Name: ____________________________________ **Class:** _______

Targets:

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Study Tips - The following summary covers the knowledge and understanding part of the Telecommunications unit. You need to know this material thoroughly - you will be tested on it in the Prelim and Final SQA Exam and this material is your basic starting point for tackling problem solving questions.

Notes - In order to study effectively, it is best to **make your own notes** in some form that allows for self-testing.

How? – Use a Note-taking System
Your objective is to capture on paper the **main facts** and **ideas** so that you can study them thoroughly. Divide an A4 page into a narrow (5 cm) left hand "recall" column and a wide right hand "notes" column. You may also want to leave a margin at the bottom of the page where you can write a one or two sentence summary of all the information contained on that page. The wide column on the right is where you write the notes. Don't crowd them - leave plenty of white space. After completing your notes, read them over and make sure you clearly understand each fact and idea, then, in the narrow column on the left, write a brief, meaningful question (or note down key terms, concepts or formulae).
An alternative is to use a spider diagram (or "Mind Map") as notes or to use "flash cards" with questions on one side and answers and examples on the other. Flash cards are very portable so they are especially useful for testing yourself during spare moments on a bus etc.

It is important to use a method that gets **you** to ask **questions**. The process of asking questions helps you focus on the essential material and helps you understand things more clearly.

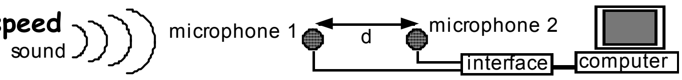
How do I remember it all? - Recitation is the most powerful method known for embedding facts and ideas into your memory.
E.g. if you have written notes as suggested:
Cover the notes in the wide column exposing only the questions in the narrow column.
Recite the answers in your own words. Recite over and over again until you get the right answer

What else can I do? - Practice!
A critical component of physics is solving problems. Work at as many problems as possible, especially exam style questions. **Attempt all the questions in this booklet.**

Section 1 Communication Through the Air and Through Wires.

The speed of sound is very much less than the speed of light. The speed of sound in air is 340 m/s; the speed of light in air is 300 million m/s. So lightning is seen before thunder is heard.

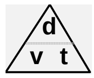
Measuring the speed of sound in air.



When the sound passes microphone 1 the computer timer starts and when the sound passes microphone 2 the timer stops. The distance (d) between the microphones is measured and the speed of sound (v) calculated from the equation:

$$\text{speed} = \frac{\text{distance}}{\text{time}} \qquad v = \frac{d}{t}$$

where d is distance, in metres (m)
v is speed, in metres per second (m/s)
t is time, in seconds (s).



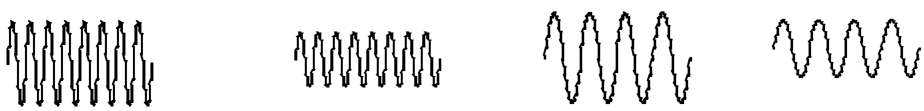
Example: Time from computer = 0.0036 s. Distance between microphones = 1.2 m.
Answer: $v = {}^{d}/_{t} = {}^{1.2}/_{0.0036} = 333$ m/s

Sending a message using code. A Morse code telegraph sends coded messages along wires by pulses of electricity. Different combinations of long and short pulses represent different letters. The pulses can be produced by a simple circuit containing a battery, a switch and a buzzer. Coded messages or signals are sent out by a **transmitter** (e.g. a switch) and are replayed by a **receiver** (e.g. a buzzer).
Advantages of communicating through wires rather than air: messages can be sent over long distances; messages travel very quickly - almost at the speed of light; messages can be more private.

The **telephone** is an example of long range communication using wires between transmitter and receiver. The mouthpiece of a telephone (transmitter) contains a microphone and the earpiece (receiver) contains an earphone (loudspeaker). It is electrical signals which are transmitted along the wires. The **microphone** changes **sound** energy into **electrical** energy and the **loudspeaker** changes **electrical** energy into **sound** energy.

A telephone signal is transmitted very quickly, at a speed of (almost) that of light.
Wave patterns. An oscilloscope can be used to look at sound wave patterns and the patterns of electrical waves in the wires. The greater the height of the wave pattern, the louder the sound. The greater the number of waves, the greater the frequency (pitch).

Example: Loud sound (Large amplitude)	Soft sound (Small amplitude)	Loud sound (Large amplitude)	Soft sound (Small amplitude)



High frequency	High frequency	Low frequency	Low frequency

The **electrical** signal pattern in telephone wires changes when the sound signal changes. If the sound gets louder, the amplitude of the electrical signal increases. If the frequency of the sound increases, the frequency of the electrical signal also increases.

