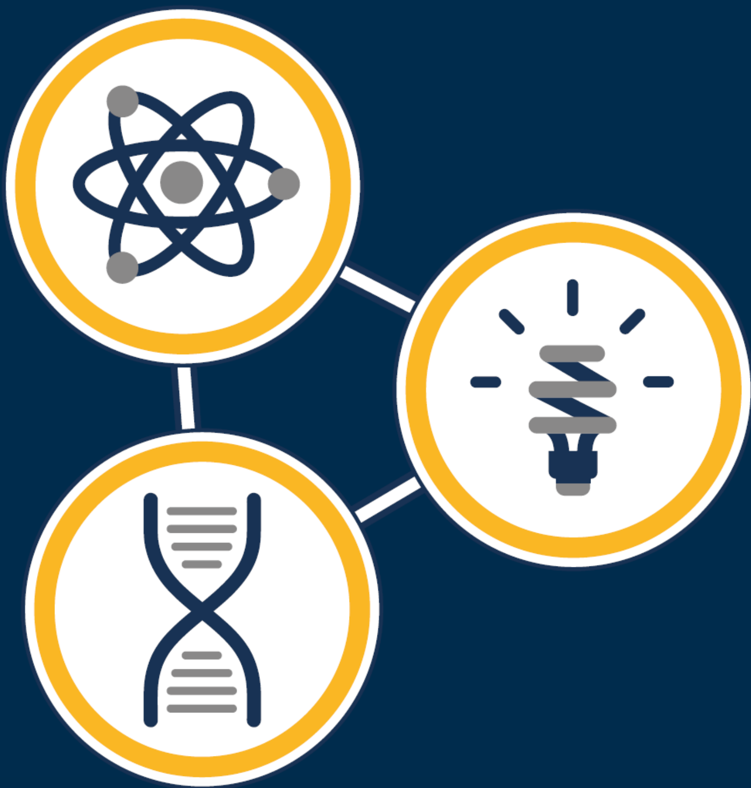
Mastery in Science

Using big ideas to make cognitive links from year 7 to year 11



Year 11 Physics Combined Science and Separate Science content

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Mastery in Science

GCSE Physics: Year 11

This is your detailed Mastery in Science pathway for Year 11 Physics. Make sure you have a look at our 'Mastery in Science' guide which gives you an overview of all the exciting things we've included, outlines how it all fits together and links out to our Journeys through Mastery in Biology, Chemistry and Physics.

Overview of content

This section covers content taught in year 11 of the GCSE Physics mastery pathways. The three big ideas in physics are broken down into smaller topics. These topics are:

Big idea: Energy

- 11.1 Properties of waves in the electromagnetic spectrum
- 11.2 Waves, detection, uses and dangers (combined and separate science content)

Big idea: Forces and Fields

- 11.3 Forces, work done and momentum
- 11.4 Forces and effects (combined and separate science content)
- 11.5 Forces and Motion
- 11.6 Magnets
- 11.7 Electromagnetism
- 11.8 Electromagnetic induction (combined and separate science content)

Big idea: Matter and materials

- 11.9 Radioactive emission
- 11.10 Radioactive half-lives and dangers of radioactivity (combined and separate science content)
- 11.11 Nuclear Physics (Physics only)

Features of mastery pathways

Each topic is designed with the following features:

- The equivalent of 4-5 hours of teaching (approximately a week)
- **Bold** content in learning objectives, teaching ideas and success criteria is **Higher tier only**
- Includes prior learning, topic overview and progression links to the next time this is covered. In this y11 scheme, this links to A level content
- Broadening curriculum links such as:
  - Scientist of the month
  - Diversity tasks
  - STEM careers videos and poster
  - GCSE Maths links (separate mapping document)
  - Working Scientifically and Programme of Study links
  - Teaching ideas split into learning objectives, teaching ideas and success criteria linked to assessment objectives
  - Exemplification of mastery sections: visual representations of learning that has happened that week with prompt questions or comments to use with students
  - Common misconceptions to watch out for when teaching students
  - Links to Future Skills and Employability framework

Big Idea: Energy	Topic: 11.1 Properties of waves of the electromagnetic spectrum	Indicative hours: 5 CS, 5 SS

Prior knowledge

Students should be familiar with the vocabulary used to describe waves, especially frequency, wavelength, amplitude and wavefront, and be able to use the equation $v = f \times \lambda$. They should remember the basic rules for reflection and refraction and be aware that different substances absorb and transmit electromagnetic waves in different ways that vary with wavelength. Previous knowledge gained from P7.5, Understanding waves, P8.2, Light, P9.5 Waves and the electromagnetic spectrum, as well as 10.1 (Using reflection and refraction) will be revised. For Separate Physics, students should also recall the differences between specular and transmission and absorption of light of different colours.

Topic overview

Students will learn the properties common to all electromagnetic waves and be able to recall the groupings of the spectrum in order of decreasing wavelength. Learn the colours of the visible spectrum and recognise that visible light is the limited range of frequencies in the electromagnetic spectrum that can be detected by the human eye. A core practical will also be carried out to investigate the refraction of light as it passes from air into a glass block. For Separate Physics, ray diagrams to include reflection, total internal reflection and some properties of lenses are needed.

Topic progression

The content in this topic is drawn upon when teaching A level as part of paper 2 content in Edexcel Advanced Physics. This includes refraction, lenses and diffraction.

Links to National Curriculum Programme of Study

- Amplitude, wavelength, frequency, relating velocity to frequency and wavelength;
- electromagnetic waves, velocity in vacuum; waves transferring energy; wavelengths and frequencies from radio to gamma-rays; and
- velocities differing between media: absorption, reflection, refraction effects

Links to Working Scientifically skills

Development of scientific thinking

- Use of models (e.g. slinky or CRO to model waves, ray diagrams, ripple tank) to make predictions and to develop scientific explanations and understanding of familiar and unfamiliar facts.

Experimental skills and strategies

- Plan experiments to investigate refraction.
- Use appropriate measurement techniques and apparatus, to measure angles, and distance.
- Pay attention to accuracy and health and safety.

Analysis and evaluation

- Present observations and data using appropriate methods, including tables and graphs.
- Interpret observations and data, including identifying patterns and using observations, measurements and data to draw conclusions

Scientific vocabulary, quantities

- Use scientific vocabulary, terminology and definitions.

- Use SI units (e.g. N, Hz, s, km, m, mm, J)

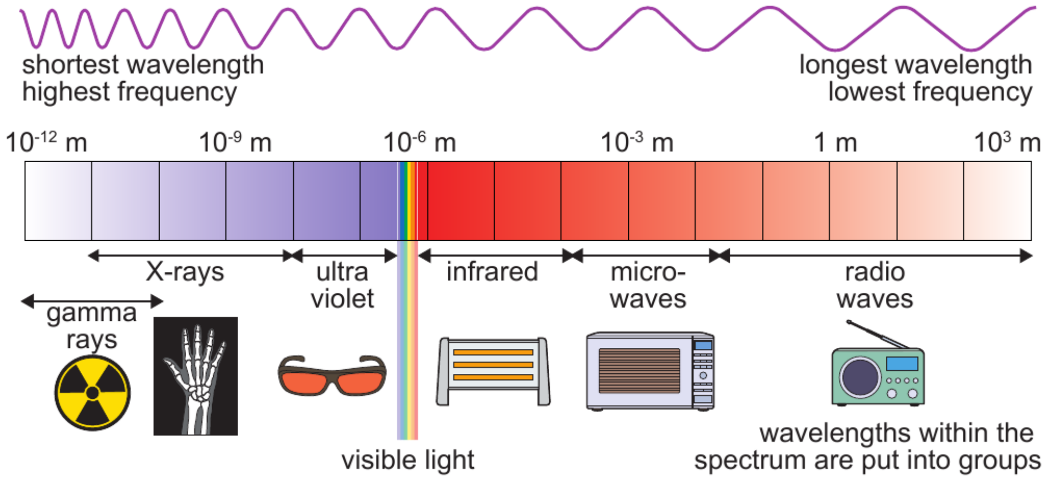
Details of practicals	Misconceptions	Future Ready
• Use of ray box and prism to produce a visible spectrum. • Core Practical: Investigate refraction in rectangular glass blocks in terms of the interaction of electromagnetic waves with matter. • Construction of ray diagrams and measurement of angle. • Use of a semi-circular glass block to show total internal reflection and critical angle. (P)	• That the speed of the wave is constant when refraction occurs rather than the frequency because the speed of all electromagnetic waves (in a vacuum) is constant. • Confusion over meanings of terms speed, frequency and amplitude. Use card matching activities to help embed the meaning of these terms.	KS4 step 9 • Powerful influencers can... develop different writing styles for different purposes • Powerful influencers can... structure a presentation to propose an idea e.g. literacy task

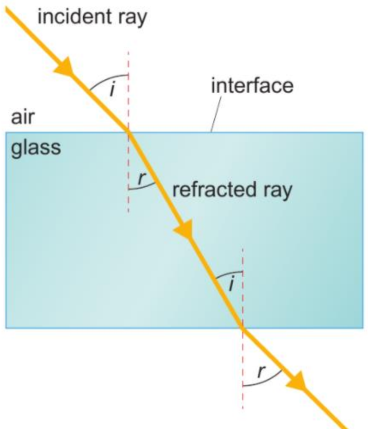
Literacy ideas and terminology	Broadening curriculum
Ideas: Write a mnemonic for the electromagnetic spectrum starting from the longest wave length e.g. Robots Make Interesting Videos Using eXtreme Games. Write a seven-line verse, each line starting with the colours of the visible spectrum in order R O Y G B I V. ***Diversity task*:** Explore the influence of Ibn Al-Haitham (Alhazen) in the development of the theory of light. Particularly Ancient Greek influences, and his works influencing more modern scientists. Possible sources: Britannica, articles in 'Nature' ('In retrospect: Book of Optics'). During the International Year of Light 2015, Ibn al-Haytham was celebrated at UNESCO as a pioneer of modern optics, there are details of this on the UNESCO website ('Ibn al-Haytham's scientific method') ***Key words:*** Tier 1: vacuum (may be used differently in common language, ensure students	***Pearson scientists of the month:*** Jocelyn Bell Burnell (Physics, Female, Northern Ireland) helped build a radio telescope co discovered the first radio pulsars Ibn al-Haitham (Known in the west as Alhazen) (Physics, Male, Iraq) astronomer, gave explanations of behaviour of light. Notably that eyes receive light reflected from objects. Fascinating life story (see Britannica which has more detail) Born as Ibn al-Haitham. Notable work 'Kitāb al-manāẓir ('Book of Optics'). Influenced Western scientists such as Johannes Kepler (see literacy ideas for activity) ***Other notable scientist links:*** Isaac Newton (Laws of Reflection) Willebrord Snellius(Laws of refraction. Snell's Law) William Herschel (discovery of infrared) Johann Ritter (discovery of ultraviolet) Ole Roemer (1676 astronomical determination of speed of light)

understand the scientific meaning) Tier 3: Frequency, wavelength, hertz, amplitude, wavefront, electromagnetic, transverse, reflect, refraction, absorption, radiation.	Michelson and Moreley(1887) terrestrial determination of speed of light ***STEM careers links***: neuroscientist, optician, telecoms technician, urologist, x-ray technician

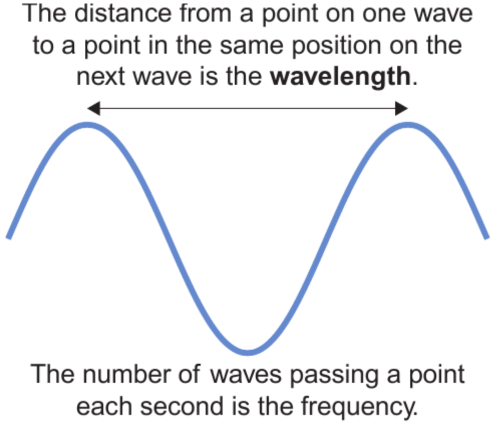
Learning objectives	Teaching ideas/ links to resources	Indicative success criteria
Electromagnetic Waves: *GCSE specification 5.7-5.12,**5.14** (higher)* • Know the properties of electromagnetic waves. • Recall the electromagnetic spectrum in order of decreasing wavelength / increasing frequency. • Explain with examples that all electromagnetic waves transfer energy from source to observer. • Recall that our eyes can only detect a limited range of frequencies. • Know that light refracted by a glass block changes direction, speed and wavelength but there is no change in frequency. • **Explain the effect of differences in the velocity of e-m waves in different substances.**	• Revise key terms covered in previous units. • Use slinky or wave machine or ripple tank to demonstrate transverse waves. • Show transfer of energy using for example, a radio, microwave oven or a heating coil. • Practical - produce a visible spectrum using a prism and ray box • Calculations using $v=f \times \lambda$. • Mnemonic e-m spectrum or seven line verse for visible spectrum. • Show refraction of waves from deep to shallow water in a ripple tank. • Core practical-refraction through a glass block, plot angle of incidence i against r. • Show how a toy car changes direction when two inside wheels travel in water or sand and move at a different speed to the outside wheels as a model of refraction **(links to higher tier content)** *Opportunities for extension*: Research how the speed of light was found, literacy task linked to diversity *GCSE resource links:* Active learn P5a, P5d, P5e, P5f	• Recall the order of the groupings of waves in the e-m spectrum (AO1). • Recall e-m waves are transverse and all travel at the same speed in a vacuum (speed of light)(AO1). • Explain that e-m waves transfer energy from source to observer (AO2) • Recall that our eyes can only detect a limited range of frequencies of e-m radiation. • Carry out core practical and understand that the change in direction of light ray due to refraction (AO3). • **Explain why the velocity of light is different in different substances (AO2).** Be able to calculate velocity, frequency or wavelength using the equation $v= f \times \lambda$ (AO2).

Exemplification of mastery





If shown this diagram, are students able to describe what is happening? Can they explain how to carry out a practical to investigate this?



Are students able to identify frequency, amplitude and wavelength correctly?

Rewind grid

This topic	10.1 Reflection and refraction	9.5 Waves and the EM spectrum
Give two properties of all electromagnetic waves. 1 **point**	Complete the sentences Light rebounding from the surface of a mirror is............... Light changing direction as it passes from air into glass is .... **1 point**	State what all waves transfer from one place to another? **1 point**
Give the order of the groups of waves in the electromagnetic spectrum, starting with the group of waves that has the longest wavelength. **3 points**	Explain what happens to the wavelength and speed of a ray of light when it passes from air into glass. **3 points**	Compare longitudinal and transverse waves **3 points**
Describe the experiment you would do to show that when light passes into a glass block, that the angle of incidence is proportional to the angle of refraction for small angles of incidence. **5 points**	Describe an experiment to measure the velocity of a water wave in a ripple tank **5 points**	A sound wave travels at 330m/s and has a frequency of 12.000Hz. Calculate the wavelength of the wave. give the unit of wavelength **5 points**

ANSWERS

All are transverse All travel through a vacuum All travel at the same speed /speed of light	REFLECTION REFRACTION	Energy
Radio waves, microwaves, infrared, visible light, ultraviolet, X rays, gamma rays	Glass is more (optically) dense than air . Glass slows down the speed of the light. As the frequency is constant then the wavelength is also reduced	Longitudinal- the motion of particle is (back and forth) parallel to the direction of energy transfer / the wave Transverse- the motion of the particles is at right angles to the direction of energy transfer of the wave
Describe the experiment you would do to show that when light passes into a glass block, for small angles of incidence, the angle of incidence is proportional to the angle of refraction. Set up a glass block on a sheet of paper mark the position of the glass block. Use a ray box to give a ray of light incident on the side of the glass block. Mark the incident and emergent ray. Remove the glass block. Draw in the normal and refracted ray and measure the angles of incidence and refraction. Repeat for different angles of incidence. Plot a graph of i against r and check for a straight line for small angles of incidence.	Count the number of ripples that pass a point in the tank in a given time Calculate the frequency of the waves using f = number of wave/time Measure the wavelength using the shadows of the waves below the ripple tank. Measure with a ruler Calculate the velocity of the wave using $V=f \times \lambda$	λ =0.028m accept 0.0275m or 2.8×10^{-2}m accept 2.75×10^{-2}m

Big Idea: Energy	Topic: 11.2 Waves, detection, uses and dangers	Indicative hours: 4.5hrs CS 5hrs SS

Prior knowledge

Students should be familiar with the terms wavelength, frequency and amplitude. They should know that longitudinal waves transfer energy and be able to describe a longitudinal wave in terms of particle movement as exemplified by sound waves and seismic P waves. Students should also recall a method for determining the velocity of sound in air. These ideas come from P 7.5 (Understanding waves) P8.3 (Sound) P9.5 (Waves and the electromagnetic spectrum). Infrared being radiant heat should also be linked to P9.2 (Heat energy). For Separate physics, students also need to review P.9.5 (Waves and the electromagnetic spectrum) for 'the way the human ear works' and P10.1 (reflection and refraction) to recall ultrasound, infrasound and their uses.

