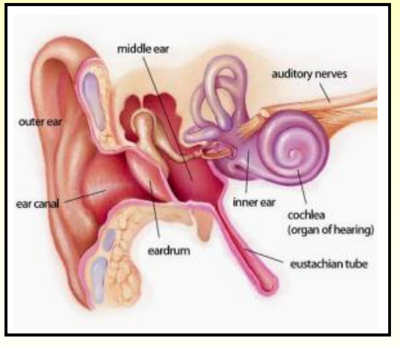
- **SOUNDS** travel as waves which are produced when an object vibrates.

EXAMPLES OF VIBRATING OBJECTS THAT PRODUCE SOUND

- VOCAL CHORDS.
- LOUDSPEAKER CONNECTED TO A SIGNAL GENERATOR.
- A RULER TWANGED ON THE EDGE OF A BENCH.
- A BIRD OR A BUMBLE BEE BEATING ITS WINGS.
- A PLUCKED GUITAR STRING.

- A vibrating object sends out sound waves through the air because its surface **pushes and pulls** repeatedly on the air in front of it. When the waves reach a person's ear, they cause the **eardrum** to vibrate. The vibrations are transmitted to the **inner ear** via the **ossicles** and then to the brain via the **auditory nerve** and so the sound is heard.



- Sound waves require a **material medium** (e.g. air, water, rock) for their transmission.

The fact that air is needed for sound to be heard may be shown by pumping the air out of a 'bell jar' containing a ringing electric bell. As the air is pumped out of the jar, the ringing sound gradually fades away. Eventually the sound cannot be heard even though the striker can still be seen striking the gong.

If the air is let back into the jar, the sound of the ringing bell returns.

This shows that:

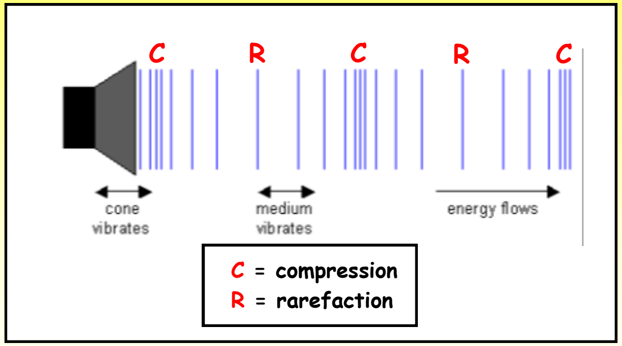
SOUND WAVES CANNOT TRAVEL THROUGH A VACUUM

FREQUENCY RANGE OF HUMAN HEARING

- The **frequency** of a sound wave is the **number of vibrations** produced per second. It is measured in **hertz (Hz)**.
- Young human beings can hear sound frequencies between **20 Hz and 20 000 Hz**.
- Older people generally cannot hear frequencies at the higher end of this range.

SOUND WAVES ARE LONGITUDINAL

In a sounding loudspeaker, the cone vibrates in and out, alternately **pulling** and **pushing** at the air molecules adjacent to the cone. This produces a sound wave consisting of a series of **expansions** (or **rarefactions**) and **compressions** of the air in front of the cone.



- The number of **compressions** or **rarefactions** produced per second is the **frequency (f)** of the sound wave.

- The distance between consecutive **compressions** or **rarefactions** is the **wavelength (λ)**.

REFLECTION OF SOUND

- Sound waves are **reflected** well from **hard, flat surfaces** (e.g. smooth walls or cliffs). The reflected sound forms an **ECHO**.

- When a sound is reflected, it follows the same law as for light reflection (i.e. **angle of incidence = angle of reflection**).

- Echoes can be heard in large halls having bare, smooth walls.

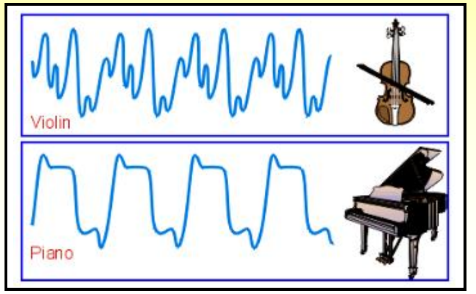
  If the walls are covered in soft fabric, the sound is absorbed and no echoes are heard.
  If the wall surface is rough and uneven, the sound is scattered and no echoes are heard.

