EDEXCEL

GCSE Separate **Physics**

Paper 1

Outcomes Revision

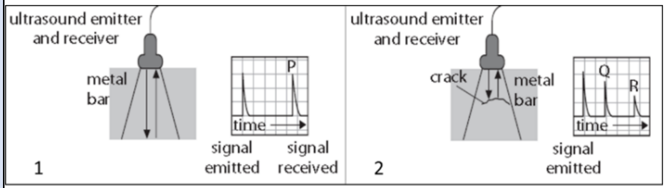
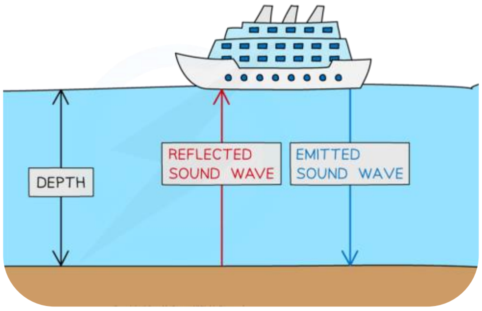
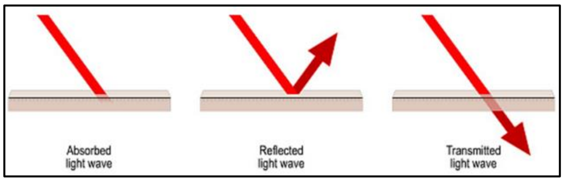
<table>
<tr><th>Outcomes</th><th>Physics key concepts</th></tr>
<tr><td>Ph1
Recall and use the SI unit for physical quantities, as listed in the specification</td><td>The SI units defined in the specification are:
<table>
<tr><td>Distance
Metre
(m)</td><td>Mass
Kilogram
(kg)</td><td>Time
Second
(s)</td></tr>
<tr><td>Current
Ampere
(A)</td><td>Temperature
Kelvin
(K)</td><td>Amount of a substance
Mole
(mol)</td></tr>
<tr><td>Frequency
Hertz
(Hz)</td><td>Force
Newton
(N)</td><td>Energy
Joule
(J)</td></tr>
<tr><td>Power
Watt
(W)</td><td>Pressure
Pascal
(Pa)</td><td>Electric charge
Coulomb
(C)</td></tr>
<tr><td>Electric potential difference
Volt
(V)</td><td>Electric resistance
Ohm
(Ω)</td><td>Magnetic flux density
Tesla
(T)</td></tr>
</table></td></tr>
<tr><td>Ph2
Recall and use multiples and sub-multiples of units, including giga (G), mega (M), kilo (k), centi (c), milli (m), micro (μ) and nano (n)</td><td>Some numbers are very large or very small, to make these easier to handle we use prefixes.
Prefixes tell you how much bigger or smaller a unit is than the base unit. For example, 1 kg is 1000 times bigger than a gram and 1 mm is 1000 times smaller than a metre. These numbers are called the conversion factors.
So, to convert 4.5 kg into grams you do the following: 4.5 x 1000 = 4500 g. To convert 45 mm in meters: 45 x 0.001 = 0.045 m.
(N.B. 45 x 0.001 is the same as 4.5 ÷ 1000).
A table of common prefixes and their conversion factors is here:</td></tr>
<tr><td colspan="2">
<table>
<tr><td>Tera (T)</td><td>Giga (G)</td><td>Mega (M)</td><td>Kilo (k)</td><td>Milli (m)</td><td>Micro (μ)</td><td>Nano (n)</td></tr>
<tr><td>10^{12}</td><td>10^{9}</td><td>10^{6}</td><td>1000</td><td>0.001</td><td>10^{-6}</td><td>10^{-9}</td></tr>
</table>
In a question you might get given a value such as 5.6 GHz, the first thing you need to do is convert this to Hz (not GHz) 5.6 GHz = 5.6 x 10^{9} Hz. (5.6 x 1,000,000,000)
Or 2.3 μA, to convert this: 2.3 μA = 2.3 x 10^{-6} A. (2.3 x 0.000,001 or 2.3 ÷ 1,000,000)</td></tr>
<tr><td>Ph2a
Be able to convert between different units, including hours to seconds</td><td>You may get given time in minutes, or even in hours, but we need time in seconds if we are using it in an equation. This is easy to convert as there are 60 seconds in a minute and 60 minutes in an hour.
Convert 5 minutes into seconds: 5 x 60 = 300 s
Convert 2 hours into seconds: 2 x 60 x 60 = 7200 s</td></tr>
<tr><td>Ph3
Calculate mean averages, giving answer to appropriare number of significant figures</td><td>To calculate a mean average, you must first find the sum of the individual values (add them all up and press equals). You then divide the sum by the number of values (often 3 or 5 for investigations).
Find the average of 25, 28 and 25.
25 + 28 + 25 = 78
78 ÷ 3 = 26
Sometimes the average will not be a whole number, when presenting you average value you should never give your answer to more significant figures than were given in the original data. (See Ph4 for more information on significant figures.)
Find the average of 5.6, 6.2 and 5.5
5.6 + 6.2 + 5.5 = 17.3
17.3 ÷ 3 = 5.766666, however the original data is only 2 significant figures so 5.8 should be written on the answer line.</td></tr>
</table>

Outcomes	Physics key concepts
Ph3a *Calculate mean averages, identifying and handling anomolus results*	To calculate a mean average, you must first find the sum of the individual values (add them all up and press equals). You then divide the sum by the number of values (often 3 or 5 for investigations). Find the average of 25, 28 and 25. 25 + 28 + 25 = 78 78 ÷ 3 = 26 Sometimes there is a result that clearly does not fit the pattern, this is called an anomaly, is usually due to an error. When calculating the average, we ignore this value and calculate the average of the remaining values. Find the average of 4.5, 8.2, 4.3 and 5 8.2 is clearly an anomaly so we ignore it: 4.5 + 4.3 + 5 = 13.8 13.8 ÷ 3 = 4.6
Ph4 *Use significant figures where appropriate*	The first significant figure (s.f.) of a number is the first digit that is not a zero. The second and third significant figures come straight after the first (even if they are zeros). *Remember that:* *If the number you are rounding is followed by 5, 6, 7, 8, or 9, round the number up. Example: 38 rounded to the nearest ten is 40* *If the number you are rounding is followed by 0, 1, 2, 3, or 4, round the number off. Example: 33 rounded to the nearest ten is 30* Examples: Round 0.005642 to 2 s.f. = **0.0056** Round 56.42 to 2 s.f. = **56** Round 5642 to 2 s.f. = **5600** Round 7.685 to 2 s.f. = **7.7** *N.B. it is good practice to give your final answer to the lowest number of significant figures given in a question.*
Ph4a *Use decimal places where appropriate*	Sometimes you will get asked to give an answer to a certain number of decimal places (d.p.) - these are the digits that come after a decimal place. *Remember that:* *If the number you are rounding is followed by 5, 6, 7, 8, or 9, round the number up. Example: 38 rounded to the nearest ten is 40* *If the number you are rounding is followed by 0, 1, 2, 3, or 4, round the number off. Example: 33 rounded to the nearest ten is 30* Examples: Round 0.005642 to 2 d.p. = **0.01** Round 5.642 to 2 d.p. = **5.6** Round 5642 to 2 d.p. = **5642.00** Round 7.685 to 2 d.p. = **7.69**

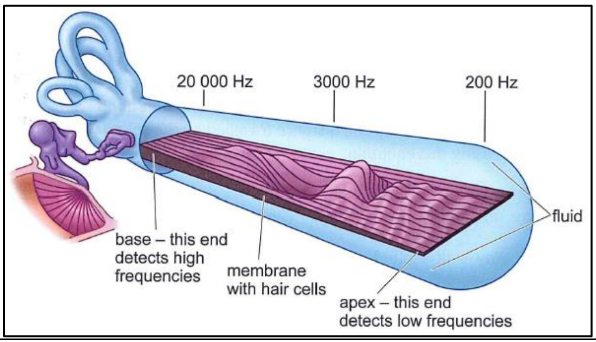
<table>
<tr><th>Outcomes</th><th>Physics key concepts</th></tr>
<tr><td>Ph4b
Use standard form where appropriate</td><td>Standard form, or standard index form, is a system of writing numbers which can be particularly useful for working with very large or very small numbers. It is based on using powers of 10 to express how big or small a number is.
Standard form uses the fact that the decimal place value system is based on powers of 10:
<table>
<tr><td>For larger numbers we use a positive power of 10</td><td>For smaller numbers we use a negative power of 10</td></tr>
<tr><td>$10^2 = 100$
$10^3 = 1000$
$10^4 = 10000$
$10^5 = 100000$
$10^6 = 1000000$</td><td>$10^{-2} = 0.01$
$10^{-3} = 0.001$
$10^{-4} = 0.0001$
$10^{-5} = 0.00001$
$10^{-6} = 0.000001$</td></tr>
<tr><td>Example
Write 50,000 in standard form.
50,000 can be written as: $5 \times 10,000$
$10,000 = 10 \times 10 \times 10 \times 10 = 10^4$
So: $50,000 = 5 \times 10^4$</td><td>Example
Write 0.0005 in standard form.
0.0005 can be written as 5×0.0001.
$0.0001 = 10^{-4}$
So $0.0005 = 5 \times 10^{-4}$</td></tr>
<tr><td>To input this into your calculator, press:
</td><td>To input this into your calculator, press:
</td></tr>
</table></td></tr>
<tr><td>Ph5
Devise an investigation</td><td>You may be asked to describe how to carry out an investigation similar to one of the core practical tasks.
You should think about:
• The measurements you need to make
• The equipment you will use to make these measurements
• How the equipment should be used
• Any health and safety to consider?
• Describe any equations that would be used to complete the investigation
• Would you take repeats and find an average?
• What range of results you would collect</td></tr>
<tr><td>Ph5a
Can write, or comment on, a conclusion</td><td>In a conclusion you should say what your results show, and how this relates to any prediction given in the question.
e.g. As mass increased so did weight
In a conclusion we try to us evidence from our results to support our answer.
e.g. When mass was 3 kg, weight was 30 N and when mass 6 kg, weight was 60 N. When mass doubled so did weight.
For better marks we try to explain why we got those results
e.g. Mass and weight are linked by the equation ‘W = m x g’ so if the value of g does not change then mass and weight are directly proportional.
See Ph8a for more information on directly proportional relationships.</td></tr>
</table>