Topic overview

For a longitudinal wave, determination of speed of sound in a solid. For transverse waves, the absorption, transmission and reflection of electromagnetic waves is also covered and the uses of each of the groupings of waves in the electromagnetic spectrum. Students learn that almost all the waves in the electromagnetic spectrum are radiated due to changes in the electron structure of the emitting energy. It is only gamma rays that are produced by changes in the nucleus of the atom and radio waves are generally produced by oscillations in electrical circuits. The potential danger of exposure to electromagnetic radiations is linked to increasing frequency and specific dangers of exposure for particular groups of radiation are studied. For separate physics, the radiation and absorption of thermal energy is studied and this is exemplified by the core practical investigating how the nature of a surface affects the amount of thermal energy (infrared) radiated or absorbed.

Topic progression

Waves is one of the topics studied for Paper 2 in Edexcel Advanced Physics and this includes determination of the velocity of sound, standing waves and the absorption and emission of energy by changes in electron energy levels.

Links to National Curriculum Programme of Study

- Transverse and longitudinal waves;
- production and detection, by electrical circuits, or by changes in atoms and nuclei; and
- uses in the radio, microwave, infra-red, visible, ultra-violet, X-ray and gamma-ray regions, hazardous effects on bodily tissues.

Links to Working Scientifically skills

Development of scientific thinking

- Use of models (e.g. slinky wave machine or ray diagrams, to make predictions and to develop scientific explanations and understanding of familiar and unfamiliar facts.

Experimental skills and strategies

- Use appropriate measurement techniques and apparatus, to measure frequency, distance, time and infrared radiation.
- Pay attention to accuracy and health and safety.

Analysis and evaluation

- Present observations and data using appropriate methods, including tables and graphs.
- Interpret observations and data, including identifying patterns

and using observations, measurements and data to draw conclusions.

Scientific vocabulary, quantities

- Use scientific vocabulary, terminology and definitions.

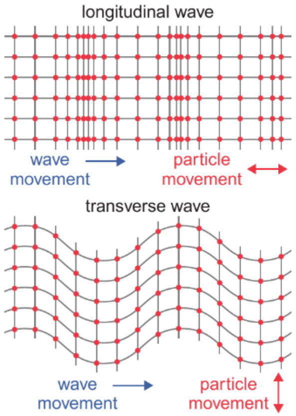
Use SI units (e.g. N,Hz, s, km, m, mm, kJ, J).

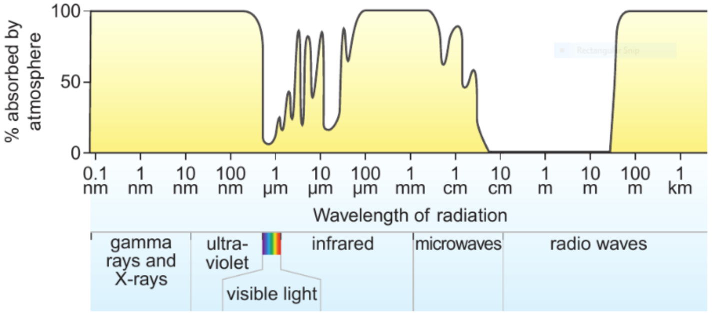
Details of practicals	Misconceptions	Future Ready
• Core Practical: Investigate how the nature of a surface affects the amount of thermal energy radiated or absorbed (separate physics only). • Core Practical (part): Investigate the suitability of equipment to measure the speed of a wave in a solid.	Confusion that radio waves are the same as sound waves because radios produce sound. Be clear with using terminology with students, and clarify differences between longitudinal waves and transverse waves. Outline that radio waves are received (these are transverse), and then the reveicer converts it into sound waves (longitudinal). Detail is covered in Electromagnetic induction when looking at loudspeakers (higher tier)	KS4 step9 Powerful influencers can… develop different writing styles for different purposes. E.g. methods for core practicals, revision notes, presentations for different audiences Powerful influencers can… structure a presentation to propose an idea e.g. respond to the statement 'All EM waves are dangerous'. Digital superusers can… research and present information in a well-designed, visually effective presentation e.g dangers of radioactivity Digital superusers can… demonstrate effective ways to communicate and share research findings. E.g. results and analysis from core practical

Literacy ideas and terminology	Broadening curriculum
Ideas: Discuss the benefits and drawbacks of using gamma rays and X-rays for medical diagnosis and treatment. ***Key words:*** Tier 1: reflect, vacuum (aware of differences in common usage and scientific meanings) Tier 3: Frequency, wavelength, hertz, electromagnetic, refraction, absorption, radiation, transverse, longitudinal, , oscillations.	***Pearson scientist of the months:*** *Jocelyn Bell Burnell* (Physics, Female, Northern Ireland) helped build a radio telescope co discovered the first radio pulsars ***Other notable scientist links:*** *Percy Spencer* (invented the microwave oven) *Thomas Edison* (invented the filament Lamp) *Wilhelm Roetgen* (discovered X-rays) *Guglielmo Marconi* (invented long distance radio transmission) *Tim Berniers-Lee* (invented the world wide web) ***STEM careers:*** neuroscientist optician telecoms technician urologist, x-ray technician

Learning objectives	Teaching ideas/ links to resources	Indicative success criteria
Waves and light and the electromagnetic spectrum *(spec points: 4.5,* ***4.11****, 4.17, 5.19P, 5.20-24,* ***5.23****)* • Difference between longitudinal and transverse wave referring to sound, electromagnetic, seismic and water waves. • Core practical: Investigate the suitability of equipment to measure the speed of a wave in a solid. • Recall that the potential danger associated with an electromagnetic wave increases with increasing frequency. • Describe the harmful effects on people of excessive exposure to electromagnetic radiation. • Describe some uses of electromagnetic radiation. • **Recall that radio waves can be produced by or can themselves induce oscillations in electrical circuits.** • Recall that changes in atoms or nuclei can (a) generate radiations over a wide frequency range, and (b) be caused by absorption over a range of radiations. *Physics only:* *(spec points:* **5.16P – 5.18P** and 5.19P) • **Know that to maintain a steady temperature a body must aborb the same amount of power as it radiates**	• Show longitudinal wave on a slinky or wave machine. • Core practical: Set up a metal bar horizontally suspended on rubber bands, hit with a hammer. Students measure length of bar (½ a wavelength) measure frequency of sound from a microphone and CRO or using mobile phone app and calculate velocity of sound in a metal. • Set up devices for each part of the e-m spectrum, radio, microwave oven, heating coil, filament lamp, UV lamp or sunglasses, X-ray photograph, G-M tube detecting background radiation. Discussion the origins of each part of the e-m spectrum or students find out and report back. • Students in groups where each group researches the dangers of their part of the e-m spectrum. Each group presents findings to the class. The class orders the dangers and establishes the link to frequency. • In groups, uses of e-m are researched and reported back to class. Each student produces a Mind map to illustrate uses. • Diagram to show absorption and transmission of different wavelengths of electromagnetic radiation by the atmosphere • Core practical using Leslie's Cube and an infrared detector to produce a bar chart showing radiation of thermal energy from different surfaces, Or painted coke cans filled with water and containing a thermometer placed equal distances from a radiant heat source (P). • **Write out a process for how radio waves are used to transmit radio signals (see diagram in exemplification section for detail)** *Physics only:* • Carry out the investigation on how the nature of a surface affects the amount of thermal energy radiated and absorbed *Opportunities for extension* • Research the important inventions that use EM waves and have an effect on our everyday lives. *GCSE Resource links:* P4a (part), P4b, P5f, P5g	• Explain why sound waves are longitudinal waves (AO2). • Calculate the velocity of sound in a solid from measurements of wavelength and frequency (AO3). • Be able to link the frequency of electromagnetic waves to the danger associated with them (AO1). • Give reasons for X-rays and gamma rays being dangerous (AO1). • Know which electromagnetic waves are not produced by changes in the atom (AO1). • Be able to describe at least one use of each group of waves in the electromagnetic spectrum. (AO1) • Be able to describe the difference between the radiation of thermal energy for shiny and matt surfaces (AO1, Physics only) • Be able to explain what is necessary in terms of radiation and absorption for a body to remain at a constant temperature (AO1). • **Label a blank diagram to show how radio waves are transmitted and received (AO1).** *Physics only:* • **Be able to explain how a body can maimtain a steady temperature.** • **Be able to explain how incoming and emitted radiation affects the temperature of the Earth**

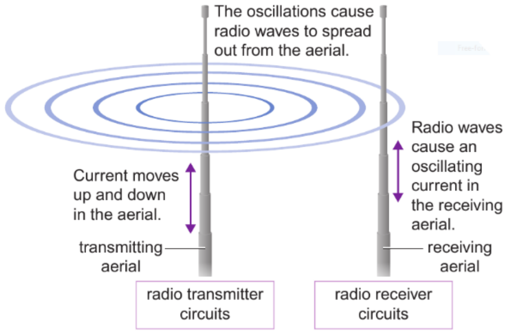
Exemplification of mastery



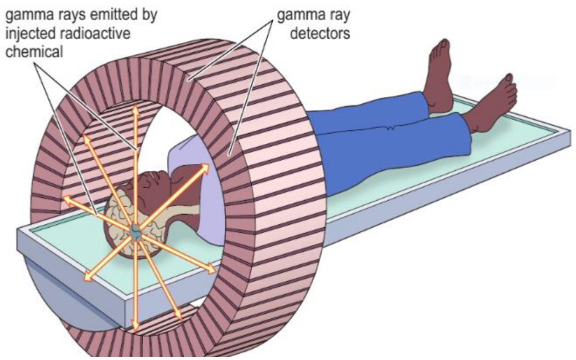


Absorption of electromagnetic radiation by the atmosphere (no need to recall details)

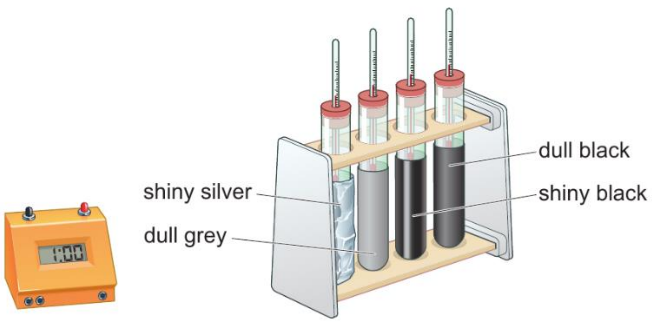
Be able to describe the differences between longitudinal and transverse waves



Using the long wavelengths of EM spectrum. Can students explain what is happening here?



Uses of short wavelengths in EM spectrum: gamma rays emitted by a chemical that has been injected into the body can be detected by the scanner. Used in detection of cancers.



Core practical: investigating radiation. Use this image as stimulus material. Can students explain what will happen?

Rewind grid

This topic	10.1 Reflection and refraction	9.5 Waves and the electromagnetic spectrum
Give one use of infrared. **1 point**	State which of the following is constant when a wave is refracted from air into glass: direction/ frequency/ speed/ wavelength **1 point**	Name the unit of frequency. **1 point**
Describe the sources of waves that make up the electromagnetic spectrum. **3 point**	Explain why some electromagnetic waves from outer space do not reach the surface of the Earth. **3 points**	Describe the movement of particles in a seismic P wave. **3 points**
Compare the dangers of excessive exposure to the different groups of electromagnetic waves as determined by the frequency of the waves. **5 points**	Describe an experiment to measure the speed of sound in a metal. **5 points**	Describe an experiment to measure the speed of sound in air. **5 points**

ANSWERS

cooking, thermal imaging, television remote control, optical fibres etc	Frequency.	Hertz (Hz).
Gamma rays come from the nuclei of atoms x-rays, UV, visible light and infrared come from electrons changing energy levels microwaves and radiowaves are produced by electrical circuits	The waves from outer space have a wide range of wavelengths and many are absorbed by the Earth's atmosphere and do not reach the surface.	The particles in the Earth move to and fro parallel to the direction of transfer of energy or the direction in which the wave is travelling.
Answer: Radio waves are not dangerous but as the frequency of the waves increase the waves become more dangerous to humans. Microwaves heat body cells. Infrared burns the skin. UV can cause skin cancer and damage to eyes. X-rays and gamma rays penetrate the body and can damage cells and mutate DNA.	: Set up a metal bar horizontally suspended on rubber bands, hit with a hammer. Students measure length of bar (½ a wavelength) measure frequency of sound from microphone and CRO or using mobile phone app and calculate velocity of sound in a metal. Use v=f x λ.	A distance of say 100m is measured out. A starting pistol is fired 100m from students that have stop watches. (mobile phone lapse timers). Students time from seeing smoke to hearing report. Calculate speed from v=x/t.

Big Idea: Forces and fields	Topic: 11.3 Forces, work done and momentum	Indicative hours 4 CS, 4hrs SS

Prior knowledge

Students need to know that when work done is energy transferred and that work is done when a force moves an object through a distance (P 10.4, Force and work done) E =F x d. Students should also be able to calculate the change in gravitational potential energy when an object is lifted above the ground ΔGPE=m x g x h and the kinetic energy associated with a moving object $KE = \frac{1}{2} \times m \times v^2$ Students should also be familiar with the idea that mechanical process are wasteful, dissipating heat to the surroundings, that power is the rate of doing work and that efficiency is the ratio of the useful energy transferred to the total energy supplied to the device.

Topic overview

Application of Newton's third law (Action and reaction are equal and opposite) to forces in equilibrium and to collision interactions. Understand that momentum is the product of mass and velocity (p=m x v) of an object and that momentum is a vector quantity and is always conserved in a collision. The momentum of objects before a collision is the same as the momentum of the objects after the collision. Know that to change the momentum of an object a force must be applied, and that Newton's second law can be given as $F = \frac{mv - mu}{t}$. Be able to use this equation and understand that the shorter the time for the change in momentum the larger the force that is exerted.

Most of this topic is higher tier content, with only the section on recalling and applying Newton's third law to equilibrium situations being foundation.

Topic progression

This work is the basic requirement for the study of Topic 2, Mechanics, Edexcel Advanced Physics Paper 1 and is extended in this topic

Links to National Curriculum Programme of Study

- Forces being needed to cause objects to stop or start moving, or to change their speed or direction of motion (qualitative only); and
- change depending on direction of force and its size.

Links to Working Scientifically skills

Development of scientific thinking

- Use a variety of models, such as representational, spatial, descriptive, computational and mathematical, to solve problems, make predictions and to develop scientific explanations and an understanding of familiar and unfamiliar facts (e.g. force is proportional to rate of change of momentum, momentum is always conserved in a collision).
- Evaluate risks both in practical science and the wider societal context, including perception of risk in relation to data and consequence.

