Gleniffer High School

Level 4

Unit 3

Summary Notes

Name:_____

S3 Physics – Unit Three – Summary Notes

Sound Waves

To produce a sound the particles in an object must **vibrate**. This means that sound can travel through solids, liquids and gases. Sound cannot travel through a **vacuum** as it contains no particles.

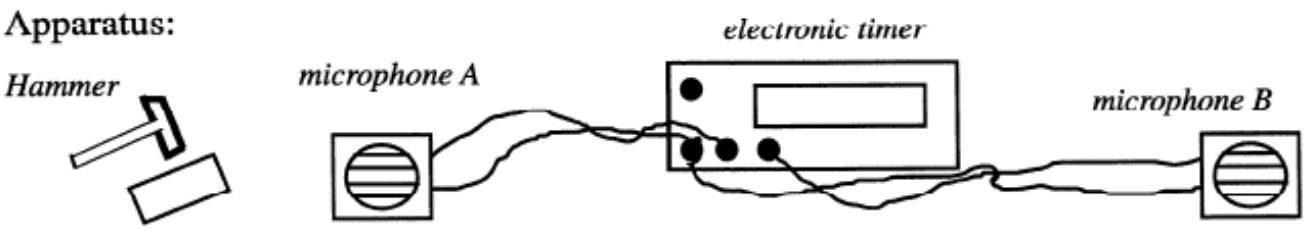
Sound is a wave which carries energy. The number of waves in one second is called the frequency. Frequency is measured in a unit called Hertz (Hz). Most humans can hear sounds in the range 20Hz to 20,000Hz.

High frequency sounds, beyond the range of human hearing, are called **ultrasound**.

Calculating the speed of sound

In a laboratory the speed of sound can be calculated using the formula below.

$$\text{speed} = \frac{\text{distance}}{\text{time}}$$



A loud sound is made. As the sound reaches microphone A, the timer starts; when the sound waves reach microphone B, the timer stops. The distance between the microphones is measured with a metre stick.

Example

Time: 0.0030s, 0.0029s, 0.0031s, 0.0027s, 0.0029s

Average time = (0.0030 + 0.0029 + 0.0031 + 0.0027 + 0.0029s) / 5 = 0.0029s

Distance travelled = One metre =1m

speed = distance / time

speed = 1 / 0.0029

speed = $345ms^{-1}$

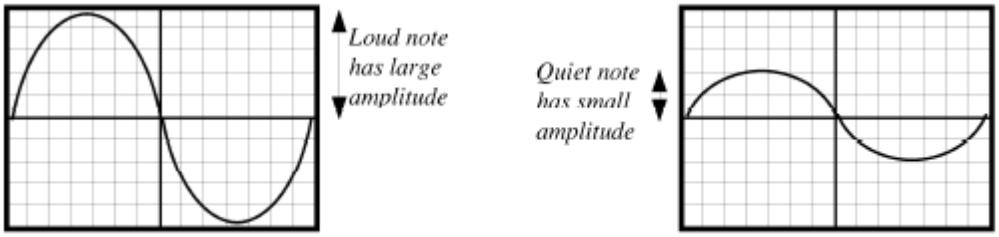
The speed of sound in air is normally quoted as **$340ms^{-1}$** and can be found on the data sheet provided in Unit Tests.

S3 Physics – Unit Three – Summary Notes
CRO Traces

A Cathode Ray Oscilloscope (CRO) is a device that can display a "picture of sounds". The "picture" can give information about the frequency and amplitude of the sound.

Loud and quiet sounds

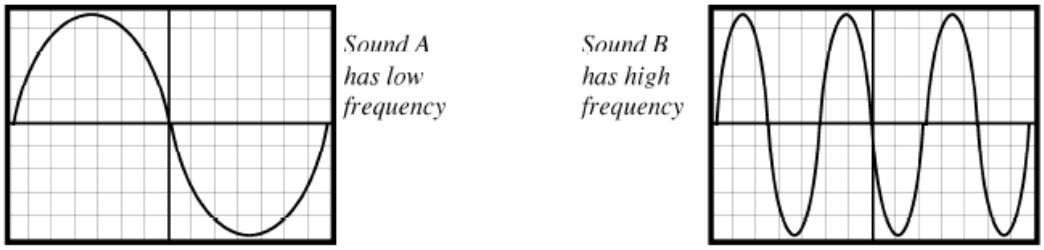
A loud sound transfers more energy so the oscilloscope trace will have a large amplitude. The amplitude of a wave is the distance from the middle of the wave to the top or bottom of the wave.