Outcomes	Physics key concepts
Ph6 *Apply a given equation*	Sometimes you get given an equation that you will never have seen before- don't let this throw you. Find the numbers that are reprinted in the equation and substitute the symbols with the numbers. Re-arrange the equation, if you need to. Resolve the equation- work out the answer.
Ph7 *Justify the use of equipment for an investigation*	Think about which equipment would be the best choice and why. For example, if you were measuring a small length or short distance you would use a ruler- but if you were measuring 300 m then you would use a trundle wheel or possibly a tape measure. When measuring time, we generally use a stopwatch however when recording short time intervals or timing things that move quickly then human riming error can become a problem and a digital timer may be a more accurate choice of equipment.
Ph8 *Interpret data from diagrams, tables and graphs*	These questions are about understanding information you are given in the question and will often be different to any question you may have seen before. **Diagrams** These could contain **values** that you need to **use in an equation** or **equipment** you may need to use in a **practical**. There is no set pattern to this- you will need to apply 'common sense' and think your way through what you are being asked. **Tables** For simple marks you are looking to **describe any relationships** you see- for example as mass increases so does weight. There may be **further patterns**- for example does weight keep going up by the same amount? Or **do the intervals getter smaller? Bigger?** Sometime you may need to use **values in an equation** to show a trend or relationship- for example a table could contain values for voltage and current- but you are asked about resistance. In this case you would need to calculate the resistance values. **Graphs** Is the graph **linear** (straight line) or **non-linear** (curved)? **What is the trend**? As the '**X axis values' increase**, what happens to the '**Y axis values'**, does it **increase or decrease**. Is there a **maximum** or a **minimum point**? Sometime you might have to **extract data** and 'do something with it' perhaps **use it in an equation** or work out a range.
Ph8a *Describe a directly proportional relastionship*	A directly proportional relationship is relationship between two variables that meets the following two rules: • If one value doubles, then the other value also doubles • If one value is zero, then the other value is also zero This type of relationship can be seen on a graph when: • You get a straight line of best fit • That passes through the origin (0,0)

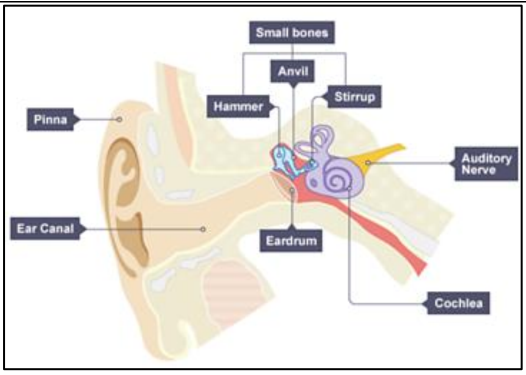
Outcomes	Separate Forces
Ph44a *Estimate how the distance required for a road vehicle to stop in an emergency varies over a range of typical speeds*	You need to be able to recall some typical data: ➢ Speed on town roads ≈ 13 m/s ➢ Speed on motorway ≈ 31 m/s ➢ Typical reaction time ≈ 0.25 seconds ➢ Mass of car ≈ 1000 kg **You should remember that:** **Total stopping distance = thinking distance + braking distance** **Work done by the brakes = kinetic energy of moving vehicle** You will also need the following equations: **Thinking distance = speed x reaction time** **Kinetic energy = ½ mass x velocity^2** **Work done = braking force x braking distance** You need to use these values to first find the thinking distance and then find the braking distance before adding these two values together. ***Worked example:*** *A car is travelling in town and has to brake sharply. The braking force is 5000 N. Estimate the total stopping distance.* Step 1: estimate thinking distance **Thinking distance = speed x reaction time** Typical speed in town ≈ 13 m/s, typical reaction time ≈ 0.25 s Thinking distance = 13 x 0.25 Thinking distance = **3.25 m** Step 2: estimate braking distance **Kinetic energy = ½ mass x velocity^2** Typical speed in town ≈ 13 m/s, typical reaction mass ≈ 1000 kg Kinetic energy = 0.5 x 1000 x 13^2 Kinetic energy = **84,500 J** **Work done = braking force x braking distance** 84,500 = 5000 x braking distance Braking distance = 84,500 ÷ 5000 Braking distance = **16.9 m** Step 3: estimate total stopping distance **Total stopping distance = thinking distance + braking distance** Stopping distance = 3.25 + 16.9 Stopping distance = **20.15 m**
Ph44b *Carry out calculations on work done to show the dependence of braking distance for a vehicle on initial velocity squared (work done to bring a vehicle to rest equals its initial kinetic energy)*	A moving car stores kinetic energy. When a car to breaks this kinetic energy must be transferred into thermal energy by the brakes. The work done by the brakes is equal to the kinetic energy stored in the car. **Kinetic energy = ½ mass x velocity^2** **Work done = braking force x braking distance** If the velocity of a car doubles, then the kinetic energy will quadruple (because velocity is squared and $2^2 = 4$). The work done by the brakes will quadruple and therefore the braking distance will also quadruple. ***Worked example:*** *A 1000 kg car is travelling at 5 m/s and has to brake sharply. The braking force is 5000 N. Calculate the braking distance.* **Kinetic energy = ½ mass x velocity^2** Kinetic energy = ½ 1000 x 5^2 Kinetic energy = 12,500 J Work done by brakes = kinetic energy = 12,500 J **Work done = braking force x braking distance** 12, 500 = 5000 x braking distance Braking distance = 12, 500 ÷ 5000 Braking distance = 2.5 m *Calculate the braking distance if the velocity doubled to 10 m/s.* Kinetic energy = ½ 1000 x 10^2 = 50,000 J Braking distance = 50,000 ÷ 5000 Braking distance = 10 m (quadruple the braking distance at 5 m/s)

Outcomes	Separate Waves
Ph74 *HT ONLY: Calculate depth or distance from time and wave velocity*	Sonar is used to find distance or depth using the principles of wave speed and reflection. Pulses of ultrasound are sent out through material and the time for the reflection to return is used to determine how far the wave has travelled. This principle can be used to investigate the depth of the sea floor or even used to detect cracks in solid materials.  Diagram 1 shows a wave travelling through a metal bar without a crack and reflecting from the edge of the metal bar (pulse P). Diagram 2 shows that if there is a crack then some of the wave gets reflected from the crack (pulse Q) and a weaker signal is reflected from the edge of the metal bar (pulse R). This diagram shows a pulse of ultrasound being sent towards the ocean floor and then reflecting back to the boat.  In both cases, if the speed of sound is known in the material and the time can be measured then the distance travelled by the wave can be calculated- remember that the wave goes there and back. **Distance = speed x time**
	The ship in the diagram above sends out a pulse of ultrasound that takes 0.5 seconds to return. The speed of sound in sea water is 1500 m/s. *Calculate the depth of the sea floor at this point.*
	Distance = speed x time Distance = 1500 x 0.5 Distance (travelled by the wave) = 750 m Depth is equal to half the distance covered Depth = 750 ÷ 2 = **375 m**
Ph75 *Describe the effects of reflection, refraction, transmission, absorption of waves at material interfaces*	The boundary between two materials is called the interface. When waves meet an interface, they can be absorbed, reflected or transmitted. Waves that are transmitted are often also refracted.  **Absorbed-** when the waves energy is transferred to the material (usually as thermal energy). **Reflected-**when the wave 'bounces back' off the material (the angle of incidence is always equal to the angle of reflection). **Transmitted-** when the wave passes through the material. **Refracted-** when the wave passes through the material at an angle and changes direction (due to a change in speed).
Ph78 *HT ONLY: Recall that different substances may absorb, transmit, refract or reflect waves in ways that vary with wavelength*	The light we see from lamps is usually what we call 'white light'. It is a mixture of all the different colour of light, different colours of light have different frequencies and therefor different wavelengths. When light waves are **transmitted** through different materials the different frequencies of light change speed by different amounts at the interface- so they are **refracted** by different amounts- this is why we see a rainbow (or a visible spectrum of light). As sound waves are **transmitted** through different materials the frequency does not change, but the speed and wavelength do. Sound waves travel faster in solids than in the air (solids are denser) and their wavelength increases **(speed = frequency x wavelength)**.

