PHYSICS 2204
Unit 4: Waves
Worksheet #4: Sound and Its Properties

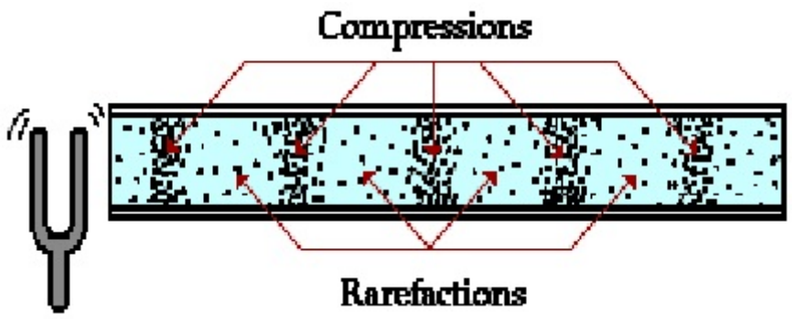
Student Name: _____

What is Sound :

- It is a mechanical wave. It needs a medium to travel through.
- Is a wave which is created by vibrating objects and propagated through a medium from one location to another
- A form of energy made by vibrations.
- When an object vibrates it causes the air particles around it to move.

How does sound travel?

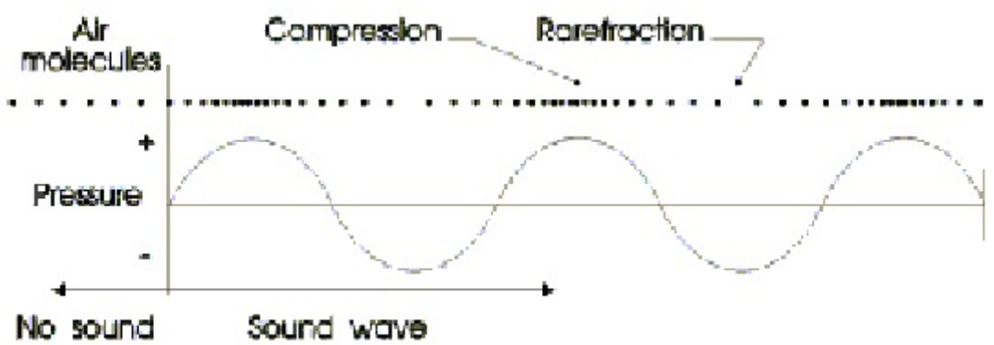
- Sound travels as a longitudinal waves:



Compression: where the particles are close together

Rarefaction: where the particles are spread apart

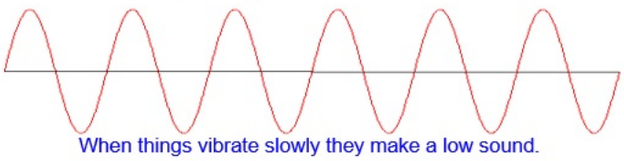
A sound wave is a longitudinal wave but transverse waves are used because they are a lot easier to draw than are longitudinal waves!



Characteristics of sound:

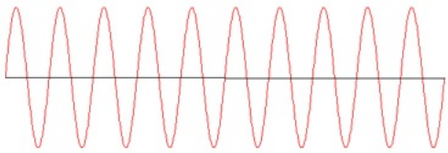
1. Pitch is a description of how high or low a sound . It depends on the frequency of a sound wave.

Low frequency sound waves = low pitch



When things vibrate slowly they make a low sound.

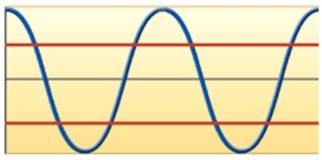
High frequency sound waves = high pitch



When things vibrate quickly they make a high pitched sound.

2. Loudness- how loud or soft a sound is perceived to be. It depends on what we actually hear sounds. A sound wave of greater intensity sounds louder. It depends on the amplitude of the wave

A sound wave with a higher amplitude and energy is perceived as a louder sound.



A sound wave with a lower amplitude and energy is perceived as a softer sound.

