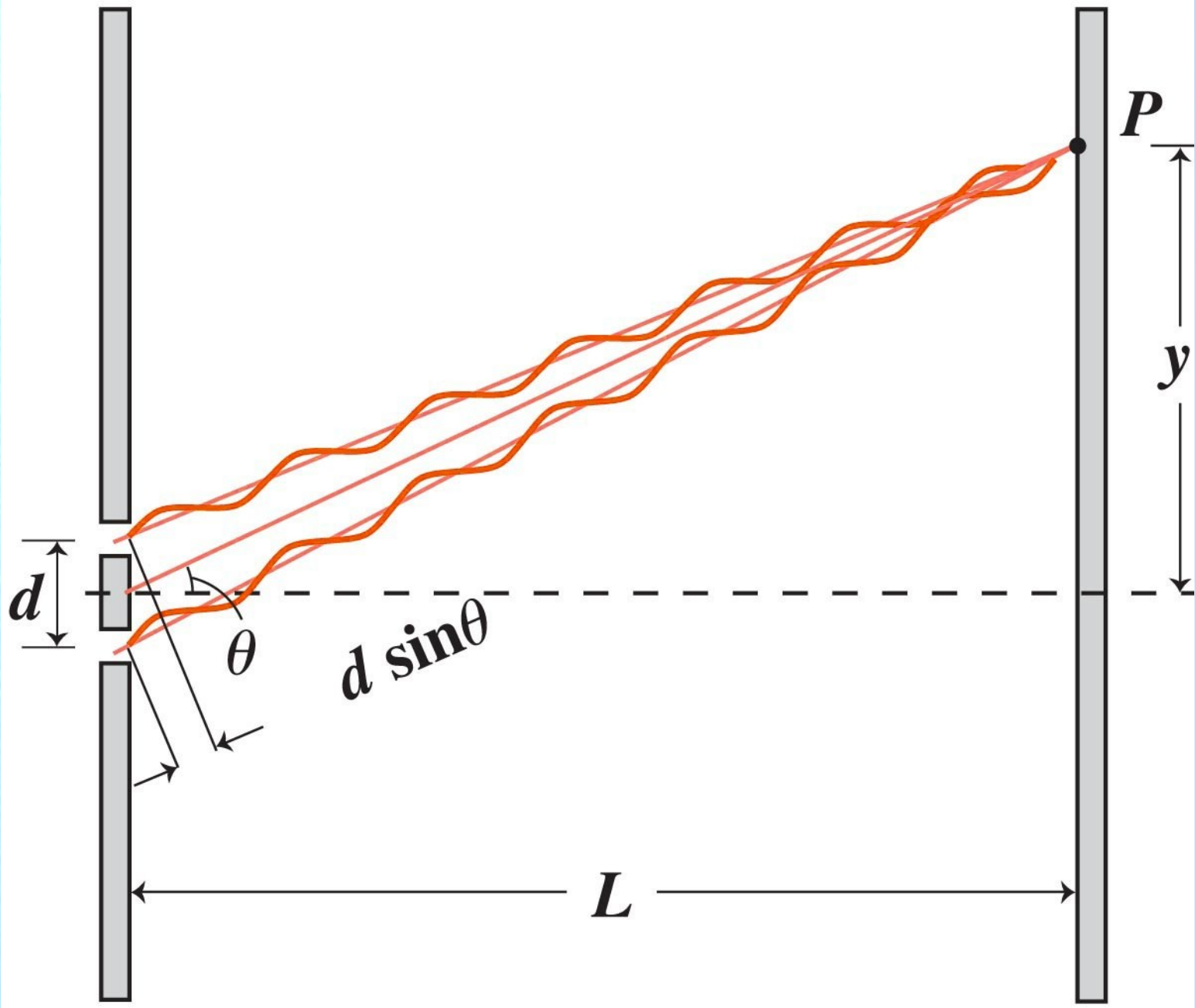


Double slit interference



Double slit Constructive interference

$$d \sin\theta = m\lambda$$

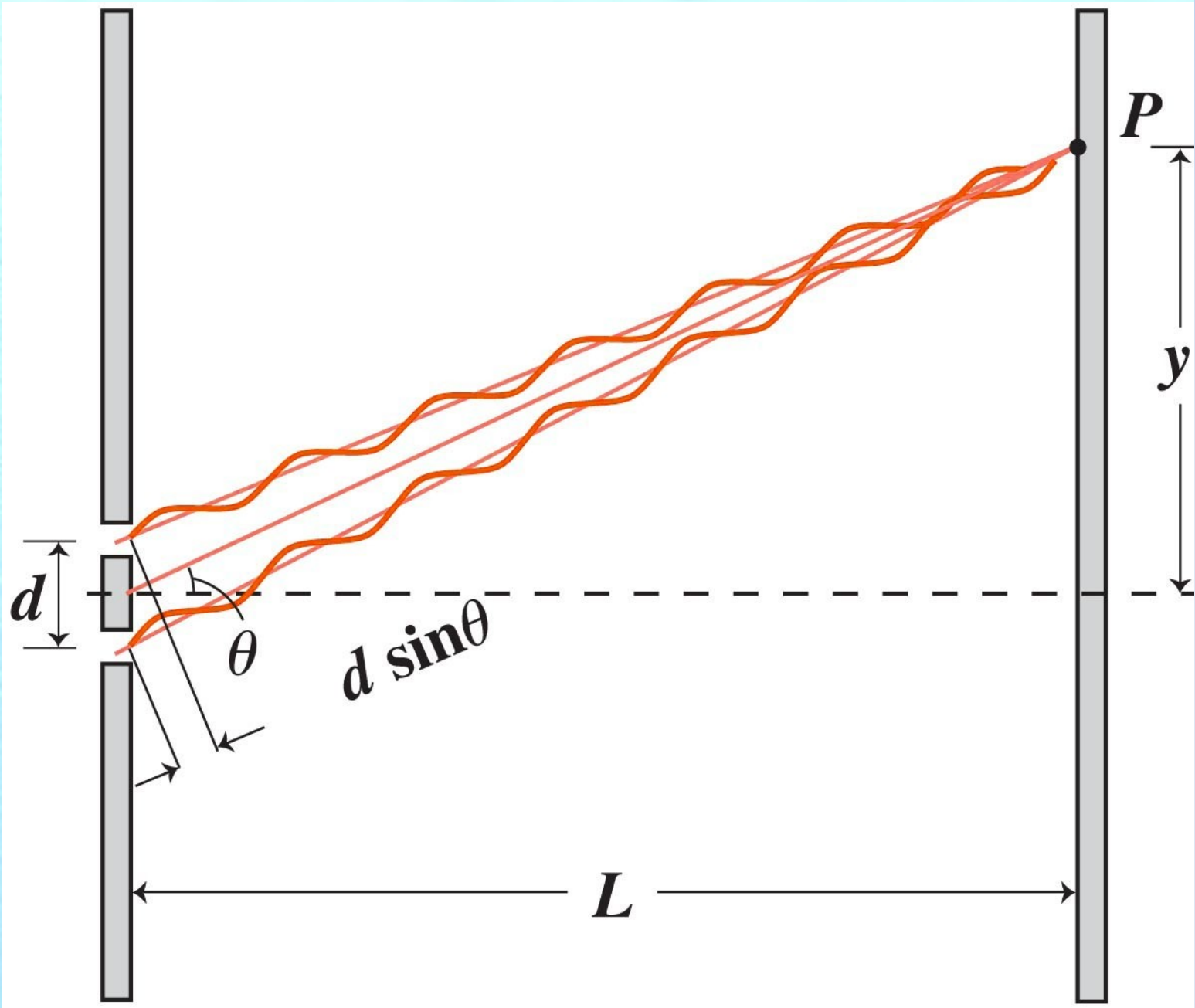


Double slit Constructive interference

$$d \sin\theta = m\lambda$$

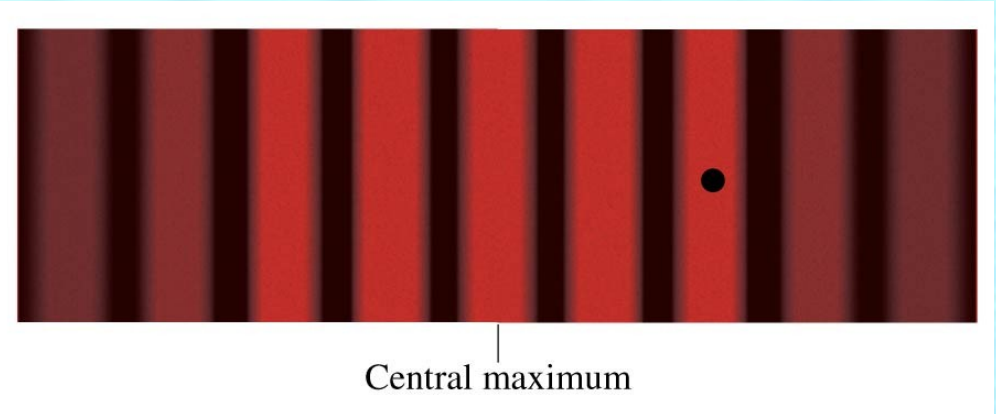
$$d\frac{y}{L} = m\lambda$$

$$y_{max} = m\lambda\frac{L}{d}$$



Clicker

A laboratory experiment produces a double-slit interference pattern on a screen. The point on