Experimental skills and strategies

- Plan experiments to investigate conservation of momentum using trolleys and slopes or air track and sliders with light gates and data loggers.
- Use appropriate measurement techniques and apparatus, to determine velocity of trolleys and sliders.
- Paying attention to accuracy and health and safety.

Analysis and evaluation

- Presenting observations and other data using appropriate methods.
- Translating data from one form to another.
- Carrying out and representing mathematical and statistical analysis

Scientific vocabulary, quantities

- Use scientific vocabulary, terminology and definitions.
- Use SI units e.g. N,s, m, kg m/s, m/s^2, kg/m/s or Ns.

Details of practicals	Misconceptions	Future Ready
Using trolleys on friction compensated slope or sliders on a linear air track with light gates to measure the velocity of objects before and after collisions.	Confusion between momentum and moments for those studying separate physics. Confusion between the scientific use of the terms and the general meaning of some words (see key terms)	KS4 Step 8 Forward thinkers can… break down complex problems into chunks. E.g. steps in calculations Forward thinkers can… build patterns and links between data and ideas. E.g. use practical observations to assess what is happening and link the theory to the results of practical.

Literacy ideas and terminology

Ideas:

Give COLLISION as the horizontal starting word. The words force, vector, scalar, velocity, time, mass, gravity, newton and momentum then have to be fitted in vertically (one possible solution below).

	V					G	N	M
F	E	S				R	E	O
O	C	C	V		M	A	W	M
R	T	A	E	T	A	V	T	E
C	***O***	***L***	***L***	***I***	***S***	***I***	***O***	***N***
E	R	A	O	M	S	T	N	T
		R	C	E		Y		U
			I					M
			T					
			Y					

Broadening curriculum

The physics of snooker*:* show some interesting snooker shots and help students explain what's happening. How do balls 'jump'? Why does the cue ball sometimes change direction after encountering a collision? Expand to discuss how friction could affect this. What if snooker was played on a smooth metal surface?

Karate chop: the science behind a karate chop – how does it work? What's really happening? Can you see anything different if you watch a karate chop in slow motion?

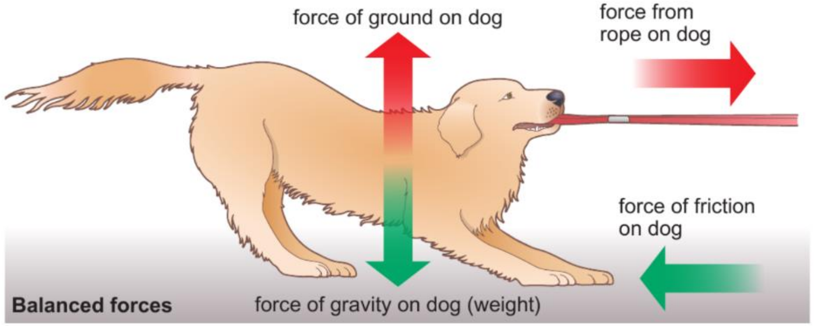
***Scientists*:** Bela Barenyi ((engineer male Austro-Hungarian) invented many crash protection methods including the crumple zone. Show videos of crash tests demonstrating crumple zones. Why do these exist?

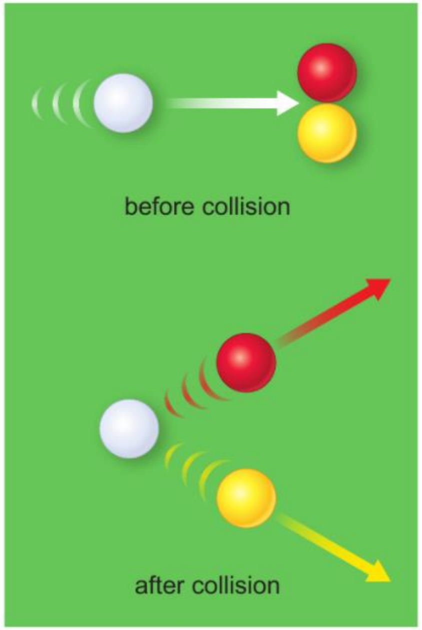
***STEM careers*:** Aeronautical engineer, robotist, sports scientist

Key words: *Tier 1:* Force, power, force (these words in particular have different meanings in common language and will need to be addressed) *Tier 3:* newton, work done, joule, efficiency, kinetic energy, watts gravitational potential energy, energy transfer, energy store, efficiency velocity, acceleration, mass, momentum.	

Learning objectives	Teaching ideas/ links to resources	Indicative success criteria
Momentum and Collisions *(spec points: **2.23(part HT) – 2.26**)* • Know that Newton's third law applies to two equal and opposite forces of the same type acting on different objects. • Apply Newton's third law to different situations. • **Know how momentum is calculated.** • **Understand how momentum is related to force.** • **Understand how momentum is conserved in collisions.**	• Give examples of Newton's third law as a pair of forces (action-reaction forces) e.g. a weight on the bench or the force of attraction between the Moon and the Earth. Discuss these equilibrium situations and understand what is happening. • **Demonstrate a Newton's Cradle to show that the metal spheres have momentum and that this is transferred and conserved.** • **Make measurements of momentum of objects using trolleys or sliders on an air track with light gates and data loggers to measure velocities.** • **Demonstrate that momentum (p) conserved in a collision of trolleys or sliders. Explain that this is only exactly true when there is no friction. Expand on this by exploring one of the ideas from the broadening curriculum section.** • **Calculation on p=m x v before and after collisions.** • **Calculations given that the equality of momentum before and after collisions.** • **Use of *F=(mv-mu)/t* to explain the longer it takes to lose momentum the smaller the force generated, or vice versa.** *GCSE Resource links*: P2e, P2f	• Recall and apply Newton's third law both to equilibrium situations **and to collision interactions and relate it to the conservation of momentum in collisions (AO2).** • **Define momentum, recall and use the equation: momentum (kilogram metre per second, kg m/s) = mass (kilogram, kg) × velocity (metre per second, m/s) p = m× v (AO2).** • **Describe examples of momentum in collisions (AO2).** • **Use Newton's second law as: force (newton, N) = change in momentum (kilogram metre per second, kg m/s) ÷ time (second, s) (AO2).** $F = \frac{(mv - mu)}{t}$

Exemplification of mastery





Show this diagram. Can students use this diagram to explain Newton's third law?

The total momentum of the two coloured balls will be the same as the momentum of the white ball that hit them.

Rewind grid

This topic	10.4 Forces and work done	10.4 Forces and work done
State Newton's third law. **1 point**	Define power. **1 point**	Give the unit for work done. **1 point**
Explain, in terms of rate of change of momentum, why it is better to bend your knees when you jump up or land on the ground. **3 points**	Explain why lubricating the moving parts of a machine will make it more efficient. **3 points**	Calculate the amount of work done when a force of 20 N moves an object through a distance of 14m. **3 points**
A trolley of mass 1.1 kg moving at 0.5m/s collides with a stationary trolley of mass 0.9kg on a frictionless surface. The trolleys stick together. Calculate the velocity of the trollies after the collision. **5 points**	A cyclist of mass 60 kg is at the top of a hill 12m high. 60% of the cyclist's gravitational potential energy is transferred to kinetic energy when the cyclist reaches the bottom of the hill. Calculate the speed of the cyclist at the bottom of the hill. **5 points**	Describe an experiment to measure your personal power by running up a set of stairs. **5 points**

ANSWERS

joule (J)	Power is the rate of doing work.	Action and reaction are equal and opposite.
E =F x d = 280J	Lubrication reduces friction and dissipation of heat to the surroundings. More of the total energy supplied is converted to useful energy, this increases efficiency	The time taken to lose all momentum and become stationary is greater when the knees are bent than when landing with straight legs. Rate of change of momentum is smaller and the force generated by landing is smaller.
Weigh yourself. Measure height of stairs. Time how long it takes to run up the stairs. Use power = $\frac{\text{weight x height of stairs}}{\text{Time}}$ To find personal power.	60% of calculated gravitational energy is converted to kinetic energy. $KE = \frac{1}{2} \times m \times v^2$ Velocity v can then be calculated V=12m/s	Momentum before collision = 1.1 x 0.5 =0.55kg/m.s. Momentum after collision = 2.0 x v. Equating momentum before and after collision v = 0.275m/s

Big Idea: Fields and Forces	Topic: 11.4 Forces and their effects	Indicative hours: 3hrs CS 4hrs SS

Prior knowledge

Students need to know that quantities can either be scalar or vector (P9.4 Describing motion) and that a vector quantity such as force can be represented in magnitude and direction by an arrowed line. Students should be able to recall Hooke's law and be able to calculate the work done in stretching a spring using

$E = \frac{1}{2} \times k \times x^2$ (P9.5 Forces and matter). It is also necessary for students to be familiar with energy types and transfers as learnt in (p10.4 Forces and work done).

Topic overview

Students will revise contact forces and forces at a distance and then show these forces using examples represented in vector diagrams. Scalars and vectors will also be used to explain the difference between speed and velocity when an object moves in a circle and why the centripetal force produced is always towards the centre of the circle. Vector diagrams to scale will be used to illustrate resolution of forces and forces will be shown acting in free body diagrams. The stretching of an elastic band will be used to revise Hooke's Law. Stopping distances of a vehicle including thinking distance and braking distance will also be studied. In separate physics, students will also study moments and the rotational effects of forces.

Topic progression

This work is the basic requirement for the study of Topic 2, Mechanics, and Topic 4 Materials in Edexcel Advanced Physics Paper 1.

Links to National Curriculum Programme of Study

- Using force arrows in diagrams, adding forces in 1 dimension, balanced and unbalanced forces;
- moment as the turning effect of a force;
- forces: associated with deforming objects; stretching and squashing – springs; with rubbing and friction between surfaces, with pushing things out of the way; resistance to motion of air and water;
- forces measured in newton, measurements of stretch or compression as force is changed;
- force-extension linear relation; Hooke's Law as a special case; and
- work done and energy changes on deformation.

Links to Working Scientifically skills

Development of scientific thinking

- Use a variety of models, such as representational, spatial, descriptive, computational and mathematical, to solve problems, make predictions and to develop scientific explanations and an understanding of familiar and unfamiliar facts.
- Evaluate risks both in practical science and the wider societal context, including perception of risk in relation to data and consequence.

Experimental skills and strategies

- Plan experiments to investigate forces used to stretch an elastic material.
- Use appropriate measurement techniques and apparatus, to
- measure extension and force paying attention to accuracy and health and safety.

Analysis and evaluation

- Presenting observations and other data using appropriate methods.
- Translating data from one form to another.
- Carrying out and representing mathematical and statistical analysis.

Scientific vocabulary, quantities

- Use scientific vocabulary, terminology and definitions.
- Use SI units e.g. N,s, m, kg m/s, m/s^2 , j.

Details of practicals	Misconceptions	Future Ready
• Stretching an elastic band and plotting a graph of force against extension. Find the spring constant. • Measure reaction time using, dropping ruler technique or a mobile phone app. • Measure the effect of different surfaces and speeds on the stopping distance of a trolley rolled down a wooden slope. • Core practical: Investigate the extension and work done when applying forces to a spring Physics only • Use lathe on a wooden prism to show the effect of masses and distances from fulcrum on moments of a force	• Students think a driving force must be continuous to keep an object moving • Students think an object at rest has no forces acting on it. Use a model to show this is not the case. e.g. a tug of war competition when both sides are balanced initially nobody looks like they are moving. • Confusion over mass and weight, especially as they are used incorrectly in common language. Reiterate the meanings, quiz frequently, draw up comparison tables to determine difference in terms • Confusion over the terms power, work, energy and force. Students often think they mean the same thing. Card sort activities, focus on key words.	(no specific links here)

Literacy ideas and terminology	Broadening curriculum
Ideas: Discuss how the stopping distance for a car is affected by; • driver reaction time; • car maintenance; and • road conditions. Why should cars bother sticking to speed limits? Debate these points and answer the comment 'I have a fast car, so as long as I'm careful why can't I drive it however fast I want?'	***Circular motion in Funfairs****:* why don't you fall out of rides like 'round up'? Why do the swings on rides like 'star flier' swing out? Use theories to decide… are fairground rides safe? ***Highway Code*****:** stopping and thinking distances, forces involved on a public road ***Scientists:*** *Robert Hooke* (Scientist English Male) discovered law of elasticity ***STEM careers****:* Aeronautical engineer, robotist, sports scientist

Key words:

Tier 1: mass, weight, stopping distance, reaction time, thinking distance, braking distance.

Tier 3: Scalar, vector, non-contact and contact forces, centripetal force, contact forces. Non-contact forces resultant force, balanced forces, extension

Learning objectives	Teaching ideas/ links to resources	Indicative success criteria

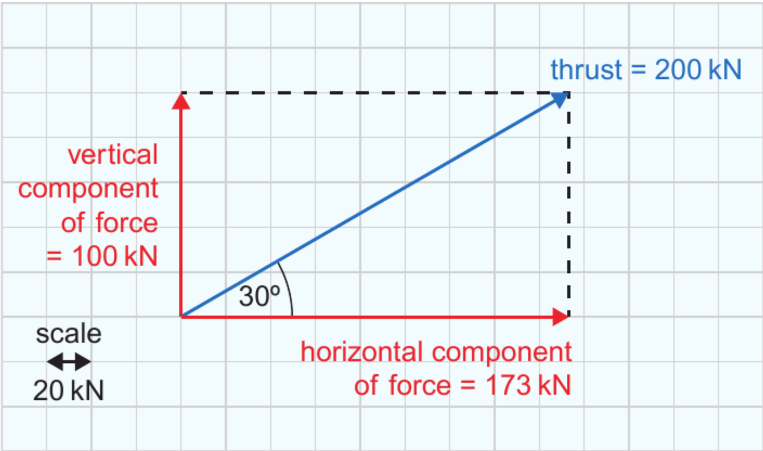
Representing forces
 	
(spec points: 9.1-9.2, ***9.3-9.5****, 9.10, Separate science 9.6P-9.9P)*
 	
• Describe different types of forces and their interaction using vector diagrams.
• **Be able to draw a free body diagram.**
• **Be able to draw scale diagrams to show resolution of forces and net resultant force.**
 	
Physics only
 	
• Be able to describe situations where forces can cause rotation
• Be able to complete calculations on the application of moments
• Know that levers and gears use rotational forces
	• Use drawing board pulleys and thread to show resultant forces and parallelogram of forces
	  • Draw diagrams of forces represented in magnitude and direction by a line with an arrow. Complete diagrams to show the second force of a pair or a resultant force.
	  • **Draw a vector diagram to scale to show resolution of forces.**
	
	Physics only
	
	  • Calculate the moment of a force and apply the principle of moments to situations where rotational forces are in equilibrium
	
	GCSE resources links: P9a, P9b, P9c
		• Describe, with examples, how objects can interact
		  ○ at a distance without contact, linking these to the gravitational, electrostatic and magnetic fields involved
		  ○ by contact, including normal contact force and friction producing pairs of forces which can be represented as vectors.
		• Use vector diagrams to illustrate resolution of forces, a net force, and equilibrium situations (scale drawings only).
		• Draw and use free body force diagrams.
		