<table>
<tr><th>Outcomes</th><th>Separate Waves</th></tr>
<tr><td>Ph79
HT ONLY: Describe the processes which convert wave disturbances between sound waves and vibrations in solids</td><td>Sound waves are longitudinal (the particles oscillate parallel to the direction of wave transmission). When a sound wave hits a solid some of the energy is reflected and some is transmitted or absorbed.
The longitudinal wave causes the particles at the surface of the solid to vibrate, these vibrations can cause both longitudinal and transverse waves in the solid.
The shape, size and structure of the material will determine how different frequencies of waves will affect it.</td></tr>
<tr><td>Ph80
HT ONLY: Explain why processes that convert wave disturbances only work over a limited frequency range</td><td>Human ears detect sounds with a frequency between 20 and 20,000 Hz. As humans evolved it was not beneficial to hear lower or higher frequencies so the structure of our ears did not evolve to hear them.
The shape, size and structure of the different parts of ear determine how different frequencies of waves will affect them.
Our ear drums will detect sounds between 20 and 20,000 Hz and these sounds waves are amplified by the three small bones.



Different frequencies of sound are detected by different parts of the cochlea. The base of the cochlea is thick and detects higher frequency sounds (20,000 Hz), this becomes thinner towards the apex which detects lower frequency sounds (20 Hz).</td></tr>
<tr><td>Ph81
HT ONLY: Use the process that converts wave disturbances to explain the way the human ear works</td><td>Sound waves are funnelled into our ears by the pinna and travel through the ear canal.
When sound waves strike the eardrum, they make it vibrate.
These vibrations are amplified the three small bones before being passed into the cochlea.
The liquid inside the cochlea vibrates and causes hairs on membrane to vibrate. The hairs are connected to neurones which send electrical impulses, via the auditory nerve, to our brain.


</td></tr>
<tr><td>Ph82
HT ONLY: Recall the frequency of ultrasound and state its units</td><td>Ultrasound waves are sound waves that are too high pitch for humans to hear.
The prefix “ultra” means above or beyond.
Ultrasound waves have a frequency higher than 20,000 Hz (or 20 kHz).</td></tr>
<tr><td>Ph82a
HT ONLY: Recall uses of ultrasound and infrasound</td><td>Ultrasound waves (frequencies higher than 20,000 Hz) can be used in sonar to measure the depth of ocean floors or to detect flaws (cracks) in solid objects (such as aeroplane wings). They are also used medically in foetal scans or to treat muscle injuries. They can be used to clean jewellery and are also used in echolocation by bats and dolphins.
Infrasound waves (frequencies lower than 20 Hz) can be used to monitor and detect volcanic eruptions, earthquakes or avalanches. They can also be used to track large animals such as elephants and whales because these animals use infrasound to communicate. Seismic waves caused by earthquakes give scientists lots of information about the structure of the Earth.</td></tr>
<tr><td>Ph82b
HT ONLY: Recall the frequency of infrasound and state its units</td><td>Infrasound waves are sound waves that are too low pitch for humans to hear.
The prefix “infra” means below.
Infrasound waves have a frequency lower than 20 Hz.</td></tr>
</table>

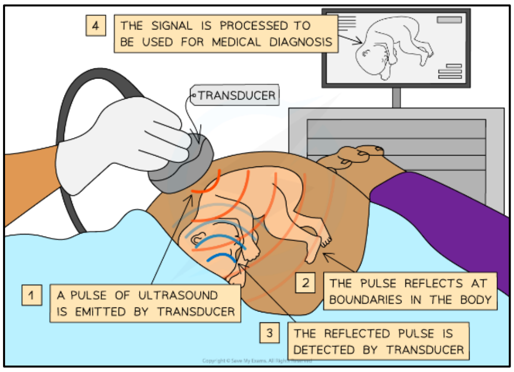
<table>
<tr><th>Outcomes</th><th>Separate Waves</th></tr>
<tr><td>Ph83
HT ONLY: Explain uses of ultrasound</td><td>

For more information about how sonar can be used to investigate depth or distance see outcome Ph74.

Sonar works by sending out **pulses of ultrasound** that **reflect** when they hit solid objects (such as the ocean floor or a whale). The reflection is detected and the **time between** sending out the pulse and detecting the reflection can be used to calculate the distance travelled by the ultrasound.

Ultrasound waves are not only reflected by solid surfaces, some of the wave is reflected every time the **wave passes into material with a different density**- such as when it passes a crack in a metal block.

Foetal scans use an ultrasound transmitter that sends out **pulses of ultrasound** into a mother's womb, whenever the waves **pass a boundary** between two materials that have different densities (such as fluid, skin, muscle or bone) some of the **wave is reflected** and detected. The timings of the reflected waves are used to form the image that we see in a foetal scan.



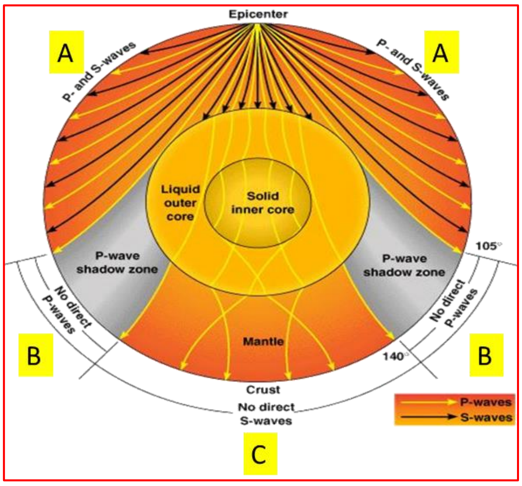
</td></tr>
<tr><td>Ph83a
HT ONLY: Explain uses of infrasound</td><td>

Seismic waves tell scientists a lot about the structure of the Earth. The main seismic waves are P waves and S waves.

P waves are **longitudinal** and **travel through solids, liquids** & gases.

S waves are **transverse**, they are **slower** than P waves and can **only travel through solids**.

Seismic waves are detected by seismometers and this diagram shows the pattern of waves typically detected.



Section A shows both S and P waves so the mantle must be **solid** (as S waves only travel through a solid). The lines are **curved,** this tells us that the rock has **changing density** and causes the waves to **refract**.

Section B shows no waves detected. This is due to the large **refraction** caused as the P waves pass into the **liquid outer core** (large change in density). S waves are absorbed by the liquid.

Section C shows only **P waves**- this proves that part of the core must be **liquid**- because **S waves cannot travel through liquids**.

The large refraction of P waves is caused as the waves pass between solid and liquid as there are large changes in density.

Section B, where no P waves are detected, is called the **P wave shadow zone**.

Section B and C, where no S waves are detected, is called the **S wave shadow zone.**

</td></tr>
<tr><td>Ph84
Describe how changes, if any, in velocity, frequency and wavelength, in the transmission of sound waves from one medium to another are inter-related</td><td>

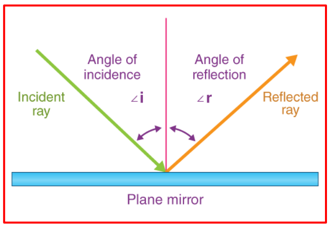
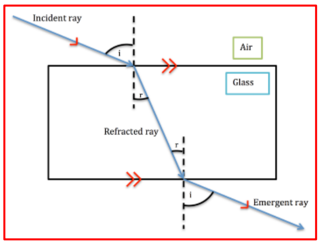
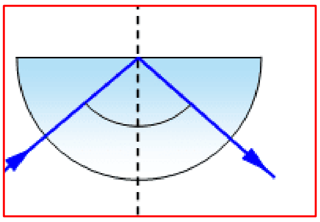
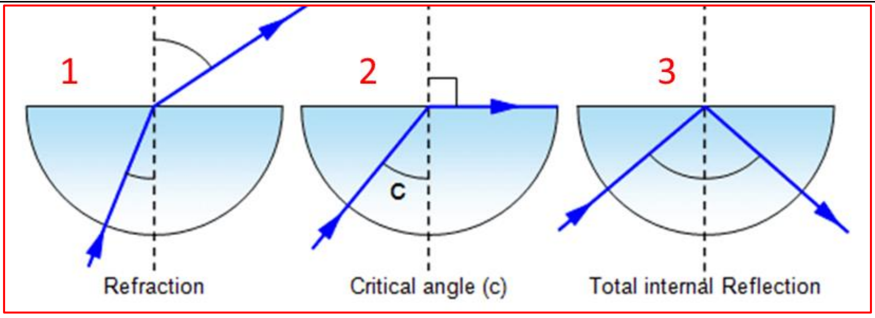
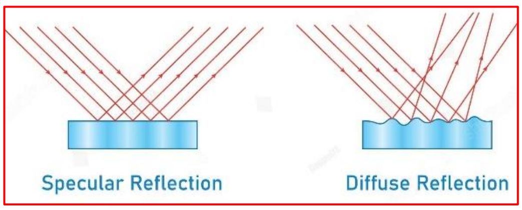
Sound waves travel faster in liquids than they do in gases, and faster in solids than they do in liquids.

