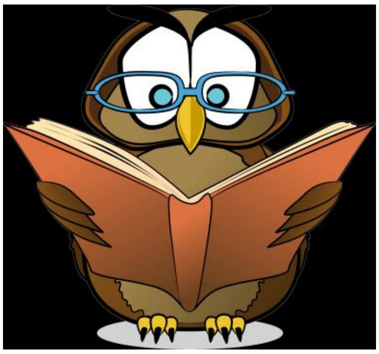


KNOWLEDGE

ST MARY'S SCIENCE DEPARTMENT:

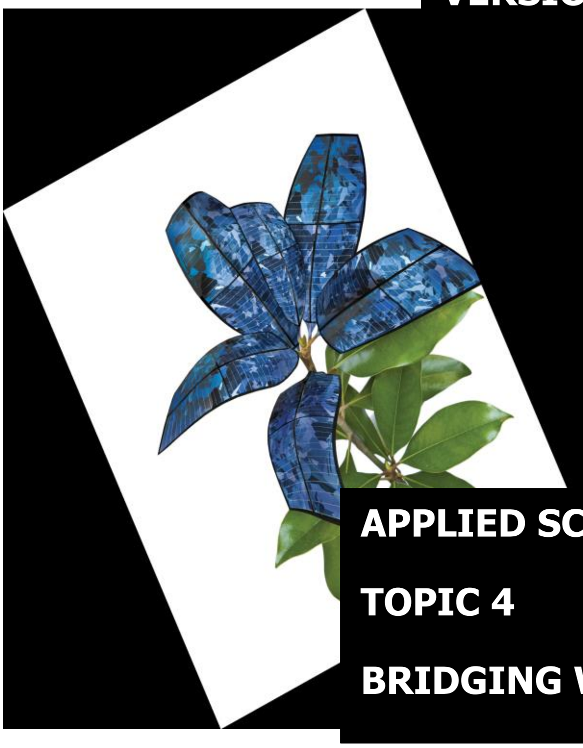
APPLIED SCIENCE

APPLIED SCIENCE BRIDGING COURSE ELECTROMAGNETIC SPECTRUM

WEEK 4

NAME	
CLASS	

VERSION 1.1



APPLIED SCIENCE

TOPIC 4

BRIDGING WORK

THIS MUST BE BROUGHT TO LESSONS AT THE START OF YEAR 12.

WEEK 4
Contents

Overview
This bridging course will provide you with a mixture of information about Extended Certificate Applied Science and what to expect from the course, as well as key work to complete. Students who are expecting to study Extended Certificate Applied Science, and are likely to meet the entry requirements, must complete the bridging course fully and thoroughly, to the best of their ability.
You should complete all work on paper and keep it in a file, in an ordered way. You will submit it to your teacher in September.

All of the work will be reviewed, and selected work will be assessed, and you will be given feedback on it. This work will be signalled to you. If you do not have access to the internet, please contact the school and appropriate resources will be sent to you.

If you are thinking about studying Extended Certificate Applied Science, you should attempt this work to see whether or not you think studying a subject like this is right for you. If you later decide to study Extended Certificate Applied Science, you must ensure you complete this work in full.

This work should be completed after you have read and completed the Study Skills work that all of Year 12 should complete.

Introduction

Welcome to the Science Department at St Mary's Catholic School. I am delighted that you have chosen to study this qualification and hope you feel comfortable with your study environment, and that you value the support you will be given by your teaching staff. This book has been designed to inform you about your programme of study; including the ways you will be assessed and how to fully understand the grade you can achieve on completion.

BTEC courses do work differently to other subjects and you will be expected to work hard both in and out of your lesson to meet coursework deadlines. You will also be presented with many different opportunities to broaden your vocational learning, as this qualification contains a wide range of contemporary topics pertaining to Applied Science. A variety of assessment methods are used, ranging from external exams to course work. Additionally, this BTEC qualification has been designed with employers and representatives from higher education and professional bodies. In this way, the qualification is up to date and covers all of the knowledge, skills and attributes that are required across a range of technical science sectors.

I have high expectations of all students studying this BTEC qualification and all of the teachers in the department have researched and prepared in great depth to ensure that you receive quality teaching. Please use this book to get a feel of what the course is about and to ensure you are fully aware of what is expected of you. The Science Department has planned lots of innovative and creative ways to deliver the programme. This will help to promote your learning and successfully prepare you for the various assessments.

The Science Department has planned an exciting year ahead. We wish you the absolute best in your academic pathway and we look forward to working with you to achieve great success!

Course Overview

The BTEC Applied Science Extended Cerifiicate is a 2 year course comprising of 4 units.

Year 12

Unit 1 – 90 GLH

Unit 2 – 90 GLH

Year 13

Unit 3 – 120 GLH

Unit 10 – 60 GLH

GLH stands for Guideline Learning Hours, and represents the amount of time you will spend on each part of the course, and also how much each unit contributes to the final grade. You will see that Year 12 and 13 contribute equally to the final grade. In Year 12 Units, 1 and 2 are equally split and will take the same amount of time. In Year 13 Unit 3 contributes 66% of the mark and will take 66% of the time.

Each unit is awarded a grade (Distinction, Merit, Pass or Unclassified). Each grade is worth a certain number of marks.

	Unit 1*	**Unit 2**	**Unit 3***	**Unit 10**
Distinction	24	24	32	16
Merit	15	15	20	10
Pass	9	9	12	6
Unclassified	0	0	0	0

*These units are examined. For examined units marks may be awarded between these boundries. These marks are the minimum you need for a grade.

To arrive at your final grade your marks are added together. The final grade boundries are shown in the table.

Grade	**Points**	**A-Level Equivelent Grade**
Distinction*	90	A*
Distinction	74	A
Merit	52	C
Pass	36	E

To gain a pass you must achieve a pass in all units. If you fail a unit you will fail the course regardless of your score.

In units 2 and 10, a numbes of assignments contribute to each unit. Your grade for that unit will be the lowest grade you achieve. For example if you achieved a P, M, D, D in Unit 2, your grade for that unit would be a Pass.

Assessment Schedule

In Year 12 you will complete Unit 1 and Unit 2

Unit 2

This will be taught between the start of the year and Christmas.

You will complete 4 assignments

Assignment A – Titration and Colorimetry.
You will investigate methods to determine the pH of a solution. You will also use colorimetry to determine the concentration of a solution.

Assignment B – Calorimetry.
You will investigate different methods of measuring temperature. You will also use a cooling curve to determine the rate of cooling, and the melting point of different substances.

Assignment C – Chromatography.
You will use chromatography techniques to identify substances in a plant leaf extract and a mixture of amino acids.

Assignment D – Personal Review.
You will produce an assignment evaluating the personal and technical skills that you have developed over the unit.

This unit will be assessed by your teacher. All work must be submitted by the given deadline. A sample of assignments will be moderated by a Pearson moderator. Remember that you must pass the unit to pass the course, and that the grade awarded will be the lowest one you achieve.

You will be given interim and final deadlines for each assignment which must be met.

Unit 1
Unit 1 is made up of Biology, Chemistry and Physics theory, and will be taught by specialist teachers.
The level of difficulty is around that of A-level.

This will be taught between Christmas and May.

You will complete a Biology, Chemistry and Physics exam, each of which are worth 30 marks and last 40 minutes.

Biology

Chemistry

Physics

You are allowed to resit each exam once.

Aim

In this bridging course, we will outline the basic principles of the key topics covered in Unit 1.

In each topic, we will start by reviewing the understanding which you gained in GCSE Science and apply it to more advanced applications found in Extended Certificate Applied Science.

This is not a comprehensive overview of the Extended Certificate Applied Science specification, rather a taster on what is covered throughout the course.

This bridging course should give you an experience of the level you will be expected to study at, at the start of Year 12

Important

Please remember to look after your own wellbeing as you work through this bridging course.

Please take regular breaks as you go through this work.

This work should take approximately 5 hours, so should not be completed in one sitting.

Do not worry or panic if there is something challenging or which you do not understand at first. This is completely normal.

If you do not understand a concept after reviewing this work, please contact Mr. Turnbull on his school e-mail address.

WEEK 4: PHYSICS 2

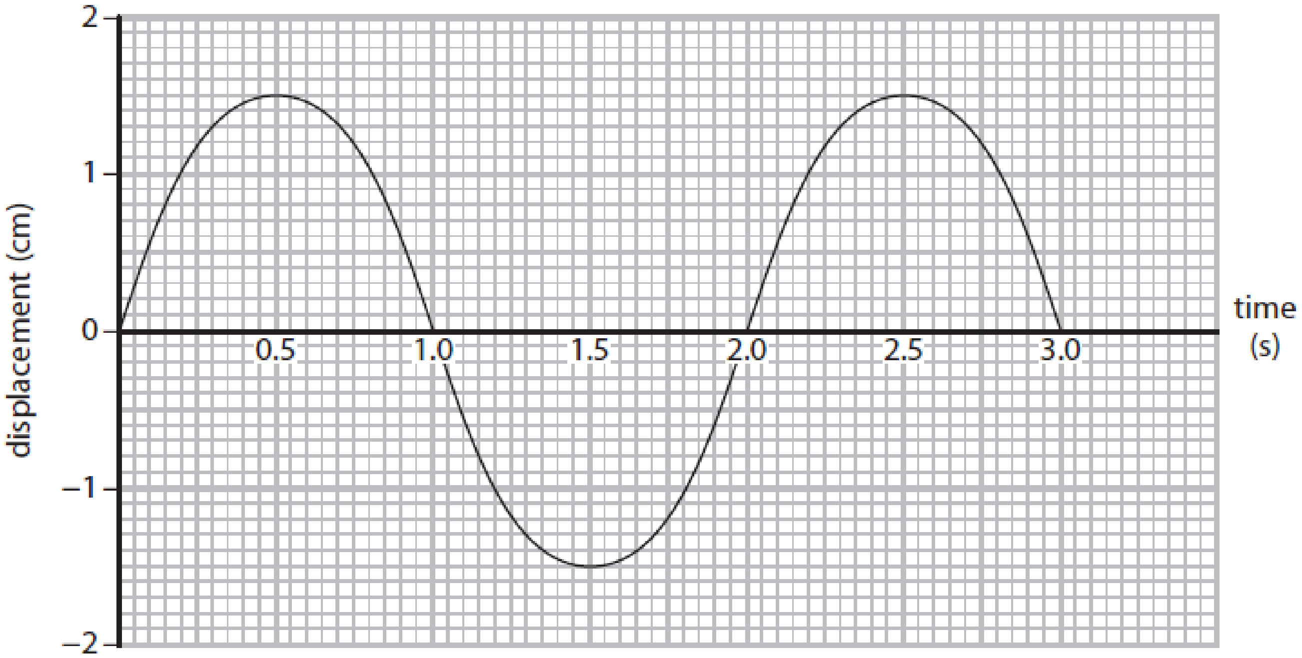
RECAP TASK

In the previous week, we looked at key concepts in the subject of Physics found in Unit 1 of Applied Science.

This included looking at the principles of wave properties, superposition, and wave speed.

To recap and assess your understanding, answer the following questions on these topics.

1. A student uses a cathode ray oscilloscope (CRO) to investigate the properties of waves produced by a signal generator.
The student obtains the following output.



1.1 Give the amplitude of the wave.

[1 Mark]

Amplitude = ... cm

1.2 Give the periodic time of the wave.

[1 Mark]

....

....

1.3 The student investigates a different water wave.
The wavelength is 0.05 m and the wave speed is 0.075 m/s.
Calculate the frequency of the water wave.
Show your working.

[3 marks]

....

....

....

....