A soft / quiet sound transfers less energy so the oscilloscope trace will have a small amplitude.

High and low frequency

The effect of changing the frequency of a note can be seen on the oscilloscope screen.



Sound B has a higher frequency than Sound A. Both sounds have the same amplitude.

Noise

Sounds that you do not like or do not want to hear are called noise. If you are forced to hear these noises it is called **noise pollution**. Some examples of noise pollution are:-

- Aircraft
- HGVs
- Pneumatic drills

Loud sounds are the most common type of noise pollution. Loudness of a sound is measured in **decibels (dB)** on a sound level meter.

Some common sound levels are shown below…

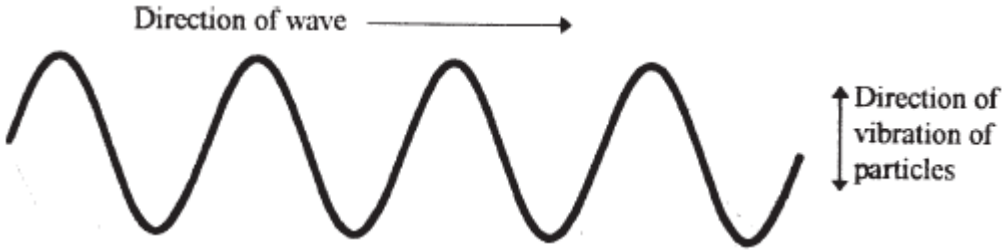
Source of noise	Sound Level (dB)
Threshold of hearing	0
Whispers	30
Classroom	60 to 70
Lorry	90
Rock concert	120
Threshold of pain	140

Hearing damage can happen if you regularly listen to sounds above 90dB. Ear mufflers can be used to reduce the sound level. Ear mufflers work by absorbing some of the energy before it reaches your ear. Noise cancelling headphones can also prevent damage to your hearing. These headphones use electronic components to identify and "cancel out" unwanted background noise.

S3 Physics – Unit Three – Summary Notes

Transverse Waves

A water wave is a transverse wave. The direction of vibration is at right angles to the direction of wave travel. In this diagram the water particles move up and down but the wave travels from left to right.

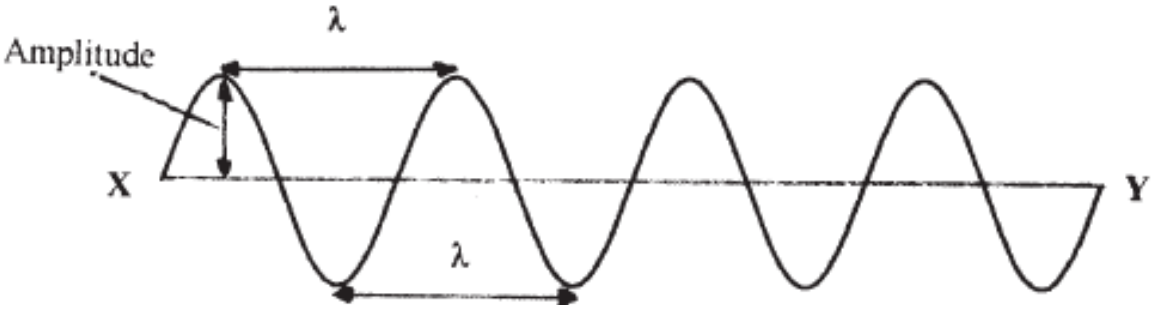


Longitudinal Waves

A sound wave is a longitudinal wave. The direction of vibration is in the same direction as the travel of the wave.

Wave Calculations

A typical wave diagram is shown below: -



For this wave a number of terms can be measured or calculated.

The **frequency (f)** of the wave is the number of waves that pass a point in one second.

The **wavelength (λ)** is the horizontal distance between any two corresponding points on adjacent waves.

The **amplitude** is the vertical distance measured from the middle of the wave to the top or to the bottom.

