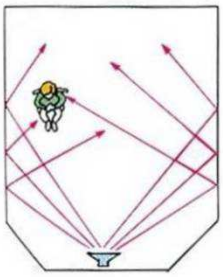
SPH3U UNIVERSITY PHYSICS

WAVES & SOUND

☞ Nature & Sound Waves (P.472-474)

Reflection of Sound Waves

Just as a mirror reflects light, when sound waves radiating out from a source strike a rigid obstacle, the angle of reflection of the sound waves equals the angle of incidence. Thus sound waves conform to the Laws of Reflection.

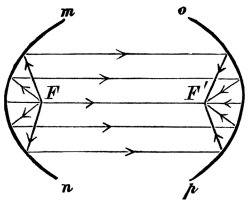


REFLECTION OF SOUND

- sound waves obey the laws of reflection

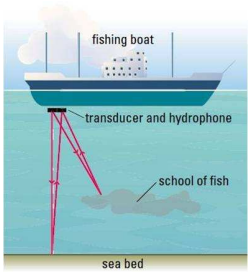
Reflection of Sound Waves – DYK?

Sound waves emitted at the focal point of a curved reflector are reflected in a specific direction. If the sound waves encounter a curved surface, they are reflected to a specific area, and thus, are concentrated. For example, in the dome of St. Paul's Cathedral, whispers can be heard clearly 32 m away.



Applications of Reflection

Echoes *are produced when sound is reflected by a hard surface, such as a wall or cliff. The echo-sounder is a device that uses sound reflection to measure the depth of the sea.*

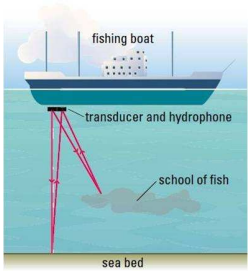


ECHO

- produced when sound is reflected by a hard surface

Applications of Reflection

Similar equipment is used in the fishing industry to locate schools of fish. More sophisticated equipment of the same type is used by the armed forces to locate submarines. All such devices are called ***sonar*** *(sound navigation and ranging) devices.*

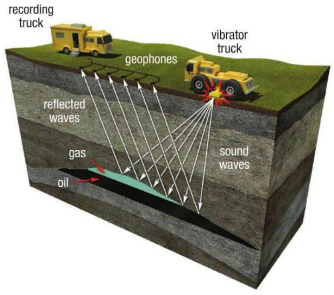


SONAR

- sound navigation and ranging

Applications of Reflection

Sound waves can also be used to study Earth's interior. Most minerals and fuels are deep underground – 1000 m or deeper. Drilling is time-consuming and expensive, so companies will not drill until they are reasonably sure something of value is beneath the ground.



Cats & Sound Waves

House cats have excellent hearing, among the best of any mammal (55 Hz to 79 kHz). They also have large movable pinnae (ears), which help amplify the sound and sense the direction form which the sound is coming. This is extremely helpful in hunting.

Cats & Sound Waves

NOTE!

Cats can see in dim lighting but, in doing so, sacrifice some detail and the perception of some colours. As a result, cat vision is poor up close. They often compensate for this by using their large pinnae to detect the high-pitched noises produced by their prey at the end of the hunt.

Echolocation – Dolphins, Orca Whales, & Bats

Dolphins and orca whales rely on the production and reflection of sound to navigate, communicate, and hunt in the dark and murky waters. The location of an object using reflected sound is called ***echolocation****.*

ECHOLOCATION

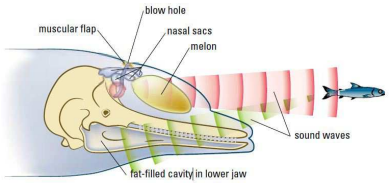
- location of an object using reflected sound

Echolocation – Dolphins, Orca Whales, & Bats

Both animals produce clicks, whistles, and other sounds that vary in intensity, frequency, and pattern. Scientists speculate that the lower frequency sounds (0.5-50 kHz) are probably used for communication, while the higher frequencies (40-150 kHz) are probably used for echolocation.

Echolocation – Dolphins, Orca Whales, & Bats

In the dolphin, the clicks pass through the melon, which acts as an acoustical lens focussing the sound waves in a beam in front of the dolphin. These sound waves bounce off objects in the water and return to the dolphin as an echo. The fat-filled cavities in the lower jawbones then conduct these vibrations to the ear. The brain then receives this information as nerve impulses, enabling the dolphin to interpret the meaning of the echoes.



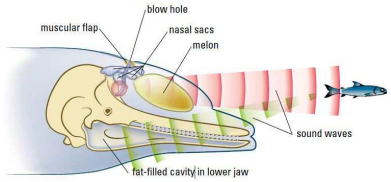
Echolocation – Dolphins, Orca Whales, & Bats

Most bats use echolocation for navigation in the dark and for finding food. The bat can identify an object by the echo and can even tell the size, shape, and texture of a small insect. If the bat detects a prey, it will generally fly toward the source of the echo, continually emitting high frequency pulses until it reaches its target and scoops the insect into its wing membranes and into its mouth.

Echolocation – Dolphins, Orca Whales, & Bats

ECHOLOCATION

- used in sonar applications including:
  - navigation
  - mineral and oil exploration
  - food collection by some animals (dolphins, whales, bats)



Nature & Sound Waves

PRACTICE

1. A woman makes a sound and 3.5 s later, the echo returns from a nearby wall. How far is the woman from the wall, assuming that the speed of sound is 350 m/s?

   d = 610 m

Nature & Sound Waves

PRACTICE

2. A ship is travelling in a fog parallel to a dangerous, cliff-lined shore. The boat whistle is sounded and its echo is heard clearly 11.0 s later. If the air temperature is 10°C, how far is the ship from the cliff?

   d = 1900 m

Nature & Sound Waves

PRACTICE

3. A ship is anchored where the depth of water is 120 m. An ultrasonic signal sent to the bottom of the lake returns in 0.16 s. What is the speed of sound in water?

   v = 1500 m/s

Nature & Sound Waves

PRACTICE

4. Ultrasonic sound is used to locate a school of fish. The speed of sound in the ocean is 1.48 km/s, and the reflection of the sound reaches the ship 0.12 s after it is sent. How far is the school of fish from the ship?

   d = 0.089 km

Nature & Sound Waves

PRACTICE

5. Echolocation only works well when the object is as long as or longer than one wavelength of the sound produced.
   (a) Why do you think bats need to use such high frequencies for echolocation?

   (b) because their prey is so small

Nature & Sound Waves

PRACTICE

5. Echolocation only works well when the object is as long as or longer than one wavelength of the sound produced.
   (b) Estimate the size of the smallest object a bat can detect using echolocation when the air temperature is 22°C. Use a frequency of 110 kHz.

(b) $\lambda_{min} = 3.1 \times 10^{-3}$ m (3.1 mm)

✔ Check Your Learning

TEXTBOOK

P.474 Q.2,6,8
P.397 Q.11

WIKI (SOUND)

- 3U5 - QUIZ#2 (Sound - Part 2)