Sound Waves, Hearing and the Ear

- The outer ear "catches the sound waves". The middle ear takes the sound waves and "vibrates" the eardrum. The inner ear sends the messages to the brain.
- **Infrasonic frequencies** refers to frequencies lower than 20-25 Hz
- **Ultrasonic frequencies** refers to frequencies beyond 20 000 Hz
- The typical frequency range of human hearing is 20 Hz to 20,000 Hz. Strictly . Therefore, we can not hear infrasonic or ultrasonic frequencies
- **Sonar** stands for **SOund NAvigation Ranging**. It is used in navigation, forecasting weather, and for tracking aircraft, ships, submarines, and missiles.
- **Echolocation** is the use of echoes of sound produced by certain animals to detect obstacles and food. Some of these animals are bats, porpoises, some kinds of whales, several species of birds, and some shrews
- Loudness will depend on both the intensity and pitch of the sound. Frequencies between 1000 Hz and 5000 Hz are perceived to be louder than any other frequencies. This has something to do with the shape of the ear canal leading into our ear drums. The shape of the canal is such that the frequency range 1000 Hz - 5000 Hz is amplified more than any other frequencies.

SPEED OF SOUND

Sound is a mechanical wave. It needs a medium to travel through. Sound travels faster in warm air than in cold air. The speed of sound can be determined at ANY temperature, T, by the equation.

$$v_{sound} = 332 m/s + 0.6(\frac{m/s}{^oC})T$$

V: speed of sound (m/s)
T : Temperature (degrees Celsius)

Example 1:
What would the speed of sound be on a 15 ^oC day?

Example 2:
Suppose you measure the speed of sound in air to be 348.8 m/s. What is the temperature of air?

Example 3:
How far away is the thunderstorm if thunder is heard 4.4 s after the lightning is seen? The air temperature is 20^oC.

ECHOES AND THE SPEED OF SOUND:

An echo is the sound you hear when you make a noise and the sound wave reflects off a distant object. Besides the novelty of hearing your words repeated, echoes can be used to estimate the distance of an object, its size, shape and velocity, as well as the velocity of sound itself

Sound is a waveform made from vibrating matter. The sound wave travels through matter—especially air—in a straight line. When the wave hits a different material, some of it is reflected, absorbed and transmitted through the material. In the case of a sound wave in air hitting a solid wall, most of the sound is reflected.

If the wall is relatively flat, perpendicular to the source of the sound, and far enough away (but not too far), then you can hear the reflected waveform or echo. If the sound comes back in about 0.1 second or longer, you can readily distinguish the echo.

Since sound travels at approximately 300meters per second and if the wall was 15 meters away, the sound would return in 0.1 second. This can be seen from the relationship:

$$v = \frac{d}{t}$$

where

•d = the distance the sound wave traveled back and forth,
•v = velocity of sound, and
•t = the time it takes the sound to go back and forth.

t = 30 m / 300 m/s = 0.1 sec.

(Note that the distance was doubled to show the back and forth motion of the sound.)

That is enough time to be able to distinguish between the noises you made and the reflected sound.

Sonar is based on the concept of Echo. The device is attached to the ship at its base. Then the sound wave is originated from the sonar. The sound wave travels to the bed of the sea, and is reflected from the sea bed and is received by the sonar receiver. This distance traveled is equal to the depth of the sea. It is used to see the obstacle also. It consists of a transmitter and a receiver.

Example 4:

The echo of a ship's foghorn reflected from an iceberg is heard 5.0 seconds after the horn was blown. If the temperature of the air is - 10.0°C, how far away is the iceberg?

Example 5:

How many seconds will it take an echo to reach your ears if you yell toward a mountain 82 m away on a day when the air temperature is 0ºC?

Example 6:

A ship’s horn blasts through the fog. The sound of the echo from an iceberg is heard on the ship 3.8 s later. How far away is the iceberg if the temperature of the air is -12°C?

