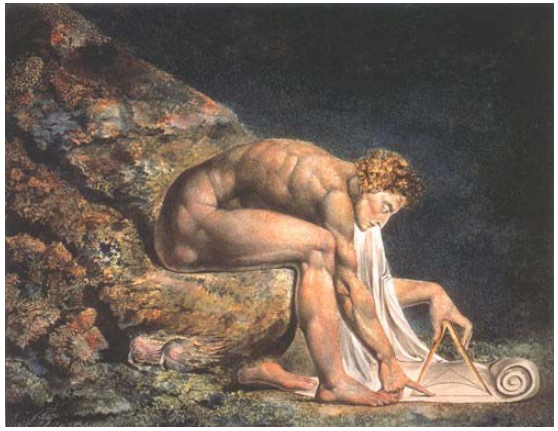
William Blake's *Newton* (1795)



1

About the Discussion Board on the Course Web Page

- I regularly read and respond to questions that appear there
- Other students are also "jumping in" to the discussions
- The Teaching Assistants may also participate in this forum
- I do not participate on BIOME

2

Written Homework #1

- Released in the **Assignments** section of the course web page
- Due in the appropriate "Drop Box" by 5 PM Friday September 30
- To be done with the "Team" you work with in the Practicals

Suggested Exercises and Problems From Chapter 22

3, 7, 29, 35, 73

3

Problem Set 3 – Chapter 22

- Released on *MasteringPhysics*
- The last *MasteringPhysics* Problem Set of the Waves section
- Due by 11:59 PM on Friday January 23, 2009

Pre-Class Quiz 3 – Chapter 23

- Released on *MasteringPhysics*
- The last Pre-Class Quiz of the Waves section
- Due by 10 AM on Monday January 26, 2009

4

Syllabus Update for Chapter 22

- Drop the mathematical details of diffraction in §22.4 – *Single Slit Diffraction* and §22.5 – *Circular Aperture Diffraction*
- Some qualitative aspects of diffraction will be required
- A little document on these aspects has been prepared
  - A link to the document will appear in the summary for today's class
  - You should have also received an email with the link

5

Last Time

- Sound waves
  - The displacement wave oscillates around the equilibrium position of the air molecules
  - The pressure wave oscillates around atmospheric pressure

6

Last Time

- Sound waves
- Standing Waves on a String fixed on both ends:
  - Nodes at ends
  - In general all modes occur at once: "fundamental" and "overtones"
- Sound Standing Waves in a closed tube
  - Nodes in displacement wave at ends
  - Anti-nodes in pressure wave at the ends

7

Last Time

- Sound waves
- Standing Waves on a String fixed on both ends
- Sound Standing Waves in a closed tube
- 2 Sources: same wavelength and frequency
  - Phase difference $m \times 2\pi$: "constructive interference"
  - Phase difference $(m + \frac{1}{2}) \times 2\pi$: "destructive interference"

8

Last Time

- Sound waves
- Standing Waves on a String fixed on both ends
- Sound Standing Waves in a closed tube
- 2 Sources: same wavelength and frequency
- 2 Sources: different wavelength and frequency
  - Beats: $D_{sum} = [2a\cos(\omega_{\text{mod}}t)]\sin(\omega_{avg}t)$

$$\omega_{\text{mod}} \equiv \frac{1}{2}(\omega_1 - \omega_2)$$

$$\omega_{avg} \equiv \frac{1}{2}(\omega_1 + \omega_2)$$

9

Same Idea, Different Terminology

We have the superposition of 2 waves at some point in space. The two waves have the same wavelength and frequency. The phase difference between the two waves is $\Delta\varphi$.