The **speed** of the wave can be calculated by measuring the horizontal distance between X and Y and dividing it by the time the wave takes to travel that distance.

$$\text{speed} = \frac{\text{distance}}{\text{time}}$$

It is also possible to find the speed of the wave by using the wave equation.

wavespeed = frequency x wavelength

Which is often written as:-

$$v = f\lambda$$

Where,

v = wave speed measured in ms^{-1}

f = frequency measured in Hz

λ = wavelength measured in m

For wave calculations it is important to write down all the information from the question before selecting the appropriate method for calculating the speed of the wave.

Example One

A water wave takes 0.2 seconds to travel 1.6 metres. What is the speed of the water wave?

time = 0.2 s distance = 1.6 m speed = ?

speed = distance ÷ time

speed = 1.6 ÷ 0.2

speed = 8 ms^{-1}

Example Two

If water waves have a frequency of 640 Hz and a wavelength of 0.2 metres, what is the speed of the waves?

frequency = 640 Hz wavelength = 0.2 m speed = ?

speed = frequency x wavelength

speed = 640 x 0.2

speed =128 ms^{-1}

Example Three

A sound wave travelling at 340 ms^{-1}, has a frequency of 2720 Hz. What is the wavelength of the wave?

speed = 340 ms^{-1} frequency = 2720 Hz wavelength = ?

speed = frequency x wavelength

340 = 2720 x wavelength

wavelength = 0.125 m

Example Four

How far does a sound wave travel in air in 15 s?

Time = 15 s Speed = 340 ms^{-1} Distance = ?

speed = distance ÷ time

340 = distance ÷ 15

distance = 5100 m

S3 Physics – Unit Three – Summary Notes

The Electromagnetic Spectrum

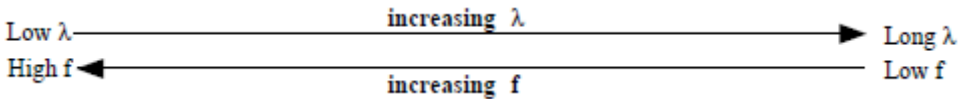
The electromagnetic (EM) spectrum is a family of waves. Like all families the members have lots in common. But each family member is also unique.

The names of the members of the **EM Spectrum** are:-

- Radio
- Microwave
- Infrared
- Visible
- Ultraviolet
- X-ray
- Gamma Ray

All members of the EM Spectrum share two very important characteristics. They travel at the same **speed 3 x 10^8ms^{-1}**. (300million metres per second) They are **transverse waves.**

Although only the visible part can be viewed, all parts can be identified by their frequency or wavelength.



Gamma Ray	X-ray	Ultraviolet	Visible	Infrared	Microwave	Radio

The EM spectrum has many **industrial and medical** applications.
A summary table is shown below.

EM Wave	Detector	Source	Application
Radio	Telescope	Transmitter	Radar
Microwave	Aerial	Transmitter	Mobile phones
Infrared	Photodiode	Lamp	TV remote
Ultraviolet	Fluorescent pigments	The Sun	Reduce acne
X-ray	Photographic film	Particle accelerators	Crystallography
Gamma ray	GM Tube	Radioactive nuclei	Tracers

The members of the EM spectrum are often known as radiations. (You should review your knowledge of radiations from Unit One before the end of unit test.)

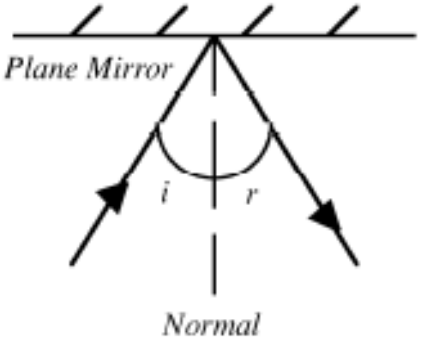
The other member of the EM spectrum is **visible light** which can be easily detected by the human eye. Light has many applications. Perhaps one of the most useful types of light comes from a laser.

Lasers can be used in eye surgery, removing tattoos, “reading” a CD or a bar code and they can even cut metal.

S3 Physics – Unit Three – Summary Notes
Light

As light is a member of the EM spectrum it will behave like a **transverse wave** and travel at **3 x 10^8ms^{-1}** in air. As light travels almost a million times faster than sound, when you witness a thunderstorm the lightning always happens before you hear the thunder.