PART A: MULTIPLE CHOICE

Instructions: *Instructions: Shade the letter of the correct answer on the computer scorable answer sheet provided.*

1. Which of the following is an example mechanical wave?

   (A) Infrared radiation
   (B) Light wave
   (C) Radio wave
   (D) Sound wave

2. Where can sound waves not travel?

   (A) Air
   (B) Steel
   (C) Water
   (D) Vacuum

3. Which of the following quantities is transferred during wave propagation?

(A) Energy
(B) Mass
(C) Matter
(D) Speed

4. If an astronaut popped a balloon on the moon, would his partner hear it?

(A) No, although the sound waves will travel to his partner, the sound waves would not be transmitted through his partner's helmet.
(B) No, the moon has no atmosphere so there is no medium through which the sound waves can be transmitted.
(C) Yes, the air expanding out of the balloon as it popped will transmit the sound waves to his partner.
(D) Yes, the sound waves will first be transmitted through the astronaut's body, then through the ground, and finally through his partner's body.

5. Sound cannot propagate in which of the following?

(A) Solidified air
(B) Vacuum
(C) Water
(D) Water vapour

6. Which of the following transmit energy without transmitting matter?

(A) Baseball bats
(B) Electrons
(C) Protons
(D) Waves

7. What is the source of all sound waves?

(A) Harmonic object
(B) Region of variable high and low pressure
(C) Vibrating object
(D) Wave pattern

8. How do particles move as sound travels through air?

(A) Vibrate along the direction of wave propagation
(B) Vibrate but not in any fixed direction
(C) Vibrate perpendicular to the direction of wave propagation
(D) Do not vibrate

9. How are sound waves like ripples in a pond?

(A) They are both types of electromagnetic radiation.
(B) They travel faster in water than they do in the air.
(C) They radiate outward from a central point.
(D) They have the same wavelengths.

10. Compressions and rarefactions are characteristic of

(A) Longitudinal waves
(B) Transverse waves
(C) Both of these
(D) Neither of these

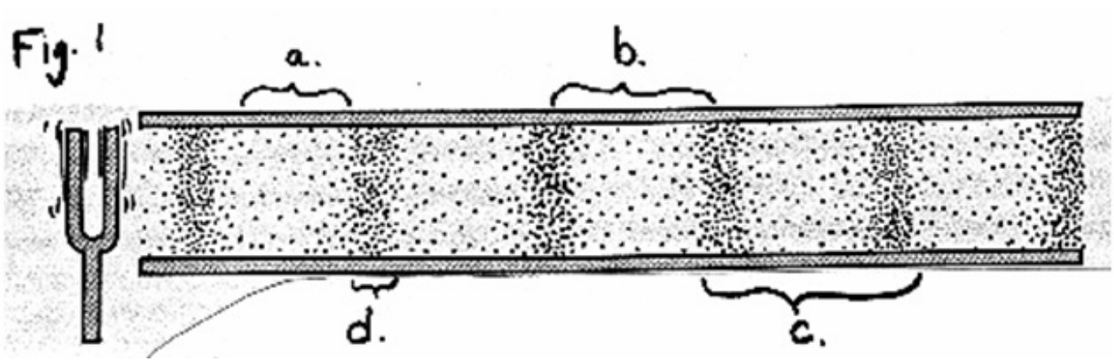
11. A(n) _____ is a high-pressure area of tightly packed molecules.