1. What is the speed of sound in air?

2. What is the word for a device which sends out a signal?

3. State two advantages of communicating using wires rather than through air.

4. What is the energy change that takes place in a telephone earpiece?

5. What is the speed of light in air?

6. What is the equation that links speed, distance and time?

7. What is the unit that we use to measure speed?

8. What is the energy change that takes place in a telephone mouthpiece?

9. Draw two diagrams: one showing a wave pattern with a low frequency and the other showing a wave pattern with a high frequency.

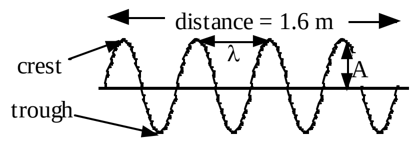
10. What is the effect on the pattern in question 9 if the signals are made louder?

11. Give an example of where we notice that sound and light do not travel at the same speed.

12. What type of signals can be transmitted along wires during a telephone communication?

13. How fast is the signal transmitted along a wire?

Section 2 **Waves**.



Waves carry energy and are one way of transmitting signals.

Frequency (f) is the number of waves which pass a point in one second. It is measured in hertz (Hz). The higher the frequency, the higher the pitch.

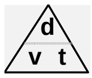
Wavelength is the distance between a point on one wave and the same point on the next wave. Wavelength is measured in metres (m). The symbol is λ (lambda). For the wave above, four waves are 1.6 m so λ =0.4 m.

Speed (or velocity) is the distance a wave travels in one second. Speed (v) is measured in metres per second (m/s).

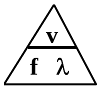
Amplitude: the height of the wave measured from the centre line to the top of the crest or the bottom of the trough. The bigger the amplitude, the more energy the wave carries, the louder the sound. Amplitude is measured in metres.

Calculating the speed of a wave:

Either use **distance = speed x time**



OR **speed = frequency x wavelength**



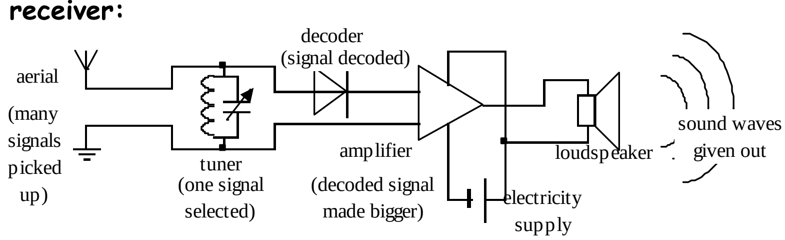
Example: The waves shown in the diagram above are produced with a frequency of 20 Hz. Find (a) their wavelength, and (b) their speed.

Answer:
(a) Wavelength = distance from crest to crest = 0.4 m
(b) speed = frequency x wavelength = $f\lambda$ = 20 x 0.4 = 8 m/s

Section 3 Radio and Television.

Radio and television are examples of long range communication which do not need wires. They carry energy and are transmitted through air at very high speed (300 000 000 m/s - the same speed as light).
The distance travelled or the time taken by a radio wave can be calculated from the equation: distance = speed x time or (where speed is 300 000 000 m/s)

Radio receiver:



Aerial: detects radio waves (of different wavelengths and frequencies) coming from different radio transmitters.

Tuner: adjusted to select 1 station from the many signals of different λ and f.

Decoder: separates the transmitted information (speech or music) from the rest of the radio wave and changes the a.c signal into a d.c. signal.

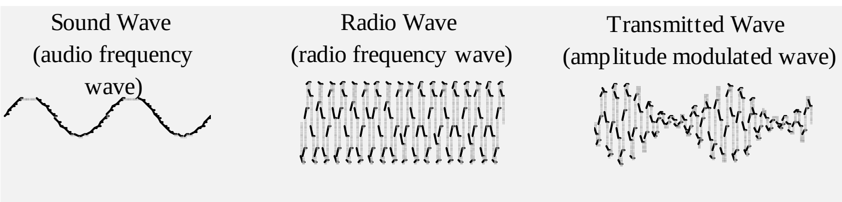
Amplifier: increases the amplitude of the signal.

Electricity supply: provides energy to the amplifier.

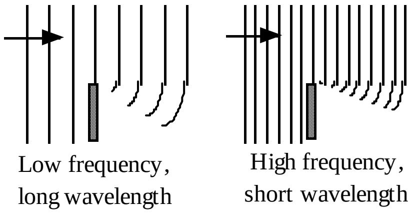
Loudspeaker: changes the electrical waves in the radio into sound waves.
Each radio transmitter can be identified by its wavelength or frequency (e.g. Radio 5 Live 693 kHz, 433 m). The equation $v = f\lambda$ can be used with radio waves.
Since the speed of radio waves in air is 300 000 000 m/s, $f\lambda$ = 300 000 000.