Frequency = ... Hz

Reference: Applied Science Unit 1 Examination June 2017

2. When two coherent waves meet, they can interfere.

2.1 What is meant by the term **coherent?**

[2 marks]

....

....

....

2.2 Describe what happens during constructive and destructive interference?

[2 marks]

....

....

....

....

2.3 Select the option that describes the phase difference required for destructive interference.

[1 mark]

A	Multiple of 45°
B	Multiple of 90°
C	Multiple of 180°
D	Multiple of 360°

2.4 Select the option that describes the path difference required for constructive interference.

[1 mark]

A	$n\lambda$
B	$\frac{n}{2}\lambda$
C	$\frac{n+1}{2}\lambda$
D	$(n+1)\lambda$

Reference: Zig Zag Educational Resources

3. There are many examples of waves in nature, such as sound waves or ripples on the surface of water.
3.1 Complete the sentences below using the following words.
Some words may not be used at all.

[3 Marks]

amplitude	periodic time	rate	speed	oscillation
frequency	distance	phase	displacement	coherence

A wave's .... is the rate at which it transfers energy. The regular movement of particles in a wave is called an ....

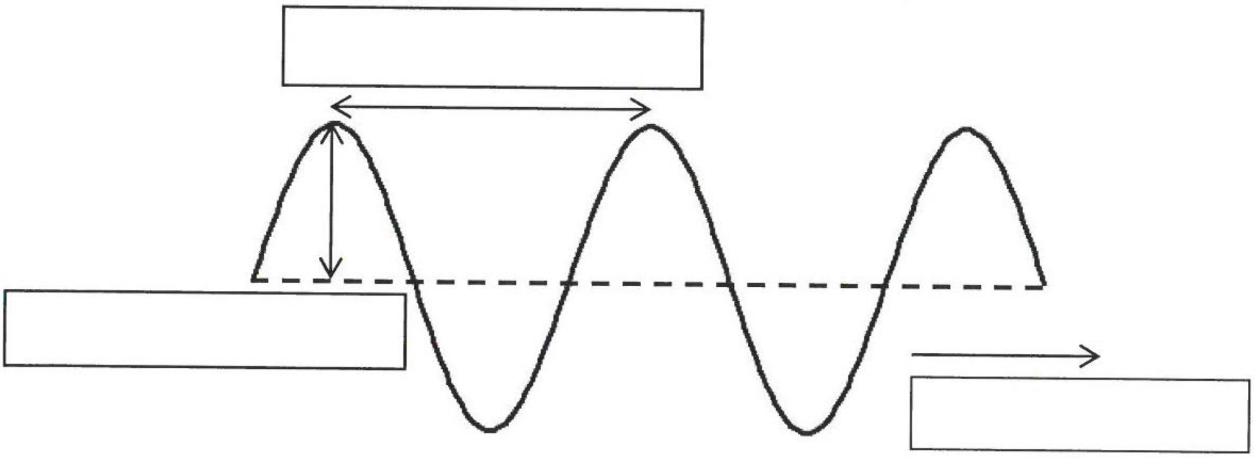
The time taken for one complete wavelength to pass through a point is its .... and the number of waves passing a point in a second is its ....

The distance that particles have been moved from their equilibrium position by the wave is their .... The maximum distance of particles from their equilibrium position in a wave is the wave's ....

3.2 Fill in the boxes with the words provided to label the wave below.

[3 Marks]

Frequency	Wavelength	Displacement	Amplitude	Velocity	Oscillation	Period



3.3 Match the quantities below to their symbol and unit.

[3 Marks]

Speed	f	m
Frequency	λ	Hz
Wavelength	v	m s^{-1}

Reference: Zig Zag Educational Resources

4. Figure 1 shows a pendulum pulled to the right-hand side.

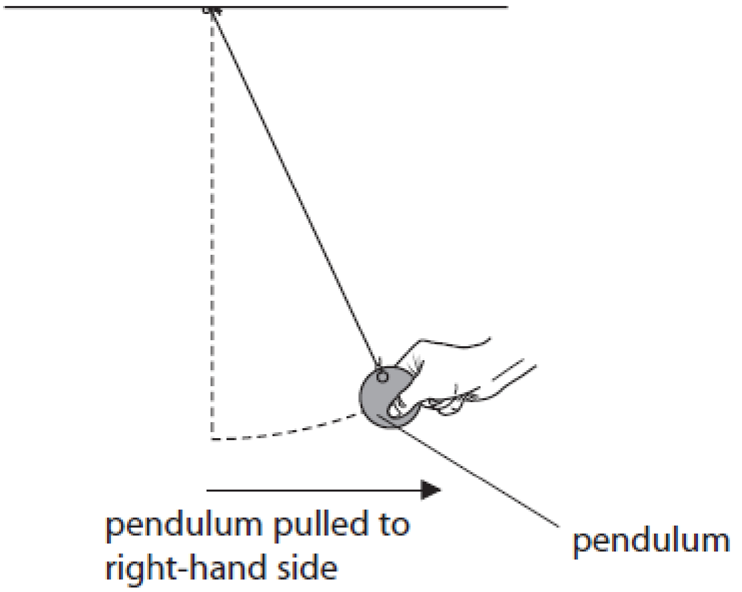


Figure 1

The pendulum is released and starts to swing.
Figure 2 shows how the displacement of the pendulum changes with time.

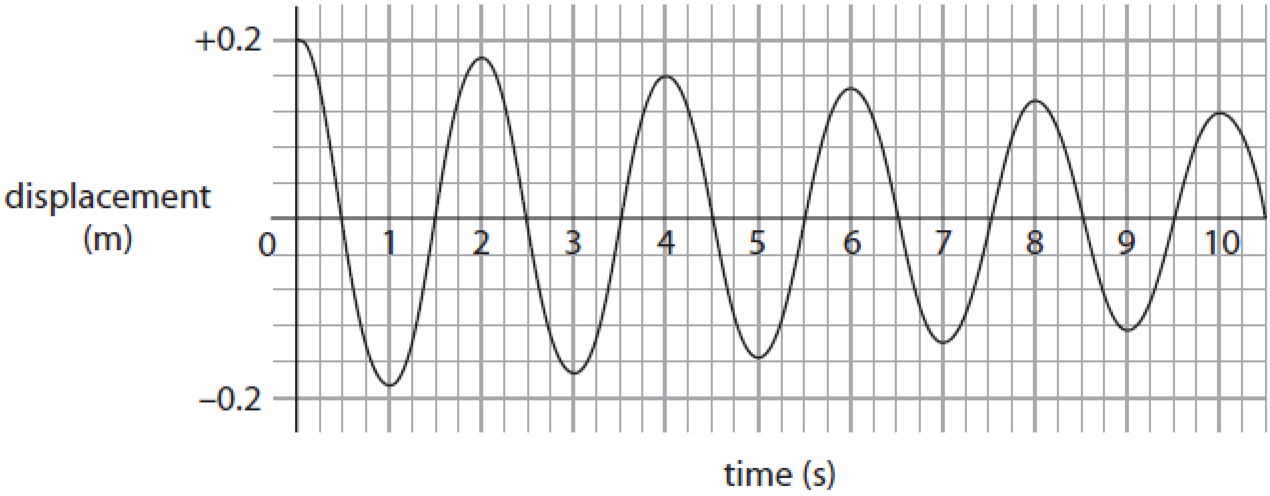


Figure 2

4.1 Give the time taken for one complete oscillation.

[1 Mark]

....

....

Time for one complete oscillation = ... s

4.2 Which statement correctly describes the amplitude of the oscillations in **Figure 2**?

[1 Mark]

☒ **A** The amplitude is constant.

☒ **B** The amplitude decreases then increases.

☒ **C** The amplitude increases then decreases.

☒ **D** The amplitude gradually decreases.

4.3 A learner uses a different pendulum.
The time for one complete oscillation (T) is 5.0 seconds.
Calculate the frequency (f).

Use the equation: f = 1/T

[2 marks]

....

....

....

....

Frequency = ... Hz

ANSWERS

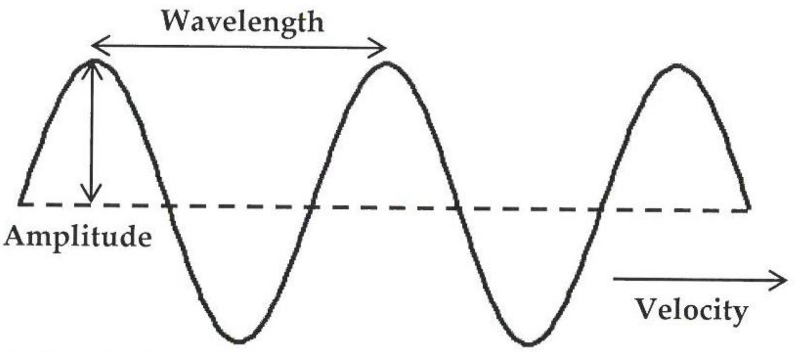
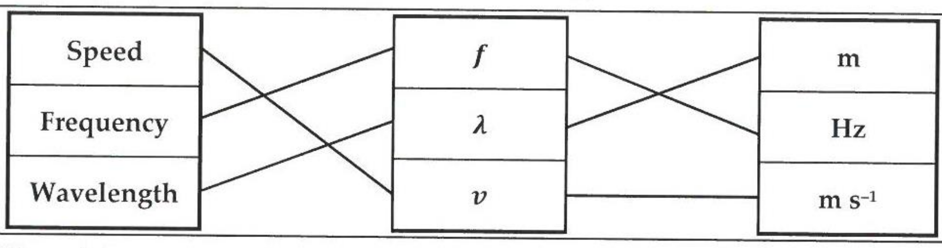
Q1.

Question Number	Answer	Additional guidance	Mark
1.1	Either 1.5 (cm) (1) Or -1.5 (cm) (1)		1
1.2	2.0(s)		1
1.3	substitution (1) 0.075 = f x 0.05 rearrangement (1) f = $\frac{0.075}{0.05}$ evaluation (1) 1.5 (Hz)	substitution and rearrangement in either order	3
			Total 5 Marks

Q2.

2.1	Waves in phase / waves have constant phase difference and with the same frequency	1 1
2.2	In constructive interference the amplitudes of two waves add to a large amplitude In destructive interference the opposite amplitudes of two waves add to 0	1 1
2.3	C Multiple of 180 °	1
2.4	A $n\lambda$ (where $n = 0, 1, 2\ldots$)	1

Q3.

Question	Answer	Mark
3.1	In order: speed oscillation periodic time frequency displacement amplitude	1 for every two correct (total of 3)
3.2		1 for each correctly filled box (total of 3)
3.3		1 for each correct row (total of 3)

Q4.

Question	Answer	Additional Guidance	Mark
4.1	2(s)	accept 2.0, two	1
4.2	D The amplitude gradually decreases		1
4.3	substitution (1) (f) = $\frac{1}{5.0}$ evaluation (1) 0.2 (Hz)	accept for full marks 0.2 without working shown	2
		Total	4 marks

TOPIC 1: ANALOGUE AND DIGITAL SIGNALS SPEC CHECK

This the key specification points of the Applied Science course for this part of the topic.