		Physics only
		• *Describe the uses of rotational forces*
		• *Recall and use the equation for the moment of a force and the principle of moments*
		• *Explain the uses of levers ,gears and lubrication*

Forces used for elastic distortion	• Plan and carry out an experiment to find the	• Recall and use the equation for linear elastic

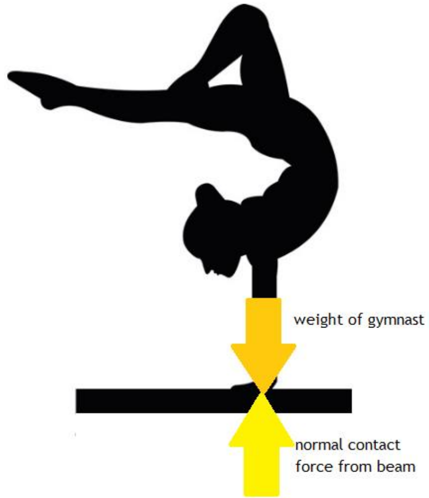
(spec points: 15.3, 15.4, 15.6) • Core practical: Investigate extension of a material and calculate the spring constant for the material • Calculating spring constants, and work done	spring constant of an elastic material • Use a force extension graph for a spring to calculate the work done in stretching the spring *GCSE resource links: P15b*	distortion including calculating the spring constant: force exerted on a spring F = k × x. • Use the equation to calculate the work done in stretching a spring: energy transferred in stretching (joules, J) = 0.5 × spring constant (newton per metre, N/m) × (extension (metre, m). $E = \frac{1}{2} \times k \times x^2$
Circular Orbits *(spec points: **2.20, 2.21**)* • **Understand that a centripetal force is needed to keep an object moving in a circle.** • **Understand that an object moving in a circle is accelerating.**	• **Revise scalar and vector quantities for the difference between speed and velocity.** • **Use a rubber bung on end of a string to demonstrate centripetal force.** *GCSE resource links: P2b*	• **Explain that an object moving in a circular orbit at constant speed has a changing velocity (qualitative only) (AO2).** • **Explain that for motion in a circle there must be a resultant force known as a centripetal force that acts towards the centre of the circle (AO2).**
Stopping Distance *(spec points: 2.27 – 2.33)* • Be able to calculate average reaction time. • Know that stopping distance is made up of two parts thinking distance and braking distance. • Understand how the stopping distance of a vehicle is affected by its speed and human reaction time and factors such as road conditions and the condition of the vehicle including its mass. • Understand how stopping distance is related to energy (P).	• Investigate reaction time – e.g. compare two different methods of measuring human reaction time. • investigate the relationship between the work done to stop a trolley and different surfaces on which the trolley stops. • Investigate the relationship between stopping distance and speed on a particular surface. • Analyse data to investigate the relationship between the kinetic energy of a car and its stopping distance. *GCSE resource links: P2g, P2h, P2i*	• Explain methods of measuring human reaction times and recall typical results (AO2). • Recall that the stopping distance of a vehicle is made up of the sum of the thinking distance and the braking distance (AO2). • Explain that the stopping distance of a vehicle is affected by a range of factors including: (AO1) a the mass of the vehicle b the speed of the vehicle c the driver's reaction time d the state of the vehicle's brakes e the state of the road f the amount of friction between the tyre and the road surface • Describe the factors affecting a driver's reaction time including drugs and distractions

		(AO1). • Explain the dangers caused by large decelerations and **estimate the forces involved in typical situations on a public road (AO2).** • Estimate how the distance required for a road vehicle to stop in an emergency varies over a range of typical speeds (AO2) (P). • 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) (AO2)(P).

Exemplification of mastery

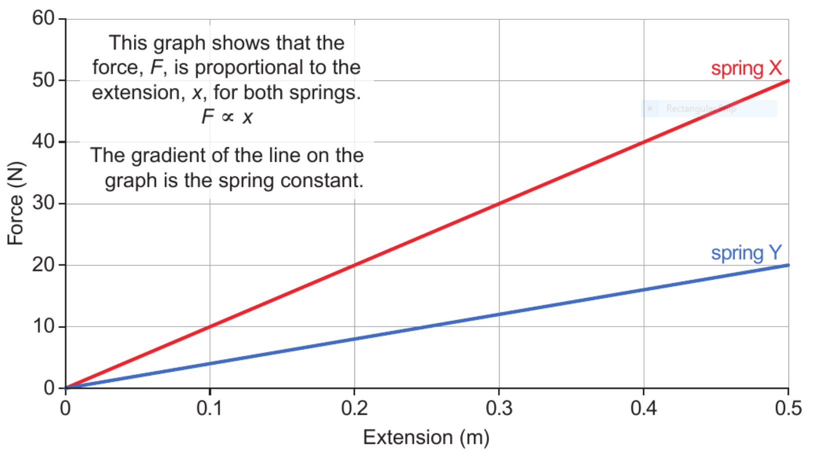


- Draw a force arrow to scale at the correct angle.
- Draw a rectangle with the sides in the directions you are interested in (e.g. horizontal and vertical).
- The resolved forces are the sides of the rectangle.

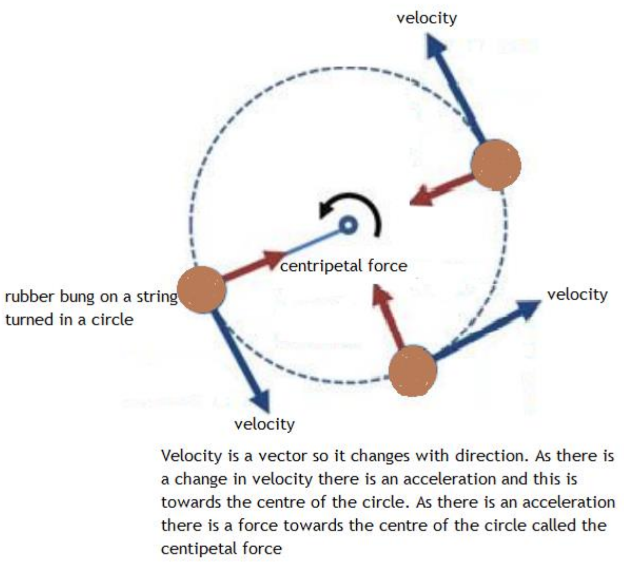


What do you notice about the forces?.

Why are the forces not applying Newtons third law?

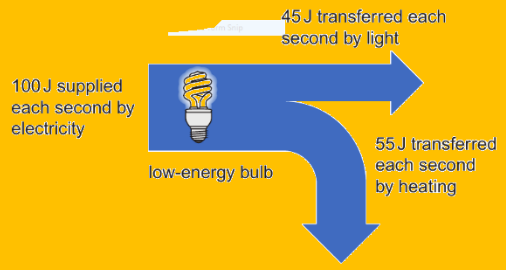


This graph shows that the force, F, is proportional to the extension, x, for both springs.
F ∝ x
The gradient of the line on the graph is the spring constant.
spring X
spring Y
Force (N)
Extension (m)
0
10
20
30
40
50
60
0
0.1
0.2
0.3
0.4
0.5



velocity
centripetal force
rubber bung on a string turned in a circle
velocity
velocity
Velocity is a vector so it changes with direction. As there is a change in velocity there is an acceleration and this is towards the centre of the circle. As there is an acceleration there is a force towards the centre of the circle called the centipetal force

Rewind grid

This topic	10.4 Forces and work done	9.6 Forces and matter
State how the magnitude and direction of a vector force is represented. **1 point**	The diagram is a Sankey diagram for a lamp. Calculate how much energy is wasted.  **1 point**	State what is 'k' in the equation F=k x *x* **1 point**
Draw a vector diagram to find the resultant of two forces of 3N and 4N fight angles. **3 points**	Using the information in the Sankey diagram. Calculate the efficiency of the lamp. **3 points**	Describe the difference between elastic and inelastic distortion. **3 points**
A car of mass 900kg is travelling at 8 m/s when it has to stop. The driver's reaction time is 0.4 s and then the brakes are applied with a force of 1100N. Calculate the total stopping distance of the car. **5 points**	Describe how to measure the work done by a force. **5 points**	A spring is 6cm long. When a weight of 5N is added to extend the spring the new length is 8cm. Calculate the work done in stretching the spring. **5 points**

ANSWERS

A line of the correct length representing the magnitude of the force and an arrow on the line to show the direction of the force.	55J the energy transfer is for a lamp, so any heat produced is wasted.	K is the spring constant.
Draw a vector diagram to find the resultant of two forces of 3N and 4N at right angles.	Efficiency =useful energy output/total energy input Efficiency = 45/100 =0.45	It a material distorts elastically it returns to its original shape once the distorting force is removed. If the force causes an inelastic distortion the material is permanently changed and will not return to its original shape.
Thinking distance = 8 x 0.4 =3.2m KE of car =0.5 x 900 x 8 x 8 =28800J This is the work that must be done on the car to bring it to rest; E =F x d d = E/F =28800/1100 = 26.2 m This is the braking distance Total stopping distance = 3.2 + 26.2 =29.4m	Pull a trolley along a bench using a spring balance. Keep the spring balance parallel to the bench and in line with the trolley so that the force applied to pull the trolley is in the direction that the trolley moves. Note the force applied to pull the trolley and the distance through which the trolley is moved. Calculate work done using E=F x d	Extension for the addition of 5N is 2 cm 2 cm = 0.02 m K=5/0.02 =250 N/m Work done E =0.5 x 250 x 0.02 x 0.02 =0.05J

Big Idea: Forces and Fields	Topic: 11.5 Forces and motion	Indicative hours: 4hrs CS, 4hrs SS

Prior knowledge

Students should be familiar with the vocabulary used to describe the motion of objects including distance x, time t, speed, initial velocity u, final velocity v and acceleration a,and should know the difference between scalar and vector quantities Previous knowledge should also include the use of distance - time graphs to determine velocity and velocity-time graphs to determine uniform acceleration from a gradient and total distance travelled from the area between the graph line and the time axis. Students should also be able to use and rearrange the equations speed = distance / time, a =(v-u)/t and v^2-u^2= 2 x a x *x* P9.4 (describing motion), to determine velocity and acceleration and recall typical everyday speed for cyclists and transportation systems. From prior knowledge, students should also be able to describe practical investigations to determine the speeds of objects using measurements of distance and time or light gates (core practical) and recall the value of g, (gravitational field strength or o acceleration of an object in free fall as 10m/s^2

Topic overview

Students will learn that an object remains stationary or moving uniformly in a straight line unless acted upon by a resultant force (Newton's first law) and will apply this when the resultant force is zero and there is no change in velocity and when the resultant force is not zero and the resultant force produces an acceleration F=m x a (Newton's second law). Students will recall and apply F=mx a to various situations when objects have a force applied. This is then applied to the special case when an object is in the Earth's gravitational field and the acceleration is g(10m/s^2). The weight of an object can then be determined using W =m x g. Mass is constant but weight is measured with a spring balance and depends on the gravitational field strength g.

Topic progression

This work is the basic requirement for the study of Topic 2, Mechanics, Edexcel Advanced Physics Paper 1.

Links to National Curriculum Programme of study

- Estimating speeds and accelerations in everyday contexts;
- interpreting quantitatively graphs of distance, time, and speed;
- acceleration caused by forces; Newton's First Law; and
- weight and gravitational field strength.

Links to Working Scientifically skills

Development of scientific thinking

- Use a variety of models, such as representational, spatial, descriptive, computational and mathematical, to solve problems, make predictions and to develop scientific explanations and an understanding of familiar and unfamiliar facts, (e.g. terminal velocity).
- Evaluate risks both in practical science and the wider societal context, including perception of in relation to data and consequence.

Experimental skills and strategies

- Plan experiments to investigate force, mass and acceleration using trolleys and slopes e.g. using light gates.
- Use appropriate measurement techniques and apparatus, to measure distance, time and force paying attention to accuracy and health and safety.

Analysis and evaluation

- Presenting observations and other data using appropriate methods.
- Translating data from one form to another.
- Carrying out and representing mathematical and statistical analysis.

Scientific vocabulary, quantities

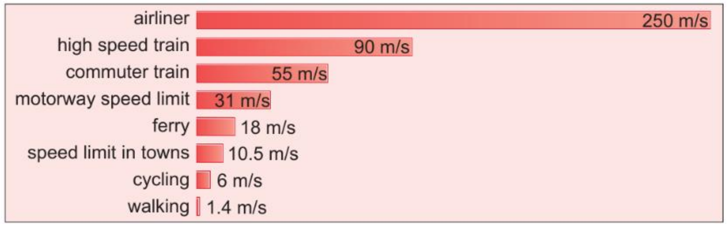
- Use scientific vocabulary, terminology and definitions.
- Use SI units, e.g. N,s, m, kg m/s, m/s^2

Details of practicals	Misconceptions	Future Ready
• Use spring balances to measure weight of objects. • Core practical: Investigate the relationship between force, mass and acceleration by varying the masses added to trolleys.	When a parachutist opens the parachute, students tend to believe the parachutist goes up, instead of still falling but at a reduced speed. This is what is seen in films because of the relative motion of the parachutist and the cameraman. Students think gravity only affects heavy things.	KS4 step 8 Forward thinkers can… break down complex problems into chunks. Forward thinkers can… build patterns and links between data and ideas.

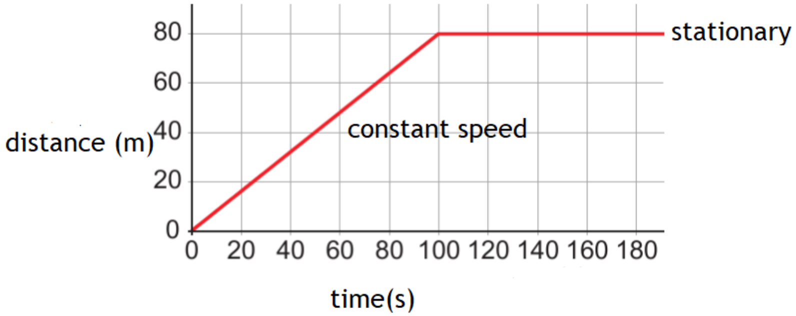
Literacy ideas and terminology	Broadening curriculum
Ideas: Create a 12 x 12 word search using the following words; Scalar, vector acceleration, kilogram, force, newton, velocity, mass, distance, time, seconds, metres. To increase the challenge, give a definition or a clue for the word rather than the word itself. Students could work in groups for this. ***Key words:*** *Tier 1:* speed, mass, weight *Tier 3:* scalar, vector, initial velocity, final velocity, acceleration, resultant force, balanced forces, gravitational field strength.	***Scientists:*** *Isaac Newton* (Physicist English Male, laws of motion) *Galileo Gallilei* (Astronomer Italian Male) measuring time using a pendulum ***STEM careers*****:** Aeronautical engineer, robotist, sports scientist

Learning objectives	Teaching ideas/ links to resources	Indicative success criteria
Force and Acceleration *(spec points: 2.14-2.19,* ***2.22****)* • Know what happens to the motion of an object when the forces acting on it are balanced. • Understand what happens to the motion of an object when there is a resultant force acting on it. • Understand the difference between mass and weight. • Understand that weight is the force acting on something due to the pull of gravity. • **Know that inertial mass is the ratio of force to acceleration and the inertial mass is a measure of how difficult it is to move, start moving, or change the velocity of an object.** .	• Students calculate average velocity of a trolley moving down a slope by using a ruler (distance) and stop clock or light gates and data logger (time) a= • Revise use of equations a=(v-u)/t , v^2-u^2=2 x a x x , distance-time and velocity-time graphs to find acceleration from gradient and total distance travelled. • Apply Newton's first law to a parachutist, free falling, (high terminal velocity) balanced forces. Opening parachute gives resultant force acting upwards this slows parachutist down until weight is equal to air resistance, balanced forces (low terminal velocity). • Students apply F=ma to moving objects and calculate an acceleration when there is a resultant force. When forces are balanced there is no resultant force F =0 and, therefore, no acceleration. • Measure weight in newton of masses in kilograms using a spring balance. To show weight is dependent on gravitational field strength g which is 10m/s^2 on Earth which is also called the acceleration due to gravity. The equation relating mass and weight is W =mg. • Students investigate the relationship between force, mass and acceleration using a slight slope to compensate for friction and a constant force to pull the trolley. The acceleration can be measured using light gates and a data logger. The masses on the trolley are increased the force is constant The acceleration is measured for trolleys of different masses and a graph plotted to show mass is inversely proportional to acceleration. *GCSE resource links: P2a, P2b, P2c, P2d*	• Recall Newton's first law and use it in the following situations: a where the resultant force on a body is zero, i.e. the body is moving at a constant velocity or is at rest. b where the resultant force is not zero, i.e. the speed and/or direction of the body change(s) (AO1). • Recall and use Newton's second law as: force (newton, N) = mass (kilogram, kg) × acceleration (metre per second squared, m/s^2) (AO2) F = m× a • Define weight, recall and use the equation: weight (newton, N) = mass (kilogram, kg) × gravitational field strength (newton per kilogram, N/kg) (AO2) W = m× g • Describe how weight is measured (AO1). • Describe the relationship between the weight of a body and the gravitational field strength (AO1). • **Explain that inertial mass is a measure of how difficult it is to change the velocity of an object (AO2).**