1. Give an example of a long range telecommunication system that doesn't need cables.
2. What do we mean when we talk about the frequency of a wave?
3. Draw the symbol we use for wavelength.
4. What is the equation that links frequency, speed and wavelength?
5. Draw a diagram of a wave and mark in the amplitude.
6. What is the unit we use to measure frequency?
7. What carries more energy; a wave with a small amplitude or a wave with a large amplitude?
8. What do we mean when we talk about the wavelength of a wave?
9. What is the frequency of a wave pattern if 10 waves pass a point in 2 seconds?
10. Wavelength can be measured in ……….?
11. Describe a method of measuring the speed of sound in air (using the relationship between distance, time and speed).
12. A girl sees the flash from a firework that is 600 m away. She hears the explosion 1.8 s later. Use this information to calculate the speed of sound.
13. What is the frequency of a water wave that has a speed of 12 m/s and a wavelength of 3 m?

Radio transmission: The radio station produces a carrier wave which is a high frequency wave. Its amplitude is altered to take on the shape of the low frequency sound wave which is the sound we want to hear. This is called amplitude modulation. The modulated carrier wave is then sent by the transmitter.

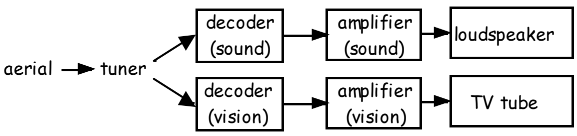


Diffraction: as waves pass the edge of an obstacle, they bend (see diagrams). Waves of long wavelength diffract more than waves of short wavelength. Television waves have shorter wavelength than radio so television reception may be poorer in hilly regions.



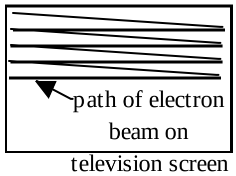
Properties of different radio bands:
Extra low frequency waves (ELF) are able to pass into the sea. Low, medium and high frequency waves are used by radio stations. Some shorter wavelengths travel large distances by reflecting from the ionosphere. Very high frequency waves (VHF) are used for high quality sound transmissions. Ultra high frequency (UHF) waves are used for televisions signals. Microwaves pass straight through the ionosphere and can link with satellites.

Television receiver. The television receiver contains many of the parts found in the radio receiver but requires a separate decoder and amplifier for vision.



Each part performs a similar job in a TV to that carried out in a radio. The TV (or picture) tube converts electrical energy from the vision amplifier into light energy. An electricity supply (not shown in the diagram) is needed to supply energy to the amplifiers.

Producing a picture on a TV screen.
Line build-up: the picture on a television screen is made up of 625 lines. These lines are made by an electron beam moving backwards and forwards across the screen. The lines build up to make a picture.



Brightness variation: Light and dark parts are made by changing the number of electrons in the beam.
Image retention: There are 25 different pictures produced every second. The human eye retains an image for a short time and this image retention ensures that the pictures are seen as changing smoothly.
A colour television screen is made up from three different sets of dots - red, green and blue. Three electron guns are arranged so that each gun can only hit one colour of dot. Different combinations of electron guns with different intensities can light up the dots to give a range of colours.
Colour mixing: red, green and **blue** are known as the primary colours. These can combine to produce other colours. Red + green gives **yellow**; red + blue gives **magenta**; blue + green gives **cyan**. All three primary colours together give **white**.

1. What is the speed of radio waves?

2. What does the decoder do in a radio receiver?

3. What is the energy change that takes place in a loudspeaker?

4. What do we mean by the word diffraction?

5. All the colours on a TV screen can be made by mixing which three colours?

6. How does diffraction of long waves compare with the diffraction of short waves?

7. What feature of our eye allows us to see a series of still pictures as movement?

8. The electricity supply provides energy for which part of a radio receiver?

9. How many lines are in a UK TV picture?

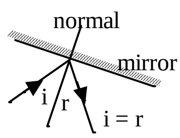
10. In a black and white TV how do we get shades of grey?

11. How is the colour yellow produced on a television screen?

12. Draw a block diagram to show the main parts of the radio.

section 4 Optical fibres

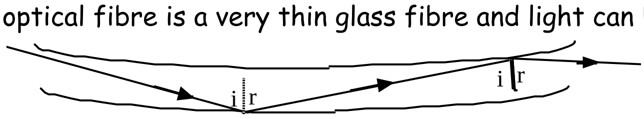
Reflection:



Light can be reflected. When light is reflected from a plane mirror, the angle of reflection is always equal to the angle of incidence. Light travels in straight lines and the path a ray follows is reversible.