Specification	Learning Outcomes	Completed?
Fibre Optics C2.2	Understand how a light ray passes by total internal reflection through a bundle of optical fibres in an endoscope to illuminate an area of interest Know that light is reflected from this area and enters a second bundle of optical fibres Know that the image is returned to be viewed through this second bundle of optical fibres by total internal reflection Know that each fibre gives a small part of the complete image	
Analogue and Digital Signals C2.2 C2.3	Understand and be able to describe and draw analogue and digital signals Understand the advantages and disadvantages of digital signals compared with analogue signals e.g. that digital signals are less affected by noise and have less energy loss (attenuation) than analogue signals and can therefore travel further Know that a continuously varying analogue signal is sampled at fixed intervals of time Know that the sample values are then converted into a digital binary code to be transmitted as a stream of pulses Know that broadband is the system that gives rapid internet access through cables, optical fibres or satellites using electromagnetic waves with a range of frequencies Know that the frequencies are divided into separate bands, each band carries a separate channel of data	

	Know that in a fibre optic cable, light of different frequencies travel down the cable at the same time Know that each frequency carries data, this is multiplexing Know that that broadband can be analogue or digital	

KEY INFORMATION

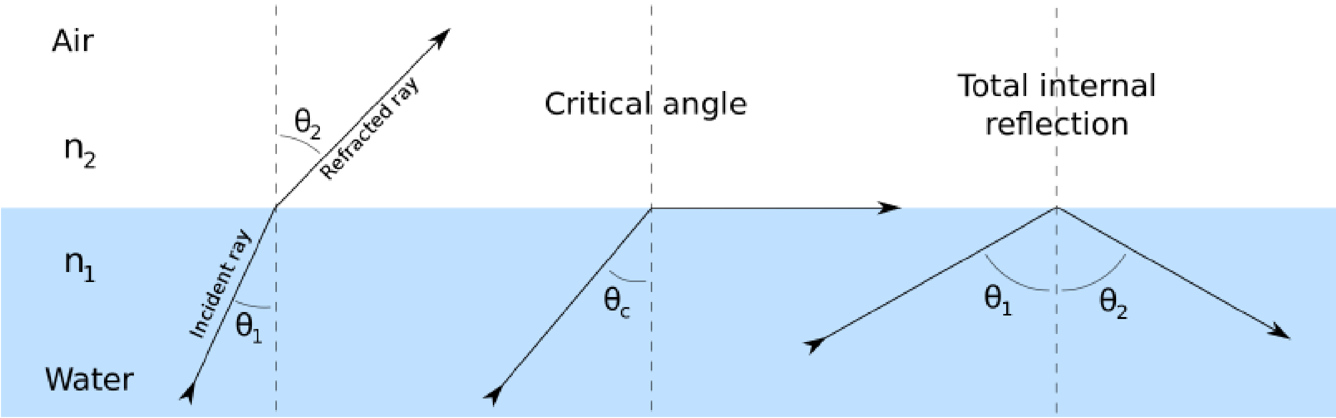
Read the information found in the key information to understand the concepts of this topic.

Light (or electromagnetic radiation of other frequencies) travels best through a vacuum. Its rapidly oscillating electric field generates an oscillating magnetic field, and the changing magnetic field in turn generates another nearby oscillating electric field. And so, the wave progresses rapidly through space.

When the waves have to travel through matter, their progress is impeded by the electronic charges in the atoms and molecules. Metals, which are full of freely moving electrons, just stop the wave oscillation completely.

Many other materials absorb some or all of the light and so look coloured or even black.

In transparent materials, like water, glass and many plastics, the waves are not stopped or absorbed, but they are slowed down. The ratio of the speed of light in vacuum, c, to its speed in the material medium, v, is called the refractive index, n, of the medium.
There are two processes that can occur when light hits a new medium; refraction or total internal reflection – the interchange between the two is called the **CRITICAL ANGLE.**



Refractive Index

The refractive index of a material is a measure of how the wave speed of a wave changes at it moves through different material. The refractive index of material, *s,* can be calculated using:

$$n = \frac{c}{c_s}$$

The speed of a wave can change as the wavelength of the wave changes, in slower mediums, the wavelength decreases.

Throughout refraction, frequency remains constant.

This equation is only valid if you consider the starting medium of the wave to be either a vacuum or air.

This is because the refractive index of air/vacuum is 1.00

If the starting medium is not air or a vacuum a more detailed equation must be used.

Where n is the refractive index, c is the speed of light in a vacuum and c_s is the speed of light in material s.
Refractive Index, n, has no units

If light can travel at c in material x then the refractive index is: $n = \frac{c}{c_x} \rightarrow n = \frac{c}{c} \rightarrow n = 1$

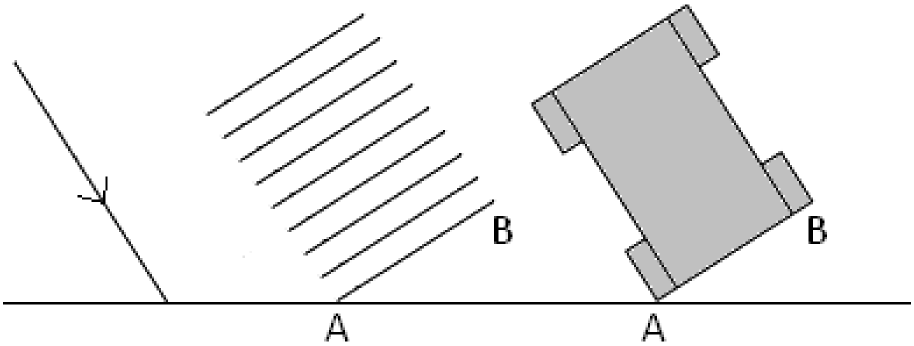
If light can travel at $c/2$ in material y then the refractive index is: $n = \frac{c}{c_y} \rightarrow n = \frac{c}{c/2} \rightarrow n = 2$

The higher the refractive index the slower light can travel through it

The higher the refractive index the denser the material

Bending Light

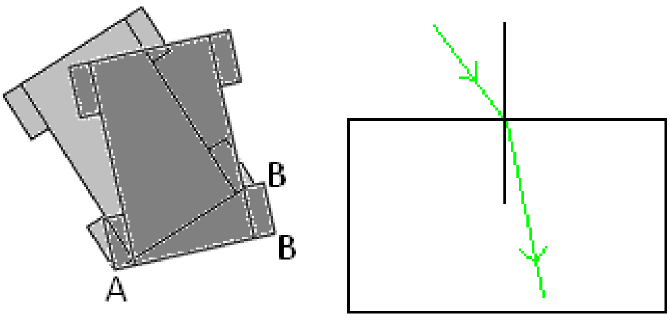
When light passes from one material to another it is not only the speed of the light that changes, the direction can change too.



If the ray of light is incident at 90° to the material then there is no change in direction, only speed.

It may help to imagine the front of the ray of light as the front of a car to determine the direction the light will bend. Imagine a lower refractive index as grass and a higher refractive index at mud.

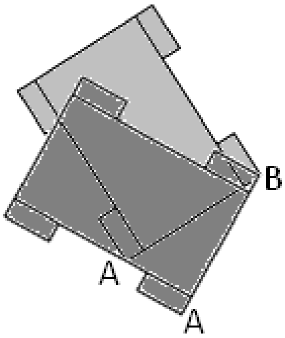
Entering a Denser Material

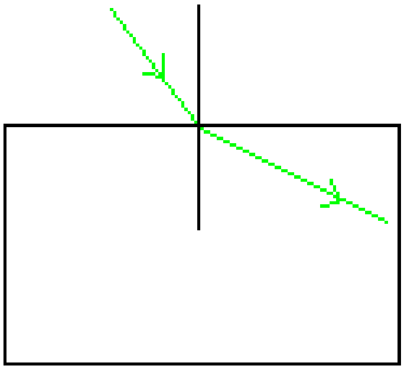


The car travels on grass until tyre A reaches the mud. It is harder to move through mud so A slows down but B can keep moving at the same speed as before. The car now points in a new direction.

Denser material – higher refractive index – bends towards the Normal

Entering a Less Dense Material





The car travels in mud until tyre A reaches the grass. It is easier to move across grass so A can speed up, but B keeps moving at the same speed as before. The car now points in a new direction.

Less dense material – lower refractive index – bends away from the Normal

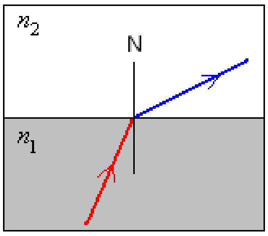
Total Internal Reflection

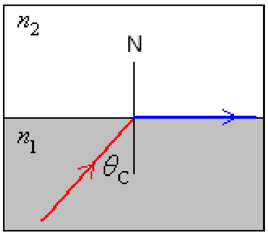
We know that whenever light travels from one material to another the majority of the light refracts but a small proportion of the light also reflects off the boundary and stays in the first material.

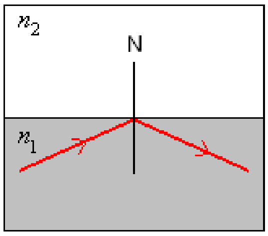
When the incident ray strikes the boundary at an angle **less than the critical angle** the light refracts into the second material.

When the incident ray strikes the boundary at an angle **equal to the critical angle** all the light is sent along the boundary between the two materials.

When the incident ray strikes the boundary at an angle **greater than the critical angle** all the light is reflected and none refracts, we say it is total internal reflection has occurred.
This is called total internal reflection.
Total because all of the energy is reflected.
Internal because the energy stays inside the material.
Reflection because the light is reflected.







At exactly the critical angle, the angle of refraction and reflection is 90 degrees.

This is another way to define critical angle.

In addition, for total internal reflection to occur, the second medium must have a lower refractive index than the first medium.

$$n_1 > n_2$$

If the **refractive index of the second medium was higher than the first medium**, then total internal reflection would not occur and **some of the wave would be refracted.**

Critical Angle

We can derive an equation that connects the critical angle with the refractive indices of the materials.

$$\frac{\sin \theta_1}{\sin \theta_2} = \frac{n_2}{n_1}$$

But at the critical angle θ_2 is equal to 90° which makes $\sin\theta_2 = 1$ this gives…

$$\frac{\sin \theta_1}{1} = \frac{n_2}{n_1}$$

θ_1 is the critical angle which we represent as θ_C making the equation:

$$\sin\theta_C = \frac{n_2}{n_1}$$

When the second material is air $n_2 = 1$,

So, the equation becomes:

$$\sin\theta_C = \frac{1}{n_1}$$

or

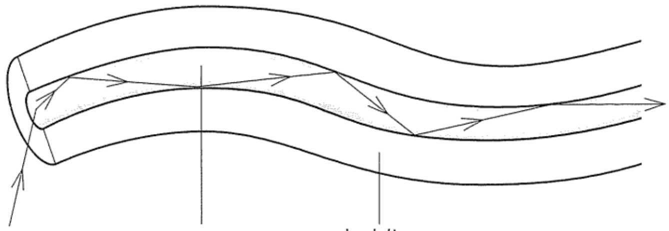
$$n_1 = \frac{1}{\sin\theta_C}$$

Optical Fibres/Fibre Optics

Optical fibres are very long thin cylinders of glass or, sometimes, plastic. Light is fed into the cut end of the fibre, so when it hits the sides of the fibre, it al-most always does so at angles greater than the critical angle. That means all the rays of light get totally internally reflected and keep bouncing down the length of the fibre.

No wave energy gets lost through the walls of the fibre, although as glass is not perfectly transparent, some is gradually absorbed.
This makes light in optical fibres a much more efficient way of transmitting signals than sending electrical pulses down copper cables. Copper cables suffer from quite large losses due to electrical resistance, meaning that after a few hundred metres most of the signal has been attenuated away and amplifiers are needed to boost it up again.

Light can travel down it due to total internal reflection. Thier uses include:



Communication such as phone and TV signals: they can carry more information that electricity in copper wires. The data is encrypted as a binary code of flashing of light.
This requires an optical material with a high critical angle to reduce the number of possible total internal reflection paths.

Optical fibres are better than copper wires because optical fibre signals:
Have lower losses, so travel further before needing amplification.
Are secure, so cannot be tapped into.
Are at higher frequencies, so provide greater bandwidth.

But optical fibres cost more and need specialist installation.