- Standing Wave:
  - Superposition of the incident and reflected wave
  - $\Delta\varphi = m\times(2\pi)$: "Node",
    $\Delta\varphi = (m + ½)\times(2\pi)$: "Anti-node"
- Two sources
  - Superposition of the waves from the 2 sources
  - $\Delta\varphi = m\times(2\pi)$: "Constructive Interference",
    $\Delta\varphi = (m + ½)\times(2\pi)$: "Destructive Inteference"

10

Today

- Begin Chapter 22
  - §22.1 – Light and Optics
  - §22.2 – The Interference of Light

We *may* finish Chapter 22 and begin Chapter 23 – *Ray Optics* on Wednesday

11

What is Light? (Greece circa 300 BCE)

A. Euclid, Ptolemy: some sort of ray that travels from our eye to the object being seen

B. Aristotle: some sort of ray that travels from the object being seen to our eye

Do you know why Answer B is correct?

Alhazen, Basra, circa 865 CE: the first to figure out why Answer B is correct

12

What is Light? (Europe, circa 1670 CE)

A. Newton: some sort of particle
B. Hooke and Huygens: some sort of wave
C. All of the above (according to 19th century physics)
D. None of the above

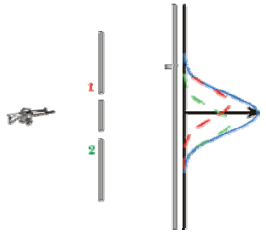
Do you know why according to 19th Century Physics Answer B is correct?

Thomas Young, 1801 CE: the first to figure out why Answer B is correct

13

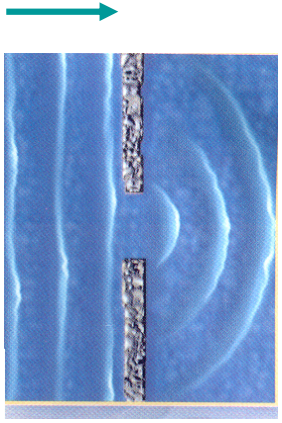
For particles:

$N_{both} = N_1 + N_2$



14

Diffraction of Water Waves From a Slit



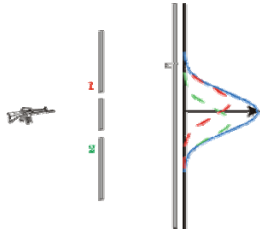
To the right of the slit, the waves spread out

As the angle with the horizontal increases, the amplitude of the diffracted wave becomes less

15

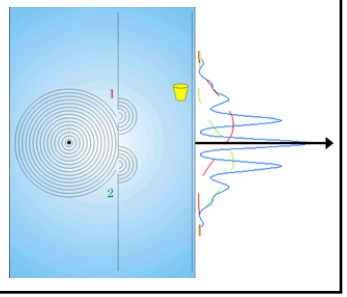
For particles:

$N_{both} = N_1 + N_2$



For waves:

$I_{both} \neq I_1 + I_2$



The Double Slit Experiment

When only one slit is open, at the centre of the observing screen, equally distant from both slits, the intensity is the same from the slits: $I_1 = I_2 \equiv I$. When both slits are open, what is the total intensity at that position on the screen?

17

The Double Slit Experiment

When only one slit is open, at the centre of the observing screen, equally distant from both slits, the intensity is the same from the slits: $I_1 = I_2 \equiv I$. When both slits are open, what is the total intensity at that position on the screen?

A. I

D. $4I$

B. $\sqrt{2}I$

E. 0

C. $2I$

18

The Double Slit Experiment

When only one slit is open, at the centre of the observing screen, equally distant from both slits, the intensity is the same from the slits: $I_1 = I_2 \equiv I$. When both slits are open, what is the total intensity at that position on the screen?

A. I

D. $4I$

B. $\sqrt{2}I$

E. 0

C. $2I$

Doesn't this violate conservation of energy?

