Lecture #3

Waves and Interference

PHYS102

January, 25th

Tues., January 18th: Lecture #1 Introduction to Course.
Thurs., January 20th: Lecture #2 Waves and the Concepts Describing Them
Tues., January 25th: Lecture #3 Interferences of Waves: Young's Experiment.
Thurs., January 27th: Lecture #4 Traveling Waves; Longitudinal vs. Transverse Waves,
Tues., February 1st: #5 Diffraction
Thurs., February 3rd, #6 Electromagnetic Waves
Tues., February 8th; #7 Review Meeting
Thurs., February 10th: Exam 1

Lecture objectives

1) Review of the basic concepts of waves.

2) The nature of interference.

3) The Thomas Young Experiment of 1801.

Workshops

They begin this week!
Subject of both the Wednesday and the Friday workshop:
Interference

Labs meet in Room 110.

Why is the interference important?

Observation of *interference* is a
method of detecting that a particular phenomenon is a wave.

Example: How did we first discover that light is a wave?

Experiments showing *interference* revealed this.

Review of Basic wave Concepts

a) The **frequency** f: This is the number of full cycles per time, performed by the wave.

Note: The *location* (along the wave direction) is fixed.

b) The **wavelength** λ:

This is the distance for a full cycle.
It is taken along the wave-direction.

Note: *Time* is fixed.

c) The **wave-speed** v.

We allow both location and time to vary, now.

The wave-speed v is the speed of the crests.

Recall: A *crest* occurs when the wave-value is maximum.

The Wave-Relation

This relation connects these three quantities. It states:

$v = f\lambda$.

So, if we know any two of these quantities, we can compute the third quantity.

Detection of Waves

Interference is a way to detect waves

Interference

Suppose that more than one wave occupies the same space at the same time.

Then, the wave values *add*.

This is the **superposition principle.**

Example

We have two waves.

Suppose that the crest of the first overlaps the crest of the second.

Then, the effect is that the net wave has *increased* amplitude at this point and time.

This is **constructive interference**.

$d \sin \theta = m\lambda$, $m = 0, 1, 2, 3, \ldots$

d=the distance between slits

- **Second Example**

- Suppose the *crest* of one wave overlaps the *valley* of another.

- Then, the net wave has its amplitude *reduced.*

- This is **destructive interference**.

$d \sin \theta = (m+1/2)\lambda$, m= 0, 1, 2, 3, …

Demonstration of Interference

The *interference model.*

Two sinusoidal waves superpose on each other.

When the waves are *in-phase*, we have **constructive interference**.

When the waves are 180 degrees out-of-phase, we have **destructive interference.**

Controversy: Is light a particle or a wave?

Newton: **Particle**

Descartes: **Wave**

The issue was settled in 1801 by the experiment of Thomas Young.

Light passes through two holes.

Demonstration: The Young Experiment

Observe: Some places light adds, at other places it cancels.

This would not happen if light is a particle.

If so, the intensity would always add.

Find: The wavelength of light.

Pick any point on the screen. Call it P.

Measure distance from P to the first slit. Call it $d_{1.}$

Repeat for the second slit. Call it $d_{2.}$

Let ΔD be the path difference.

That is,

$$\Delta D = d_1 - d_2.$$

How ΔD varies, as point P changes.

For the center of the screen, $d_1 = d_2$ and so $\Delta D = 0$.

The same # of wavelengths is needed to reach P, from slits 1 and 2.

The waves arrive *in-phase*.
There is constructive interference.
(reinforcement).

See a bright spot.
the screen-center is a point Q such that $\Delta D = ½ \lambda$.

The two waves arrive 180 degrees out-of-phase. There is destructive interference (cancellation).
See a dark spot.

Measure the distances d_1 and d_2 for point Q. Compute $\Delta D = d_1 - d_2$.

Require $\Delta D = ½\ \lambda$.
Solve for λ.

Result: The first accurate measurements of the wavelength of light.

Find λ is between 400 and 700, in units of nanometers (nm).
1nm = 10^{-9} meters.

The differing values of λ correspond to different colors of the light.