MUSICAL SOUNDS

- Musical notes are pleasant to listen to because the sound waveform is smooth and it repeats regularly. With noise, the sound waveform varies randomly in frequency and amplitude and it has no pattern.

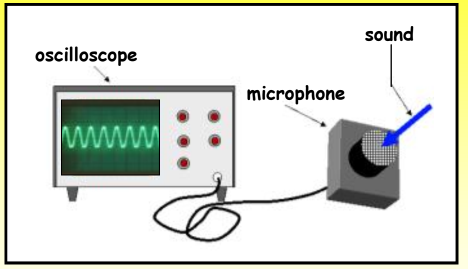
- The same note played on different instruments sounds different because the notes then have a different waveform. We say that the notes have different **QUALITY**.

  This is illustrated in the picture opposite which shows the difference in the shape of the waveform when the same note is played on a **violin** and a **piano**.



OBSERVING THE WAVEFORMS OF DIFFERENT SOUNDS

A **microphone** connected to an **oscilloscope** can be used to show the **waveforms** of a variety of different sounds.



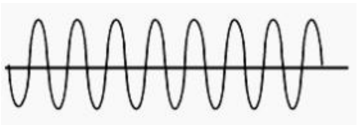
Your teacher will show you the Waveforms produced by each of the following :

- **A sounding tuning fork.**
- **A person speaking.**
- **A loudspeaker connected to a signal generator.**

FREQUENCY AND PITCH

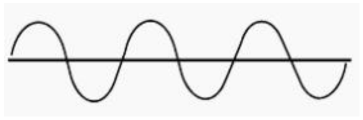
The FREQUENCY of a sound wave is the number of vibrations produced per second.

The HIGHER the FREQUENCY the HIGHER the PITCH.



High frequency = High pitch

For example : A train whistle
A baby's scream
A snake hissing



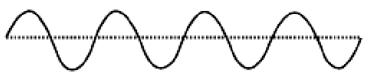
Low frequency = Low pitch

For example : Thunder
An ocean liner's horn

AMPLITUDE AND LOUDNESS

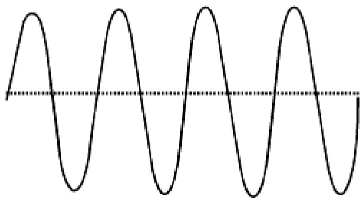
The AMPLITUDE of a sound wave is the peak movement of the Sound wave from its rest position.

The GREATER the AMPLITUDE the LOUDER the sound is.



Small amplitude = soft sound

e.g. A whisper or sigh.



Large amplitude = loud sound

e.g. A large jet aircraft taking off, or a large explosion.

- PRACTICE QUESTIONS

1 Finish the sentences by ringing the correct word from each pair.

- Sound is produced by a **stationary/vibrating** object.
- Sound travels as a **longitudinal/transverse** wave.
- Sound cannot travel through a **pipe/vacuum**.
- Sound travels faster in a **solid/gas** than in a **solid/gas**.

2 Complete the sentences using words from the list below :

Absorbed **reflected** **refracted** **scattered**

(a) An **echo** is heard when sound is .... from a **bare, smooth** wall.

(b) Sound waves are .... by a **rough** wall and .... by **soft fabric**.

(c) Sound waves may be .... when they pass from a layer of **hot** air into a layer of **cold** air.

3 **(a)** What is the **highest and lowest frequency** of sound which humans can hear ?

(b) Describe how a loudspeaker produces sound waves when it is vibrating.

(c) Explain why sound waves cannot travel through a **vacuum**.

(d) Sound waves are **longitudinal**. What does this mean ?

4 **(a)** Which property of sound waves leads to the formation of **echoes**?

(b) State the law which relates the angles of **incidence and reflection** in the case of sound waves.

(c) Explain why notes of the same frequency **sound different** when they are played on **different** musical instruments.

5 **(a)** Most young people can hear sounds in the frequency range **20 Hz to 20 000 Hz**.
Which of the following is the best description of the term **frequency**?