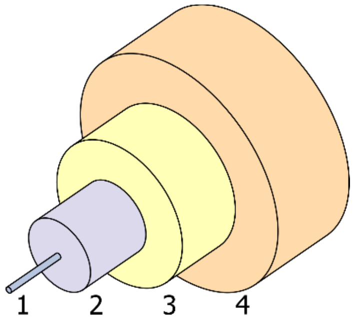
Broadband networks

Bandwidth is a measure of the number of distinct signals at different frequencies that a network can carry.

High frequency carrier waves can accommodate many small 'bands' of frequencies.

Fibre optical cables allow extremely high bandwidth, and so networks using them are called **BROADBAND.**

The long-distance backbone of broadband network use 'single mode' fibres in which the dense glass core is so narrow (about 8 micrometers) that there is only one light path, straight down the centre of the fibre core.



Broadband is used as a relative term to indicate the speed and carrying capacity of a data channel.

In connection with the internet it has been used to market the improvement from earlier telephone dial up connections, which were extremely limited and slow. Fibre optic broadband has been progressively replacing copper cable connections with consequent gains in data speed.

Multimode fibre is the standard fibre cable used for sending optical signals over short to medium distances – for example, connections to instruments, jumpers in cabinets, small local area networks

Single mode fibre has an even narrower core (8 μm to10 μm), which is less than ten wavelengths of the infra-red light that is used in them. This means there is just no space for different beams travelling at different angles down the core. Instead, the light wave moves as a single wave-front straight down the centre of the fibre, and all the signal energy reaches the far end of the fibre at the same instant. Millions of kilometres of this high-quality cable is laid every year to build the fibre optic networks for telephone, cable TV and broadband internet communications.

Fibre Optics in Medicine

Endoscopes are optical instruments with long tubes that can be inserted into a body organ through an opening such as the throat, nose, ear canals or anus.

Medical endoscopes: they allow us to see down them and are flexible, so they do not cause injury to the patient.

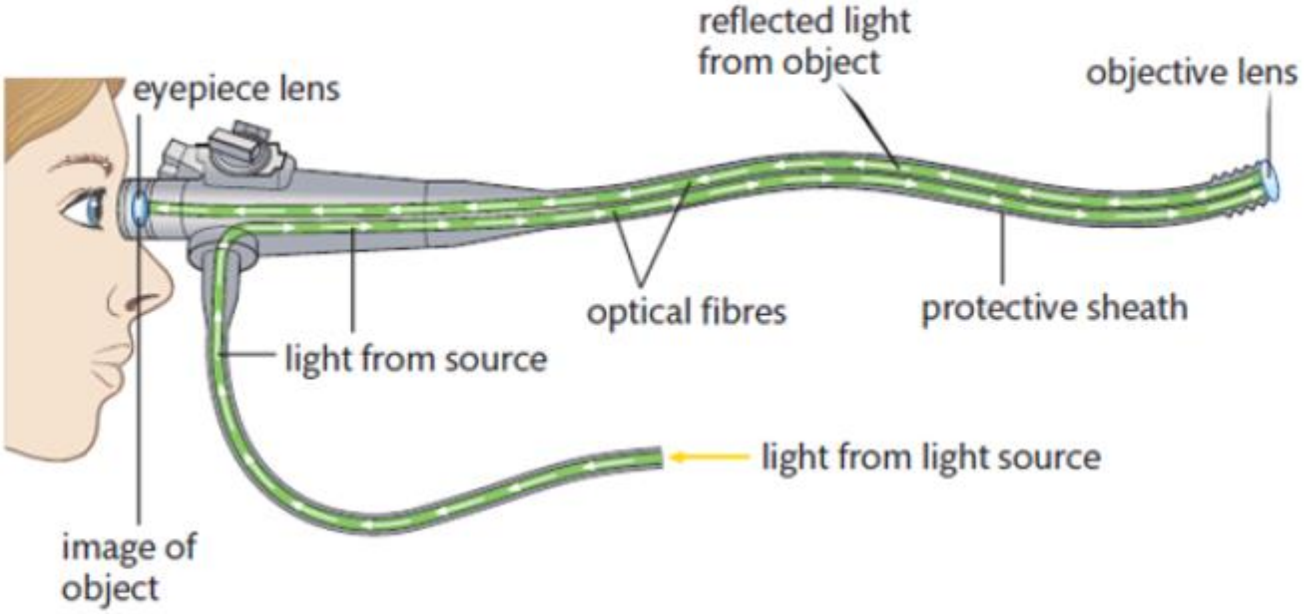
This requires an optical material with a low critical angle to have a high number of possible total internal reflection paths.

These allow a trained medical practitioner to see inside a body organ, for example, the upper oesophagus and stomach or the colon and intestines, without undertaking surgery.

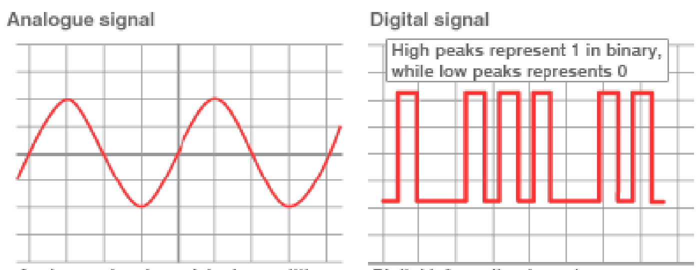
Endoscopes are also used during keyhole surgery to guide the use of surgical instruments with remote handling, which are often incorporated into the same tube system.

Each fibre in the bundle is as thin as a human hair and consists of:
A core
Cladding
Protective plastic buffer coating

The image transmitted is pixelated (i.e. formed of coloured dots), since each fibre only transmits one pixel of coloured light. So the



Analogue and Digitals
Signals of information can be transmitted in two forms - analogue and digital.
Analogue signal – a signal whose strength is proportional to the quantity it is representing.
Analogue signals include:
The electrical signals made by a microphone, which mimic the shape and intensity of the sound waves they are detecting
The position of the pointer on a pressure dial gauge
The waveform displayed on a cathode ray oscilloscope, which copies and shows the variation of an AC voltage with time.
Digital signal – conveys in binary code a number that represents the size of the measured quantity.
Digitising information not only makes it possible to send more data faster than using analogue transmission. It also makes the transmission much more reliable and interference free.
Converting a signal from analogue to digital is carried out electronically using an analogue to digital (**A** to **D**) converter.



Analogue signals work by transmitting sounds and pictures as continously varying waves.

Digital information is sent as computerised pulses of information, coded as 1s and 0s.

REVISION SHEET

Highlight or underline the key information on the revision sheet to consolidate your understanding.

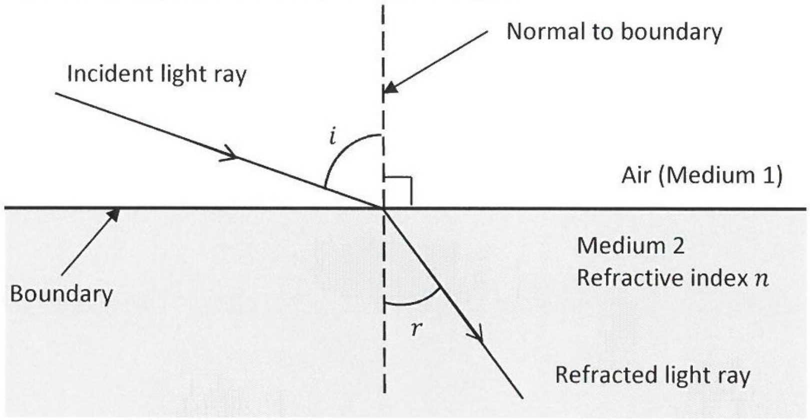
Definitions

Optical fibre	a glass wire which carries information in the form of light
Signal	light transmitting information in its amplitude and frequency
Refraction	light changing direction and speed as it enters a new medium (substance)
Reflection	light bouncing back from a boundary
Normal	a line at right angles to a surface

In this chapter you will learn how optical fibres are used to direct waves for communication over large distances, and how similar ideas can be used in medicine and industry. Being able to transmit waves over large distances relies on the wave not being absorbed or spread out too much and being able to change the direction of the wave to bend around corners.

Refraction

When light moves from one medium to another, the light bends as it speeds up or slows down. This can be seen when putting a pencil into a glass of water – the straight pencil appears to bend where it meets the water, because the light takes a different path from the pencil to our eyes.



Every transparent material has a **refractive index**, which is a ratio of the speed of light in a vacuum to the speed of light in that material.

The higher the refractive index of a substance, the more the light bends as it passes from air into the substance.

$n =$ refractive index
$c =$ speed of light in a vacuum $= 3.0 \times 10^8 \text{ m s}^{-1}$
$v =$ speed of light in medium, in m s^{-1}

$$n = \frac{c}{v}$$

FS

A vacuum has a refractive index of $n = 1$, and air has a refractive index of $n = 1.0003$, which is usually just written as $n \approx 1$.

Example

The refractive index of ethanol is 1.36. What is the speed of light in ethanol?

Use $n = \frac{c}{v}$ and rearrange to $v = \frac{c}{n}$

Putting in numbers:

$$v = \frac{3.00 \times 10^8}{1.36} = 2.21 \times 10^8 \text{ m s}^{-1}$$

Because Medium 2 has a higher refractive index than air, the light slows down and bends towards the normal.

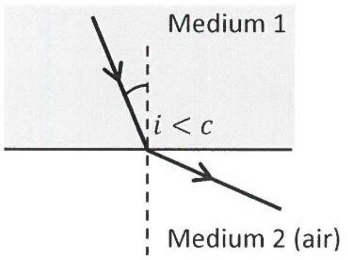
$$n = \frac{\sin i}{\sin r}$$

n = refractive index
i = angle of incidence
r = angle of refraction

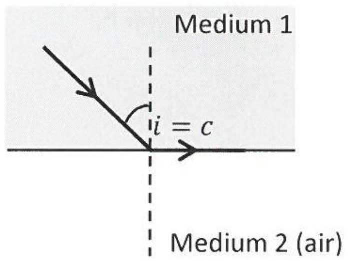
Total internal reflection

When light passes from a medium back into air, it can undergo **total internal reflection**. This is where all of the light reflects back into the medium instead of travelling through air.

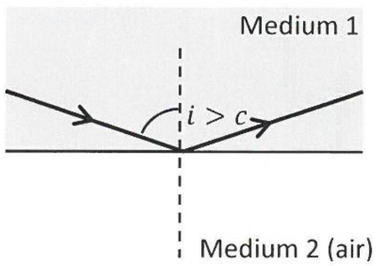
Total internal reflection can only occur if the angle of incidence is greater than the **critical angle** for the material.



If $i < c$, the light passes through the boundary into air and bends away from the normal



If $i = c$, the light moves along the boundary



If $i > c$, the light reflects back from the boundary and into the medium

The critical angle of a medium is given by

$$\sin c = \frac{1}{n}$$

Total internal reflection can occur between any two mediums where the refractive index of medium 1 is greater than the refractive index of medium 2.

n = refractive index
c = critical angle

Example

What is the critical angle at an interface of air and olive oil, with a refractive index of 1.47?

Use: $\sin c = \frac{1}{n}$

which rearranges to

$$c = \sin^{-1}\frac{1}{n}$$

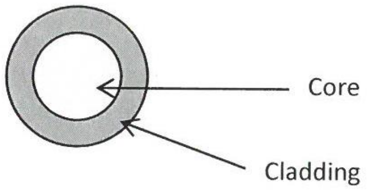
Putting in numbers:

$$c = \sin^{-1}\frac{1}{1.47} = 42.9°$$

Optical fibres

Optical fibres are used to transmit light from one location to another. This can be across a room or even across countries and oceans. While light can only travel in straight lines through air, light can pass from one end of an optical fibre to the other even if the cable is bent, folded back on itself or even tied in a knot.