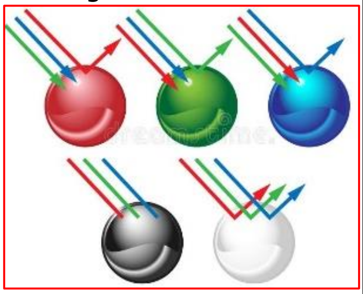
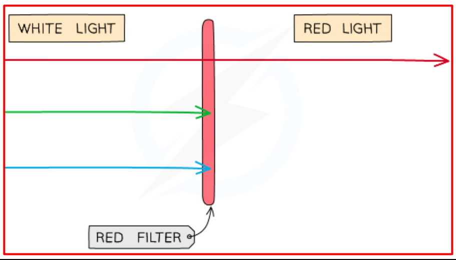
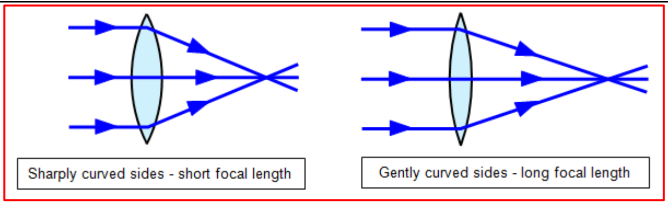
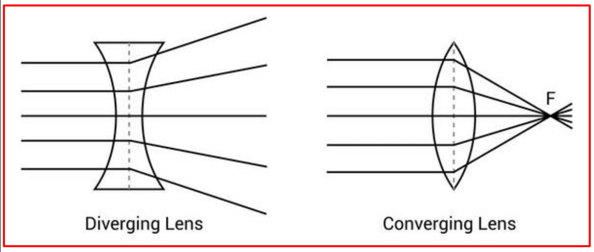
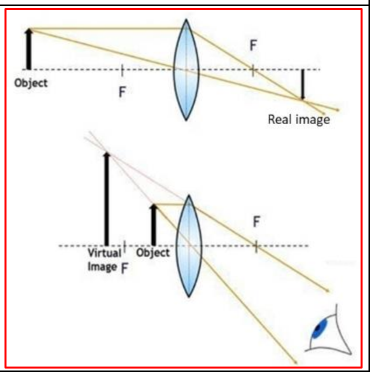
When a wave passes into a new material and changes speed the frequency of the wave stays the same.

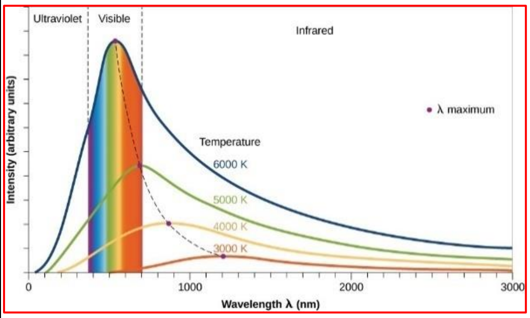
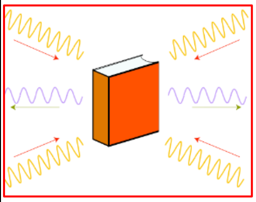
Speed = frequency x wavelength

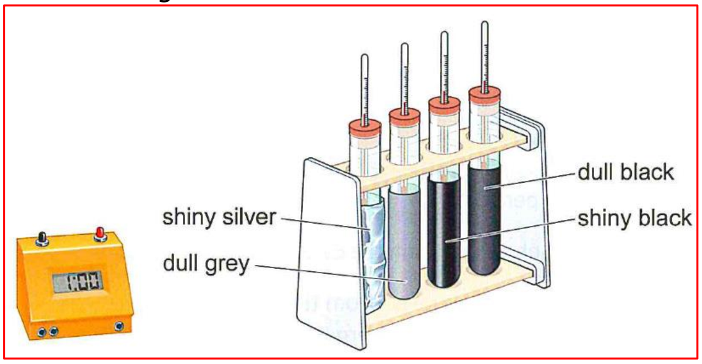
If the frequency stays the same and the **speed increases** then the **wavelength** must also **increase**. If the speed decreases and the frequency stays the same then the wavelength must also decrease.

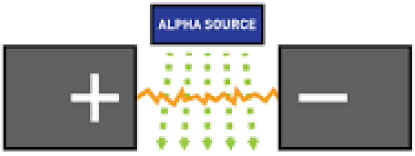
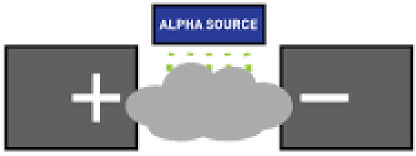
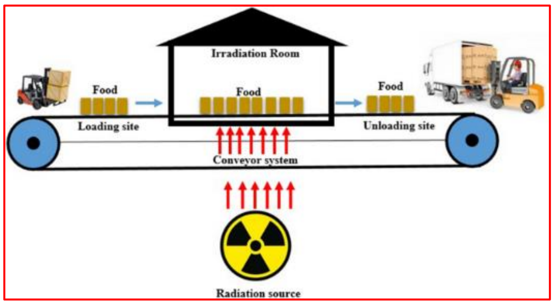
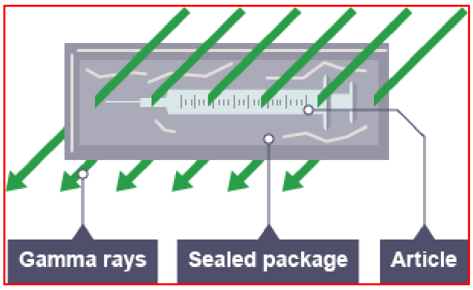
</td></tr>
</table>

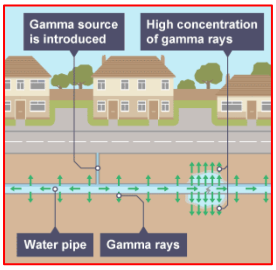
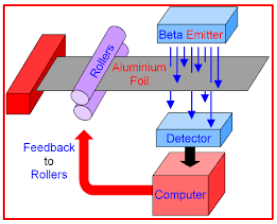
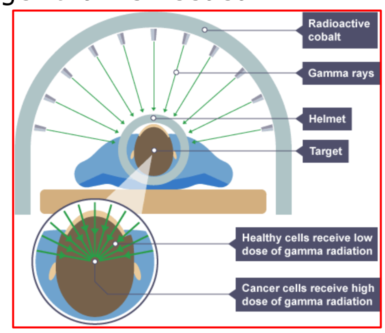
Outcomes	Separate Light and the electromagnetic spectrum
Ph86 *Explain, with the aid of ray diagrams, reflection, refraction and total internal reflection (TIR), including the law of reflection and critical angle*	There is a lot in this criterion point- which bit do you need to revise? **Reflection**  The **angle of incidence** is always **equal to** the **angle of reflection.** **Refraction**  As light enters the glass it **slows down** and **refracts towards** the normal. As it leaves the glass and enters the air it **speeds up** and **refracts away from** the normal. **TIR & the critical angle**  When a wave travels through a dense material like glass, towards a less dens material, like air, it can be reflected from the surface back into the material- this is called **total internal reflection (TIR).** TIR only happens when the angle of incidence is larger than a specific angle called the **critical angle.** TIR reflection is used in fibre optic cables- such as for delivering broadband or for an endoscopy.
Ph86a *Describe how to investigate total internal reflection (TIR)*	 1- Shine a thin beam of light through the **curved edge** of a glass block, the angle of incidence should be low. Light will be **refracted** at the flat edge. 2- **Increase the angle of incidence**, by moving the ray box, until the refracted **ray shine along the edge** of the flat edge. Measure the angle of incidence, with a protractor, this is **the critical angle**. This is the point that **total internal reflection (TIR) begins.** 3- As you increase the angle of incidence even further you now see (TIR) the **angle of incidence** is **equal to** the **angle of reflection**.
Ph87 *Explain the difference between specular and diffuse reflection*	 **Specular reflection** is when waves are reflected in a **single direction**, from a **smooth surface**- we see a **clear reflection**. **Diffuse reflection** is when the waves are reflected in **different directions**, from a **rough surface**- we do **NOT see a clear reflection**.

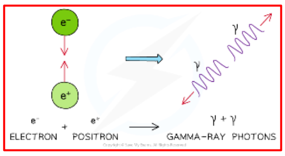
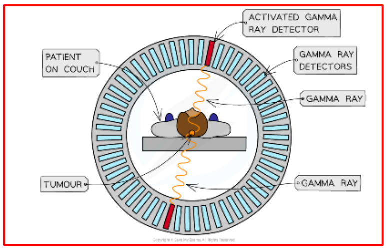
Outcomes	Separate Light and the electromagnetic spectrum
Ph88 *Explain how colour of light is related to differential absorption at surfaces and transmission of light through filters*	White light is a mixture of all the different colours of light. **Colour related to absorption at surfaces** Different surfaces reflect or absorb different frequencies (colours) of light. A red book **reflects red** light, it **absorbs blue** and **green**.  **Colour related to transmission of light through filters**  Filters transmit some frequencies (colours) of light and absorb others. A red filter **transmits red** light, it **absorbs blue** and **green**.
Ph89 *Relate the power of a lens to its focal length and shape*	 A **thicker lens** causes light to refract through bigger angles- we say it is **more powerful.** The focal length is the distance between the centre of the lens and the focal point (the point where the light rays meet). A **thicker lens** has a **shorter focal length**.
Ph90 *Use ray diagrams to show the similarities and differences in the refraction of light by converging and diverging lenses*	 A **concave** lens is **thinner at** the **middle**, they cause light to **diverge** (move away from each other). We call these **diverging** lenses. **Convex** lenses are **thicker** at the **middle,** they cause light to c**onverge** (come together). We call theses **converging** lenses.
Ph91 *Explain the effects of different types of lens in producing real and virtual images*	A **real image** is formed when the light rays **actually meet** to form the image. A real image **can be seen on a screen**. A **virtual image** is formed when the light rays **appear to be coming** from a **different place** to where they are actually coming from. The light rays **do not actually meet** where the image forms- it just appears that they do. A virtual image **cannot be seen on a screen.** 

