Sound as a Wave

Physics – Leaving Cert

Quick Notes

Sound as a wave

Sound is caused by a vibrating object. The sound travels away from this object as a longitudinal wave.

The vibrating object causes air molecules around it to vibrate, this vibration travels through the air as a series of compressions and rarefractions. When the wave hits the eardrum, the eardrum starts to vibrate with the same frequency – i.e the frequency of the source of the sound.

Proof that sound is a wave – sound shows all the properties of a wave – can be reflected (echo) refracted (heard more clearly on cold night than hot day due to bending of sound in different density air masses), diffracted (sound travels around corners) and shows interference patterns.

Interference of sound:

If two speakers are set up 1m apart and you walk slowly along a line in front of them you will hear louder and quieter areas, due to constructive and destructive interference.

If you strike a tuning fork and rotate it near your ear you will hear a pattern of loud-quiet-loud-quiet etc due to interference between the two waves being produced by vibration of the two prongs of the fork.

Terminology:

Overtones – frequencies which are multiples of a certain frequency

Characteristics of a note:

Loudness – depends on amplitude of the wave

Pitch – depends on the frequency of the wave

Quality – depends on the number and strengths of overtones.

Frequency limits of audibility – highest and lowest frequencies that can be heard by the human ear (20 Hz – 20kHz). (The upper limit decreases with age)

Resonance – the transfer of energy between two bodies having the same natural frequency (natural frequency – objects that are free to vibrate tend to do so at certain preferred frequencies called their natural frequencies)

***Sound intensity – at a point is the rate at which sound energy is passing through unit area at right angles to the direction in which the sound is travelling (I = Power/Area) – measured in watts per metre squared ($W\ m^{-2}$)

***Threshold of hearing – the smallest sound intensity that the average human ear can detect at a frequency of 1kHz.

The sound level intensity – is a scale measuring the amount of sound energy per second carried into your ear. Because this can vary over a large range it is more convenient to use a decibel scale which allows you to represent a large range with a much smaller one. The relationship between sound intensity and sound intensity level is beyond the scope of the leaving cert course but you need to be aware that **when the sound intensity doubles, the sound intensity level increases by 3dB**

Frequency response of the ear

The ear is more sensitive to some sounds than others. The ear responds best to sounds between 2000Hz and 4000Hz.

Hence, even though two sounds can have the same amount of energy, the ear will hear one as louder than the other depending on their frequency. A sound level meter is a device which mimics the response of the ear. It measures sound intensity level but includes a factor for the frequency response of the ear. It uses a decibel adapted scale (dBA).

Noise Pollution

Very loud noises can immediately and permenantly damage your hearing. Long term exposure to lower levels of noise can also damage hearing. Employers have a responsibility to protect hearing in their employees. Guidelines exist to limit the number of hours per day someone μ

***Vibrations on a stretched string.

If a string is plucked, it can vibrate in a number of ways. The simplest mode of vibration is with a node at both ends (fixed points) and an anitnode in the centre. – <u>this string is vibrating at its fundamental frequency.</u>

The string may also be made to vibrate in other modes.

Factors effecting the frequency of a stretched string:

Experimentally it can be shown that

$f \propto 1/l$

$f \propto \sqrt{T}$

$f \propto \frac{1}{\sqrt{\mu}}$

Linking these factors we get that the factors which determine the frequency of a string are given by

$$f = \frac{1}{2l}\sqrt{\frac{T}{\mu}}$$

f = Frequency of the string

l = length of the string

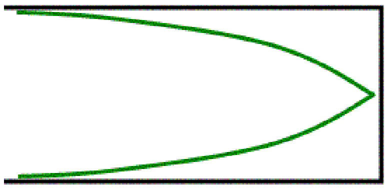
T = Tension in the string

μ = mass per unit length of the string

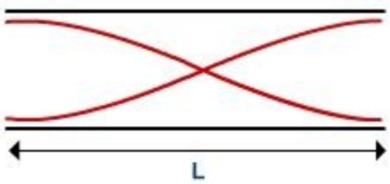
These dependencies can be experimentally verified using a sonometer.

Closed and open pipes.

If a pipe is closed at one end, open at the other, the simplest wave that can be set up in the pipe has a node at the closed end and antinode at the open end.



Antinode **Node**



Antinode