Exemplification of mastery

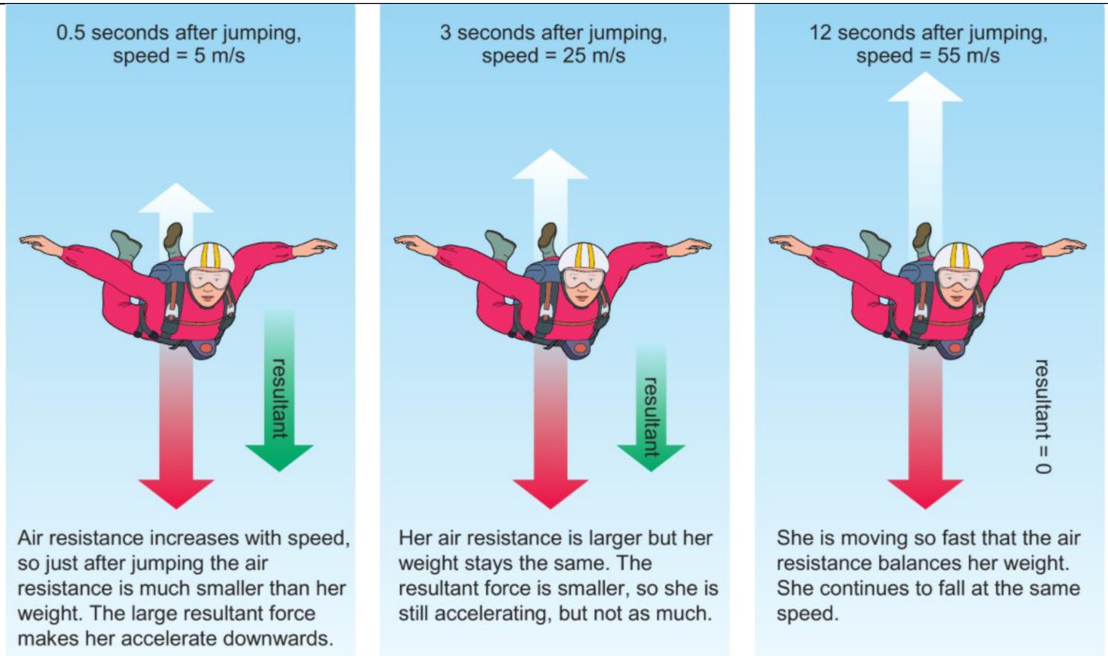


some typical speeds

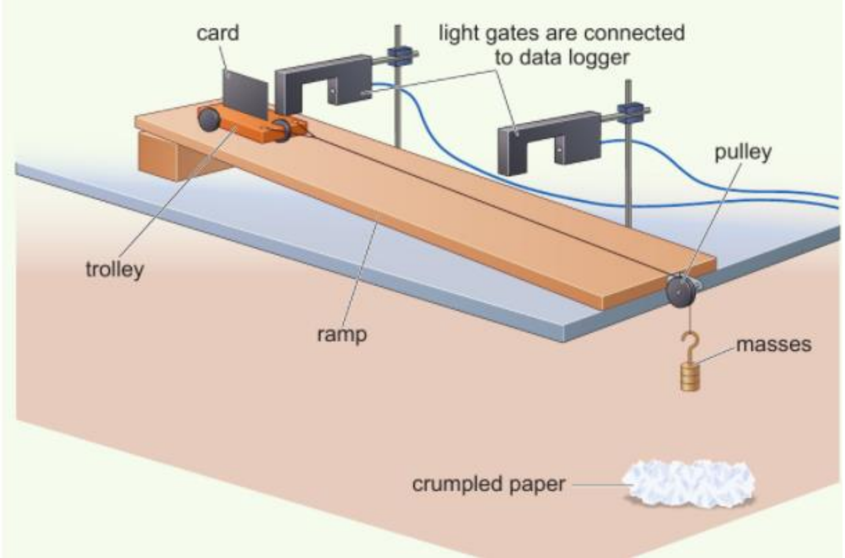


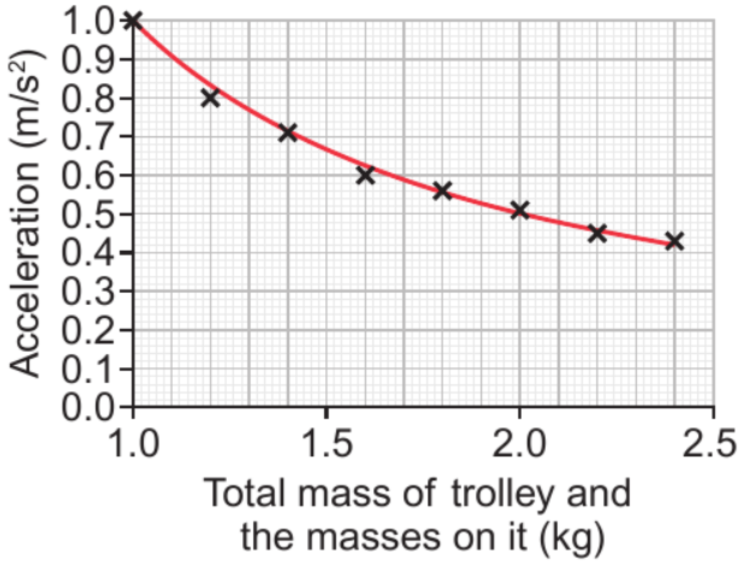
At what distance is the object not moving? Ans =80 m

Find the constant peed of the car. speed = x/t ans =80/100 = 0.8 m/s



0.5 seconds after jumping, speed = 5 m/s
resultant
Air resistance increases with speed, so just after jumping the air resistance is much smaller than her weight. The large resultant force makes her accelerate downwards.
3 seconds after jumping, speed = 25 m/s
resultant
Her air resistance is larger but her weight stays the same. The resultant force is smaller, so she is still accelerating, but not as much.
12 seconds after jumping, speed = 55 m/s
resultant = 0
She is moving so fast that the air resistance balances her weight. She continues to fall at the same speed.

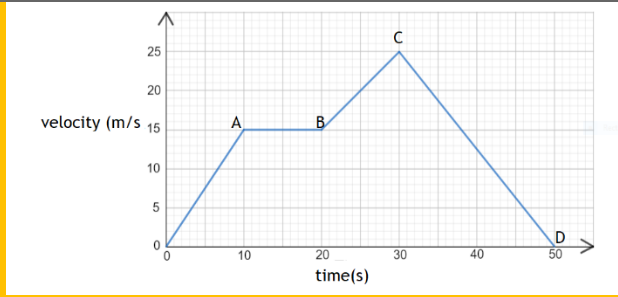




Can students explain how the core practical is carried out using the diagram? Show graph on the right, and ask students to interpret the graph. What does the graph show? How could they present the results in a different way to determine whether the relationship between mass and acceleration is inversely proportional?

Answer: Plot acceleration against 1/mass. If this is a straight line, it shows that acceleration is inversely proportional to the accelerating mass

Rewind grid

This topic	9.4 Describing motion	9.4 Describing motion
Give the value of the acceleration due to gravity (g). **1 point**	 Which part of the graph shows deceleration. **1 point**	Give the unit of acceleration. **1 point**
An object has a mass of 8kg. Calculate the weight of the object. **3 points**	Compare the values of the acceleration from 0 to A with the acceleration from B to C on the graph. **3 points**	Calculate the average speed of a sprinter that runs 100m in 9.8 s **3 points**
A parachutist jumps from an aeroplane, free falls then opens the parachute and after a time land safely. Explain using Newton's first how the resultant forces acting on the parachutist change during the descent and the effect this has on the velocity and acceleration of the parachutist. **5 points**	Calculate the total distance travelled in 50s using the graph. **5 points**	Calculate the acceleration of a car which starts from rest and reaches a velocity of 12m/s in a distance of 40m. **5 points**

ANSWERS

$g=10m/s^2$	CD	metre per second squared, m/s^2
W=mg W=80N	gradient of 0A and BC: 0A acceleration is $1.5m/s^2$ BC acceleration is $1.0m/s^2$	Average speed =100/9.8 =1.02m/s
On jumping out of plane accelerates as weight greater than air resistance. As velocity increases, air resistance increases until weight becomes equal to air resistance and the parachutist falls at a constant velocity (free fall). When the parachute is opened, air resistance increases and is greater than weight and there is a deceleration. As the velocity of the parachutist gets less the air resistance reduces and becomes equal to the weight and there is no resultant force, so the velocity is constant (terminal velocity) and slow enough for the parachutist to land safely.	Each of the four parts in order 75m + 150m+ 200m + 250m. Total distance travelled =675m.	Use $v^2-u^2 =2ax$ $a=1.8m/s^2$

Big Idea: Forces and Fields	Topic: 11.6 Magnetism	Indicative hours 4hrs CS, 4hrs SS

Prior knowledge

This topic was studied in Year 8 (P 8.6 magnets and electromagnets), students should recall that magnets have poles (N and S) where the magnetic force is concentrated and know that magnetic forces act at a distance (non-contact force). They should also know the Law of Magnetism that like poles repel and unlike poles attract. Students should know that the area around a magnet, where the effect of the magnet can be felt is called a magnetic field and the shape of the field can be shown using ion fillings or a compass

Topic overview

Students will learn the difference between permanent and induced magnets and describe the uses of permanent and temporary magnetic materials. The law of magnetism will be reviewed and students will be able to describe uniform magnetic fields and the field of bar magnets and know the shape of a magnetic field is represented by field lines which do not cross, an arrow gives the direction of the field and the closer the lines are together the stronger the magnetic field. Students will learn how to use a plotting compass to show the shape and direction of a magnetic field around a bar magnet, the shape and direction of a uniform magnetic field and the Earth's magnetic field

Topic progression

This work is the basic requirement for the study of Topic 7, Electric and magnetic fields in Edexcel Advanced Physics Paper 2 It also progresses to the following Electromagnetism Topic.

Links to National Curriculum Programme of Study

- magnetic poles, attraction and repulsion
- magnetic fields by plotting with compass, representation by field lines
- Earth's magnetism, compass and navigation

Links to Working Scientifically skills

Development of scientific thinking

- use of models (e.g. field patterns) to make predictions and to develop scientific explanations and understanding of familiar and unfamiliar facts.

Experimental skills and strategies

- Carry out experiments appropriately, having due regard to the correct manipulation of apparatus and health and safety considerations. For example when investigating magnetic fields

Analysis and evaluation

- present observations and data using appropriate methods
- interpret observations and data, including identifying patterns and using observations, measurements and data to draw conclusions

Scientific vocabulary, quantities

- use scientific vocabulary, terminology and definitions (see key words)

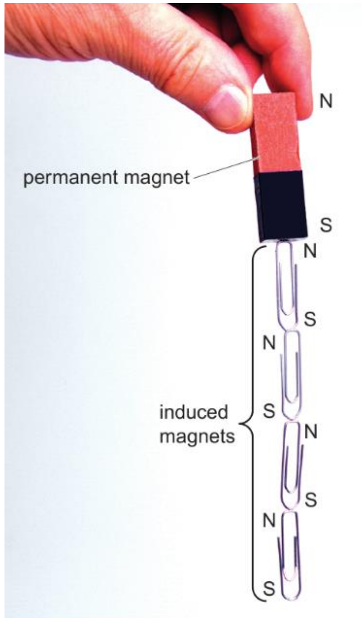
Details of practicals	Misconceptions	Future Ready
• Test magnetic forces are non-contact by adding slips of paper between the poles of two magnets and finding out how many slips of paper are needed to stop the attraction between the poles. • Test permanent and temporary magnetic substances using magnets and non-magnetic objects • Test the effectiveness of induced magnetism using magnets and paper clips • Investigate the magnetic field around a bar magnet, the uniform magnetic field between the faces of two Magnadur magnets and the Earth's magnetic field using a plotting compass.	The north pole of a compass points geographically north, but as a north pole is attracted to a south pole the pole which is geographically north must be a south pole Students should carry out practical work to ensure they understand this.	KS4 step 8 Forward thinkers can...break down complex problems into chunks e.g. build patterns and links between data and ideas when investigating magnetism and analysing patterns and data from those investigations.

Literacy ideas and terminology	Broadening curriculum
Ideas: Compare the uses of permanent and induced magnets. Create a table to compare these uses. ***Key words:*** *Tier 1: compass,* *Tier 2:* attraction, repulsion *Tier 3: Permanent magnetic materials*, temporary magnetic materials, magnetic poles, magnetic forces, magnetic field lines, Earth's magnetic field, magnetic force,	***Notable Scientists:*** *William Gilbert* (Physicist Male English) pioneer researcher into magnetism *Esther Conwell* (Chemist/physicist, Female, American) Known for her pioneering semiconductor science. Spent much of her life mentoring women in science and encouraging careers in STEM. In 2002, names as one of the top 50 women in science by Discover magazine Mary Somerville (Scottish, phycisist, Female). Experiments on magnetism, and exploring light and magnetism ***STEM careers****: Aeronautical engineer geoscientist kinesiologist* robotist weather forecaster yacht master

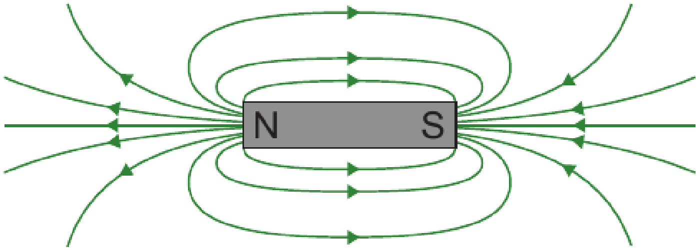
Learning objectives	Teaching ideas/ links to resources	Indicative success criteria
Magnetism (spec points: 12.1 – 12.6) • Know that magnets can attract some materials	• Review the Law of Magnetism • Test the effect of magnets and non-magnetic materials on metals such as iron, cobalt, steel and nickel to establish the difference between permanent and temporary magnetic materials.	• Recall that unlike magnetic poles attract and like magnetic poles repel (AO1) • Describe the uses of permanent and temporary • magnetic materials including cobalt, steel, iron

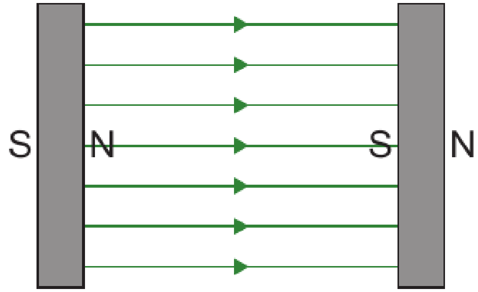
• Understand that a magnetic force is a non-contact force. • Know the law of magnetic poles • Know that the space around a magnet where magnetic forces can act is called a magnetic field. • Understand that the Earth has a magnetic field. • Know how the Earth's magnetic field affects a compass. • Know how to show the shape and direction of a magnetic field.	Only two magnets produce a force of repulsion. • Students explain why paperclips attached to a magnet are induced magnets. • Students learn how to use a plotting compass and know that the point of the compass is the north pole of a magnet which rotates on a pivot • Use a plotting compass to plot the magnetic field of a bar magnet • Be able to sketch the magnetic field of a bar magnet and describe how the shape and direction (N to S) of the field is obtained using a plotting compass. • Test in the absence of any other magnetic fields a compass will always point geographically north in line with the Earth's Magnetic field, because the geographical north pole is a magnetic south pole *GCSE resource links: P12a*	and nickel (AO2) • Explain the difference between permanent and induced magnets (AO1) • Describe the shape and direction of the magnetic field around bar magnets and for a uniform field, and relate the strength of the field to the concentration of lines (AO2) • Describe the use of plotting compasses to show the shape and direction of the field of a magnet and the Earth's magnetic field (AO2) • Explain how the behavior of a magnetic compass is related to evidence that the core of the Earth must be magnetic (AO2)

Exemplification of mastery



A permanent magnet can turn objects made from magnetic materials into induced magnets.