An optical fibre is made of a long glass wire called the **core** surrounded by a sheath of a different material called the **cladding**.

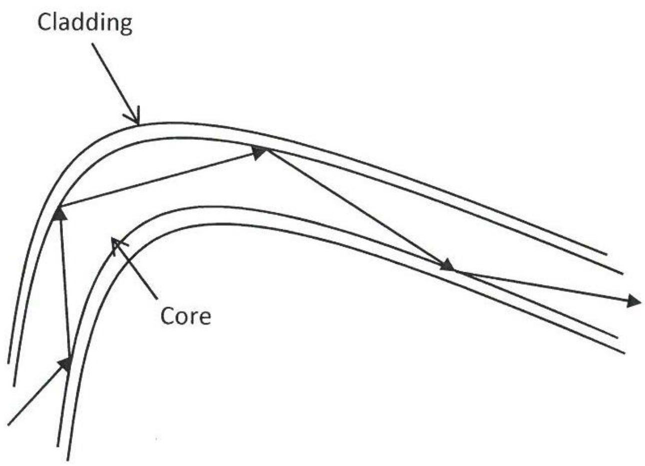


Light travels through the core of the optical fibre, and reflects off the boundary between the core and the cladding.

This can happen due to the **refractive indices** of the core and cladding.

Total internal reflection in fibre optics

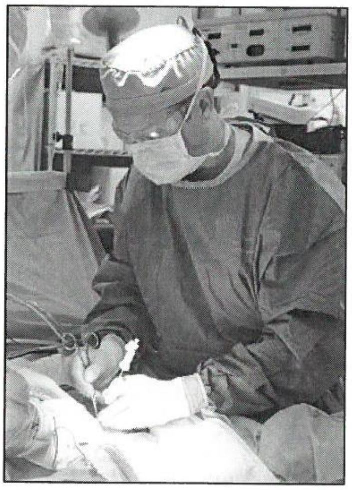
In an optical fibre, a pulse of light enters in one end of the cladding and then reflects each time the pulse reaches the core–cladding boundary by total internal reflection.



This means that the light can pass through the optical fibre even when the fibre isn't straight.

Optical fibres in medicine

Endoscopes are optical fibres used in medicine. These cables consist of many bundles of optical fibres, which are inserted into a patient's body.



Some of the fibres transmit light into the body, while others are used to carry light back through the endoscope to build an image of the patient's body. This allows a doctor to see inside a patient's body to check for problems without having to carry out major surgery.

The advantages of using endoscopes in medicine are:

- reduces risk of complications in operations
- reduces blood loss
- reduces risk of infection

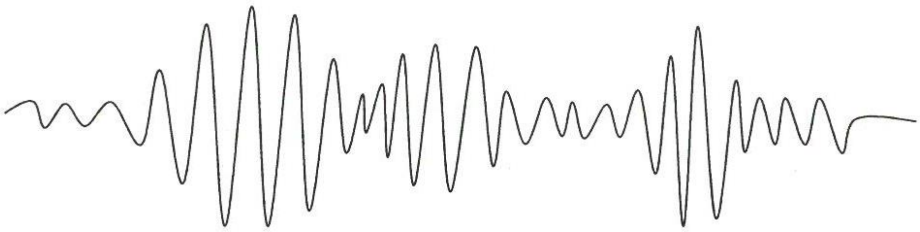
Other uses of endoscopes in medicine are:

- endoscopes can be used directly for surgery, with lasers to cut or vaporise
- collecting tissue samples through tubes

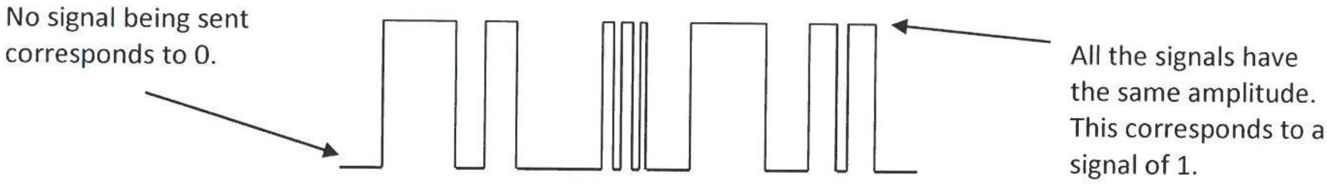
Optical fibres in communication

Many types of communication use **analogue signals**.

Analogue signals transmit waves by changing the amplitude of the wave through a range of values. The signal strength is proportional to the value it represents.



Digital signals only transmit at a single amplitude, in short bursts.



A digital signal is cut into short sections of time. If a signal is received during a section of time, the signal is 1, or on. If no signal is received in a section of time, the signal is 0, or off.

Digital signals use binary code to transmit information, with different sequences of 1s and 0s standing in for different values.

Digital signals have a number of different advantages over analogue signals:

- Digital signals are high frequency, so can transmit a lot of information quickly
- Multiple digital signals can be sent along the same cable
- No loss of signal over large distances
- Very little interference

An analogue signal often needs converting into a digital signal so we can send it, and is then converted from a digital signal back to an analogue signal so we can interpret it.

Converting an analogue signal to a digital signal

1. Use a transducer to produce an analogue electrical signal proportional to the signal you want to send.

⇩

2. Connect the output of the transducer to the input of an analogue-to-digital converter.

⇩

3. The cable must be screened by earthing to avoid electrical interference.

⇩

4. Sample the analogue signal using the analogue-to-digital converter.

⇩

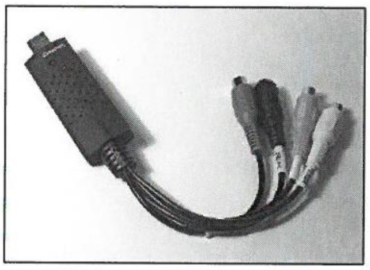
5. Select an appropriate sampling rate, which sets how frequently the signal is taken.

⇩

6. Select the smallest appropriate unit for converting the voltage signal into data.

⇩

7. Transmit the data through an aerial or optical fibre.



Broadband

Broadband refers to any signal that contains multiple sets of information. Most information is sent one piece of data at a time, while broadband can send a lot of data at once. This greatly improves the speed of data transfer. Broadband is most commonly used for Internet access.

Broadband optical fibres carry multiple signals at once. The signals do not interfere with each because each signal is sent as a different frequency, or colour. The receiver only interprets a single frequency at a time, so only picks up one signal.

Credit: Zig Zag Resources Revision Guide Editions

VIDEO

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SELF ASSESSMENT

To practice your understanding, answer the following questions.

DO NOT WORRY IF YOU STRUGGLE AT FIRST.

The answers are found after the questions.

A1. Describe how a wave refracts.

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A2. Light travels through water at 2.3×10^8 ms^{-1}.
Calculate the refractive index of water.

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A3. A beam of light enters silicon from air at an angle of 40^o. The refractive index of silicon is 3.4.
Calculate the angle of refraction for the beam of light.

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A4. The refractive index of glass is 1.47. Calculate the critical angle of glass.

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A5. How does an optical fibre transmit information from one end to another?

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A6. What are the advantages of transmitting a signal as digital instead of analogue?

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ANSWERS

A1. A wave enters a new medium. This causes the speed of the wave to change, and so the path of the wave bends. Moving into a new medium with a higher refractive index causes the wave to bend towards the normal.

A2.

$$n = \frac{c}{v}$$

$$n = \frac{3.0 \times 10^8}{2.3 \times 10^8}$$

$$n = 1.3$$

A3.

$$n = \frac{\sin i}{\sin r}$$

$$\sin r = \frac{\sin i}{n}$$

$$r = \sin^{-1}\left(\frac{\sin i}{n}\right)$$

$$r = \sin^{-1}\left(\frac{\sin 40}{3.4}\right)$$

$$r = 11°$$

A4.

$$\sin c = \frac{1}{n}$$

$$c = \sin^{-1}\frac{1}{n}$$

$$c = \sin^{-1}\frac{1}{1.47}$$

$$c = 43°$$

A5. Every time the light hits the core-cladding boundary, it undergoes total internal reflection and bounces back into the optical fibre. This means the light moves along the entire fibre reflecting around corners until the end of the fibre.

A6. Digital signals are high frequency, so a lot of information can be transmitted at once.
Multiple signals can be sent along the same cable.
No loss of signal over large distances.
Very little interference.

KEYWORDS

To assess your understanding on this topic, complete this table with the keywords of this topic.

The process of a wave changing speed and direction as it changes medium	
The process of a wave bouncing off a surface with no absorption	
A property of a medium that represents the ratio between the speed of light in a vacuum and the speed of light in the medium	
90° to a surface	
The entire reflection of all light back into the original medium when its angle of incidence is greater than the medium's critical angle	
Angle above which total internal reflection occurs	
The boundary between two mediums	
Long, thin tubes of glass used to transmit light	
A camera that can be inserted into a patient to observe internal organs	
A continuous time-dependent signal	
A signal made up of short bursts of information at the same amplitude	
A process which turns a continuous signal into a discrete signal	
A signal containing many wavelengths, so more information is carried	
The superposition of two waves to make a resultant wave that can have either a greater or lower amplitude than the two waves individually	
The process by which electromagnetic radiation is taken in by matter	

ANSWERS

Refraction	The process of a wave changing speed and direction as it changes medium
Reflection	The process of a wave bouncing off a surface with no absorption
Refractive index	A property of a medium that represents the ratio between the speed of light in a vacuum and the speed of light in the medium
Normal	90° to a surface
Total internal reflection	The entire reflection of all light back into the original medium when its angle of incidence is greater than the medium's critical angle
Critical angle	Angle above which total internal reflection occurs
Interface	The boundary between two mediums
Fibre optic	Long, thin tubes of glass used to transmit light
Endoscope	A camera that can be inserted into a patient to observe internal organs
Analogue	A continuous time-dependent signal
Digital	A signal made up of short bursts of information at the same amplitude
Analogue to digital conversion	A process which turns a continuous signal into a discrete signal
Broadband	A signal containing many wavelengths, so more information is carried
Interference	The superposition of two waves to make a resultant wave that can have either a greater or lower amplitude than the two waves individually
Absorption	The process by which electromagnetic radiation is taken in by matter

ASSESSMENT QUESTION

Please answer this assessment question on this topic in Applied Science.

This work will be formally assessed with feedback given.

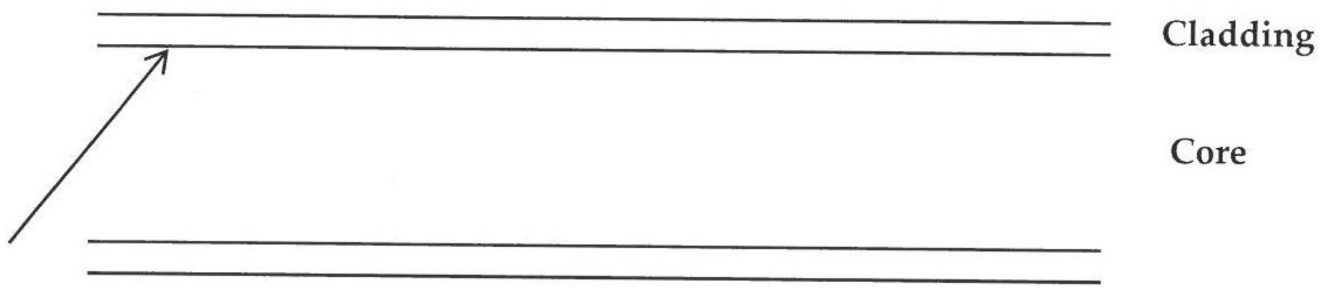
This work will be submitted at the start of the KS5 course in Year 12.