A. Yes

B. No

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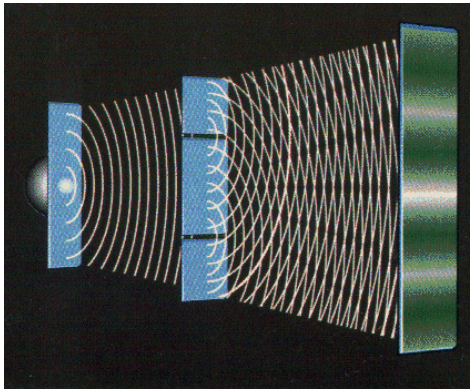
Two Slit Experiment for a "Non-Coherent" Source

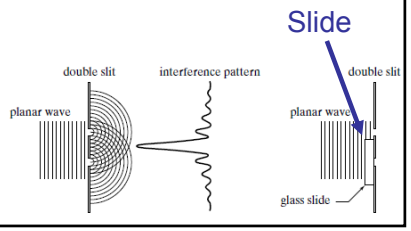


http://abyss.uoregon.edu/~js/21st_century_science/lectures/lec13.html

20

A planar light wave incident on a double slit forms an interference pattern

We cover the lower slit with a glass slide that shifts the emerging wave by π radians. How is the interference pattern altered?



A planar light wave incident on a double slit forms an interference pattern

We cover the lower slit with a glass slide that shifts the emerging wave by π radians. How is the interference pattern altered?

A. The pattern vanishes

B. Bright and dark spots are interchanged

C. The bright spots are farther apart

D. The bright spots are closer together

E. There are no changes

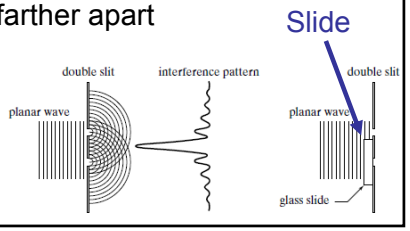
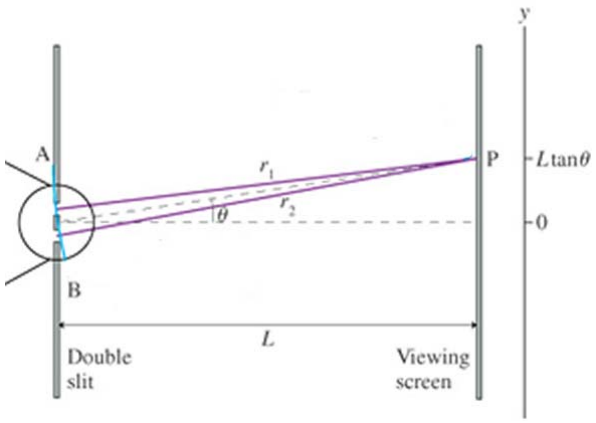


Figure 22.4 (right part, slightly modified)



23

Constructive Interference

L >> *d*: $d\sin(\theta_m) = m\lambda,\ \ m = 0,1,2,3,\ldots$

θ small: $\theta_m = \dfrac{m\lambda}{d},\ \ m = 0,1,2,3,\ldots$

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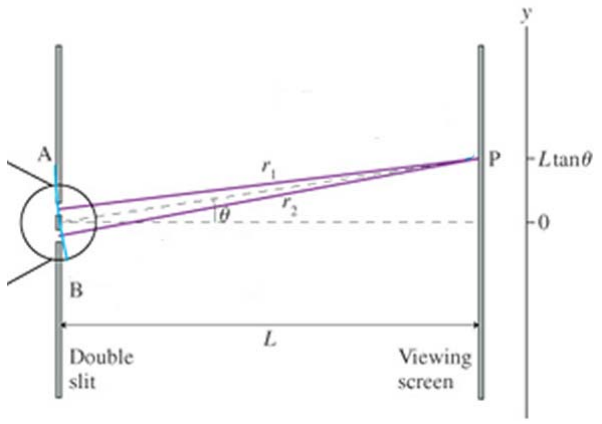
Figure 22.4 (right part, slightly modified)



25

Constructive Interference

L >> *d*: $d\sin(\theta_m) = m\lambda,\ m = 0,1,2,3,\ldots$

θ small: $\theta_m = \dfrac{m\lambda}{d},\ m = 0,1,2,3,\ldots$

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

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