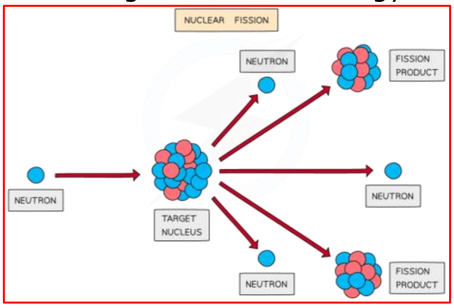
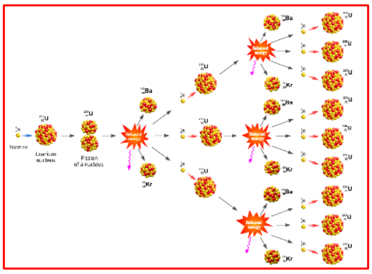
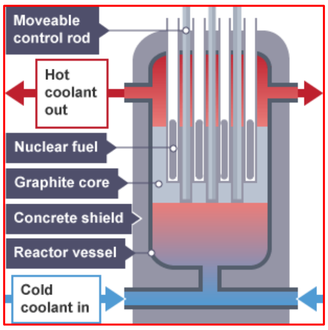
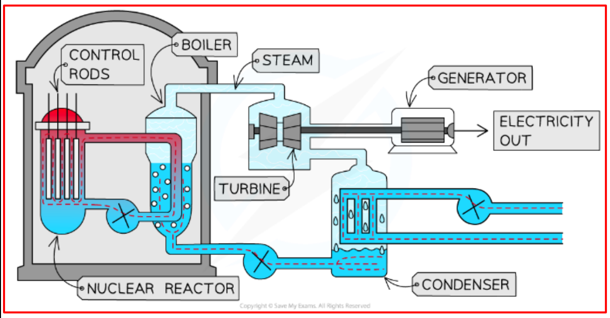
Outcomes	Separate Light and the electromagnetic spectrum
Ph100 *Explain that all bodies emit radiation, that the intensity and wavelength distribution of any emission depends on their temperature*	All objects are emitting (and absorbing) electromagnetic radiation all the time.  **Hotter** objects **emit** radiation with **higher frequencies**. If an object gets hot enough then the frequency of the radiation emitted moves from infrared to visible light- we can see the radiation emitted. Objects emitting yellow light are hotter than object emitting red light (yellow light has a higher frequency that red light).
Ph101 *HT ONLY: Explain that for a body to be at a constant temperature it needs to radiate the same average power that it absorbs*	All objects are constantly radiating (emitting) and absorbing EM radiation. The amount of radiation **radiated** or **absorbed per second** is called the **power.** If an object **radiates and absorbs at the same average power** then its **temperature will be constant** (remain the same).  If an object **radiates more power than it absorbs then its temperature will increase**. If an object **radiates less power than it absorbs then its temperature will decrease.** *This image shows that the book is radiating less power than it is absorbing- the temperature of the book will increase.*
Ph102 *HT ONLY: Explain what happens to a body if the average power it radiates is less or more than the average power that it absorbs*	If an object **radiates more power than it absorbs** its **temperature will decrease** because it is giving out more energy than it is taking in. As the **temperature decreases** it will start to **radiate less power**, until eventually the it will **radiate and absorb at the same power**- it will now be at a **lower constant temperature**. If an **object radiates less power than it absorbs** its **temperature will increase** because it is giving out less energy than it is taking in. As the **temperature increases** it will start to **radiate more power**, until eventually the it will **radiate and absorb at the same power**- it will now be at a **higher constant temperature.**
Ph103 *HT ONLY: Explain how the temperature of the Earth is affected by factors controlling the balance between incoming radiation and radiation emitted*	The average temperature on Earth is determined by the amount of radiation it reflects, absorbs and radiates (emits). **Energy is transferred to the Earth from the Sun**, during the day most of this energy is absorbed, some it is reflected, by the atmosphere, by clouds and by the surface. At night energy is emitted to space. Overall, the Earth's temperature is fairly constant (when its night time here it is daytime somewhere else). Scientist believe that increased levels of greenhouse gases (such as carbon dioxide) are affecting the average global temperature. Greenhouse gases are believed to absorb energy- reducing the amount of energy that the Earth emits to space. This means that the **Earth** will still **absorb** the **same power** but will **radiate less**- the **temperature of the Earth increases**. As the Earth's **temperature rises** it will begin to **radiate more power**, until the Earth **radiates and absorbs at the same power**- however, it will now be at a **higher constant temperature.**

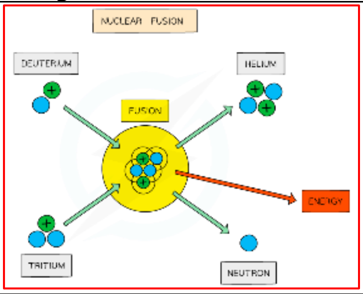
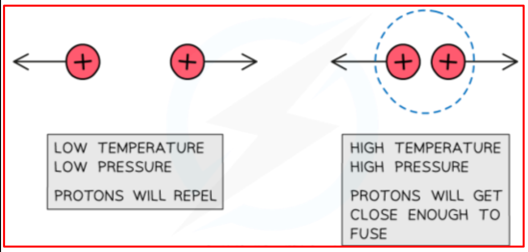
Outcomes	Separate Light and the electromagnetic spectrum
Ph104 *Core Practical: Investigate how the nature of a surface affects the amount of thermal energy radiated or absorbed*	It is possible to investigate how well different surfaces emit radiation.  Wrap four identical boiling tubes in different material or paint them different colours. Add equal amounts of boiling water to each tube. Use a **thermometer** to **record the temperature** every minute. The material that is the '**best emitter'** will **cool down the fastest.** You should find that the **dull black surface cools down the fastest** because dull black surfaces **emit radiation better** than white or shiny ones. Take note- dull black objects are also better at absorbing heat- so if we used cold water and placed the tubes Infront of a heater- the dull black tube would heat up fastest. *Some students find this confusing but dull, black objects are better at absorbing and emitting heat- if they are cold, they heat up faster but if they are hot, they cool down faster (than white or shiny objects).*

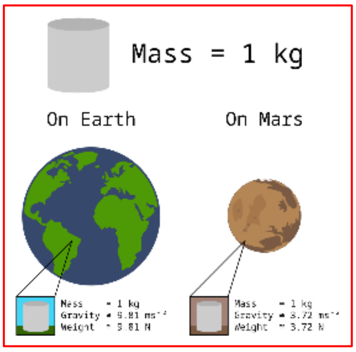
Outcomes	Separate Radioactivity
Ph144a *Explain how the dangers of ionising radiation depend on half-life and relate this to the precautions needed*	The higher the activity of radioactive source- the more dangerous it is to be around. If you have two radioactive sources with the same activity and different half-lives then the source with the longer half-life will be more dangerous. This is because after any period of time activity of the source with the longer half-life will have reduced by less than the source with a shorter half-life. When selecting radioactive sources, it is important to **consider the half-life**- you will need the **activity to be high enough for the right amount of time to complete its desired function**, but if **the half-life is too long then it will be too dangerous for too long**.
Ph145a *Describe how radiation can be used in: Smoke alarms*	A weak source of **Americium-241**, an alpha emitter, is placed close to two electrodes. It **ionises the air** in between the electrodes, **completing the circuit**, and allowing **current to flow**- the **alarm does not sound**. If there is a fire then the smoke will **absorb** the radiation, **current does not flow** and the **alarm sounds**.  Current due to ionization flow from + to -  Current flow stopped by smoke
Ph145b *Describe how radiation can be used in: irradiating food*	**Food** can be **irradiated** with **gamma rays** to help it stay fresher for longer. A high dose is used to **kill any bacteria** (microbes), this helps to preserve the food for longer. This method, unlike boiling, does not involve heating the food to a high temperature.  The source must be a high emitter of gamma rays and have a long(ish) half-life (several months) so that it does not have to replaced too often.
Ph145c *Describe how radiation can be used in: sterilisation of equipment*	Some medical equipment would be damaged if it was sterilised through  boiling. Medical equipment can be **sterilised** by i**rradiating** them with a strong source of **gamma rays**. **Gamma rays kill bacteria** (microbes). The source must be a high emitter of gamma rays and have a long(ish) half-life (several months) so that it does not have to replaced too often.