Rewind grid

This opic	Magnetism	8.6 Magnets
Describe a magnetic field **1 point**	Name a magnetic material. **1 point**	Name the poles of a magnet **1 point**
Describe how could you show that the Earth has a magnetic field? **3 points**	Describe how you would show that paper clips attached to a magnet have induced magnetism **3 points**	State the law of magnetism **3 points**
Describe how you would use a plotting compass to plot the field due to a bar magnet. **5 points**	Describe an experiment to show that magnetism is a non-contact force. **5 points**	You have a magnet. Explain how you would separate aluminium and steel cans **5 points**

Note: magnetism is not covered in year 10, so two columns in this rewind grid both relate to this topic.

ANSWERS

The region around a magnet where the effect of the magnet force is exerted	Any one from: iron, cobalt, nickel or steel	north and south
Use a compass. The compass will always point towards the north pole(along the line of the Earth's magnetic field)	When the magnet is removed the paper clips will lose their magnetism and the chain of paperclips will break.	Like poles repel, unlike poles attract
Put a magnet on a piece of paper and draw round it. Start a plotting compass at a pole of a magnet. Mark where the arrow is pointing at both ends. Move the plotting compass so the end of the arrow matches up with the mark you made furthest away from the magnet. Mark the other side of the arrow on the paper, and continue until you achieve an arc. Start at the magnet again in a different place and repeat.	Use two magnets with unlike poles facing. Suspend one magnet. Add small pieces of paper between the magnets there will still be an attraction. Keep adding pieces of paper until the second magnet is no longer attracted	Test each can with the magnet. The aluminium can will not stick to the magnet. Aluminium in non- magnetic. Steel cans will stick to the magnet, steel is a magnetic material

Big Idea Fields and forces	Topic: 11.7 Electromagnetism	Indicative hours 4hrs CS, 4hrs SS

Prior knowledge

Students should refer to electromagnets as studied in Year 8 (P8.6 Magnets and electromagnets) and understand that an electromagnet is produced when a current carrying conductor is wrapped around a piece of iron. The iron is magnetised and the shape of the magnetic field produced is the same as that of a bar magnet. Students should also know the current convention, i.e. currents flow from positive to negative in a circuit and a current is measured using an ammeter is series in a circuit (P10.2 Using electricity)

Topic overview

Revision of electromagnetism leading to understanding that a current carrying conductor always produces a magnetic field. Investigating the shape and direction of the magnetic field of a long straight current carrying conductor using iron fillings and a compass. Investigating the magnetic field inside and outside a coil of wire carrying a current (solenoid). Investigating the force on a current carrying conductor in a magnetic field and using Flemings Left Hand Rule (Motor Rule) to find the direction of the force on a current carrying wire in a magnetic field. Using the equation F=B x Ix l to calculate the force on the conducting wire

Topic progression

This topic is the basis for the study of Topic 7 Electric and Magnetic Fields Edexcel A level Physics. It also progresses to Topic 11.8 Electromagnetic induction

Links to National Curriculum Programme of Study

- magnetic effects of currents, how solenoids enhance the effect

Links to Working Scientifically skills

- Use a variety of models, such as representational, spatial, descriptive, computational and mathematical, to solve problems, make predictions and to develop scientific explanations and an understanding of familiar and unfamiliar facts. (e.g. motor effect)
- Evaluate risks both in practical science and the wider societal context, including perception of risk in relation to data and consequences.

Analysis and evaluation

- presenting observations and other data using appropriate methods
- translating data from one form to another
- carrying out and representing mathematical and statistical analysis

Scientific vocabulary, quantities

- use scientific vocabulary, terminology and definitions. (see keywords) magnetic flux density. B also called the magnetic field strength and is measured in tesla

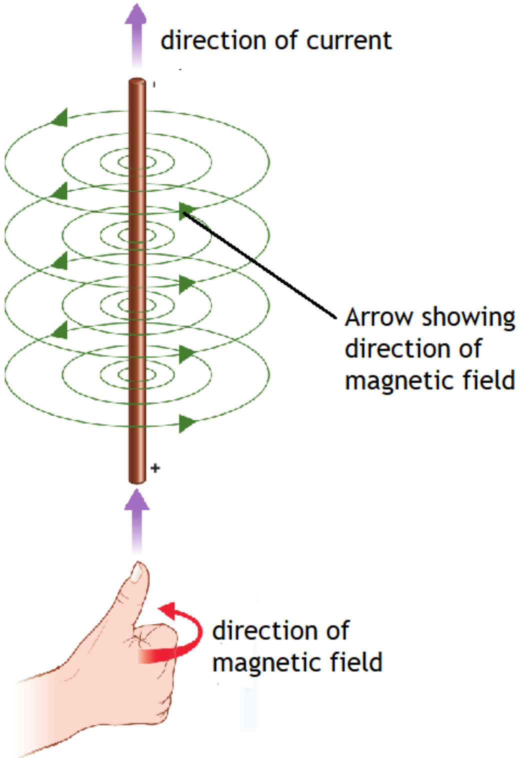
Details of practicals	Misconceptions	Future Ready
• Investigate factors affecting the strength of an electromagnet • Use a vertical long straight wire passing through a card conducting a current. Add iron fillings to the card and tap the card to see the shape of the magnetic field Remove fillings and plot the circular field with a compass • Investigate changes in the strength of the magnetic field with distance from the wire and the current passing through the wire • Build an electric motor using a motor kit	The motor rule (Left Hand), correct hand has to be used to work out the force and the thu**m**b (**M**otion), **f**irst finger **F**ield and se**c**ond finger (**C**urrent must be mutually perpendicular to find the direction of motion. Students should practice answering questions using this rule.	KS4 step 8 Forward thinkers can… break down complex problems into chunks and build patterns and links between data and ideas Most valuable players can…prepare a master plan for a new project e.g. when investigating the field around a current carrying long straight wire using iron fillings and a compass and when investigating factors affecting the strength of the motor effect

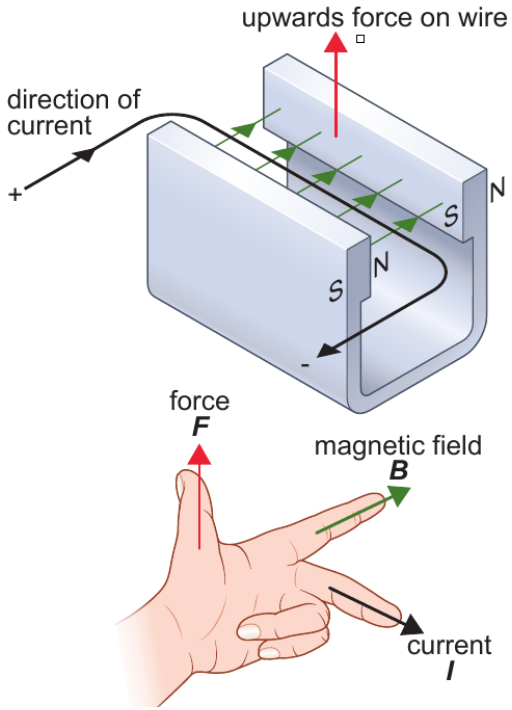
Literacy ideas and terminology	Broadening curriculum
Ideas: What applications are there using the motor effect? Are there any items you use in the home that use this technology? E.g loudspeakers, motors in cars ***Key words:*** Tier 3: Current, magnetic field lines, solenoid, Fleming's left-hand rule, magnetic flux density B, tesla	***STEM careers:*** Aeronautical engineer geoscientist kinesiologist robotist ***Scientists:*** Hans Orsted (Physicist Danish Male) discovered electric currents have magnetic effects. Nikola Tesla (Engineer Serbian- American male) Inventor of AC motor **Real life applications**: Electric motors in cars Loudspeakers and earphones

Learning objectives	Teaching ideas/ links to resources	Indicative success criteria
Electromagnetism *(Spec points: 12.7 – 12.9)* • Know that an electric current sets up a magnetic field in the space around it. • Understand the factors that affect the strength of the magnetic field around a wire.	• Revision of electromagnetic effects using a piece of iron with turns of wire carrying a current. • Investigate factors affecting strength of an electromagnet. • Investigation of the field around a current carrying long straight wire using iron fillings and a compass. • Demonstration using a large solenoid to show a strong field in the centre and a weaker field around the outside. Relate this to the strong	Describe how to show that a current can create a magnetic effect around a long straight conductor, describing the shape of the magnetic field produced and relating the direction of the magnetic field to the direction of the current (AO2) • Recall that the strength of the field depends on the size of the current and the distance from the long straight conductor (AO1) • Explain how inside a solenoid (an example

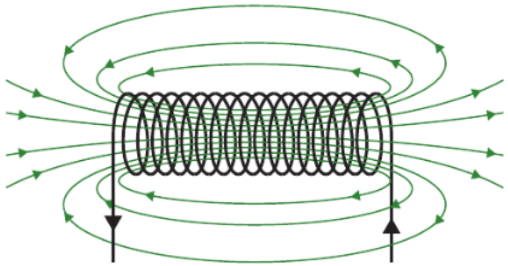
	field produced in the iron of the electromagnet. *GCSE resource links: P12b*	of an electromagnet) the fields from individual coils o add together to form a very strong almost uniform field along the centre of the solenoid o cancel to give a weaker field outside the solenoid (AO2)
Motor Effect (spec points: ***12.10 – 12.14***) • **Understand the cause of the motor effect** • **Understand how to use Flemings left hand rule** • **Know how to calculate the force produced by a current in a magnetic field** • **Understand how motors can produce rotation (P)**	• **"kicking wire" demonstration. Motor effect. Use a wire with a current, placed between the poles of a strong magnet. Switch on the current the wire jumps up or down due to the force. Reverse the current or the magnetic field the wire jumps the other way** • **Apply Flemings left Hand rule to show the direction of the force and the relationship to current direction and magnetic field direction** • **Investigate factors affecting the strength of the motor effect** • **Students build an electric motor using a motor kit** *GCSE resource links: P12b*	• **Recall that a current carrying conductor placed near a magnet experiences a force and that an equal and opposite force acts on the magnet** (AO10 • **Explain that magnetic forces are due to interactions between magnetic fields** (AO2) • **Recall and use Fleming's left-hand rule to represent the relative directions of the force, the current and the magnetic field for cases where they are mutually perpendicular** (AO1) • **Use the equation: force on a conductor at right angles to a magnetic field carrying a current (newton, N) = magnetic flux density (tesla, T or newton per ampere metre, N/A m) × current (ampere, A) × length (metre, m)** $F = B \times I \times l$ (AO2) • **Explain how the force on a conductor in a magnetic field is used to cause rotation in electric motors (AO2) (P)**

Exemplification of mastery

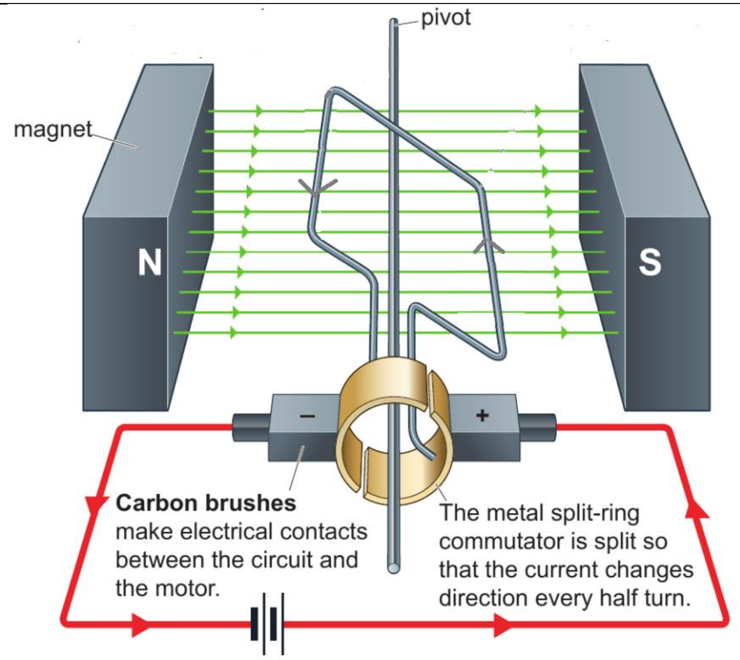




Fleming's left-hand rule. The direction of the current is from + to -.



The solenoid is a coil of wire with a current passing through it. The magnetic field is almost uniform at the centre and the field outside the solenoid is the not as strong and the same shape as the field of a bar magnet



Which way will the motor turn?

Ans. clockwise

Rewind grid

This Topic	10.2 Using electricity	8.6 Magnets and Electromagnets
Describe a solenoid. **1 point**	Give the convention for the direction of the current in a circuit? **1 point**	State why an iron core is used for an electromagnet. **1 point**
State the shape in the magnetic field produced by a long straight wire carrying a current **3 points**	State how the value of the current in a circuit can be determined. **3 points**	Describe how you would make an electromagnet. **3 points**
Describe an experiment which shows that a current carrying conductor in a magnetic field experiences a force (Motor effect). **5 points**	Explain how the current in a circuit can be varied and how the direction of the current can be changed. **5 points**	Explain how the strength of an electro-magnet can be changed and how the change in strength can be demonstrated. **5 points**

ANSWERS

A coil of wire with many turns which may be wrapped around an iron bar	Currents flow from positive to negative.	Iron is a (ferro) magnetic material
The field due to a long straight current carrying conductor is circular	Put an ammeter in series in the circuit	Wrap a coil of wire around an iron bar and pass a current through the wire by connecting it to a power-pack or battery
A magnetic field is set up with N and S poles facing so that there is a uniform field between the poles. A wire connected to a circuit is placed between the poles and the circuit is closed so that a current passes through the wire. The magnetic field of the wire interacts with the magnetic field of the magnet and the wire is moved up or down due to the force between the magnetic fields	The current in the circuit can be varied by putting a variable resistor in series in the circuit or if using a power pack by varying the output voltage. The direction of the current can be changed by reversing the connections to the power pack or batteries.	The strength of an electromagnet can be increased by increasing the number of windings or by increasing the current. The change in strength can be shown by adding a chain of paper clips to the iron core. The longer the paperclip chain the stronger the magnetic field

Big Idea: Forces and fields	Topic: 11.8 Electromagnetic induction	Indicative hours: 2hrs CS 4hrs SS

Prior knowledge

Students need to be able to describe alternating current (a.c) and know that that the domestic supply of electricity in the UK is at about 230 V and has a frequency of 50Hz (P10.2 Using electricity) That a current passing through a wire produces a magnetic field around the wire. This also builds on Topic 11.7 Electromagnetism

Topic overview

Revise alternating currents (a.c). Structure of a transformers, action of a transformers in stepping up or stepping down voltages. The use of transformers to reduce the heat loss from the transmission lines of the National Grid. Transformers are used to step-up voltages produced by power stations to high voltages for transmission. The current is then low and heat loss reduced. The voltage is then stepped down by a transformer for use by homes and factories. Use of power equation for transformers that are100% efficient

Topic progression

This topic is the basis for the study of Topic 7 Electric and Magnetic Fields Edexcel A level Physics

Links to National Curriculum Programme of Study

- how transformers are used in the national grid and the reasons for their use

Links to Working Scientifically skills

Working Scientifically skills developed

Development of scientific thinking

- Use a variety of models, such as representational, spatial, descriptive, computational and mathematical, to solve problems, make predictions and to develop scientific explanations and an understanding of familiar and unfamiliar facts. (eg transformers)
- Evaluate risks both in practical science and the wider societal context, including perception of risk in relation to data and consequences.