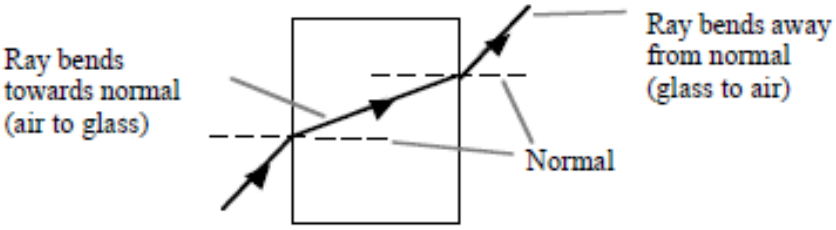
A **plane mirror** can be used to show the **reflection of light**.



i = angle of incidence
r = angle of reflection

This diagram shows the **law of reflection** as the angles i and r are the same size.

Transparent materials can be used to show the **refraction of light**.



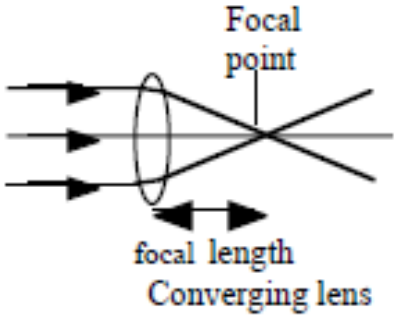
The **light changes direction** as it enters the glass. This is known as refraction of light. The light also changes direction when it leaves the glass.
These changes in direction happen because the **speed of the light changes** when it changes material. The light slows down when it enters the glass and returns to its original speed when it leaves the glass.

ALL LIGHT DIAGRAMS MUST USE ARROWS TO SHOW THE DIRECTION IN WHICH THE LIGHT IS TRAVELLING DUE TO THE REVERSIBILITY OF LIGHT.

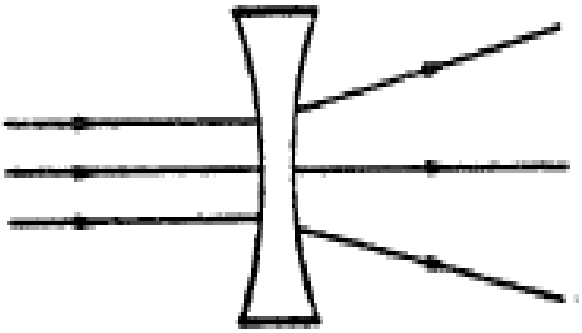
S3 Physics – Unit Three – Summary Notes
Lenses

Lenses can be specially shaped to make use of the light.

When parallel rays of light enter a **convex (converging) lens** the refraction that takes place brings the parallel light rays to a focus or focal point. Convex (converging) lenses are used in spectacles when people are **long-sighted**.



When parallel rays of light enter a **concave (diverging) lens** the refraction that takes place makes the rays of light spread out. Concave (diverging) lenses are used in spectacles when people are **short-sighted**.



S3 Physics – Unit Three – Summary Notes

DATA SHEET

Speed of light in materials

Material	*Speed* in $m\,s^{-1}$
Air	$3{\cdot}0 \times 10^8$
Carbon dioxide	$3{\cdot}0 \times 10^8$
Diamond	$1{\cdot}2 \times 10^8$
Glass	$2{\cdot}0 \times 10^8$
Glycerol	$2{\cdot}1 \times 10^8$
Water	$2{\cdot}3 \times 10^8$

Gravitational field strengths

	Gravitational field strength on the surface in $N\,kg^{-1}$
Earth	9·8
Jupiter	23
Mars	3·7
Mercury	3·7
Moon	1·6
Neptune	11
Saturn	9·0
Sun	270
Uranus	8·7
Venus	8·9

Specific latent heat of fusion of materials

Material	*Specific latent heat of fusion* in $J\,kg^{-1}$
Alcohol	$0{\cdot}99 \times 10^5$
Aluminium	$3{\cdot}95 \times 10^5$
Carbon Dioxide	$1{\cdot}80 \times 10^5$
Copper	$2{\cdot}05 \times 10^5$
Iron	$2{\cdot}67 \times 10^5$
Lead	$0{\cdot}25 \times 10^5$
Water	$3{\cdot}34 \times 10^5$

