YEAR 9 SCIENCE

PHYSICAL WORLD: PART 1

LESSON 2: SOUND WAVES

SAMPLE RESOURCES

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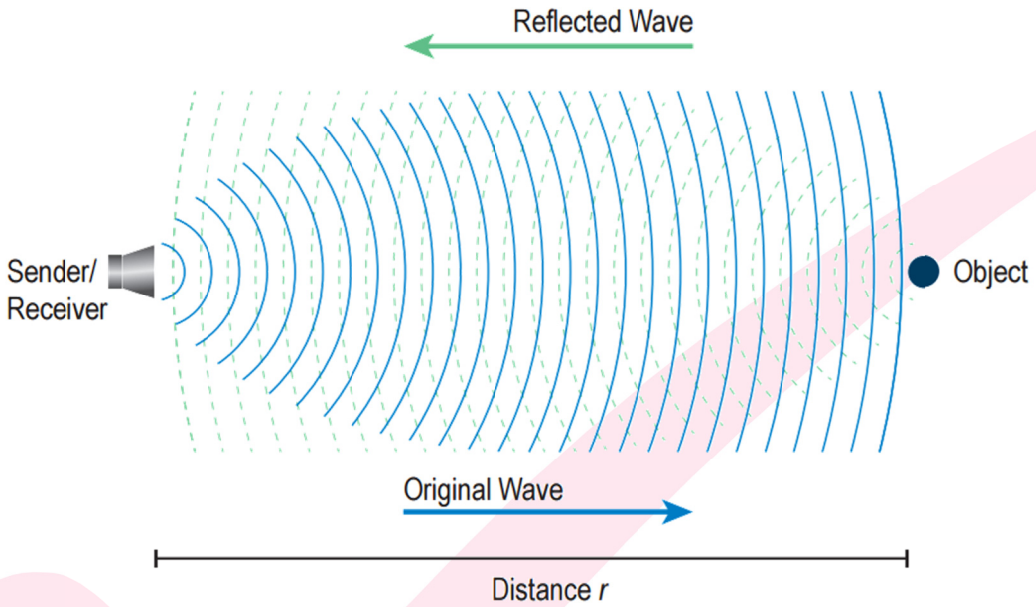
2. Applications of Sound Waves

❒ Echo

- An **echo** is a **reflection of a sound wave**, arriving at the listener some time after the sound was produced.



- Different materials interact differently with sound.
  - Soft and porous material such as foam will absorb sound.
  - Rigid, smooth and non-porous material such as concrete will reflect sound.
  - **DEMONSTRATION:** Sound waves reflecting off different types of materials.

- The exact time it takes for an echo to be heard can be calculated by knowing:
  - The **distance from the source** to the material the sound is reflected off
  - The speed of sound

NOTE TO STUDENTS
The speed of sound through dry air **at room temperature** is a constant value of 340 m/s.

- **Echoes** can be used to **determine how far away objects are**. For example, ships use echoes in navigation to measure how far away the ocean floor is.
  - Sound waves of high pitch (and therefore frequency!) are emitted from a source and reflected off an object some distance away.
  - Suggest a reason why high frequency sound waves are used.[40]

  - The echo produced upon reflection is detected by pressure sensitive detectors.
  - The detectors are designed to measure the time taken for reflection very precisely. This time can be used to calculate how far away the object is located.

$$\boldsymbol{speed = \frac{distance}{time\ taken}}$$

and therefore

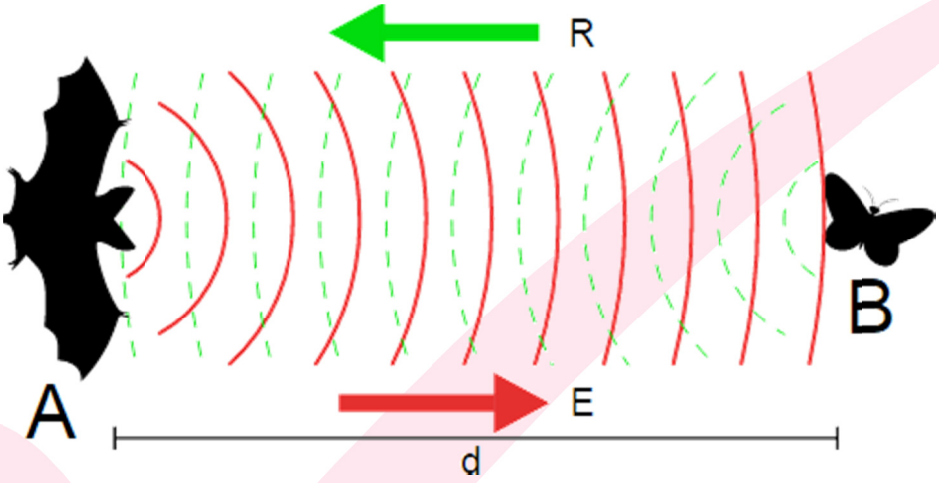
$$\boldsymbol{distance = speed\ of\ sound \times time\ taken}$$

  - The velocity of the sound in the medium is assumed to be constant.
  - Note that the **sound completes a return trip**, **so the distance to the object is half of the distance the sound travels.**

- A source emits an ultrasound wave of frequency 21 000 Hz into a dark cave. Detectors which are set up next to the source receive a signal 8 s later.
  - Assuming the wave travels at 340 ms^{-1}, what is its wavelength?[41]

  - Using the time taken for the detector to receive a signal, determine the distance between the source and the object the wave reflected off.[42]

- Bats are nocturnal animals, meaning they are active during the night. Have you ever wondered how bats navigate in the dark? They use sound waves and echo! This is called **echolocation**.
  - Bats send out sound waves from their mouth or nose.
  - When the sound waves hit an object, they reflect and produce echoes, which return to the bat's ears.
  - Bats listen to the echoes to figure out where the object is, how big it is, and its shape. This helps them avoid obstacles and also hunt food.