If we require any help or you wish to receive immediate feedback, please e-mail Mr. Turnbull.

1. Fibre optic cables can have many applications in computing and medical imaging.

1.1 Complete the diagram below to show the path a ray of light takes through a fibre optic cable.

[2 Marks]



1.2 The refractive index of the core is 1.57.

Using an equation from the formulae sheet, calculate the critical angle of the interface between the core and the air.

[3 Marks]

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1.3 Using the words below, fill in the gaps to describe the relative refractive indices in the cladding and core of an optical fibre.

[2 Marks]

higher	lower	equal	refraction	total internal reflection
transmission	diffraction	interface	membrane	cross-section

It is important that the core has a .... refractive index than the cladding,

because light can only undergo .... at the ....

between a material with a .... refractive index than the material it is

currently in.

1.4 Describe how fibre optics are used in medical imaging.

[2 Marks]

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Reference: Zig Zag Educational Resources

2. A radio programme can be transmitted as an analogue signal or a digital signal.
2.1 State what is meant by the term **analogue signal**.

[1 Mark]

………

………

2.2 State what is meant by the term **digital signal**.

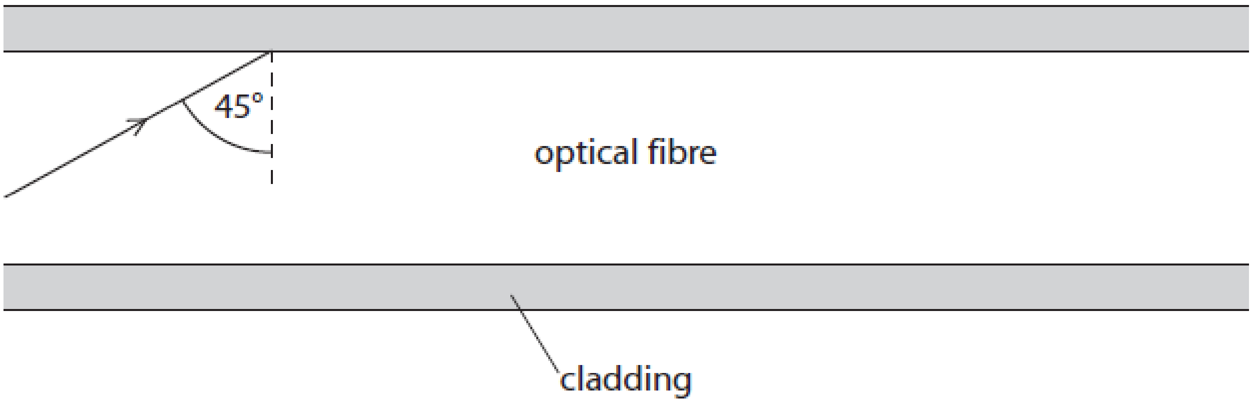
[1 Mark]

………

………

2.3 Light travels through optical fibres by total internal reflection.
The diagram shows a ray of red light in an optical fibre.
The diagram is incomplete.
Complete the path of the red light through the optical fibre.

[2 Marks]



2.4 Television programmes can be transmitted through optical fibres using digital signals.
Explain **two** advantages of using digital signals instead of analogue signals to transmit television programmes.

[4 Marks]

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Reference: Applied Science Examination Unit 1 June 2017

TOPIC 2: THE INVERSE SQUARE LAW SPEC CHECK

This the key specification points of the Applied Science course for this part of the topic.

Specification	Learning Outcomes	Completed?
Electromagnetic Spectrum Inverse Square Law C3.1 C3.2 C3.3	Understand that the speed of light in a vacuum (approx. 3×10^8 ms^{-1}) is the same as the speed for all other electromagnetic waves in a vacuum, e.g. radio-waves, microwaves, ultraviolet and infra-red Understand that: *k* is a constant for a particular source of a wave The intensity of a wave will reduce as the square of the distance from the source of the wave increases, e.g. if the distance from a source is doubled, the intensity at the new distance will be 1/ (2^2) or ¼ Be able to substitute values for any two of intensity, I or tension, T or mass per unit length, μ into this equation and calculate a value for the other term Be able to re-arrange/transform the equation, i.e. change the subject of the equation Know that the equation can also be written as $I_1/I_2 = D_1/D_2$ where: I_1 = intensity at position 1 I_2 = intensity at position 2 D_1 = distance of position 1 from source D_2 = distance of position 2 from source Know that the properties of the different regions of the electromagnetic spectrum are related to their frequencies or wavelengths Know that each region of the electromagnetic spectrum is not specifically defined	

	Know that there is an overlap in frequency and wavelength between each region of the electromagnetic spectrum Know the order in terms of increasing frequency or wavelength of the different regions of the electromagnetic spectrum	

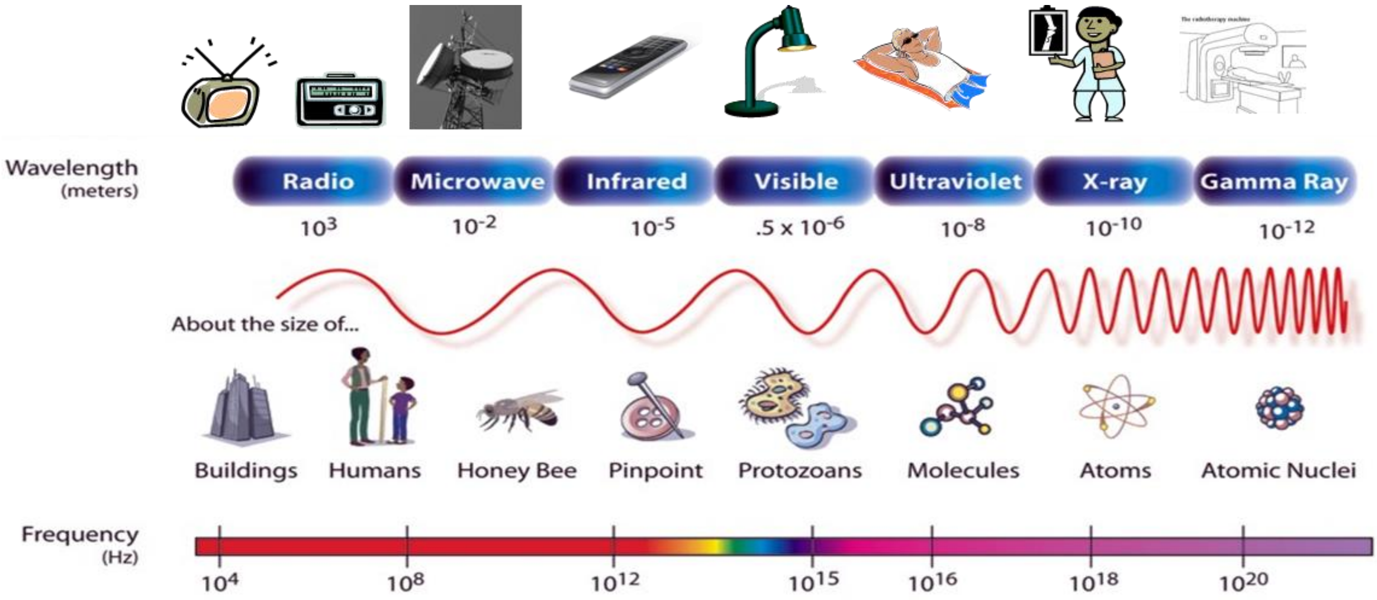
KEY INFORMATION

Read the information found in the key information to understand the concepts of this topic.

Electromagnetic waves form a spectrum of different wavelengths. This spectrum includes visible light, X-rays and radio waves. Electromagnetic radiation can be useful as well as hazardous.

The electromagnetic spectrum is a continuous range of wavelengths. The types of radiation that occur in different parts of the spectrum have different uses and dangers - depending on their wavelength and frequency.

Radio waves have the lowest frequencies and longest wavelengths, while gamma waves have the highest frequencies and shortest wavelengths.



Speed of electromagnetic waves in a vacuum
Light, and all forms of electromagnetic radiation, travel at the same speed through vacuum: 2.997 925x108 ms^{-1}.
This is a physical constant value that is usually denoted by the letter, c.

Inverse square law for intensity of a wave

Waves transfer energy, and energy is a quantity that is always conserved. Wave-fronts propagating out from a point or a spherical source will them-selves be spherical.

As each wave-front increase in radius it also increases in area. The formula for the surface area of a sphere of radius r is $4\pi r^2$. The energy in the moving wave-front is distributed over that expanding area, and so its intensity decreases accordingly.

This leads to the following equation:

$$I = \frac{k}{r^2}$$

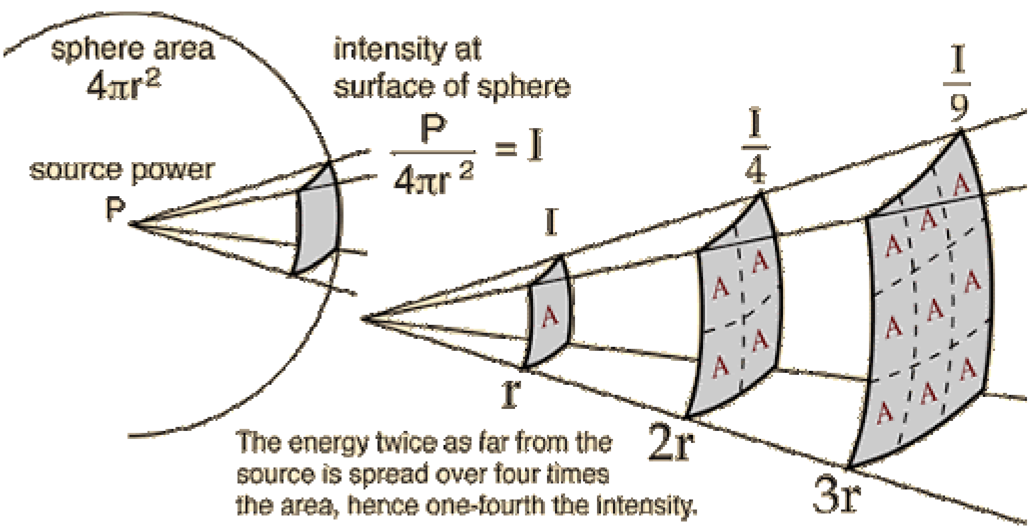
Where k is the intensity 1m from the centre of the source.
Where r is the radius from the source.
Where I is the intensity of the wave a certain distance from the source.

The value of k is constant for a source of electromagnetic radiation.

In a question, you may be given enough information to calculate the 'k' for a source.
This value can then be used for that source for the rest of the question.

This means that when you double the distance, the intensity is quartered.

Satellite communications use dish antennas that concentrate the waves into a directional beam with flat plane wave-fronts.
So, those waves lose intensity more slowly.



In this course, we simplify the term of 'P/4∏' to k to make it easier to understand.

REVISION SHEET

Highlight or underline the key information on the revision sheet to consolidate your understanding.

Definitions

Electromagnetic wave	an oscillation in an electromagnetic field, which is an electric field and a magnetic field oscillating at right angles to each other
Vacuum	a region containing no matter
Intensity	the power transferred by a wave over an area
Communications satellite	an object that sits in an orbit above Earth, relaying communication signals
Wi-Fi	a wireless Internet signal from a router connected to optical fibres
Bluetooth®	a signal connecting two selected devices over a short distance using signals of a similar frequency to Wi-Fi

In this chapter you will learn about how electromagnetic waves, such as light, are used in communication, including in mobile phones, satellites, Bluetooth® and Wi-Fi. These applications depend on the wide range of frequencies that electromagnetic waves can have.