the screen marked with a dot is how much farther from the left slit than from the right slit?



A 1.0 λ.

B 1.5 λ.

C 2.0 λ.

D 2.5 λ.

E 3.0 λ.

Question

Given 632 nm wavelength and slits separated by 0.1 mm 10 m from a wall. What is the position of the 20^{th} order maximum? 20^{Th} order minimum?

Diffraction and small angle approximation

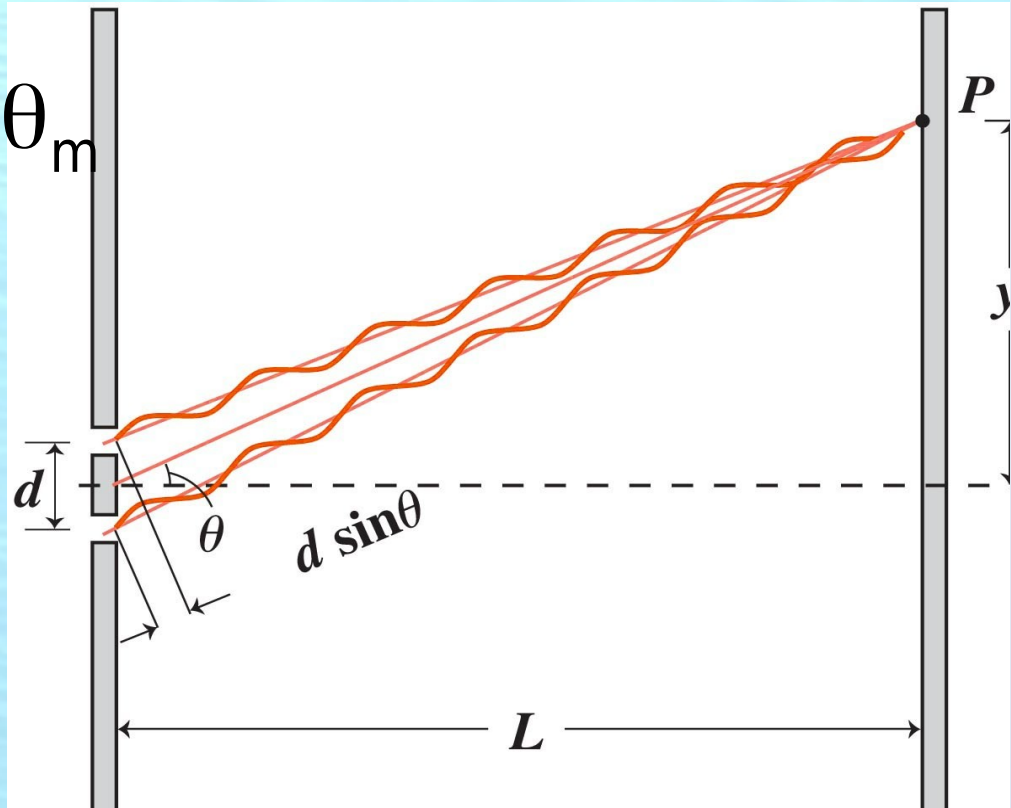
Exact: $d \sin\theta_m = m\lambda$

Approximate: $d\theta_m \sim m\lambda \rightarrow \theta_m = m\frac{\lambda}{d}$

Exact: $y_m = L\tan\theta_m$

Approximate: $y_m \sim L\sin\theta_m$

$$y_m \sim Lm\frac{\lambda}{d}$$



Taylor series and small angle approximation

$$\sin\theta = \theta - \frac{\theta^3}{3!} + \frac{\theta^5}{5!} - \frac{\theta^7}{7!} \ldots$$

$$\tan\theta = \theta + 2\frac{\theta^3}{3!} + 16\frac{\theta^5}{5!} + \ldots$$

pHeT

Question

Given the two slit pattern on the wall, how far apart are the slits?