Specific latent heat of vaporisation of materials

Material	*Specific latent heat of vaporisation* in $J\,kg^{-1}$
Alcohol	$11{\cdot}2 \times 10^5$
Carbon Dioxide	$3{\cdot}77 \times 10^5$
Glycerol	$8{\cdot}30 \times 10^5$
Turpentine	$2{\cdot}90 \times 10^5$
Water	$22{\cdot}6 \times 10^5$

Speed of sound in materials

Material	*Speed* in $m\,s^{-1}$
Aluminium	5200
Air	340
Bone	4100
Carbon dioxide	270
Glycerol	1900
Muscle	1600
Steel	5200
Tissue	1500
Water	1500

Specific heat capacity of materials

Material	*Specific heat capacity* in $J\,kg^{-1}\,°C^{-1}$
Alcohol	2350
Aluminium	902
Copper	386
Glass	500
Ice	2100
Iron	480
Lead	128
Oil	2130
Water	4180

Melting and boiling points of materials

Material	*Melting point* in °C	*Boiling point* in °C
Alcohol	−98	65
Aluminium	660	2470
Copper	1077	2567
Glycerol	18	290
Lead	328	1737
Iron	1537	2737

Radiation weighting factors

Type of radiation	*Radiation weighting factor*
alpha	20
beta	1
fast neutrons	10
gamma	1
slow neutrons	3

S3 Physics – Unit Three – Summary Notes

Prefix	Symbol	Factor
tera	T	1000000000000 $= 10^{12}$
giga	G	1000000000 $= 10^{9}$
mega	M	1000000 $= 10^{6}$
kilo	k	1000 $= 10^{3}$
hecto	h	100 $= 10^{2}$
		1 $= 10^{0}$
deci	d	0.1 $= 10^{-1}$
centi	c	0.01 $= 10^{-2}$
milli	m	0.001 $= 10^{-3}$
micro	μ	0.000001 $= 10^{-6}$
nano	n	0.000000001 $= 10^{-9}$
pico	p	0.000000000001 $= 10^{-12}$

Scientific Notation

Scientific Notation or **standard form** is a way of expressing a number in terms of power of ten. In other words, it's expressed in the form

$$a \times 10^{n}$$

where a is a real number that satisfies $1 \leq |a| < 10$ and n is an integer. a is called the *significand* and n is called the *exponent*.

Please note that the absolute value of a must be at least 1 and less than 10, hence 0.34×10^{2} and -11.23×10^{4} are not in standard form.

Examples of converting numbers to scientific notation

- 1234 becomes 1.234×10^{3}
- -0.000023 becomes -2.3×10^{-5}
- 50000000 becomes 5×10^{7}

Rounding

Some decimal numbers go on for ever! To simplify their use, we decide on a cut off point and "round" them up or down.
If we want to round 2.734216 to two decimal places, we look at the number in the third place after the decimal, in this case, 4. If the number is 0, 1, 2, 3 or 4, we leave the last figure before the cut off as it is. If the number is 5, 6, 7, 8 or 9 we "round up" the last figure before the cut off by one. 2.734216 therefore becomes 2.73 when rounded to 2 decimal places.

If we are rounding to 2 decimal places, we leave 2 numbers to the right of the decimal.
If we are rounding to 2 significant figures, we leave two numbers, whether they are decimals or not.

S3 Physics – Unit Three – Summary Notes

$Q = It$

$V = IR$

$R_{total} = R_1 + R_2 + R_3$ etc

$\frac{1}{R_{total}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$ etc

$P = E/t$

$P = IV$

$P = I^2R$

$P = V^2/R$

$\% \text{ efficiency} = \frac{\text{useful } E_o}{E_i} \times 100\%$

$\% \text{ efficiency} = \frac{\text{useful } P_o}{P_i} \times 100\%$

$E_h = Cm\Delta T$

$P = F/A$

$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

$v = d/t$

$v = f\lambda$

$H = Dw_v$

$D = E/m$

$\bar{v}$ = total displacement / total time

v = displacement / time

$v = u + at$

$F = ma$

$E_w = Fd$

$W = mg$

$E_h = mL_v$