Refraction of ripples entering shallow water

Demonstration

Shows refraction is caused when plane waves change speed as a result of a change in the depth of water in a ripple tank.

Apparatus and materials

For the class

Motor mounted on beam, with beam support

Glass plate

Hand stroboscope [1]

Nuts or washers, 4

Ripple tank and accessories [2]

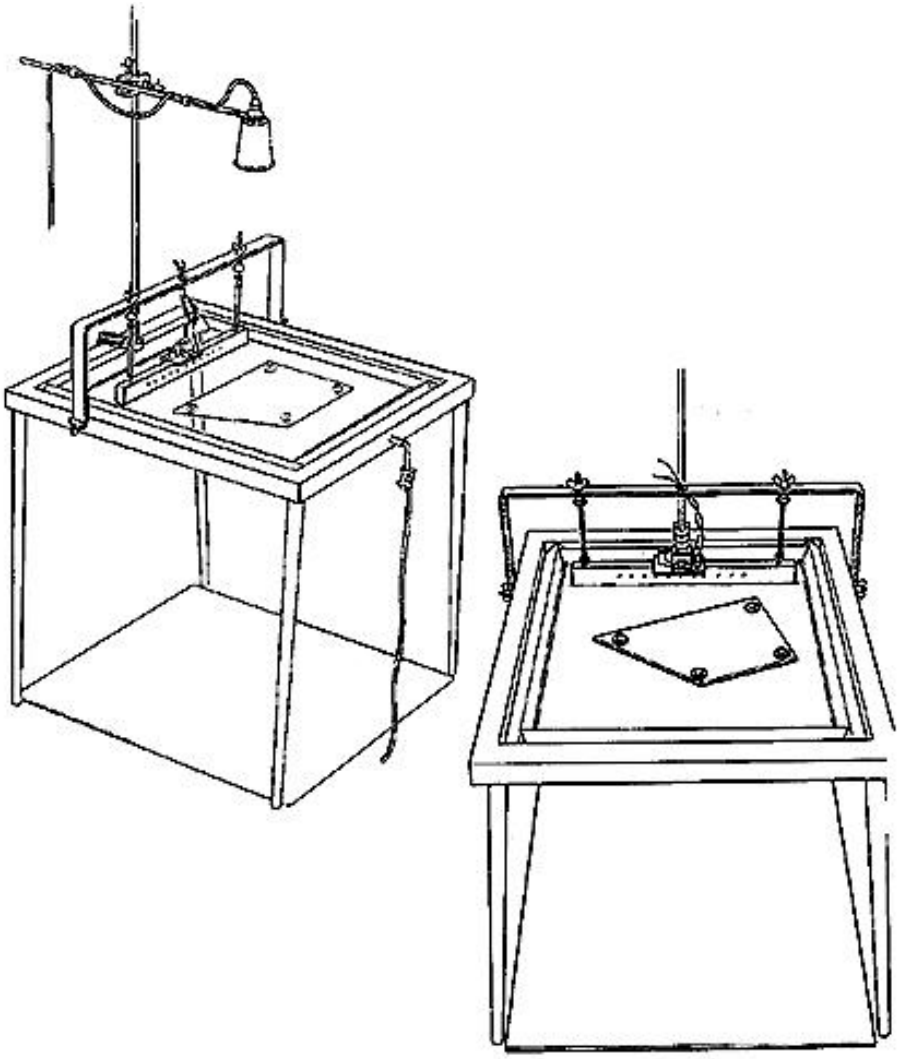
Health & Safety and Technical notes

Beware of water on the laboratory floor. Make sure you have a sponge and bucket handy to mop up spills immediately.

Place the power supply for the lamp on a bench, not on the floor by the tank.

Photo-induced epilepsy
In all work with flashing lights, teachers must be aware of any student suffering from photo-induced epilepsy. This condition is very rare. However, make sensitive inquiry of any known epileptic to see whether an attack has ever been associated with flashing lights. If so, the student could be invited to leave the lab or shield his/her eyes as deemed advisable. It is impracticable to avoid the hazardous frequency range (7 to 15 Hz) in these experiments.

Read our standard health & safety guidance



1 The glass plates should be cut as shown in the diagram above. The nuts or washers act as raisers and should be about 4 mm thick.

The tank and the glass plate need to be very clean and free from grease.

To get sufficient change in wave speed at the boundary with the glass:

- Make the water on top of the glass very shallow.
- Pour water into the tank until it just covers the glass and then drain off a little of it. It may be necessary to re-level the tank to ensure that the film doesn't break up into puddles.
- Use a low frequency, long wavelength (about 10 rev / second).

2 To get sharp waves, adjust the height of the vibrator so that it is just below the mean water level. The vibrator should just 'hold up a film of water' when it is still.

Procedure

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a With the glass edge parallel to the vibrating beam, ask students to notice the difference in the speeds and wavelengths as waves cross the boundary.

b Adjusting the glass at various angles to the incoming waves, ask students to notice the directions of the refracted waves. You may want to use a couple of metre rules, to show the change in direction clearly.

Teaching notes

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1 The waves travel more slowly in shallow water because of friction with the bottom.

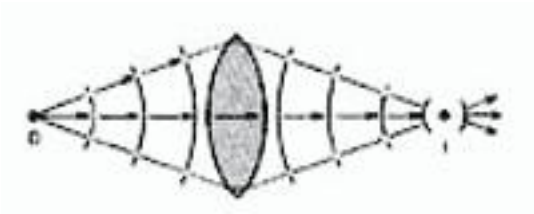
With the glass edge parallel to the vibrating beam, students should notice that the wave speed is reduced and wavelength becomes smaller as waves cross the boundary.

With the glass edge at various angles to the incoming waves, students should notice that the waves change direction as they cross the boundary.

2 What is the pattern? You may want to discuss the change in direction in terms of the 'normal'. The waves bend towards the normal when their speed decreases (and away from the normal when their speed increases). You could go on to compare this with the bending of rays of light as they pass from air to water, perhaps referring to Snell's law.

3 Light - wave or particle? You may even want to conclude: if light consists of waves, the refraction of light shows that it must travel more slowly in water than in air, the opposite of the story for particles. Is refractive index the same for all frequencies? You could repeat 1 and 2 at a higher frequency to show that refractive index may depend on frequency (wavelength).

4 How do lenses work? It is possible to use a piece of glass shaped like a biconvex lens in the ripple tank to show what happens to waves approaching a lens, though this is difficult to see clearly. It may be worth thinking about how the curvature of the wavefront changes entering and leaving the shallow area. In this way, you can build up a wave diagram and predict what will happen. What a lens does is change the curvature of wavefronts.



5 Light - wave or particle? You may even want to conclude: if light consists of waves, the refraction of light shows that it must travel more slowly in water than in air, the opposite of the story for particles.

This experiment was safety-checked in February 2006

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[1] http://www.nuffieldfoundation.org/node/1879
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