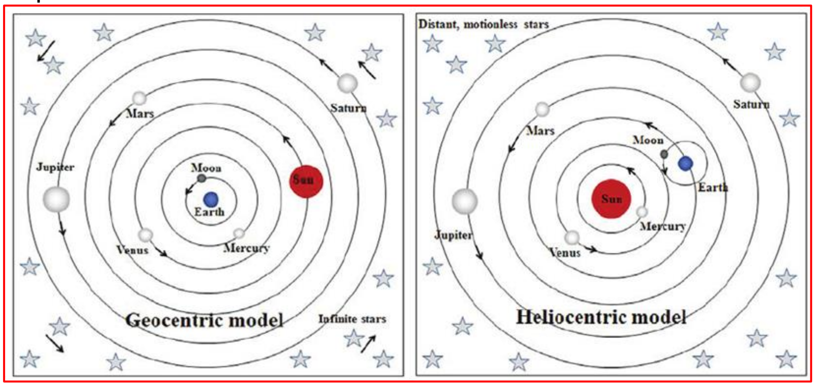
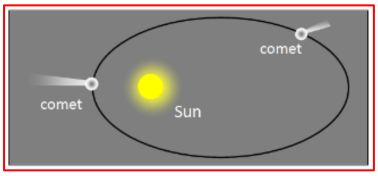
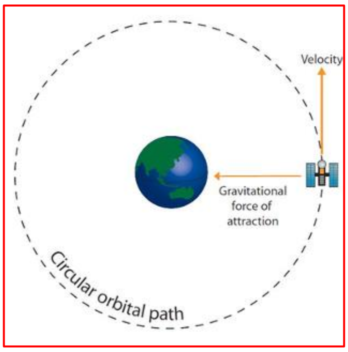
Outcomes	Separate Radioactivity
Ph145d *Describe how radiation can be used in: tracing and gauging thickness*	**Tracers in industry**  Gamma sources can be used to **detect leaks** in in underground pipes. A gamma source is placed in the pipes, the radiation is **detected by a gamma detector** on the surface. There is a spike in the reading directly above where the leak is- a hole can be dug directly to the leak-rather than digging up the hole pipe. **Tracers in medicine** A **radioactive isotope** can be **injected (or ingested**) into a patient and an external detector can be used to trace the isotope. This can be used to diagnose medical conditions- e.g. **locate tumours**. The source must be a **beta or gamma emitter** so that it will **pass out of the body** and not do too much damage to healthy tissue. Alpha sources are very ionising and will not penetrate through the body. The **half-life should be long enough to complete the scan**, but **not so long that it causes unnecessary damage**. **Gauging thickness** Some materials like paper or aluminium are rolled to a desired thickness.  If the material is rolled **too thin**, then **more beta** radiation passes through and the roller will correct the thickness. If the material is rolled **too thick**, then **less beta** radiation passes through and the roller will correct the thickness. Alpha would not pass through at all. Gamma would all pass through regardless of the thickness.
Ph145e *Describe how radiation can be used in: diagnosis and treatment of cancer*	**Diagnosis** A **PET scanner** can be used to diagnose medical conditions- such as to **locate tumours**. A radioactive isotope is injected into the body and will build up at any tumours. **External radiation detectors** will detect radiation emitted and use this information to **locate any tumours**. For more information see 146b below. **Treatment** Radiation can be used **to treat tumours**. The **high energy** will do lots of **damage to the cancerous cells** and reduce or even entirely destroy the tumour. Alpha and beta sources can used internally (inside the body) and gamma sources can be used externally (outside the body). For more information see 146a below.
Ph146a *Compare and contrast the treatment of tumours using radiation applied internally or externally*	**Internal treatment** **Alpha emitters can be injected close to a tumour**- this does a lot of damage to the tumour but the damage to surrounding (healthy) cells is limited due to the limited range of alpha particles. **Beta emitters can be implanted close to a tumou**r- the are more penetrating than alpha particle so will travel further and can damage nearby healthy cells. The half-lives of all sources use internally must be short so that the patient is not exposed to radiation for any longer than is needed. **External treatment** **Gamma sources** can be used to **aim gamma rays at tumours from outside of the body**. They must be carefully aligned to be directed at the tumour and shielding can be used to protect healthy cells. Any healthy cells in between the tumour and the radioactive source will be damaged by the gamma rays, the sources are usually rotated so that this damage is spread out as much as possible. 

Outcomes	Separate Radioactivity
Ph146b *Explain some of the uses of radioactive substances in diagnosis of medical conditions, including PET scanners and tracers*	**A PET scanner** can be used to diagnose medical conditions- such as to **locate tumours**. Cancer cells have a much higher metabolism that healthy cells- they use much more energy.  The patient is injected with glucose containing a radioactive tracer, this slowly moves through the body. The tracer will be a beta$^+$ emitter and will **emit positrons** (anti-electrons) and when **they meet electrons, they annihilate** each other (completely destroy) **releasing two gamma rays** that travel in opposite directions- these are detected by gamma detectors around the body. Areas that contain a tumour produce significantly more gamma rays; the detected rays allow doctors to locate the tumour. The half-life of the radioactive isotope must be long enough to complete the scan, but not so long that it causes unnecessary damage to healthy cells within the body. 
Ph146c *Explain why isotopes used in PET scanners have to be produced nearby*	A PET scanner can be used to diagnose medical conditions- such as to locate tumours. The **half-life** of the radioactive isotope must **be short to limit the damage done to the patient's healthy tissue**. The **isotope** must be **produced close** to the place where it is going to **be used**. If the isotope had to be transported then the activity would **be too low by the time it got to the hospital** and would not be able to used. Some hospitals have a cyclotron so that they can produce their own isotopes.
Ph146d *Evaluate the advantages and disadvantages of nuclear power for generating electricity*	**Advantages** Nuclear power is a **very reliable** energy resource (reducing or reliance on fossil fuels). Nuclear fuels **do not release carbon dioxide** (a greenhouse gas) **or sulphur dioxide** (causes acid rain) into the atmosphere. Nuclear fuels **release a lot of energy** and a lot of electricity can be generated from a small amount of fuel. Nuclear fuel (e.g. uranium) is **relatively cheap** and readily available. Nuclear power is actually a **fairly safe** way of producing electricity. **Disadvantages** Nuclear power produces a **lot of radioactive waste**- this is very dangerous and will remain radioactive for thousands of years. **Public perception** of nuclear power is that it is dangerous- this is due to high profile incidents such as **Chernobyl or Fukushima**- people are worried about nuclear leaks or a large disaster. Nuclear power plants are **expensive to build**. Nuclear power plants are **expensive to decommission**.
Ph146e *Recall that nuclear reactions, including fission, fusion and radioactive decay, can be a source of energy*	There is a lot of potential energy stored in the nucleus of an atom. This energy can be released through different processes: nuclear fission, nuclear fusion or radioactive decay. Nuclear **fission** is **splitting a large nucleus** into smaller nuclei. Nuclear **fusion** is **joining small nuclei** to form a larger nucleus. Radioactive decay is the nucleus rearranging itself and releasing radioactive particles (alpha, beta or gamma).

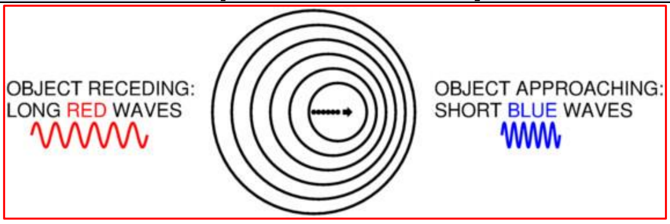
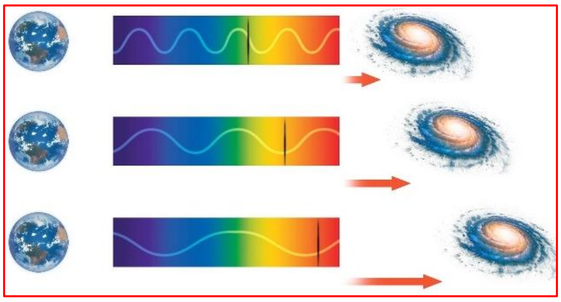
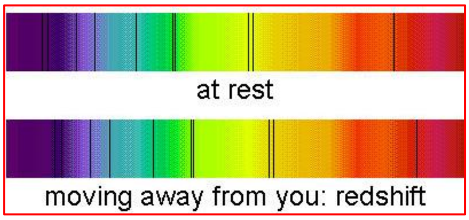
Outcomes	Separate Radioactivity
Ph146f *Explain the fission of U-235*	Nuclear **fission** is **splitting a large nucleus** into smaller nuclei, it also produces two or three neutrons and releases a large amount of energy. A slow-moving neutron is absorbed by the uranium nucleus The nucleus becomes unstable and splits into two, smaller, daughter nuclei (fission products). A lot of energy is released Two to three neutrons are also released. These neutrons will go on to be absorbed by other nuclei causing them to split and release more energy and more neutrons…. This is called a chain reaction. 
Ph146g *Explain the principle of a controlled nuclear chain reaction*	Nuclear **fission** is **splitting a large nucleus** into smaller nuclei, it also produces two or three neutrons and releases a large amount of energy. Each of the **released neutrons** can be **captured** (absorbed) by a **different uranium nucleus**. These nuclei split and release more neutrons. This excess of neutrons will cause a larger and larger number of fission reaction, this will release a lot of energy and will lead to a large nuclear explosion. If the excess neutrons are removed and the chain reaction is controlled then there will be a steady rate of fission reaction. 
Ph146h *Explain how the chain reaction is controlled in a nuclear reactor, including the action of moderators and control rods*	Nuclear **fission** is **splitting a large nucleus** into smaller nuclei, it also produces two or three neutrons and releases a large amount of energy. The neutrons released go on to cause more and more fission reactions. If this is not controlled then it will lead to a nuclear explosion. There are two main methods of controlling the chain reaction. **Moderators** (e.g. graphite) are used to **slow down the neutrons**- this makes it **more likely** that they will be '**captured**' by a uranium nucleus (fast moving neutrons will not be captured). **Control rods** (usually made from boron) are placed in between the fuel rods and will **absorb excess neutrons**. If the **reaction needs to be sped up**, the rods are **raised** and **less neutrons are absorbed**- there will be more fission reactions. If the **reaction needs to be slowed down**, the rods are l**owered** and **more neutrons are absorbed**- there will be less fission reactions. 
Ph146i *Describe how thermal (heat) energy from the chain reaction is used in the generation of electricity in a nuclear power station*	A controlled chain reaction releases thermal energy that is used to generate electricity. - The energy released by nuclear fission is transferred to the **thermal energy stores of the coolant.** - The thermal energy in the coolant is used to boil a separate water store and is transferred to the **kinetic energy (KE) stores of the steam.** - KE in the steam is transferred to the **KE stores of a spinning turbine** and then transferred to the **KE stores of a generator**. - The energy is then **transferred through** the national grid by **electricity**. 

