Mon: HW by 5pm

Weds: Read 9.4 - 9.6

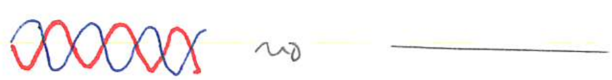
Fri: HW by 5pm

Interference of waves

It is possible to produce two or more overlapping wave patterns on a given medium. In this case the resulting disturbance is a single superposition, which is determined by adding the contributing wave patterns. In general two continuous (sinusoidal) waves with the same wavelength will produce a superposition that is also a continuous wave but whose amplitude is determined by the way that the individual waves overlap. The extremes are:

1) constructive interference (perfect match) ⇝ larger wave

2) destructive interference (perfect mismatch) ⇝ no wave



In order to observe this we need to create conditions where two or more waves overlap. This is often done in situations where the waves propagate in two dimensions

DEMO: Wave Interference PhET

- Slits
  - space the slits about 2.5 cm from source
  - separation 4cm
  - use meters along constr /destr

Demo: Loyola Univ Video - after about 20s.

Slide 1

Quiz 1 30%

Solution Slide

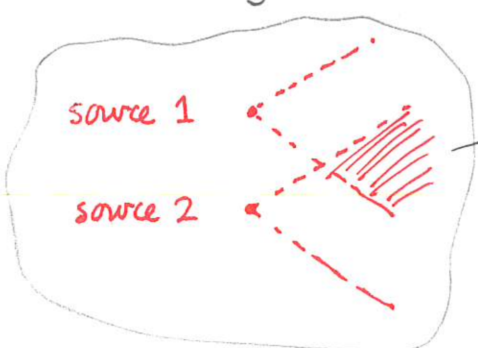
We see that the way to explain the pattern produced by overlapping water waves is to use interference of waves. The nature of the pattern depends on:

1) wavelength of waves
2) separation of slits

DEMO: ~~Sl~~ PhET Wave Interference
- Slits - vary frequency - observe pattern change
  - vary slit sep - " " "

Interference of light

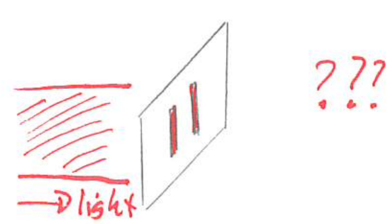
Suppose that we try an analogous experiment with light. We could try to produce overlapping beams / cones of light from two sources



Light overlaps here

→ What sort of pattern does light produce? Is there constructive and destructive interference?

We can do this by shining light on a barrier that contains two slits. We can ask what we may observe beyond the barrier. We first assume that light travels as particles.



Quiz 2 80%

On the other hand, if light was a wave then each slit would produce a wave that radiates outward. The wave crests would form circular patterns. These would overlap and interfere just as water waves.

DEMO: PhET Wave Interference

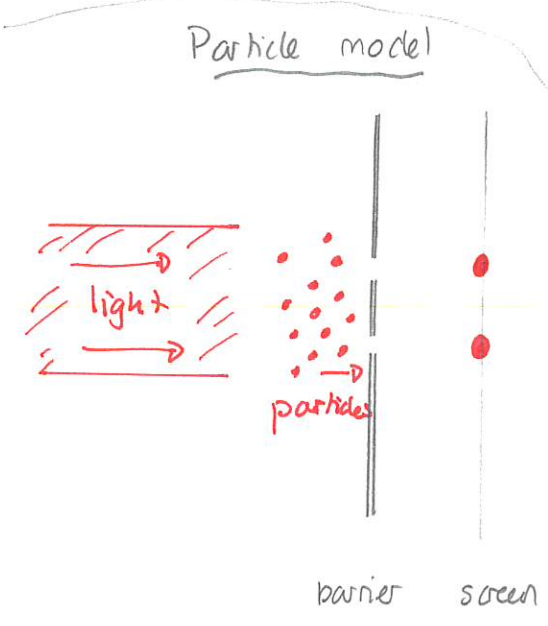
- Slits tab
- Two slits
- Screen
- Use default.

Slide 2

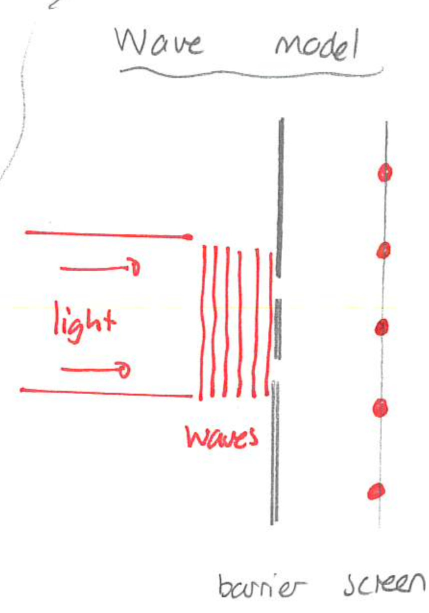
Now consider predictions of the two models of light: particle and waves.

Quiz3 60% →

So we have very different predictions



Predicts: * Two bright spots
* None across from middle



Predicts: * More than two bright spots
* one across from middle

DIFFERENT

We simply need to do the experiment and check which outcome occurs.

DEMO: Laser and Double Slit

The experiment reveals that the predictions of the wave model are correct. There are many other interference experiments that can be done with light. These all reveal

> Interference experiments with slits and other ways of combining light strongly suggest that light behaves as a wave.

Beyond addressing the nature of light, interference experiments can give extremely precise information about wavelengths, frequencies, etc,... of light.

1 Interference of Light

The PhET animation "Waves Interference" allows you to visualize interference of light. Find the animation at

https://phet.colorado.edu/sims/html/wave-interference/latest/wave-interference_en.html

and open it. Adjust the settings as follows:

- Select the "Slits" option.
- In the middle control panel on the right, select light (rightmost).
- In the middle control panel on the right, check Screen and Check Intensity.
- In the bottom control panel on the right, select "Two Slits."
- Adjust the slit separation to 1000 nm.
- Hit the green button to produce light.

a) How many bright bands do you observe on the screen?

b) Increase the slit separation to 2000 nm. Describe how the pattern on the screen changed. Did the distance between bright bands increase or decrease?

You will now consider how the pattern depends on the frequency and wavelength of the light. The animation will allow one to adjust the color of the light. The color is related to the frequency. Red light has a lower frequency than green. All frequencies travel at the same speed.

c) Explain whether the wavelength of the light increases, decreases or stays the same as the frequency decreases.

d) Reset the slit separation to 1000 nm. After the pattern has settled, adjust the frequency of the light to the red end of the spectrum. Did the distance between bright bands increase or decrease as a result of the frequency adjustment?

e) Use this to describe whether the distance between bright bands increases or decreases when the wavelength increases.

Answer: a) There are 3

b) The number of bright bands increase, The distance between adjacent bright bands decreased.

c) speed = wavelength × frequency

constant = increases × decreases ⇒ wavelength increases.

d) Distance observed increased.

⇒ As wavelength increases → distance between adjacent fringes increases