Electromagnetic waves

Electromagnetic waves all travel at the same speed in a vacuum – the **speed of light**: $c = 3.00 \times 10^8$ m s^{-1}. The speed of light is the greatest speed at which anything in the universe can move. This is only the speed of electromagnetic waves in a vacuum; through any other substance, such as water or glass, the waves travel more slowly.

As electromagnetic waves move out from their source, the intensity of the wave follows an **inverse square law**. This means that the intensity of the wave decreases with distance from the source of the wave.

$$I = \frac{k}{r^2}$$

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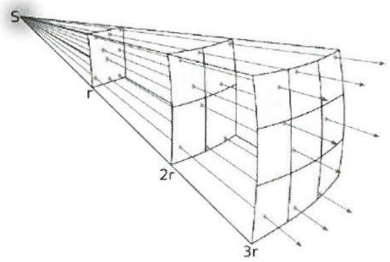

This is because waves spread out into a sphere, which has a surface area of $4\pi r^2$.

I = intensity, in W m^{-2}
k = constant of proportionality, in W
r = distance, in m

Example

At a distance of 8 m, the intensity of light from a source is 10 W m^{-2}.

What will the intensity be at a distance of 16 m?

Use: $I = \frac{k}{r^2}$

k is constant so

$$\frac{I_1}{I_2} = \frac{r_2^2}{r_1^2}$$

Rearrange this for I_2

$$I_2 = I_1 \frac{r_1^2}{r_2^2}$$

$$I_2 = 10 \times \frac{8^2}{16^2} = 2.5 \text{ W m}^{-2}$$

Credit: Zig Zag Resources Revision Guide Editions

VIDEO

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SELF ASSESSMENT

To practice your understanding, answer the following questions.

DO NOT WORRY IF YOU STRUGGLE AT FIRST.

The answers are found after the questions.

A1. At 4m from a light source, the intensity of light is $80Wm^{-2}$.
What is the intensity at distance of 2m from the light source?

....

....

....

....

A2. What speed do all electromagnetic waves travel at?

....

....

A3. The intensity of light from the Sun at the Earth is $1400\ Wm^{-2}$.
Calculate the value of K for the Sun.

....

....

....

....

A4. Calculate the intensity of light at Mars, 230×10^9m from the Sun.

....

....

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....

ANSWERS

A1.

$$I = \frac{k}{r^2}$$

$$\frac{I_1}{I_2} = \frac{r_2^2}{r_1^2}$$

$$I_2 = I_1 \times \frac{r_1^2}{r_2^2}$$

$$I_2 = 80 \times \frac{4^2}{2^2}$$

$$I_2 = 320 \text{ W m}^{-2}$$

A2. 3.00×10^8 m/s

A3.

$$I = \frac{k}{r^2}$$

$$k = Ir^2 \textbf{ [1]}$$

$$k = 1400 \times (150 \times 10^9)^2 \textbf{ [1]}$$

$$k = 3.15 \times 10^{25} \text{ W} \textbf{ [1]}$$

A4.

$$I = \frac{k}{r^2}$$

$$I = \frac{3.15 \times 10^{25}}{(230 \times 10^9)^2} \textbf{ [1]}$$

$$I = 600 \text{ W m}^{-2} \textbf{ [1]}$$

ASSESSMENT QUESTION

Please answer this assessment question on this topic in Applied Science.

This work will be formally assessed with feedback given.

This work will be submitted at the start of the KS5 course in Year 12.

If we require any help or you wish to receive immediate feedback, please e-mail Mr. Turnbull.

1. $I = k/r^2$ is an important equation for the intensity of a wave.
1.1 State the name given to this equation.

[1 Mark]

....

....

1.2 At a distance of 0.5m from the bulb, the intensity of light from the bulb is 3.2 Wm^{-2}.
Calculate the intensity of light from the bulb at a distance of 4.0m from the bulb.

[3 Marks]

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Reference: Zig Zag Educational Resources

2. Visible light transfers energy as a transverse wave.
Sound transfers energy as a longitudinal wave.
Visible light moves faster than sound.
2.1 Give **two other** differences between visible light waves and sound waves.

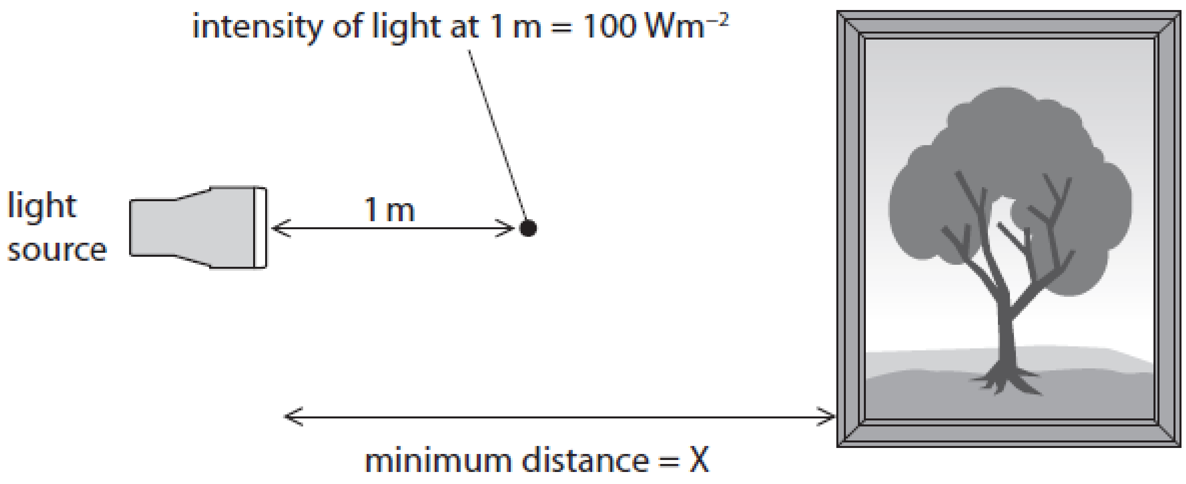
[2 Marks]

....

....

....

2.2 A painting is displayed in a dark room.
An electrician fits a single light source to illuminate the painting.
The intensity of the light 1 m from the light source is 100 Wm^{-2}.
The intensity of the light falling on the painting must not be greater than 30 Wm^{-2}. placed from the painting.



Show your working.

[3 Marks]

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Minimum Distance = ... m

Reference: Applied Science Examination Unit 1 June 2017

TOPIC 3: THE ELECTROMAGNETIC SPECTRUM SPEC CHECK

This the key specification points of the Applied Science course for this part of the topic.

Specification	Learning Outcomes	Completed?
Applications of Electromagnetic Spectrum C3.4	Know that frequency can be expressed in MHz (megahertz, 10^6Hz), GHz (gigahertz,10^9 Hz) and THz, (terahertz, 10^{12} Hz) Understand the factors that make different regions of the electromagnetic spectrum suitable for specific applications Know that microwaves are used for mobile phone networks, because their high frequency gives greater bandwidth which allows large amounts of data to be transmitted Know that there is little or no interference because microwaves can be divided into separate channels Know that reception/the quality of the signal is affected by wet weather as microwaves are strongly absorbed by water Know that terrain also affects reception as the short wavelength/ high frequency reduces the amount of diffraction of the waves. Know that upload and download signals are transmitted at different frequencies Know that the signals are high power, transmitted over long distances and in the radio-wave/ microwave region of the electromagnetic spectrum Know that microwaves can pass through the ionosphere to high orbit satellites Know that radio waves are reflected by the ionosphere and so can be used for terrestrial communication to receivers beyond the horizon	

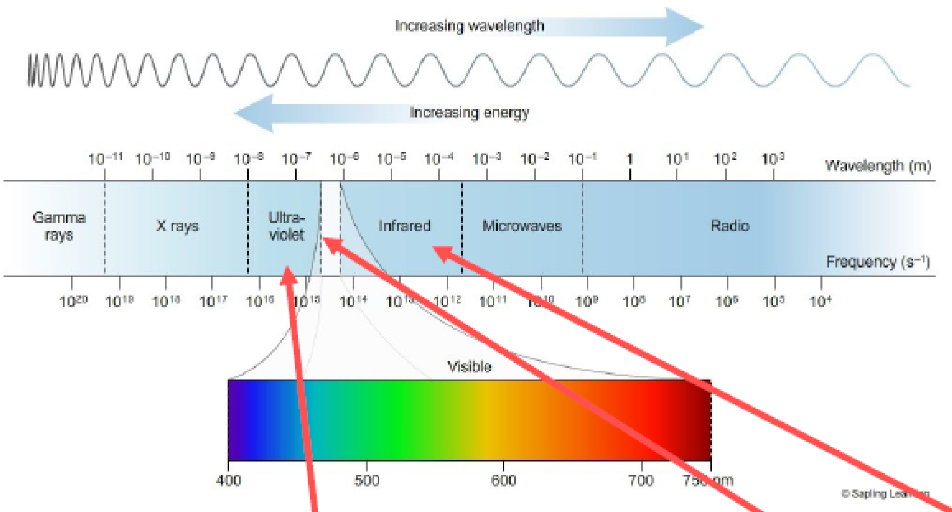
	Know that radio waves can be used for communication with low orbit satellites Know that mobile phones are used on a system of networks Understand that mobile phone providers are allocated a band of frequencies in the radio/microwave region Understand that base stations transmit and receive signals over a limited distance Know that Bluetooth devices are low power devices which work over short distances to link one device to another e.g. from a mobile phone to hands-free headset Know that Bluetooth devices in mobile phones and tablets have a range of up to 10 m Know that Bluetooth uses short wavelength radio signals and so does not need 'line of sight'. Know that Bluetooth devices can connect to more than one device Understand that Bluetooth© uses a system of 'frequency–hopping' to reduce interference with Wi-Fi as this uses similar frequencies Understand that frequency-hopping limits data loss Know that infrared is used in low power devices such as remote controls Understand that infrared operates over short distances and in 'line of sight' Understand that infrared does not work well in bright sunlight Understand that atmospheric moisture reduces the range of the infrared signal	

	Understand that infrared is a high frequency signal and can potentially transmit large amounts of data Know that Wi-Fi allows computers, smart phones and other devices to connect to the internet via a router Understand that Wi-Fi uses medium power in the radio/microwave frequency region Understand that Wi-Fi has a range of up to 100 m Understand that Wi-Fi can pass through walls to allow signals to be received in different rooms in a house Understand that Wi-Fi signals can also be transmitted through both optical fibres and electrical wiring.	

KEY INFORMATION

Read the information found in the key information to understand the concepts of this topic.

All types of electromagnetic radiation have the same nature and can be described by the same equations, but you can experience them differently.
Your eyes can only detect a very small range of frequencies. These are visible light.
You can sense frequencies just a little lower than that of red light as radiant heat that warms you. These are called infra-red radiation.
There are some frequencies just above your visible range that can be seen by some animals, which help plants grow and which cause sunburn. These are called ultra-violet light (UV) because the frequencies are above those of visible light.
The remaining types of radiation are named according to how they are produced.



Infra-red and longer wavelengths are used for various communication purposes.

Long waves penetrate better.

High frequencies/shorter waves carry more data.

There are frequencies just above your visible range that can be seen by bees and some other animals, which help plants grow and which cause sunburn. These are ultra-violet light (UV), because the frequencies are above those of violet

Your eyes can only detect a very small range of frequencies. These are visible light.

You can sense frequencies just a little lower than that of red light as radiant heat warming you. These are infra-red radiation (IR).