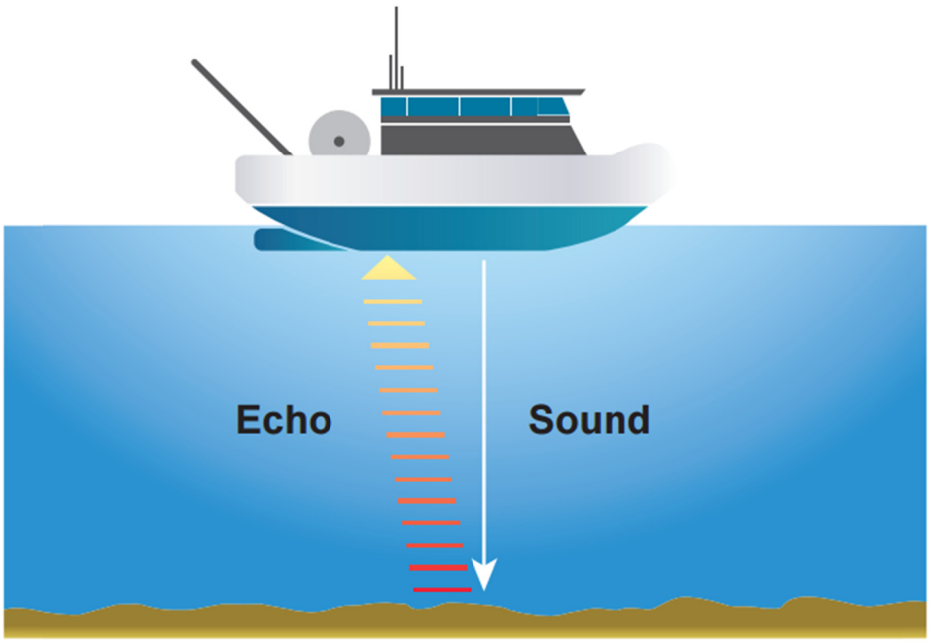


By Bat_echolocation.jpg: Shung Ecolocalizacao_morcego.jpg: José Augusto Bat_shadow_black.svg: Myself Butterfly_black.svg: *Butterfly.svg: JASC's WebDraw derivative work: Marek M (talk) derivative work: Marek M [CC BY-SA 3.0 (http://creativecommons.org/licenses/by-sa/3.0)], via Wikimedia Commons

- **VIDEO (Length 2:55):** Is It Possible? – Real Life Batman.

❒ SONAR

- **SONAR** (**SO**und **NA**vigation and **R**anging) is a technique that uses the emission and detection of reflected sound pulses to navigate, search for and map objects on the sea floor.



  - SONAR can be used to **calculate the depth of a body of water** or **detect objects beneath the surface** by measuring the time taken for the echo to return to the transmitter/receiver.
  - The speed of sound in water is assumed to be constant.

- SONAR is used for a wide range of applications, including:
  - Charting and surveying waters
  - Bathymetry (the study of underwater depth of lake or ocean floors)
  - Detecting explosive dangers underwater
  - Search and rescue missions

- SONAR is particularly powerful for exploring deep bodies of water because sound waves travel further in water than radar and light waves.

- **VIDEO (Length 1:27):** The Bluefin-21 sonar device used to search for the missing MH370 plane.

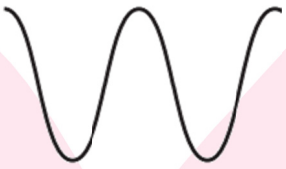
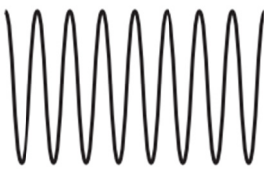
❒ Pitch and frequency

- Music is characterised by **pitch and loudness**.

- **Pitch** is the **perceived fundamental frequency** of a sound. It is a psychological response and therefore cannot be directly measured.

  - The **pitch** of a sound is **how high or low** a musical note or sound sounds to a human.
  - The higher the pitch the higher the frequency and the lower the pitch the lower the frequency.
  - Recall that **frequency (f)** is the number of complete wave cycles (wavelengths) that pass a point per second.

- The table below shows three sound waves of different frequencies (512 Hz, 384 Hz and 256 Hz) and pitches. **Label** them appropriately.

Wave			
Frequency			
Pitch (high, medium, low)			

DID YOU KNOW?

Humans can detect sound with frequencies between 20 Hz and 20 000 Hz. Sounds with a frequency above 20,000 Hz are defined as 'ultrasound'. You can test your hearing here!

❒ Loudness and amplitude

- The **loudness** of a sound is also a psychological response that is difficult to measure. Loudness depends on:
  - The **sensitivity** of the detector (e.g. your ear)
  - The **intensity** of the sound

- The intensity of a sound is proportional to the **amplitude squared**.
  - The higher the amplitude the louder the sound and the lower the amplitude the softer the sound.
  - Recall that **amplitude (A)** refers to the maximum amount of displacement of a particle on the medium from its equilibrium position.

- The table below shows two sound waves of different and loudness. **Label** them appropriately.

Wave		
Intensity (high/low)		
Loudness (loud/soft)		

- **DEMONSTRATION:** A 'wave interference' java applet. Change the amplitude and frequency of a sound wave and see how the sound you hear changes!

- **VIDEO (Length 3:19):** Pitch and loudness of a sound whistle.