Question

(1) Given 632 nm wavelength and slits separated by 0.1 mm 10 m from a wall. What is the position of the 20^{th} order maximum? 20^{Th} order minimum?

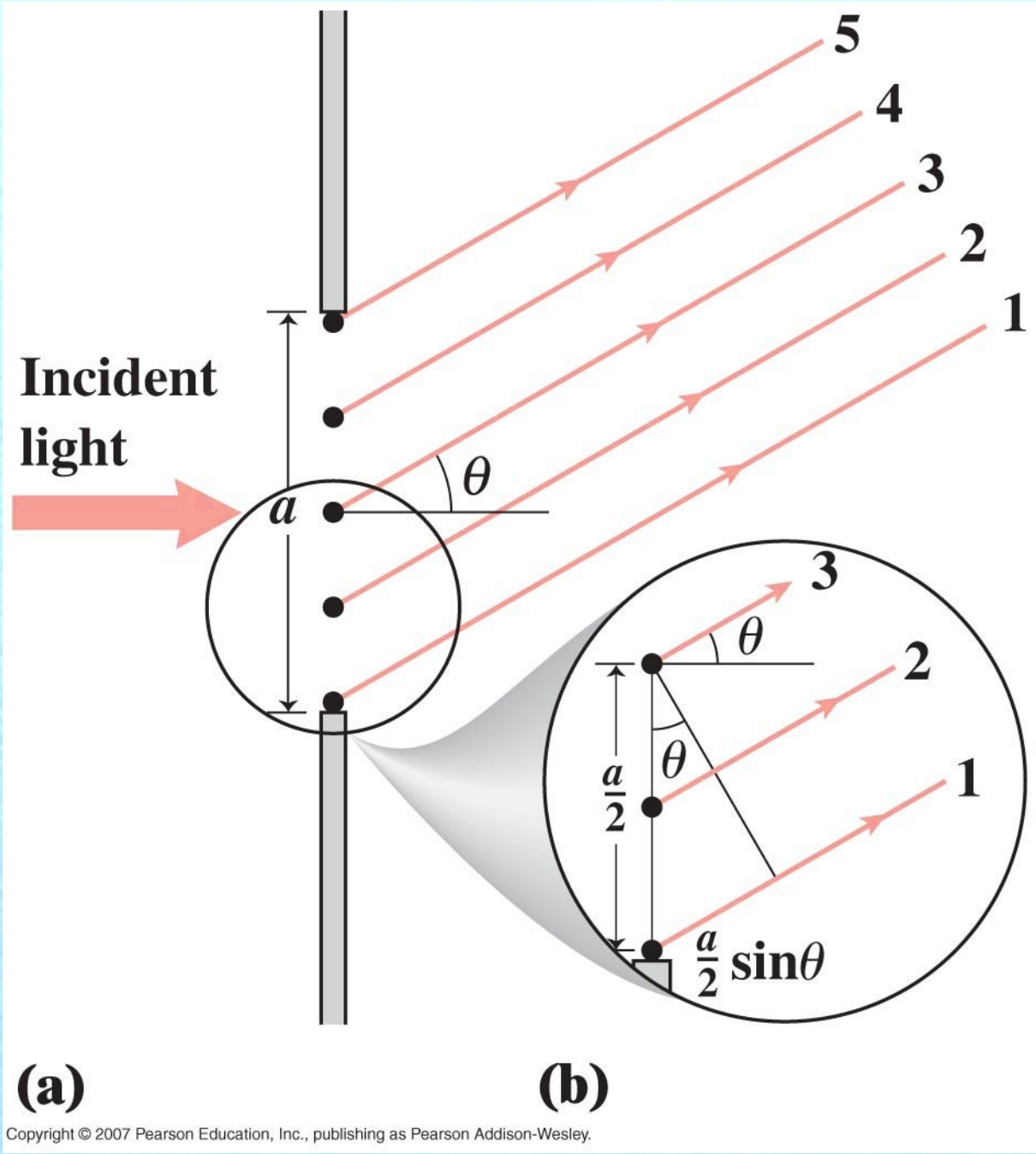
(2) Given the two slit pattern on the wall, how far apart are the slits?