Analysis and evaluation

- presenting observations and other data using appropriate methods
- translating data from one form to another
- carrying out and representing mathematical and statistical analysis

Scientific vocabulary, quantities

- use scientific vocabulary, terminology and definitions. (see keywords)

Details of practicals	Misconceptions	Future Ready
• Students use C-cores, make transformers with different numbers of primary and secondary windings. Attach primary to battery pack then ac supply and try to light a lamp from the	Primary and secondary coils of a transformer are linked electrically. Students get confused over high current and high voltage and which is more dangerous. Students should	KS4 step 9 Powerful influencers can... develop different writing styles for different purposes and structure a presentation to propose an idea e.g. compose key

secondary voltage output • Create a gap between C-cores to show the effect of alternating magnetic field • Physics only • Using magnadur magnets on a yoke and a wire connected to a galvanometer, students show that an electric current is generated by the relative movement of a wire and a magnetic field • Connect a coil of wire(solenoid) to a galvanometer and note the effect of moving a magnet in and out of the solenoid and keeping the magnet stationary in the solenoid	label diagrams and describe why each stage is important.	messages to appeal to your audience when writing the presentation on the National Grid.

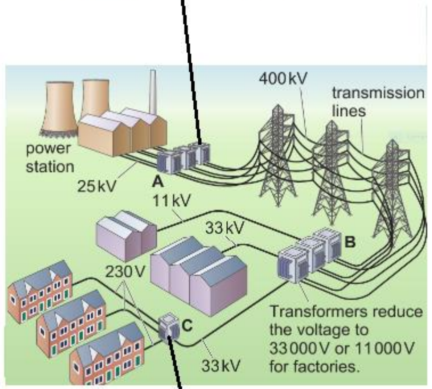
Literacy ideas and terminology	Broadening curriculum
Ideas: Produce a presentation on the importance of the national grid to maintaining the economy of the UK. ***Key words:*** *Tier 3:* alternating current, continuously changing magnetic field, transformer, primary coil, secondary coil, induced voltage, induced current	***STEM careers:*** Aeronautical engineer geoscientist kinesiologist robotist ***Scientists:*** Hans Orsted (Physicist Danish Male)(discovered electric currents have magnetic effects.) Nikola Tesla (Engineer Serbian- American male) Inventor of AC motor ***Real life links:*** How is the energy from offshore wind farms distributed by the national grid?

Learning objectives	Teaching ideas/ links to resources	Indicative success criteria
Transformers *(Spec points:* ***13.2, 13.5-13.7,*** *13.8-13.10)* • **Understand how transformers work** • **Know that an alternating current supply is needed for a transformer to work** • **Understand how transformers change voltages** **Know that a transformer has primary and**	• Review a.c • Using demountable transformer show students main parts and ask them to label a diagram • Demonstrate transformer to step-up and step-down voltages and that there is no electrical connection between the primary and secondary coils • Student practical with C –cores to make transformers and show that a current id induced in the secondary coil.	• **Explain how an alternating current in one circuit can induce a current in another circuit in a transformer** (AO1) • **Recall that a transformer can change the size of an alternating voltage** (AO1) • **Use the turns ratio equation for transformers to calculate either the missing voltage or the missing number of turns:** (AO2)(P)

secondary coils on an iron core • **Be able to use the equation to calculate the force on a current carrying conductor in a magnetic field** • Understand how transformers follow the law of conservation of energy • Apply power equation to a transformer that is 100% efficient • Know how to calculate the current and voltage produced by a transformer • Understand how transformers are used in the national grid • Know the ratio of turns is equal to the ratio of input and output voltages (P) • Physics only • Know how an induced voltage is produced • Know the factors that effect the size of the induced voltage • Know the magnetic field opposes the change producing it. • Be able to explain the uses of electromagnetic induction in generators, loud speakers and microphones • Know and be able to use the equation relating the ratio of turns to the ratio of voltages for a transformer • Know the advantage sof transmitting power at high voltages ands apply this to power equations	• Students separate C-cores and explain how transformers work • Power lines demonstration to show how the national grid works Equation practice using power equations for the transformer which is 100% efficient *GCSE resource links: P13a, P13b, P13c* Physics only • Demonstrate a.c. motors and dynamos • Students carry out experiments on electromagnetic induction using magnets and wires connected to galvanometers • Discuss the action of loudspeakers and microphones • Calculations using the ratio of turns for transformers • Complete calculations using transformer equations and be able to calculate power loss in transmission lines due to resistance of cable.	• Explain why, in the national grid, electrical energy is transferred at high voltages from power stations, and then transferred at lower voltages in each locality for domestic uses as it improves the efficiency by reducing heat loss in transmission lines (AO2) • Explain where and why step-up and step-down transformers are used in the transmission of electricity in the national grid (AO1) • Use the power equation (for transformers with 100% efficiency): potential difference across primary coil (volt, V) × current in primary coil (ampere, A) = potential difference across secondary coil (volt, V) × current in secondary coil (ampere, A) [AO2] $V_p \times I_p = V_s \times I_s$ Physics only • Explain how to produce an electric current by relative movement • Recall the features that effect the size and direction of the induced potential difference (AO1) • Explain how electromagnetic induction is used in alternators, dynamos, microphones and loudspeaker. • Use the turns ratio equation for transformers (AO2) • Explain the advantage of power transmission at high voltages and be able to calculate power loss (AO2)

Exemplification of mastery

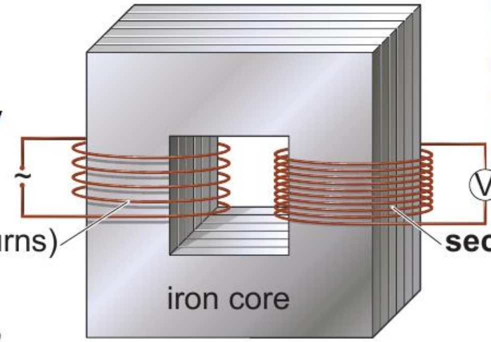
Transformers to increase the voltage from the power station to 400 000 V. To reduce energy wasted by heating in transmission lines



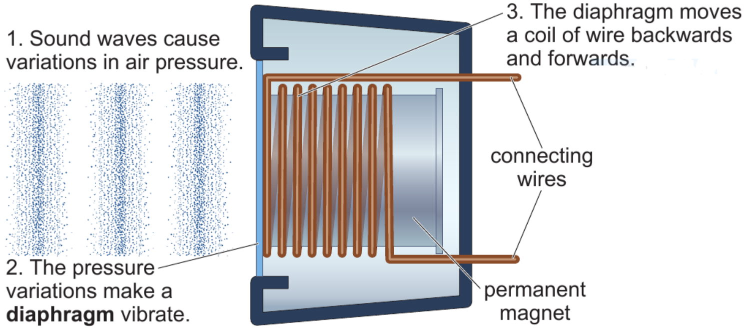
Transformers in local sub-stations reduce the voltage to 230 V for homes, shops and offices

a.c output. The voltage has been stepped-up from 5V to 10V because there are twice as many turns on the secondary coil as there are on the primary coil

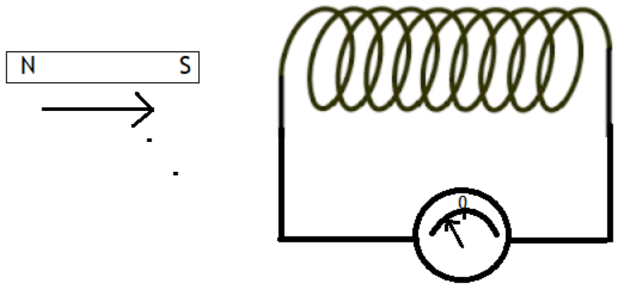
a.c supply to primary coil , input voltage



Step-up transformer



Microphones transfer sound to electricity The sound waves move the coil which is in a magnetic field and a current is induced in the connecting wires



magnet moves into the coil the galvanometer deflects to show an induced current

What happens to the galvanometer reading when the magnet is moved out of the coil . Answer galvanometer deflects the opposite way

Rewind grid

This topic	11.8 Electromagnetic induction	10.2 Using electricity
State the purpose of the national grid. **1 point**	Name the metal the transformer core is made of. **1 point**	Give the meaning of a.c . **1 point**
Describe where are step-up and step-down transformers used in the transmission of electricity by the national grid. **3 points**	State the difference in voltage output between a step-up and step-down transformer. **3 points**	Explain the difference between direct and alternating voltage. **3 points**
Explain why it is more efficient to use high voltages for the transmission of electricity by the national grid. **5 points**	Explain how a transformer works. **5 points**	Recall the voltage and frequency of the UK domestic supply and explain the different functions of the live, neutral and earth wires used to connect electrical appliances to the domestic supply. **5 points**

ANSWERS

To distribute power from power stations to all homes, schools , offices and factories in the UK	Iron, (soft iron) easily magnetised and easily de magnetised	Alternating current
Voltages generated at the power station are stepped up by transformers to very high voltages (400,000 V) for transmission in power lines. To reduce the voltage to 230V for use in homes step-down transformers are used between the power lines and local areas	For a step up transformer the voltage output from secondary coil is higher than the voltage input to the primary coil. For a step-down transformer the output voltage is lower than the input voltage.	Direct voltages are produced by batteries and do not change direction Alternating voltages are produced by generators and the mains voltage changes direction regularly
Power = I x V To carry a given amount of power if the voltage of transmission is as high as possible the current will be low It is the current in a wire that produces heat and therefore energy is lost. The lower the current the less energy is wasted and the process of transmission becomes more efficient. Efficiency= $\frac{\text{useful energy transferred}}{\text{total energy supplied}}$	An a.c. supply to the primary coil, produces an alternating magnetic field in the iron core. As the magnetic field increases and decreases the magnetic field lines cut through the secondary coil. This induces a changing voltage and current in the secondary coil. The size of the voltage induced depends on the ratio of the number of turns on the primary coil to the number of turns on the secondary coil.	Frequency 50 Hz Voltage 230 Va.c Live wire (brown) is at 230V and connects the appliance to the supply. Neutral wire (blue) at 0V provides the return path from the appliance to the supply. Earth wire (yellow and green stripes)is at 0V and connects the metal parts of the appliance to the earth point outside the house and is a safety feature to prevent the user of an electrical receiving an electric shock appliance

Big Idea: Matter and Materials	Topic 11.9: Radioactive emissions	Indicative hours: 4hrs CS, 4hrs SS

Prior knowledge

Students should be familiar with the structure and size of the atom and know that an atom has a nucleus containing protons and neutrons and electrons and that the electrons orbit at different distances from the nucleus. Students should know the charges and relative masses of the atomic particles and be able to identify the atomic number of an element and know that differences in the mass number gives the element isotopes. It is also important to understand that equality of protons and electrons make atoms neutral and that electrons can change orbit and in doing so either absorb or emit electromagnetic radiation. Also an atom can lose an electron by emission and become a positive ion. All these points have been covered in Year 9 (P9.1 Describing atoms) together with how the models used to describe the structure of the atom have changed with time.

Topic overview

Revision of atomic size and structure, charges and relative masses of atomic particles. Learn that some elements are radioactive and that these elements emit radioactive particles or waves from unstable nuclei. Know that the emission of radiation is a random process and that alpha(λ)particles, beta minus (β-) particles, positrons(β+) particles and gamma(Υ)radiation can all be emitted randomly by unstable nuclei. Know that an alpha particle is a helium nucleus, a beta minus particle is an electron, a beta plus particle is an electron with a positive charge and that gamma radiation is a high frequency electromagnetic wave. The ionising properties and penetration properties and background radiation will also be studied

Topic progression

This topic is the basis for the study of Topic 8 Nuclear and Particle Physics and Topic 11 Nuclear Radiation in Edexcel A level Physics It also progresses to Topic 11.10 Radioactive half lives and dangers of radioactivity

Links to National Curriculum Programme of Study

- radioactive nuclei: emission of alpha or beta particles, neutrons, or gamma-rays, related to changes in the nuclear mass and/or charge

Links to Working Scientifically skills

Development of scientific thinking

- Use a variety of models, such as representational, spatial, descriptive, computational, to solve problems, make predictions and to develop scientific explanations and an understanding of familiar and unfamiliar facts. (eg using a Geiger –Muller tube)
- Evaluate risks both in demonstrating practical science and the wider societal context, including perception of risk in relation to data and consequences.

Analysis and evaluation

- presenting observations and other data using appropriate methods
- translating data from one form to another
- carrying out and representing mathematical and statistical analysis

Scientific vocabulary, quantities

- use scientific vocabulary, terminology and definitions (see key words)

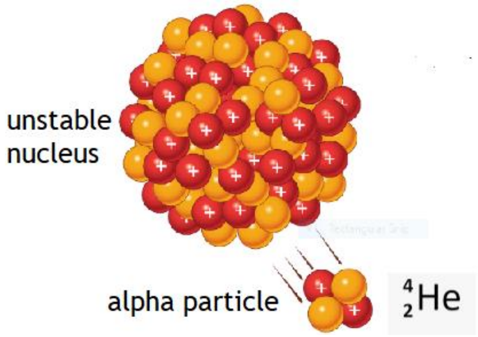
Details of practicals	Misconceptions	Future Ready
• demonstrations with radioactive sources	Although a beta particle is an electron because it comes from the nucleus of the atom it does not ionise the atom as it is emitted. Students should write out the equations and describe what happens when beta particles are emitted.	KS4 step 9 Powerful influencers can… develop different writing styles for different purposes, structure a presentation to propose an idea e.g. compose key messages to appeal to your audience when writing the magazine article. KS4 step 8 Digital superusers can… identify IT requirements and use several applications to resolve a task e.g. when computer modelling radioactive activity

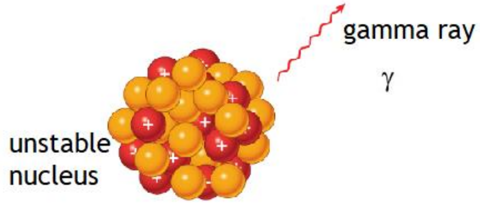
Literacy ideas and terminology	Broadening curriculum
Ideas: Write an article for a magazine advising on the use of granite counter tops in kitchens **Key words:** *Tier 2:* gamma ray *Tier 3*: Radioactive decay, activity, background radiation, becquerel (Bq), G-M tube, alpha particle, beta particle, electron, positron, ionisation, penetration, absorption, nucleus, proton, neutron, mass number, proton number,	**Pearson scientist of the months:** Chien-Shiung Wu (Physics, Female, Chinese-American) worked on the Manhattan Project. Lise Meitner (Physics, Female, Austrian-Swedish) contributed to discovery of nuclear fission. **Other Notable Scientists:** *Henri Bequerel* (discovered evidence of radioactivity) *Marie and Pierre Curie* discovered radium and polonium (radioactive elements) *Hans Geiger; Walther Müller* (invented device for counting radioactive emissions.) **STEM careers:** forensic scientist geoscientist lab technician x-ray technician **Real life applications:** Research how a radiation badge works. create an A4 poster summarising their findings, with an emphasis on the penetration properties of the three types of radiation

