Lecture 24

Mon Warm Up 10

Tues: Discussion / quiz

Supp Ex 81, 82, 83, 84, ~~85, 86, 87, 88~~ 85, 86, 87

Interference of light / waves

Electromagnetic theory predicts that light is a wave but can we do experiments that just involve intensities to reveal such wave properties? A general phenomenon associated with all waves, called interference of waves will provide an answer.

To illustrate this consider two pulses on a string or slinky that approach each other

Demo: PhET W.O.S

* loose end
* damping 0 , tension = ~~medium~~ low
* manual

We observe:

1) the pulses eventually pass through each other as though they had never interacted.

2) while they overlap they combine to form a new, more complicated pulse called a superposition.

The rule for determining the superposition profile is:

> At any instant, and at a particular location:
>
> displacement of superposition = sum of displacement of constituent waves at that location.

Demo: Slides 1, 2 (Interference)

Quiz 1 95% – 100%

Quiz 2 100%

The same basic rule applies to continuous waves.

Demo: Slides 3 → Slides (General Interference I → V)

There are two important extremes

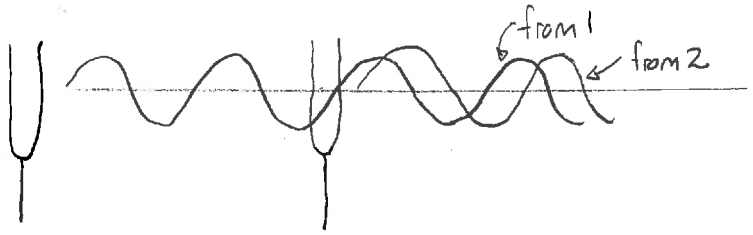
1) Constructive interference – crests of two waves coincide
troughs of two waves coincide
– waves add perfectly

2) Destructive interference – crest of one always meets trough of another
– waves subtract perfectly

Demo: Slides Constructive / Destructive

Such phenomena exist for all waves and we ask how they can be observed. One way involves using two sources to superimpose two signals.

For example with sound waves.



Demo: Two tuning forks

The type of interference depends on:

1) the relative distance or "shift" between the sources, Δr
2) the wavelength of the sources, λ

Demo: Slides with shifts

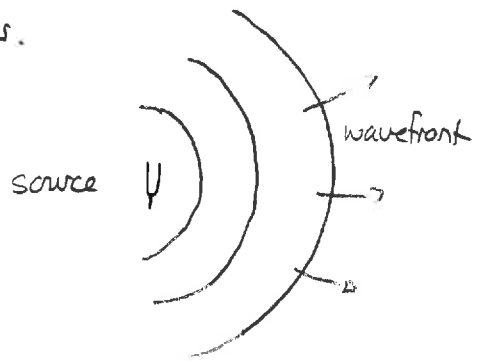
Then

Constructive interference occurs when	$\Delta r = 0, \lambda, 2\lambda, 3\lambda, \ldots$
destructive " " "	$\Delta r = \frac{\lambda}{2}, \frac{3\lambda}{2}, \frac{5\lambda}{2}, \ldots$

Quiz 3 @ 70%

Demo / Video

Now consider a two dimensional version of this. In this case waves propagate spherically from the source and we will have to consider two such waves. The two dimensional nature will complicate the pattern.



Demo: PhET Wave Interference

- ~~light — two sources~~ First water

sound

The demonstration shows entire lines along which destructive interference occurs. These are called nodal lines. There are also entire lines along which waves interfere constructively and these are called antinodal lines. Where these are produced will depend on:

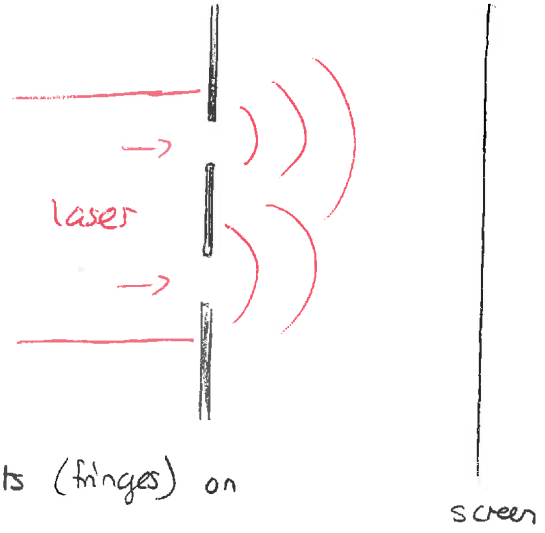
1) separation of the sources
2) wavelength of waves

Demo: PhET - use meter

- vary separation, λ - observe change in pattern

Interference of light / double slit

We can engineer two overlapping light waves by shining laser light onto two narrowly spaced slits



Demo: PASCO slits + laser

This produces a pattern of dark and bright spots (fringes) on the screen. The explanation is

1) incident light consists of a wave
2) the wave propagates spherically beyond each slit
3) these two waves overlap and interfere. Along some directions they interfere constructively, along others destructively.

Slide - overlapping waves

The first fundamental conclusion from this is:

Light behaves like a wave