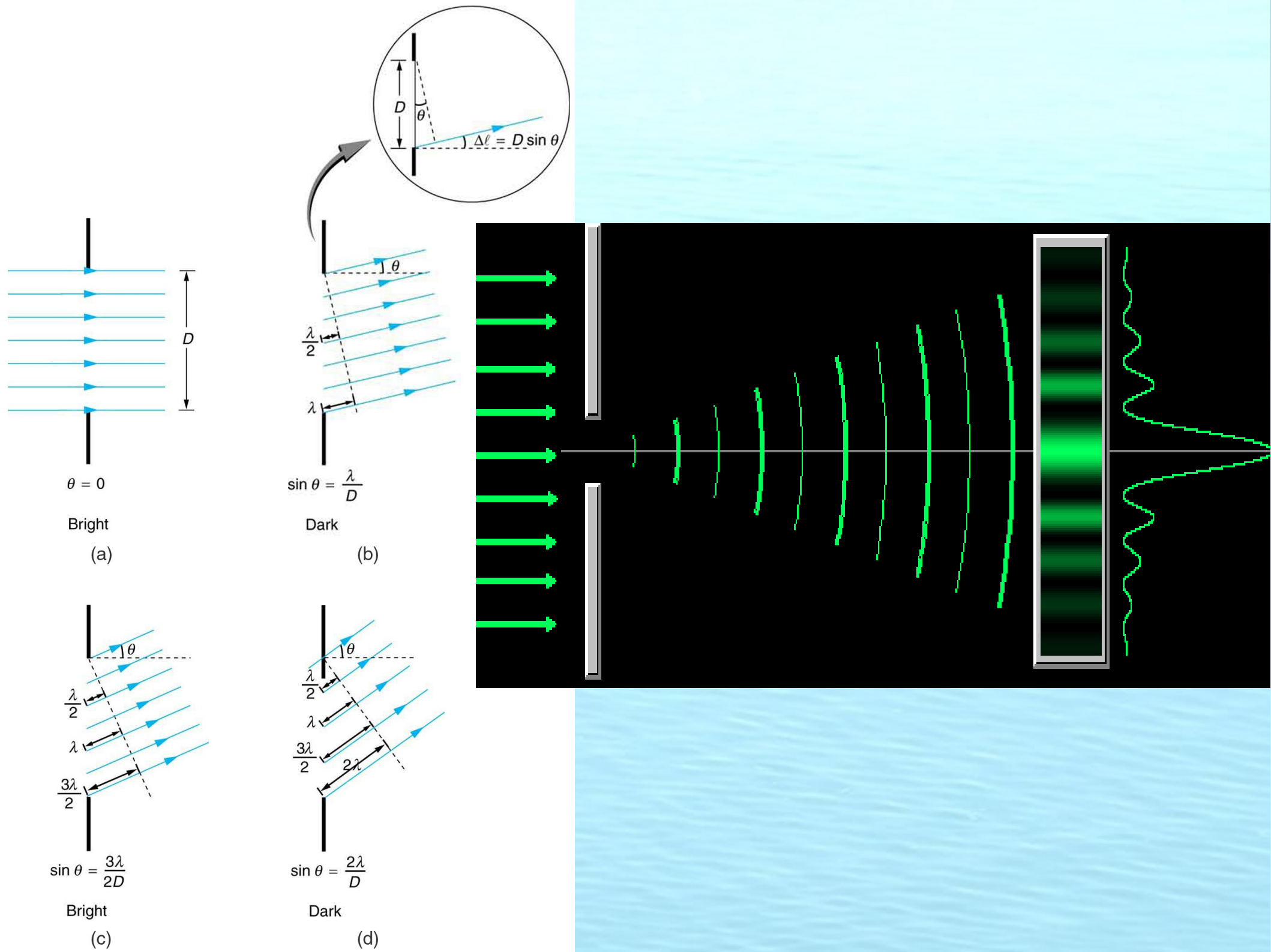
Single slit diffraction

Light from different Parts of a single slit interferes with itself Destructive Condition:

$$\frac{a}{2}\sin\theta = \lambda/2$$

$$a\sin\theta = m\lambda$$




D
θ
Δℓ = D sin θ
D
θ = 0
Bright
(a)
θ
λ/2
λ
sin θ = λ/D
Dark
(b)
θ
λ/2
λ
3λ/2
sin θ = 3λ/2D
Bright
(c)
θ
λ/2
λ
3λ/2
2λ
sin θ = 2λ/D
Dark
(d)

Ch. 22: Interference and Diffraction

$d \sin\theta = m\lambda$

Condition for constructive interference between slits separated by "d".