A the maximum disturbance caused by a wave

B the number of complete vibrations per second

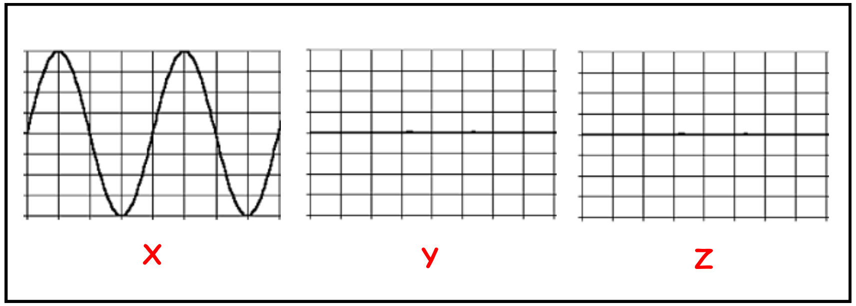
C the distance between consecutive crests of a wave

D the distance travelled by a wave per second.

(b) Diagram X shows a sound wave trace on an oscilloscope screen.

(i) In diagram Y, draw the trace which would be seen for a sound wave of **higher frequency** than that shown in diagram X.

(ii) In diagram Z, draw the trace which would be seen for a sound wave which was **louder** than that shown in diagram X.



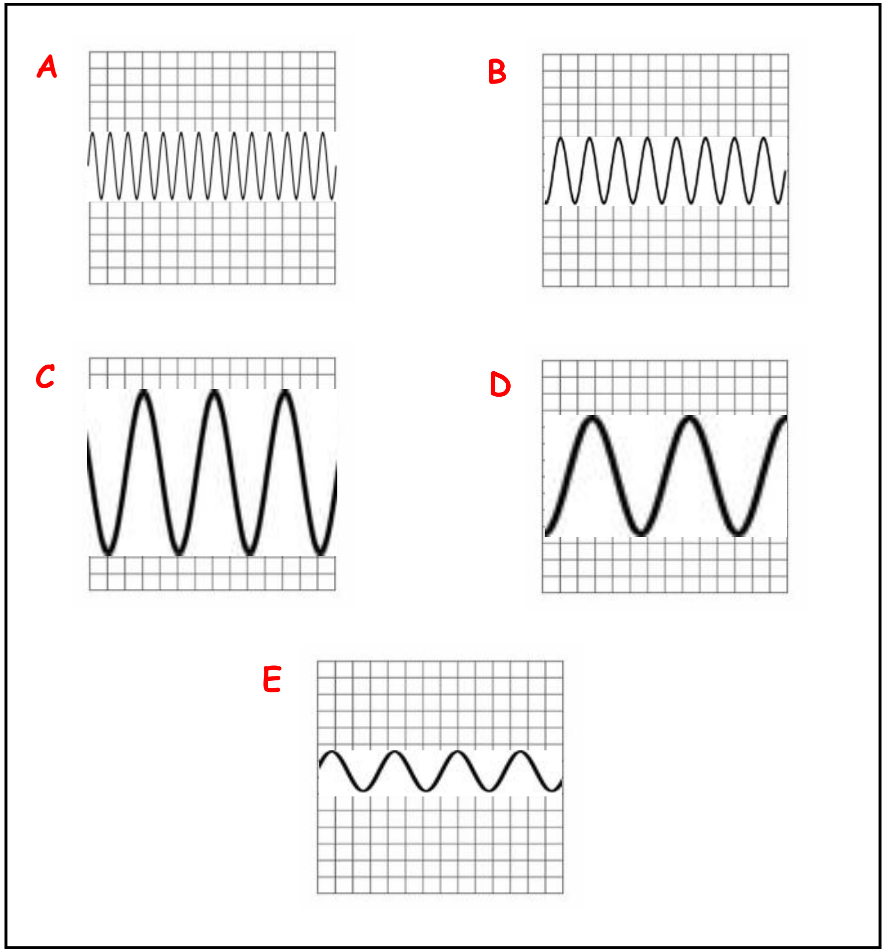
(c) Choose words from the list below to complete the following sentences.

higher **louder** **lower** **quieter**

- A musical note with a higher frequency sounds .... pitched than one with a lower frequency.

- A sound whose waveform has a small amplitude sounds .... than one whose waveform has a large amplitude.

6 Diagrams **A, B, C, D and E** are oscilloscope traces of five different pure notes.



- Which trace is that for the **LOUDEST** sound ?

- Which trace is that for the **HIGHEST PITCHED** sound ?

- Which trace shows the **LOUDEST** and **LOWEST PITCHED** sound ?

- Which trace shows the **LOUDEST** and **HIGHEST PITCHED** sound?