

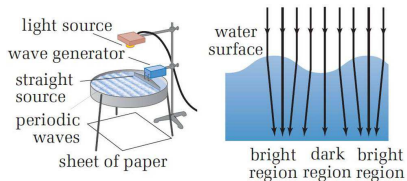
SPH4U UNIVERSITY PHYSICS

THE WAVE NATURE OF LIGHT

☛ Diffraction of Water Waves (P.459-461)

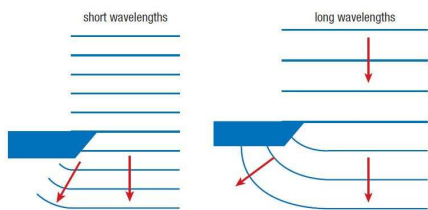
Properties of Waves

In order to study the properties of waves, a ripple tank is used. A ripple tank is a shallow, glass-bottomed tank on legs. Water is put in the tank to a depth of ~ 2 cm. Light from a source above the tank passes through the water and illuminates a screen on the table below. As illustrated, the light is made to converge by wave crests and diverge by wave troughs, creating bright and dark areas on the sheet of paper located below the tank.



Diffraction

If you observe straight wave fronts in a ripple tank, you can see that they travel in a straight line if the water depth is constant and no obstacles are in the way. If, however, the waves pass by an edge of an obstacle or through a small opening, the waves spread out.



Diffraction

Diffraction is the bending of a wave as the wave passes through an opening or by an obstacle. The amount of diffraction depends on the wavelength of the waves and the size of the opening.

short wavelengths long wavelengths

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Diffraction

PRACTICE

1. What do you think will happen if you change the width of the slit but keep the wavelength fixed?

incident waves nearly straight-line propagation incident waves

large opening small opening

as the slit width decreases, the amount of diffraction increases

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Diffraction

PRACTICE

2. What do you think will happen if you change the wavelength of the wave but keep the width of the slit fixed?

incident waves incident waves

small opening shorter wavelength, no change in opening

as the wavelength decreases (or the frequency increases), the amount of diffraction decreases

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Diffraction

PRACTICE

3. When does diffraction become more noticeable?


if waves are to undergo more noticeable diffraction, the wavelength must be comparable to or greater than the slit width ($\lambda \geq w$) – as such, for small wavelengths (such as those of visible light), you need to have extremely narrow slits to observe diffraction

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Diffraction

NOTE!

Diffraction occurs for sound and light waves as well. However, we study the phenomenon first for water waves because their long wavelength allows for easier observation of the effects of diffraction.



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Diffraction

DIFFRACTION

- ❖ the bending of a wave as the wave passes through an opening or by an obstacle
- ❖ occurs for water, sound, light, ...
- ❖ depends on the size of the opening and the wavelength of the wave
 - as the wavelength increases the amount of diffraction increases
 - as the size of the slit increases the amount of diffraction decreases
- ❖ becomes noticeable when $\lambda \geq w$ (or $\lambda/w \geq 1$)

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Diffraction

PRACTICE

4. Explain the difference between the diffractions observed.

(a) $w_0 = 2 \text{ cm}$
 $\lambda = 0.5 \text{ cm}$

(b) $w_0 = 0.5 \text{ cm}$
 $\lambda = 0.5 \text{ cm}$

(a) since $\lambda/w < 1$ then little diffraction occurs
 (b) since $\lambda/w = 1$ then more noticeable diffraction occurs

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Diffraction & Sound

The relationship between wavelength, width of the slit, and extent of diffraction is perhaps familiar for sound waves. You can hear sound through an open door, even if you cannot see what is making the sound. The primary reason that sound waves diffract around the corner of the door is that the sound waves have long wavelengths compared to the width of the doorway (i.e. $\lambda/w \geq 1$).

(a)

(b)

(c)

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Diffraction & Sound

PRACTICE

5. Why do lower frequency sounds diffract more than higher frequency sounds?

lower frequency sounds have a longer wavelength ($\lambda \geq w$) so they diffract more easily around corners

(a)

(b)

(c)

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Diffraction & Sound

PRACTICE

6. If a marching band is approaching on a cross street, which instrument will you hear first, a high pitched piccolo or a low pitched bass drum?

High pitched piccolo short wavelength.

High pitched sounds tend to be more directional because they don't diffract as much.

Low pitched bass drum, long wavelength.

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Diffraction & Sound

PRACTICE

7. Bats use echolocation to detect and locate their prey – insects. Why do they use ultrasonic vibrations for echolocation rather than audible sound?

audible sound has lower frequency (longer wavelength) than ultrasonic – leads to more diffraction and reflections (echoes) that would confuse the bat

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✓ Check Your Learning

TEXTBOOK
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