$a \sin\theta = m\lambda$

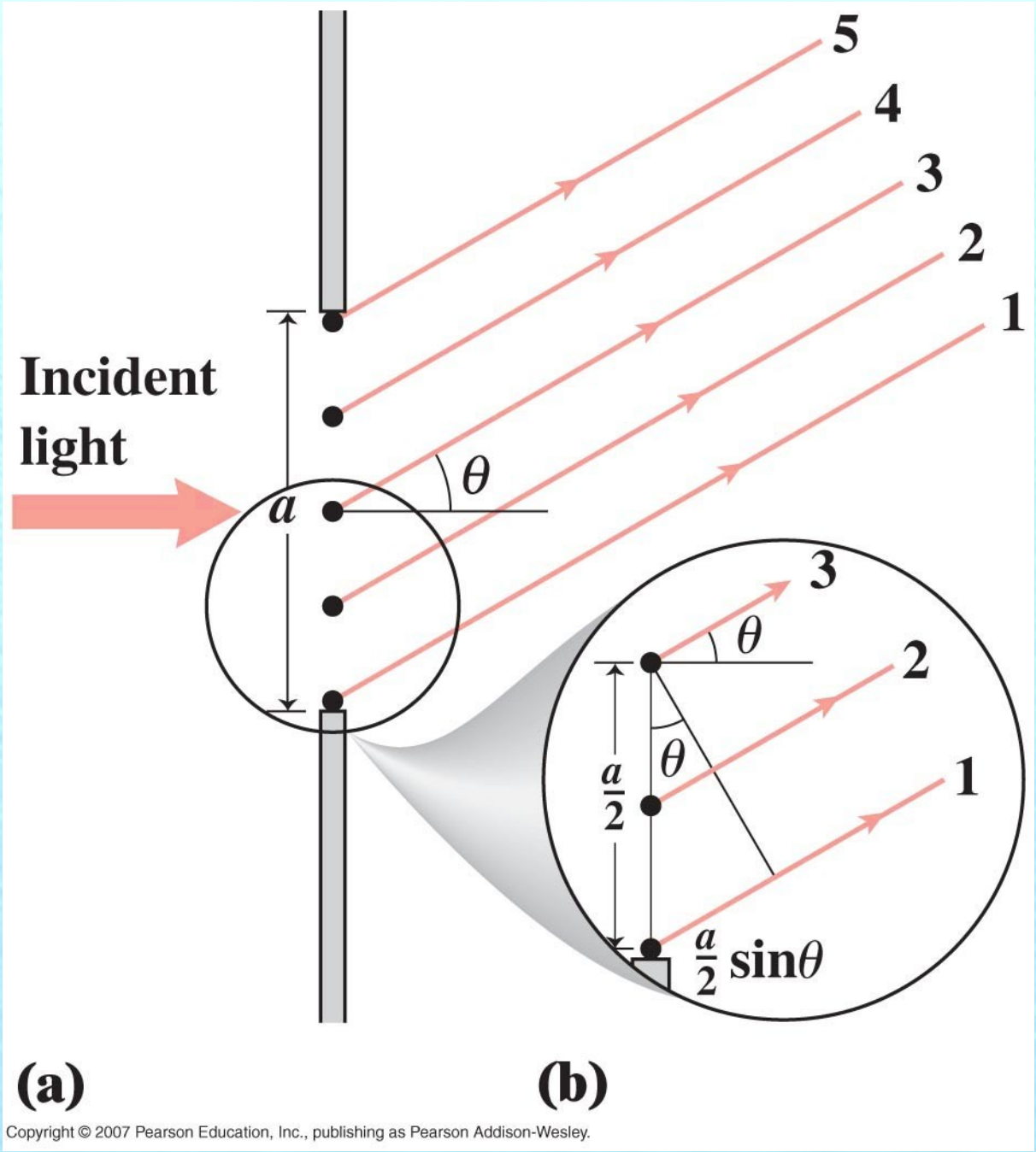
Condition for destructive interference for single slit of width "a".