(A) Compression
(B) Longitudinal
(C) Molecules
(D) Rarefaction

12. A(n) _____ is a low-pressure area of loosely-packed molecules.

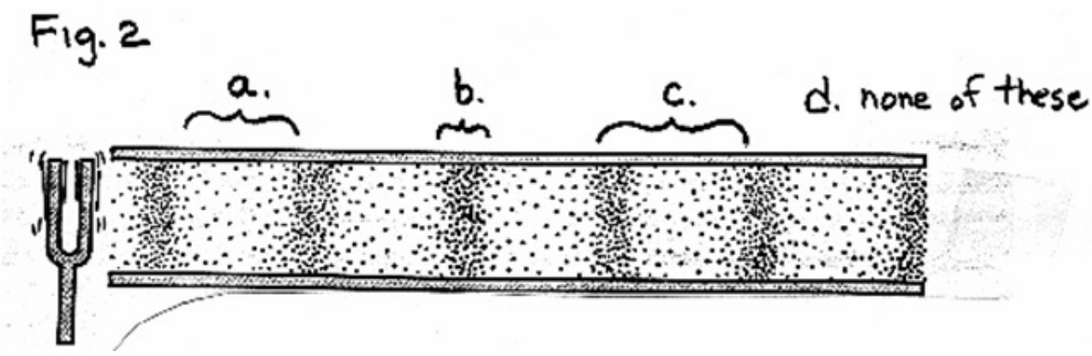
(A) Compression
(B) Longitudinal
(C) Molecules
(D) Rarefaction

13. For the diagram below, which letter shows the correct wavelength for the sound created by the tuning fork?



(A) a.
(B) b.
(C) c.
(D) d.

14. For the diagram below, which letter shows the area of compression for the sound created by the tuning fork?



(A) a.
(B) b.
(C) c.
(D) d.

15. What does it mean when a sound wave's amplitude increases?

(A) Its frequency also increases.
(B) It's moving through a denser medium.
(C) Its wavelength gets longer.
(D) It is carrying more energy.

16. The pitch of a musical sound depends on the sound wave's_____.

(A) Amplitude
(B) Frequency
(C) Speed
(D) Wavelength

17. How is frequency related to pitch?

(A) The higher the frequency of the sound wave, the higher pitched the sound
(B) The higher the frequency of the sound wave, the lower pitched the sound
(C) The lower the frequency of the sound wave, the higher pitched the sound
(D) There is no relationship between frequency and pitch

18. The loudness of a musical sound is a measure of the sound wave's_____.

(A) Amplitude
(B) Frequency
(C) Speed
(D) Wavelength

19. What happens when the amplitude of a wave increases?

(A) The softer a sound becomes
(B) The higher the frequency becomes
(C) The louder a sound becomes
(D) Both (b) and (c)

20 Which of the following increases when a sound becomes louder?

(A) Amplitude
(B) Phase
(C) Velocity
(D) Wavelength

21. A thick tuning fork vibrates at a ____ frequency and creates a sound with a ____ pitch.

(A) High; high
(B) High; low
(C) Low; low
(D) Low; high

22. When a sound can be heard it is called?

(A) Decibel
(B) Ultrasound
(C) Audible
(D) Rarefaction

23. What are the audible range of frequencies for the human ear?

(A) Below 20 Hz
(B) Between 20 and 20 000 Hz
(C) Above 20 Hz
(D) All frequencies

24. What terms describes sounds with frequencies that are lower than 20 Hz?

(A) Infrasonic
(B) Subsonic
(C) Supersonic
(D) Ultrasonic

25. Which of the following refers to sounds with very high frequencies that are used to break down kidney stones?

(A) Infrasonic
(B) Subsonic
(C) Supersonic
(D) Ultrasonic

26. What are sound waves in the range above 20,000 hertz?

(A) Decibel
(B) Intensity
(C) Rarefaction
(D) Ultrasound

27. What instruments use echolocation to locate objects?

(A) Vacuum
(B) Doppler effect
(C) SONAR
(D) Acoustics

28. What technique is used by bats to find their way or to locate food?

(A) Echolocation
(B) Flapping
(C) SONAR
(D) RADAR

29. The speed of sound in air is a function of which one of the following?

(A) Amplitude
(B) Frequency
(C) Temperature
(D) Wavelength

30. The speed of sound in air ____ as the temperature decreases.

(A) Decreases
(B) Increases
(C) Stays the same
(D) Triples

31. For every 10ºC increase in air temperature, the speed of sound in the air

(A) Decreases by 10 m/s
(B) Decreases by 6.0 m/s
(C) Increases by 10 m/s
(D) Increases by 6.0 m/s

32. The speed of sound at 0°C is 332 m/s. What is the speed of sound at 25°C?

(A) 343 m/s
(B) 346 m/s
(C) 350 m/s
(D) 356 m/s

Use the chart below to answer questions 33 to 35:

