Fri: Read 12.1-12.2

HW by 5pm

Light as a wave

We can decide between two competing models of light:

1) light consists of a stream of particles
2) light consists of waves

One way to do this is to shine light onto a barrier that contains narrow openings. When this is done we find that the wave model predicts the resulting intensity pattern correctly.

DEMO: * Laser and slits / openings

* Laser and diffraction grating

These can be described by assuming that light consists of waves and then considering how the waves interfere. This gives:

Light can be described as a wave

We can use interference phenomena to measure the wavelength of light waves. This requires some detailed theory to connect the observed patterns to the wavelength.

Quiz 1 80%

1 Interference of Light

The PhET animation "Waves Interference" demonstrates interference of light. Go to https://phet.colorado.edu/sims/html/wave-interference/latest/wave-interference_en.html and open the animation. 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.

The tape measure can be used to measure the wavelength of light.

a) Drag the tape measure somewhere between the light generator and slits. Stretch it horizontally to a length of 700 nm (anything within 10 nm will be fine).

b) Hit the green button on the light generator to produce light. Adjust the frequency of the light so that the wavelength is 700 nm. You can stop the animation and shift the tape measure to do this.

c) Once you have the wavelength adjusted correctly, observe the pattern on the screen. The intensity graph will show where the two darkest areas nearest to the center are located. Use the grid to determine the distance between these.

d) Repeat parts a) to c) for a wavelength of 350 nm.

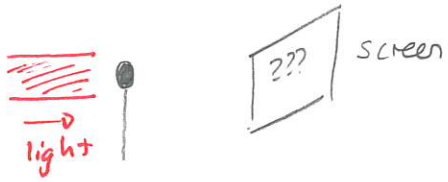
e) How does the separation between the dark bands for the 700 nm case compare to that for the 350 nm case?

Answer: c) about 1800nm

d) about 1000nm.

e) For 700nm it's roughly double that of the 350nm

The phenomenon of interference was first demonstrated for light by Thomas Young in 1801. The complete theory of this interference was developed by Fresnel in the early 1800s. A striking prediction of this theory considered light incident on a small obstacle



Quiz 2

The issue was addressed by Poisson and the theory predicted a bright spot directly opposite the center of the obstacle. This was observed by Arago in 1818. This settled, for this time, the nature of light as a wave. The issue was what sort of wave?

Electromagnetic waves

The complete theory of electricity and magnetism was finally developed by Maxwell in the 1860s. The theory describes how to determine electric and magnetic fields produced by charges and currents

DEMO: PhET Charges + Fields
- show fields produced by small collection of charges

DEMO: PhET Electric Field Hockey

DEMO: PhET Magnets and Electromagnets
Show AC and DC

Quiz 3

Both types of fields can exist in a region where there is a vacuum.

Maxwell was able to manipulate the expressions for electric and magnetic fields in a vacuum. The result was

The theory of electromagnetism predicts that, in a vacuum, there can exist waves of electric and magnetic fields.

Theory predicts that these waves travel at the speed of light.

$c = 3.0 \times 10^8 \text{ m/s}$

Theory predicts that these waves can be produced by accelerating charged particles.

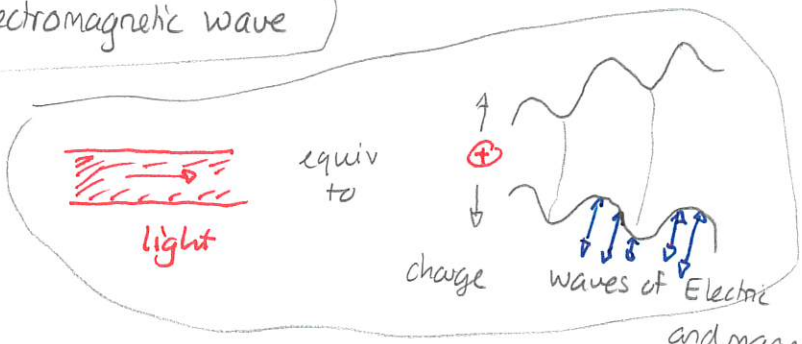
DEMO: PhET Radio Waves

* produce waves.

Thus by the late 1800s the dominant model for light was:

Light is an electromagnetic wave

Quiz 4.



There is an entire range of possible electromagnetic waves, characterized by their wavelengths (or frequencies)

DEMO: Electromagnetic Spectrum

DEMO: Microwave interference video