Diffraction

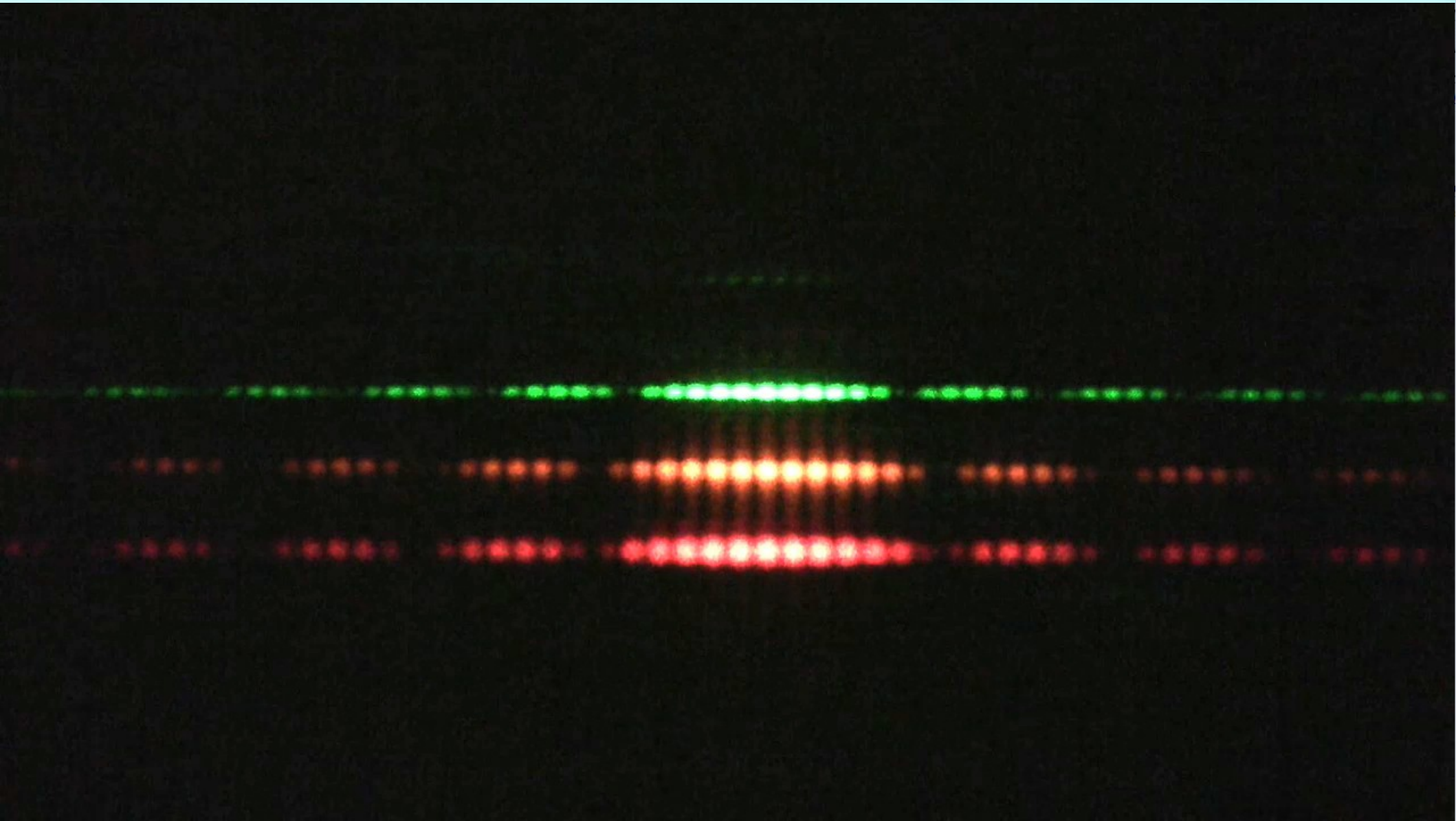
Light from different Parts of a single slit interferes with itself

Destructive Condition:

$$a \sin\theta = m\lambda$$



Doubles slit diffraction is superposition of single and double slit



Single and double slits

Slit A: $a = 40\,\mu m$

Slit D: $a = 40\,\mu m$, $d = 125\,\mu m$

Slit E: $a = 40\,\mu m$, $d = 250\,\mu m$

Constructive

$$d \sin\theta = m\lambda$$

Destructive

$$a \sin\theta = m\lambda$$

$$d \frac{y}{L} = m\lambda$$

$$y_{max} = m\lambda \frac{L}{d}$$