Speed of Sound in Different Media at 20°C

Medium	Speed
Air	343
Helium	1,005
Water	1,482
Sea Water	1,522
Wood (oak)	3,850
Glass	4,540
Steel	5,200

33. How far does sound travel in 5 seconds through glass at 20ºC?

(A) 908 m
(B) 1,715 m
(C) 4,545 m
(D) 22,700 m

34. How long does it take for sound to travel 3,044 m through sea water at 20ºC?

(A) 0.50 s
(B) 2.0 s
(C) 3.0 s
(D) 9.0 s

35. How far does sound travel in 2.5 seconds through oak wood at 20ºC?

(A) 154 m
(B) 3,825 m
(C) 3,875 m
(D) 9,625 m

36. A sound wave in air has a frequency of 500 Hz and a wavelength of 0.68 m. What is the air temperature?

(A) -18°C
(B) 0°C
(C) 13°C
(D) 27°C

37. An ultrasonic wave is sent from a ship towards the bottom of the sea. It is found that the time interval between the sending and receiving of the wave is 1.6 s. What is the depth of the sea, if the velocity of sound in the seawater is 1400 m/s?

(A) 112 m
(B) 560 m
(C) 1120 m
(D) 1400 m

38. The phenomena of echo of sound wave is due to

(A) Reflection
(B) Refraction
(C) Interference
(D) Diffraction

39. How are echoes produced?

(A) Lightning strikes during a thunderstorm
(B) Sound is absorbed by a material
(C) Sound waves reflect off a body
(D) The eardrum vibrates

40. On a certain day, the speed of sound in air is 330 m/s. A girl stands in front of a cliff and shouts. She hears her echo 6.0s later. Approximately how far away is the cliff?

(A) 25 m
(B) 55 m
(C) 1.0 km
(D) 2.0 km

41. A boy sees a lightning flash five seconds before he hears its corresponding thunder. How far away is the lightning approximately?

(A) 500 m
(B) 1,700 m
(C) 100 m
(D) Immediately above the boy

PART B: WRITTEN RESPONSE

1. While coming home after an early winter walk, you notice a man in the distance chopping wood. As you watch you determine that the sound reaches you 1.20 seconds after the axe strikes the wood. What a great time to check your Physics! A quick temperature check reveals it to be -2.00 °C. How far away is he?

2. Sammy was watching his father sight in his rifle. He used a stopwatch and timed the interval from the flash from the rifle shot to when he heard the sound. He determined the time to be about 4.20 seconds. If the air temperature was -12.0°C on that morning, how far away was Sammy's father.

3. At what air temperature is the speed of sound exactly 342 m/s?

4. How far away is the thunderstorm if thunder is heard 4.4 s after the lightning is seen? The air temperature is 15ºC.

5. The echo of a ship's foghorn reflected from an iceberg is heard 5.0 seconds after the horn was blown. If the temperature of the air is - 10.0°C, how far away is the iceberg?

6. How many seconds will it take an echo to reach your ears if you yell toward a mountain 82 m away on a day when the air temperature is 0°C?

7. On a day when the temperature is -8° C, a boat is traveling at 4.0 m/s towards a cliff. The boat sounds its horn and hears the echo 0.54 s later. How long does the boat have to turn before it smashes to bits on the cliff? HINT: There are several steps including finding the distance to the cliff, the speed of sound and the time needed to reach the cliff.

8. On a day when the temperature is 18° C, a bat is traveling at 20.0 m/s towards a cliff. The bat sends out a sound signal and hears the echo 0.54 s later. How long does the bat have to turn before it smashes its brains on the cliff? HINT: There are several steps including finding the distance to the cliff, the speed of sound and the time needed to reach the cliff.

9. The diagram shows a ship using an Echo locator (SONAR) to find a shoal of fish. The pulsed wave is transmitted from the ship, which is then reflected off the top of the shoal and is then picked up by the receiver. The time taken to receive the echo is 0.2s after transmission. The speed of the ultrasonic wave is 1500m/s. Calculate how deep the ship has to lower its fishing nets to catch the top of the shoal