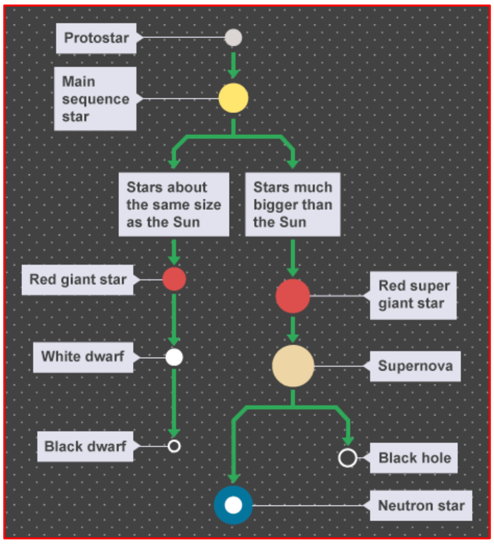
Outcomes	Separate Radioactivity
Ph146j *Recall that the products of nuclear fission are radioactive*	Nuclear **fission** is **splitting a large nucleus** into smaller nuclei, it also produces two or three neutrons and releases a large amount of energy. The two smaller nuclei, known as **fission products**, are **very radioactive**. They will remain radioactive for **thousands** (possibly millions) **of years**. This radioactive waste will emit dangerous radioactive particles so will need to be carefully and safely stored for a very long time.
Ph146k *Describe nuclear fusion*	Nuclear **fusion** is **joining small nuclei** to form a larger nucleus. Two **smaller nuclei collide** at high speed **and fuse** (join together). Typically, **two** types of **hydrogen nuclei** collide and **fuse to form a helium nucleus** (and a neutron). During this process some mass is **converted into energy**. 
Ph146l *Explain the difference between nuclear fusion and nuclear fission*	Nuclear **fission** is **splitting a large nucleus** into smaller nuclei. Nuclear **fusion** is **joining small nuclei** to form a larger nucleus. Nuclear **fission** can be controlled on Earth. Nuclear **fusion** happens in the Sun (and all stars). Nuclear **fission** produces radioactive waste. Nuclear **fusion** produces helium and does not produce radioactive waste.
Ph146m *Explain why nuclear fusion does not happen at low temperatures and pressures*	Nuclear **fusion** is **joining small nuclei** to form a larger nucleus. The **nuclei** have to **collide at high speed** for fusion to happen. **Nuclear fusion cannot happen at low temperatures or low pressures**. All nuclei are positively charged (due to their protons) so whenever they come close together there **is a strong force of electrostatic repulsion keeping them apart**.  **Very high temperatures** are needed to give the **nuclei enough kinetic energy** and velocity to **overcome this electrostatic repulsion**, and to fuse. **Very high pressures** are needed to ensure that the **nuclei are tightly packed**, making it **more likely** that **they will collide** with each other.
Ph146n *Relate the conditions for fusion to the difficulty of making a practical and economic form of power station*	Nuclear **fusion** is **joining small nuclei** to form a larger nucleus. The **nuclei** have to **collide at high speed** for fusion to happen. **Nuclear fusion cannot happen at low temperatures or low pressures**. See 146m, above, to find out why these conditions are needed. These conditions are very difficult to recreate on Earth, it can be done but, it uses a lot of energy to achieve. In fact, it takes more energy to produce the conditions than is released during nuclear fusion. It is currently too expensive to produce electricity this way.

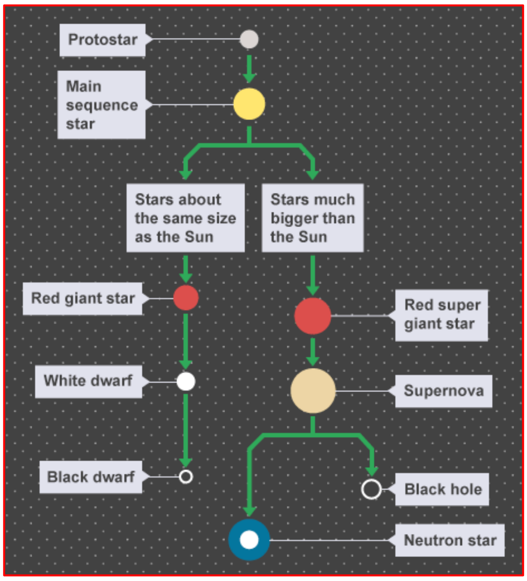
Outcomes	Separate Astronomy
Ph261 *Explain how and why both the weight of any body and the value of g differ between the surface of the Earth and the surface of other bodies in space*	**Weight** Objects have different weight on different planets (and other bodies within space such as an asteroid). The mass of an object does not change, but **the weight of object** is affected by the **gravitational field strength (g)** of the body (i.e. the planet) creating the field. Weight = mass x gravitational field strength (g)  If g increases than an object's weight will also increase. **Gravitational field strength (g)** The **greater the mass** of a body, the greater the **value of g**. The Earth has a greater mass than the Moon, so it has a larger value for g. The **value of g also depends on distance**. The further you get from Earth, the weaker the gravitational field experienced. The closer you get to the Sun, the stronger the gravitational field experienced.
Ph262 *Recall what our solar system consists of*	Our solar system is made up of the Sun, eight planets, dwarf planets, moons, asteroids and comets. There are also many artificial satellites. **The Sun** is a star **The planets** are: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune. **Dwarf planets** are like planets, but too small to class as a planet (e.g. Pluto) **Moons** are natural satellites that orbit a planet. **Asteroids** are lumps of rock and metal that orbit the Sun, most are found in the asteroid belt (between Mars and Jupiter). **Comets** are lumps of ice and dust that orbit the Sun, they have very elliptical orbits and can travel close to the Sun before reaching the outskirts of the solar system. **Artificial satellites** have been placed in space by humans- they help observe the Universe, monitor the weather, send phone signals and provide GPS signals.
Ph263 *Recall the names and order, in terms of distance from the Sun, of the eight planets*	There are **eight planets** in our solar system. There order, starting with the closest to the Sun is: **Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune.** The first four planets are known as the (inner) rocky planets. The last four planets are known as the (outer) gas giants.

Outcomes	Separate Astronomy
Ph264 *Describe how ideas about the structure of the Solar System have changed over time*	**Geocentric model** Early ideas about the solar system suggested that the **Sun, the Moon, the planets and the stars** all **orbited around Earth** in perfect circles. **Heliocentric model** Later it was suggested that the **Sun was at the centre** of the solar system and that E**arth**, along with the other **planets**, **orbited the Earth** in perfect circles.  **Invention of the telescope** Galileo's invention of the telescope **revealed four moons orbiting Jupiter**. The fact that they orbited Jupiter was **proof that not everything orbited Earth**. This **proved that the geocentric model was wrong** and provided further support for the heliocentric model. **The current model** The current model of the solar system still has the planets orbiting the Sun, but the **orbits are not perfect circles they are elliptical**. We have since **discovered more planets, moons, asteroids and dwarf planets** that were not known about when the earlier models were proposed.
Ph265 *Describe the orbits of moons, planets, comets and artificial satellites*	**Moons** follow an **elliptical** orbit around their **planet.** **Planets** have an **elliptical** orbit around **the Sun.** **Comets** have **very elliptical** orbits around **the Sun**. They orbit **close to the Sun** and **far out** into the edges of **the solar system**.  **Artificial satellites orbit** around the **Earth**, in **almost circular** orbits. They orbit at different speeds and different heights, depending on their function.
Ph266 *Explain for circular orbits how the force of gravity can lead to changing velocity of a planet but unchanged speed*	Planets orbit the Sun in near perfect circular orbits. This is same for moons and artificial satellites orbiting a planet. They **orbit at a constant speed**, but their **direction is constantly changing**. *Remember: Speed is a scalar quantity. Velocity is a vector quantity.*  Although the **speed doesn't change**, **the direction does**, so the **velocity is changing** (velocity is a vector so has size and direction). A **change in velocity** is an a**cceleration** and an acceleration requires a resultant force- for circular motion this resultant force is a **centripetal force** (provided by **gravity pulling towards the centre of the circle**). The **velocity** of the object at any given point is always at **right angles** (perpendicular) **to the centripetal force**.