The remaining types of radiation are named according to how they are produced. At the highest frequencies the frequency ranges for X-rays and for γ-rays (gamma rays) overlap somewhat. X-rays are produced by high energy atomic electron transitions and are just a higher energy version of light and UV radiation. On the other hand, γ-rays come from nuclear disintegrations and from collisions between high energy sub-atomic particles.

Applications of EM Spectrum:

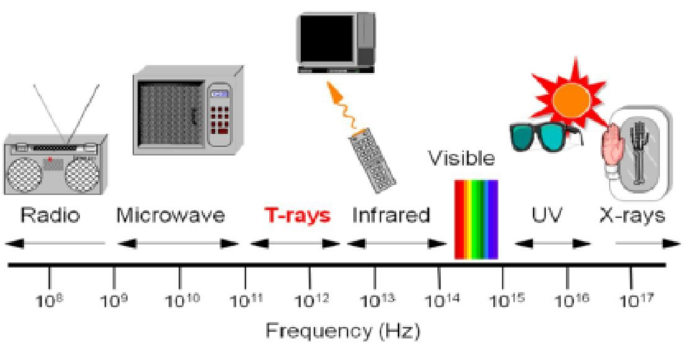
Satellite communication

Mobile phones

Bluetooth

Wifi

Infrared



We can use the different parts of the electromagnetic spectrum to transfer information in different ways.
These include:
Mobile Phones
Bluetooth
Wi-Fi
Infra-red

Each different method has different properties.

Geographical Range
Beaming signals up and down between satellites allows them to be sent right around the world.
Your mobile phone talks with the transceiver tower in a cell of a few km in radius.
This gives mobile phones their American name – cell phones.
Each Wi-Fi hub has a range of 10 to 100m.
Bluetooth is limited to about 10m.
Infra-red signals reach only a few metres.

Changing Frequency
To avoid interference:
Satellites have two dish antennas and use quite different frequency bands for uplink and down link.
A transponder unit on board receives, filters, amplifies, and retransmits on the new frequency.
Mobile phone transceivers (transmitter-receivers) also use separate frequencies for uplink and downlink, but these are nearby channels.
In addition, each cell also uses a different frequency from all its adjacent cells.
Mobile phones have 5 or 10MHz bands allocated to different network operators. 2G, 3G, 4G and 5G cellular networks offer increasing speeds for data. Higher frequencies have a greater data capacity but travel less distance through air and penetrate into buildings less well.
Bluetooth devices frequency hop across a range of channels many times a second to limit their interference with Wi-Fi, which operates in the same frequency band. This reduces the amount of data lost and, in most cases, allows both Bluetooth and Wi-Fi to maintain service at the same time.

Networking
Wi-Fi hubs connect to a wired local network and together can cover a whole building.
Mobile phone cells are networked together to cover the country and also joined to the wider telephone network.
Similarly, satellite ground stations are linked into communications networks.
Networks use a combination of cable and wireless (for example, beamed microwave) links.
Bluetooth and infra-red are not networked – they are just used fo device to device links.

Handshaking
A series of short messages sent backwards, and forwards allows one device to recognise another and to set up communication parameters. This is called **HANDSHAKING.**
Handshaking also stops information getting lost or jumbled by acknowledging when a message has been received.
Mobile phones swap from one cell tower to another as the user moves.

REVISION SHEET

Highlight or underline the key information on the revision sheet to consolidate your understanding.

Electromagnetic spectrum

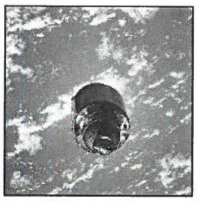
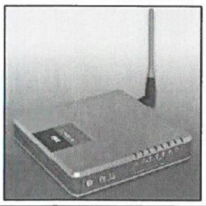
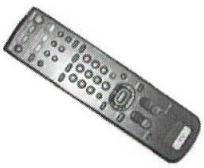
Electromagnetic waves have a number of different properties, which depend on the frequency of the wave. Higher frequency waves correspond to shorter wavelengths and higher energies.

Low frequency waves diffract easily, so can be directed in multiple directions at once. For this reason, low frequencies are often used for communications.

High frequency waves don't diffract as easily so tend to be more directed, but they can transmit energy at much higher rates. For this reason, high frequencies are often used for a concentrated effect, such as destroying tumours or sterilising medical instruments.

	Frequency	Wavelength	Applications
Radio	30 kHz to 3 GHz	10 km to 100 mm	Radio and TV broadcasts, mobile phones
Microwave	3 GHz to 300 GHz	100 mm to 1 mm	Cooking food, radar
Infrared	300 GHz to 400 THz	1 mm to 740 nm	Cooking food, remote controls, thermal cameras
Visible light	400 THz to 800 THz	740 nm to 370 nm	Sight, illumination, cameras
Ultraviolet	800 THz to 30 PHz	370 nm to 10 nm	Tanning, blacklights
X-ray	30 PHz to 30 EHz	10 nm to 0.01 nm	Medical imaging
γ-ray	> 30 EHz	< 0.01 nm	Medical imaging, radiotherapy, sterilisation

Applications of electromagnetic waves in communication

Satellite communications 	Communication satellites sit in orbit above Earth. Microwaves are transmitted to the satellite, which then retransmit microwaves back down to Earth. This allows the microwaves to be transmitted around the curve of Earth.
Mobile phones 	Mobile phones use either radio or microwave frequencies to transmit data. The signal is sent to an antenna, which then sends a signal through a network to other antennae. Different phone companies are allocated different frequencies to work in to avoid interference with each other. Higher-frequency waves can transmit data more quickly but can't travel as far.
Wi-Fi and Bluetooth® 	Wi-Fi routers and Bluetooth® devices both use similar high-frequency radio waves, which only transmit over short distances. Bluetooth® devices don't interfere with Wi-Fi signals because Bluetooth® only transmits in short bursts, while Wi-Fi continually transmits.
Infrared 	Infrared only travels a few metres in air. Infrared frequencies are used to transmit data between remote controls and TVs, and motion sensors for video game consoles. Longer wavelengths of infrared are preferred because sunlight of these wavelengths is blocked by the atmosphere. This means that the sunlight of these wavelengths won't interfere with the signal from the remote.

Credit: Zig Zag Resources Revision Guide Editions

VIDEO

To watch a video looking at this concept, please scan one of the following codes with your smartphone.

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SELF ASSESSMENT

To practice your understanding, answer the following questions.

DO NOT WORRY IF YOU STRUGGLE AT FIRST.

The answers are found after the questions.

A1. List the main regions of the electromagnetic spectrum.

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A2. List one use each for radio waves, infra-red waves and gamma rays.

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A3. How do satellites transmit signals between different sides of the Earth?

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A4. A scientist studies light from the Sun at a wavelength of 300nm. What region of the electromagnetic spectrum is this light in?

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A5. Explain the effect of wavelength on how light can be used in different applications.

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ANSWERS

A1. Radio, microwave, infrared, visible, ultraviolet, x-ray, gamma ray.

A2. Radio: broadcasts, mobile phones
Infra-red: cooking food, remote controls, and thermal camera
Gamma rays: medical imaging, radiotherapy, and sterilisation

A3. Antennae transmit signals which reflect off the atmosphere back down to other antennae.

A4. Ultraviolet

A5. Shorter wavelengths have higher energy, so can be directed for specific effects.
Longer wavelengths are more easily diffracted, they have a larger range for communication without being specifically directed.

KEYWORDS

To assess your understanding on this topic, complete this table with the keywords of this topic.

A transverse wave with vibrating electric and magnetic field components	
Empty space	
States how the intensity of light decreases from a source	
Power per unit area	
Continuous range of wavelengths	
An electromagnetic wave with wavelength between 10 cm and 100 km	
An electromagnetic wave with wavelength between 10^{-1} m and 10^{-3} m	
An electromagnetic wave with wavelength between 1 mm and 700 nm	
An electromagnetic wave with wavelength between 700 nm and 400 nm	
An electromagnetic wave with wavelength between 400 nm and 10 nm	
An electromagnetic wave with wavelength between 1 nm and 0.1 nm	
An electromagnetic wave with wavelength between 10 nm and 1 nm	
The number of complete oscillations per unit time	
Orbits Earth and relays communication transmissions	
Transmits signals between devices over short ranges	
Uses microwave frequencies to transmit Internet signals over a small area	
A portable device which can communicate with other such devices via antennae relaying radio signals	

ANSWERS

Electromagnetic waves	A transverse wave with vibrating electric and magnetic field components
Vacuum	Empty space
Inverse square law	States how the intensity of light decreases from a source
Intensity	Power per unit area
Spectrum	Continuous range of wavelengths
Radio	An electromagnetic wave with wavelength between 10 cm and 100 km
Microwave	An electromagnetic wave with wavelength between 10^{-1} m and 10^{-3} m
Infrared	An electromagnetic wave with wavelength between 1 mm and 700 nm
Visible	An electromagnetic wave with wavelength between 700 nm and 400 nm
Ultraviolet	An electromagnetic wave with wavelength between 400 nm and 10 nm
Gamma	An electromagnetic wave with wavelength between 1 nm and 0.1 nm
X-ray	An electromagnetic wave with wavelength between 10 nm and 1 nm
Frequency	The number of complete oscillations per unit time
Satellite	Orbits Earth and relays communication transmissions
Bluetooth	Transmits signals between devices over short ranges
Wi-Fi	Uses microwave frequencies to transmit Internet signals over a small area
Mobile phone	A portable device which can communicate with other such devices via antennae relaying radio signals

ASSESSMENT QUESTION

Please answer this assessment question on this topic in Applied Science.

This work will be formally assessed with feedback given.

This work will be submitted at the start of the KS5 course in Year 12.

If we require any help or you wish to receive immediate feedback, please e-mail Mr. Turnbull.

1. Various parts of the electromagnetic spectrum are used for communication.
An electromagnetic wave has a frequency of 4.5×10^9 Hz.
The speed of light is 3×10^8 m/s.
1.1 Show that the wavelength of the electromagnetic wave is approximately 7.0 cm.
Show your working.

[3 Marks]

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Wavelength = **...............** cm

1.2 Discuss the advantages and disadvantages of using radio waves and microwaves in communication.

[6 Marks]

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Reference: Applied Science Examination Unit 1 Specimen

2. Electromagnetic waves are grouped into regions based on their frequency.

2.1 Complete the table below to describe the regions of electromagnetic waves and their applications.

[7 Marks]

Region	Frequency	Applications
Radio	30 kHz to 3 GHz	
Microwave	3 GHz to 300 GHz	
	300 GHz to 400 THz	Cooking food, night-vision cameras, remote controls, motion sensors
	400 THz to 800 THz	Human sight, photography
	800 THz to 30 PHz	Forensic analysis, disinfection, bug zappers
X-rays	30 PHz to 30 EHz	
Gamma rays	> 30 EHz	

2.2 Why are higher frequency microwaves used in satellite communications, while lower frequency radio waves are used in mobile phone communications.

[2 Marks]

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2.3 Bluetooth and Wi-Fi both use similar frequencies. How are Bluetooth signals made to not interfere with Wi-Fi signals?

[3 Marks]

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2.4 Why are infra-red waves chosen for their use in remote controls?

[2 Marks]

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Reference: Zig Zag Educational Resources

EXTENSION

To further extend your understanding in the Applied Science course to prepare yourself for Year 12 course, read over information on the following topics:

Diffraction Gratings

Emission Spectra of Elements

Standing Waves on Strings

Resonance

Total Internal Reflection

Acknowledgements

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All relevant information has been credited in the document.

This document has been produced for educational purposes only.

This document has been produced for the Applied Science Extended Certificate Specification.

Student Voice

If you when using this document, you believe there is an improvement to made, please state this in the space below….

Only constructive and reasoned feedback will be considered.