Total internal reflection: When light travels from glass into air its direction changes. This is called refraction. However, when light strikes the glass-air boundary above a certain angle, the light is totally reflected and does not pass into the air. This process is called **total internal reflection**. The smallest angle of incidence at which this occurs is called the **critical angle**.

Optical Fibres. An optical fibre is a very thin glass fibre and light can be sent along it. Light travels along **optical fibres** by **total internal reflection**.



Optical fibres can be used to carry telephone messages. Electrical signals are converted into light signals which are sent along the fibres. The light can then be changed back to electrical signals again at the receiver. The light signal travels at approximately 200 000 000 m/s in the fibre.

Example calculation: How long does a signal take to travel along a 2 km fibre?
(Speed of light in glass 2×10^8 m/s).
Answer: $d = v\,t \Rightarrow 2000 = 2 \times 10^8\, t \Rightarrow t = \frac{2000}{2 \times 10^8} = 1 \times 10^{-5}$ s

Optical fibres have many **advantages** over electrical cables. They are **cheaper**; they are much **lighter**; they carry many **more signals** at the same time for the same thickness of cable; there is **little energy loss**, so fewer booster stations are needed; they are free from electrical interference; the signal quality at the end of the cable is much better.

1. Give an example of a telecommunication system which uses optical fibres.
2. At what speed do signals travel in an optical fibre?
3. Give two advantages of using optical fibres over copper wires to carry messages.
4. What is total internal reflection? (A diagram may help)
5. What is the missing word: When light is reflected from a mirror, the angle of ……….. is always equal to the angle of reflection.

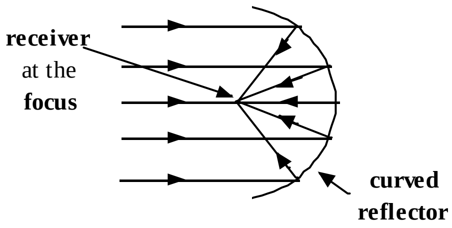
What are the missing words:
To send speech information along an optical fibre we first have to change the sound signals into pulses of …6……… energy. These pulses control a small laser which then produces pulses of light which are ……7……. through the optical fibre.

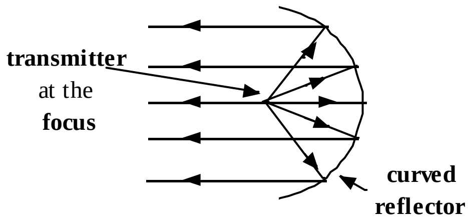
8. What do we mean by the term ‘critical angle’?
9. Why do signals in an optical cable not get affected by electrical interference?
10. What do we mean by the ‘normal line’ when we talk about reflection?

Section 5 Satellites and Dish Aerials.

World wide communication over a long distance is difficult because of the curvature of the Earth. A satellite can be used to send signals for very long distances. The higher a satellite is above the Earth, the longer is its **period** (the time it takes to make one revolution round the Earth).
A **geostationary** satellite stays above the same point on the Earth's surface - the satellite takes 24 hours to make one revolution, the same length of time as the Earth. Signals are sent from a **ground** station to the satellite, which amplifies the signal and sends it back to a different ground station. Three geostationary satellites, positioned evenly round the equator, can relay signals right round the world.

Curved reflectors The curved reflector of a dish aerial has a large area which can collect more energy from the incoming signal and can concentrate it on the detector. If there is no curved reflector, the received signal is much weaker.
A curved surface can also be used to send out a **parallel** beam of microwaves to the dish aerial of a distant receiver.





Curved reflectors have many uses in telecommunication e.g. TV link, boosters, repeaters or satellite communication, all use dish aerials to help transmit information.

1. How does the height of a satellite above the Earth's surface affect the time it takes to orbit the earth?

2. What is the missing word: A curved dish aerial has a large area and can collect more energy from an incoming signal. It then …………. this signal onto the detector.

3. What is a geostationary satellite?

4. How long does it take for a geostationary satellite to orbit the Earth?

5. When making a telephone call via satellite at what speed is the signal sent from the ground station to the satellite?

6. What does the satellite do to the signal when it receives it?

7. What do we mean by the 'period' of a satellite?

8. Give one example of how you could use a curved reflector in telecommunications.

9. Give an example of a telecommunications system that makes use of satellites?

10. How far above the Earth's surface must a geostationary satellite be?