Outcomes	Separate Astronomy
Ph267 *Explain how, for a stable orbit, the radius must change if orbital speed changes (qualitative only)*	The **closer** a satellite gets to a planet, the **stronger the gravitational field** is. Gravity is pulling the satellite towards the centre of the planet- the satellite's velocity is the only thing stopping it falling towards the centre of the planet. For an object to remain in a stable orbit the gravitational field strength must be balanced by the orbital speed. As the **gravitational field strength increases so does the orbital speed** required to balance it. The **closer the satellite** is to a planet, **the stronger the gravitational field** is and the **faster it must move** to stay in a stable orbit. **Faster moving satellites** have a stable orbit with a **smaller radius** than slower moving ones.
Ph268 *Compare the Steady State and Big Bang theories*	There are different theories about the creation of the Universe. **Steady state theory** A theory that the Universe **has always existed** and all will exist. The Universe is **expanding** because **new matter is being created.** The density of the Universe remains roughly the same. There was **no beginning** or end to **the Universe.** **Big Bang theory** At the beginning**, all of the matter** in the Universe **was in a very small space**- a singularity (very dense and very hot). At a certain point (around 13.8 billion years ago) the **space starting expanding.** The universe is becoming less dense. The **Universe starting expanding** with an 'explosion' which we call the **big bang**. Currently the B**ig Bang theory is the accepted theory** because it has **more evidence** to support it (see Ph269 below for more details).
Ph269 *Describe evidence supporting the Big Bang theory, limited to red-shift and the cosmic microwave background (CMB) radiation*	The big bang theory is supported by two main pieces of evidence. **Red shift** **Red-shift provides evidence that the Universe is expanding.** When **light** from **distant galaxies** is studied, the wavelength detected has been 'stretched', the **wavelength is longer** than expected- it has been **shifted to the red end of the spectrum**- red shift. Red shift only happens if the object producing the light (distant galaxies) is moving away from the observer (Earth), this effect is seen in all direction. For more information on red-shift see Ph273. **Cosmic microwave background radiation** Scientists have detected **low frequency, microwaves, radiation** that comes from **all parts of the Universe**. This is known as cosmic microwave background radiation (**CMBR**). This radiation is left over from the big bang 'explosion' and is **evidence that** the **Universe had a beginning**.
Ph270 *Recall that as there is more evidence supporting the Big Bang theory than the Steady State theory*	**Red shift** tells us that the **Universe is expanding** – this supports both the steady state and the Big Bang theory. Steady state suggests that the Universe has always existed, whilst Big Bang theory tells us that the Universe began 13.8 billion years ago. **Cosmic microwave background radiation** shows that **the Universe had a beginning** so **supports the Big Bang theory**. The **Big Bang theory** is the **current accepted model** because there **is more evidence to support it.**

Outcomes	Separate Astronomy
Ph271 *Describe that if a wave source is moving relative to an observer there will be a change in the observed frequency and wavelength*	 If an object emitting light waves (such as a galaxy) is **moving away** from the observer (the Earth) then the **observed wavelength is stretched**- it is **shifted towards** the **red end of the spectrum**. This is called **red shift**. *If the object were moving towards the observer, then the opposite would be true- the observed wavelength would be sorter and the light would appear blue.* In all directions **the light from distant galaxies** is **shifted towards the red end** of the spectrum, the **observed wavelength is stretched**- this provides **evidence that the Universe is expanding**.
Ph272 *Describe the red-shift in light received from galaxies at different distances away from the Earth*	 **The light from distant galaxies** is **shifted towards the red end** of the spectrum, the **observed wavelength is stretched**- this provides **evidence that the Universe is expanding**. The light from **more distant galaxies** shows **greater red shift** than closer galaxies- the observed wavelength is stretched further. **The bigger red shift** from **more distant galaxies** tells us that they are **moving away faster** than closer galaxies. This effect is the same whichever direction we look in. This provides **evidence that the universe is expanding**.
Ph273 *Explain why the red-shift of galaxies provides evidence for the Universe expanding*	If an object emitting light waves (such as a galaxy) is **moving away** from the observer (the Earth) then the **observed wavelength is stretched**- it is **shifted towards** the **red end of the spectrum**. This is called **red shift**.  The light from **more distant galaxies** shows **greater red shift** than closer galaxies- the observed wavelength is stretched further. **The bigger red shift** from **more distant galaxies** tells us that they are **moving away faster** than closer galaxies. This effect is the same whichever direction we look in. This provides **evidence that the universe is expanding**.
Ph274 *Explain how both the Big Bang and Steady State theories of the origin of the Universe both account for red-shift of galaxies*	**The steady state theory** for the origin of the Universe tells us that the **Universe** has always existed and **is expanding** because **new matter is being created.** **The Big Bang theory** for the origin of the Universe tells us that the **Universe began with an explosion** and has been **expanding ever since**. **The light from distant galaxies** is **shifted towards the red end** of the spectrum, the **observed wavelength is stretched**- this provides **evidence that the Universe is expanding**. **Red shift supports** both **steady state** and **Big Bang theory.**

Outcomes	Separate Astronomy
Ph275 *Explain how the discovery of the CMB radiation led to the Big Bang theory becoming the currently accepted model*	Scientists have detected **low frequency, microwaves, radiation** that comes from **all parts of the Universe**. This is known as cosmic microwave background radiation (**CMBR**). This radiation is left over from the big bang 'explosion' and is **evidence that** the **Universe had a beginning**. Red shift tells us that the Universe is expanding. Although red shift supports both steady state and Big Bang theory, **CMBR only supports Big Bang theory**. The **Big Bang theory** is the **accepted model** because there is **more evidence to support it**.
Ph276 *Describe the evolution of stars of similar mass to the Sun*	The Sun is a **small star**, it (and all other small stars) will follow the evolution outlined on the **left-hand side of this diagram.**  - All **stars begin** as a **cloud of dust and gas**, which is called a **nebula**. - **Gravity** begins to **pull the nebula** together, **GPE is transferred to thermal energy** and the temperature rises, this is called a **protostar**. - Once the star is hot enough, **nuclear fusion**, of hydrogen into helium, **begins** (see PH146) and **a main sequence star is formed**. The o**utward force of thermal expansion** is **balanced** by the **inwards force of gravity**- this is the star's 'stable' stage. - Once the **hydrogen starts to run out** the force of gravity is stronger than thermal expansion and the star collapses. Fusion of helium begins and thermal expansion causes **the star to expand and become a red giant**. - Eventually the **outer layers are ejected** into space and all that remains is **hot, dense**, solid core- a **white dwarf**.
Ph277 *Explain how the balance between thermal expansion and gravity affects the life cycle of stars*	**Gravity acts inwards** to pull a **nebula together**. Once fusion begins **the outward force of thermal expansion** tries to **extend the star**. During the **main sequence stage**, these **forces are balanced** and the star is a stable size. As a star begins to **run out of fuel,** the force from **thermal expansion reduces** so **gravity causes the star to collapse**. As larger elements begin to fuse, the force of **thermal expansion increases** and **causes the star to extend** producing a **red giant (or red supergiant).** In larger stars this contraction and extension repeats until eventually the **outwards force of expansion** causes the **star to explode** in a **supernova**.

Outcomes	Separate Astronomy
Ph278 *Describe the evolution of stars with a mass larger than the Sun*	Stars that are **larger than the Sun** will follow the evolution outlined on the **right-hand side of this diagram.**  - All **stars begin** as a **cloud of dust and gas**, which is called a **nebula**. - **Gravity** begins to **pull the nebula** together, **GPE is transferred to thermal energ**y and the temperature rises, this is called a **protostar**. - Once the star is hot enough, **nuclear fusion**, of hydrogen into helium, **begins** (see PH146) and **a main sequence star is formed**. The o**utward force of thermal expansion** is **balanced** by the **inwards force of gravity**- this is the star's 'stable' stage. - Once the **hydrogen starts to run out** the force of gravity is stronger than thermal expansion and the star collapses. Fusion of helium begins and thermal expansion causes **the star to expand and become a red giant**. - **Larger stars** begin to fuse larger and larger elements, they contract and expand several times before the **explode in a supernova.** - The **outer layers of dust and gas are ejected** out into space leaving **a very dense core**- a **neutron star**. If **the star was massive enough** then it will collapse in on itself and create an area that **is so dense** not **even light can escape it gravitational pull- a black hole.**
Ph279 *Describe how methods of observing the Universe have changed over time including why some telescopes are located outside the Earth's atmosphere*	Prior to the 17th century astronomers could only study space with the 'naked eye'. The invention of the **telescope** allowed astronomers to see **furthe**r into space and with **more detail**. In the 20th century it became possible to put **visible light telescopes in space**. This provides **much clearer images** that reveal far **more detail** than telescopes on Earth. The telescopes are placed **outside of the Earth's atmosphere** so there is **no light absorbed** by the **atmosphere** and **no interference from air pollution**. There is also **no light pollution** to 'drown out' the light from distant objects.  Many **waves from the electromagnetic spectrum** (such as X-rays and many radio waves) are **absorbed by our atmosphere**. Telescope on Earth cannot detect these waves because they **do not transmit through the atmosphere**. These **telescopes must be placed in space**, **outside of our atmosphere**. Improved **photography** as allowed astronomers **to record far more detailed** images of space. Many modern telescopes are controlled by **computers**- this allows astronomers to collect **vast amounts of high-quality data** (including images), 24 hours a day.