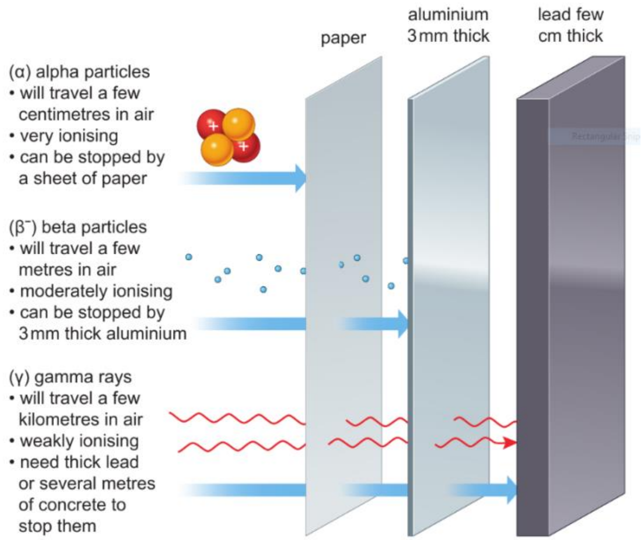
Learning objectives	Teaching ideas/ links to resources	Indicative success criteria
Background Radiation *(Spec points: 6.12 – 6.13)* • Know what is meant by background radiation • Understand that radioactive decay is a natural process and know the origin of background radiation. • Know that radiation can be detected with photographic film or a GM tube	• Revise atomic structure including proton number and mass number to describe the nucleus. • Demonstrate the presence of background radiation using a G-M tube. Ask students to note the reading every thirty seconds for 3 minutes and then calculate the average background count. *GCSE resource links: P6d*	• Explain what is meant by background radiation (AO1) • Describe the origins of background radiation from Earth and space (AO1) • Describe methods for measuring and detecting radioactivity limited to photographic film and a Geiger–Müller tube
Types of Radiation *(Spec points: 6.10,6.11,6.14 - 6.16)* • Know that alpha betta and gamma radiations are emitted randomly from unstable nuclei • Know alpha particles are helium nuclei with a charge of +2, beta minus particles are electrons with a charge of -1,positrons are electrons with a charge of +1 and gamma rays are electromagnetic waves and have no charge. • Know how the different kinds of radiation differ in their ability to penetrate materials. • Know how the different kinds of radiation differ in their ability to ionise atoms	• Show students radioactive sources and work through the safety precautions which must be observed when using the radioactive sources • Demonstrate that the G-M tube can detect alpha, beta and gamma radiations using radioactive sources but the G-M tube is best for detecting beta radiation. • Show that for beta radiation the count rate decreases as the distance from the source increases. Take readings anf students plot a graph • Put a sheet of paper in front of an alpha source to show alpha particles are stopped by a sheet of paper. • Repeat with a beta source and increasing thicknesses of aluminium strips • Repeat with a gamma source and increasing thickness of lead *GCSE resource links: P6e, P6d (part on measuring and detecting radioactivity)*	• Recall that alpha, β^- (beta minus), β^+ (positron), gamma rays and neutron radiation are emitted from unstable nuclei in a random process (AO1) • Recall that alpha, β^- (beta minus), β^+ (positron) and gamma rays are ionising radiations (AO1) • Recall that an alpha particle is equivalent to a helium nucleus, a beta particle is an electron emitted from the nucleus and a gamma ray is electromagnetic radiation (AO1) • Compare alpha, beta and gamma radiations in terms of their abilities to penetrate and ionize (AO1

Radioactive Decay *(Spec points: 6.18 – 6.22)* • Know the processes of beta minus and beta plus decay • Understand how a nucleus is changed by the emission of ionising radiation. • Know that radioactive decays can be represented by nuclear equations • Know that an alpha particle is $^{4}_{2}\text{He}$ • Know a beta minus particle is $^{0}_{-1}\text{e}$ • Know a positron is $^{0}_{1}\text{e}$	• Balance equations representing alpha-, beta- or gamma-radiations in terms of the masses and charges of the atoms involved (MS 1b, 1c, 3c). *GCSE resource links: P6f*	• Describe the processes of β– decay (a neutron becomes a proton plus an electron) and β+ decay (a proton becomes a neutron plus a positron) (AO1) • Explain the effects on the atomic (proton) number and mass (nucleon) number of radioactive decays (α, β, γ and neutron emission) (AO1) • Recall that nuclei that have undergone radioactive decay often undergo nuclear rearrangement with a loss of energy as gamma radiation (AO1) Use given data to balance nuclear equations in terms of mass and charge (AO1)

Exemplification of mastery





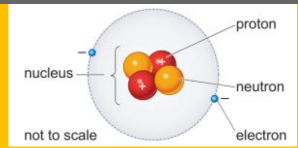


Pearson

Rewind grid

This topic	11.2 Radioactive emissions	9.1 Describing atoms
Name two radioactive emissions that are particles **1 point**	Name the source of all radioactive emissions. **1 point**	Give the approximate size of an atom. **1 point**
Explain what is meant by background radiation **3 points**	Explain why all radioactive emissions are said to be ionising **3 points**	Draw an atom and label the particles within the atom. **3 points**
Describe the process of beta plus decay. **5 points**	Describe an experiment to show that radioactive emissions penetrate materials in different ways. **5 points**	Using mass number and atomic number explain why $^{12}_{6}C$ $^{13}_{6}C$ $^{14}_{6}C$ are all isotopes of an element **5 points**

ANSWERS

Any two from Alpha, beta minus, beta plus, neutron	Unstable nuclei	10^{12}m
This is the low level ionising radiation that we are constantly exposed to and it comes from space and naturally occurring radioactive substances that are in the environment this radiation gives the background count on the G-M tube.	When radioactive emissions pass through gases they have enough energy to knock electrons out of the atoms of the gas and therefore ionise the atoms.	
A beta minus particle is an electron with a mass of 0 charge of -1 This can be emitted from an unstable nucleus by a neutron becoming a proton and emitting an electron (beta minus). The mass number of the atom stays the same but the atomic number increases by 1 $^{1}_{0}n = {}^{1}_{+1}p + {}^{0}_{-1}e$	Use a Geiger counter (G-M tube) to detect the radioactive emissions. Put a sheet of paper then aluminium sheets and finally pieces of lead between the radioactive sources and the G-M tube to find out which radioactive emission will be absorbed by or penetrate each of the materials	Atomic number is the number of protons in the nucleus which gives the element its place in the periodic table. Each has 6 protons so they are all carbon The mass number is the number of protons and neutrons in the nucleus so the atoms have different numbers of neutrons and this makes them isotopes of the element

Big Idea: Matter and Materials	Topic 11.10 Radioactive half-life and dangers of radioactivity	Indicative hours 3hrs CS 4hrs SS

Prior knowledge

Students need to have a good knowledge of the structure of the atom (P9.1 Describing atoms), know that radioactive emission is a random process and that alpha, beta and gamma radiation are emitted from unstable nuclei. There is progression from topic 11.9 Radioactive emissions

Topic overview

Radioactive emissions from an unstable nucleus are random (unpredictable). However because substances have large numbers of atoms the time taken for half the unstable atoms in a substance to decay can be predicted and measured this is called the half-life. Carry out calculations and plot graphs to show half-life. Learn the dangers of ionising radiations and relate this to precautions to limit exposure to radiation for the safety of those people that wok with radiations. Compare the hazards associated with contamination and irradiation by radioactive sources.

Topic progression

This topic is the basis for the study of Topic 8 Nuclear and Particle Physics and Topic 11 Nuclear Radiation in Edexcel A level Physics

Links to National Curriculum Programme of Study

- radioactive materials, half-life, irradiation, contamination and their associated hazardous effects, waste disposal

Links to Working Scientifically skills

Development of scientific thinking

- Use a variety of models, such as representational, spatial, descriptive, computational and mathematical, to solve problems, make predictions and to develop scientific explanations and an understanding of familiar and unfamiliar facts. (eg half life)
- Evaluate risks both in practical science and the wider societal context, including perception of risk in relation to data and consequences.

Analysis and evaluation

- presenting observations and other data using appropriate methods
- translating data from one form to another
- carrying out and representing mathematical and statistical analysis

Scientific vocabulary, quantities

- use scientific vocabulary, terminology and definitions (see below)

Details of practicals

- Student simulation of radioactive decay. Students use a table printed as shown

•	•	•	•	•	•	•	•	•	•
•	•	•	•	•	•	•	•	•	•
•	•	•	•	•	•	•	•	•	•
•	•	•	•	•	•	•	•	•	•
•	•	•	•	•	•	•	•	•	•
•	•	•	•	•	•	•	•	•	•
•	•	•	•	•	•	•	•	•	•
•	•	•	•	•	•	•	•	•	•

- Table is cut into squares total number of squares noted.
- Square tipped over table those with dots up removed these have decayed rest are counted. Note number of undecayed square repeat until no more decay. Plot a graph of number of undecayed squares

Can be done with tiddly-winks if one side marked with a permanent marker

Misconceptions

Students think half life graph will be a straight line. They should model and draw these graphs to familiarise themselves with the shape of these graphs

Future Ready

KS4 step 9

Most valuable players can… learn how to recognise work emotions and ways to stay positive e.g. discussing hospital treatments as some students may have personal experience of this.

Literacy ideas and terminology

Ideas:

Discuss the importance of half-life when radioactive sources are used in diagnosis and treatment of hospital patients

Key words:

Tier 3: Radioactive decay, activity, becquerel (Bq), exponential decay, half-life, contamination, irradiation

Broadening curriculum

Pearson scientist of the months:

Chien-Shiung Wu (Physics, Female, Chinese-American) worked on the Manhattan Project.

Lise Meitner (Physics, Female, Austrian-Swedish) contributed to discovery of nuclear fission.

Other Notable Scientists:

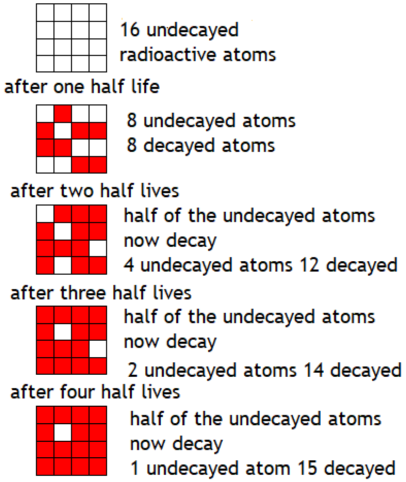
Ernest Rutherford (discovered half-life)

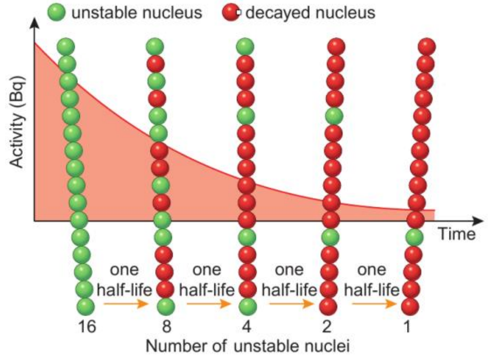
STEM careers: *forensic scientist geoscientist lab technician x-ray technician*

Learning objectives	Teaching ideas/ links to resources	Indicative success criteria
Half Life *(spec points: 6.23 -6.27)* • Understand the random nature of radioactive decay and the significance of half-life. • Know how to calculate half-life from a decay curve and to be able to carry out simple calculations using half-life to work out how much of a sample decays.	• Link emission of radioactivity to decay of atoms and the rate of decay to activity measured in Becquerel (Bq) • The activity of a substance decreases with time (example carbon dating) • Simulate radioactive decay Use about 100 5p coins. These represent atoms put the coins in a plastic cup and weigh. Tip the coins on to a sheet of paper remove those that come up tails these representing decayed atoms. Put the rest in the cup and weigh again. Repeat taking away those that have decayed until there are only a few left • Students Plot the weight against the number of weighings to get an exponential curve and find the half life. Similar results are achieved by counting the coins instead of weighing or using sweets (skittles) which are marked on one side • examples of graphs of exponential decay to find half life and calculations to determine activity after a number of half-lives *GCSE resource links: P6g*	• Describe how the activity of a radioactive source decreases over time and recall that the unit of activity of a radioactive isotope is the Becquerel, Bq (AO1) • Explain that the half-life of a radioactive isotope is the time taken for half the undecayed nuclei to decay or the activity of a source to decay by half (AO3) • Explain that it cannot be predicted when a nucleus will decay but half-life enables the activity of a very large number of nuclei to be predicted during the decay process (AO3) • Use the concept of half-life to carry out simple calculations on the decay of a radioactive isotope, including graphical representations (AO3)

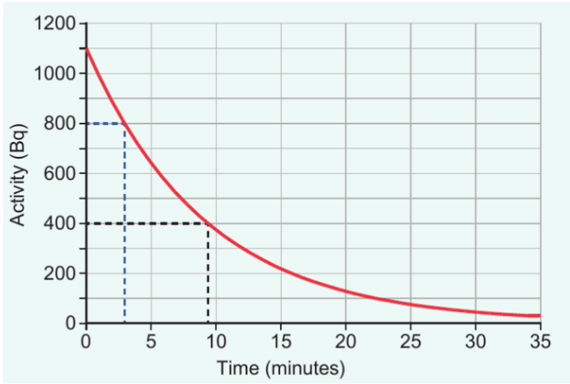
Uses and Dangers of Radioactivity *(spec points: 6.29, 6.31 6.32)* • Know of the dangers posed by ionising radiation. • Know ways of reducing the risks for people working with radioactivity • Know the difference between contamination and irradiation *Physics only* Spec points 6.28P, 6.30P3.33P-6.35 P • Know some uses of radioactivity • Know that the extent of dangers of ionising radiation depends on half –life • Know that radiation is used to treat tumours both internally and externally • Be able to explain the uses of some radioactive substance in diagnosis of medical conditions	• discuss the dangers of exposure to radiation • Students research the precautions that are taken in to limit the risks to people working with radioactive sources particularly those working in hospitals. • students use a case study of a nuclear accident(eg Chernobyl) to find the difference between contamination and irradiation. *GCSE resource links: P6i*	• Describe the dangers of ionising radiation in terms of tissue damage and possible mutations and relate this to the precautions needed (AO2) • Explain the precautions taken to ensure the safety of people exposed to radiation, including limiting the dose for patients and the risks to medical personnel (AO1) • Describe the differences between contamination and irradiation effects and compare the hazards associated with these two (AO2) *Physics only* • Explain how the dangers of ionizing radiation depend on half-life and relate this to the precautions needed • Compare and contrast the treatment of tumours using radiation applied internally and externally. • Explain some uses ofof radioactive substances in diagnosis of medical conditionsincluding PET scanners. • Explain why isotopes used in PET scanner have to be produced nearby

Exemplification of mastery

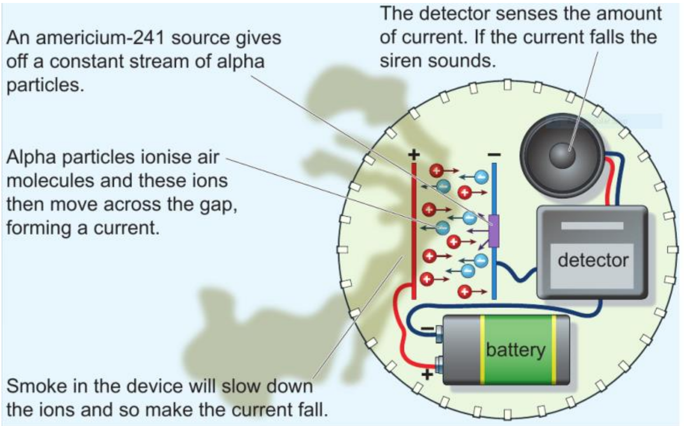




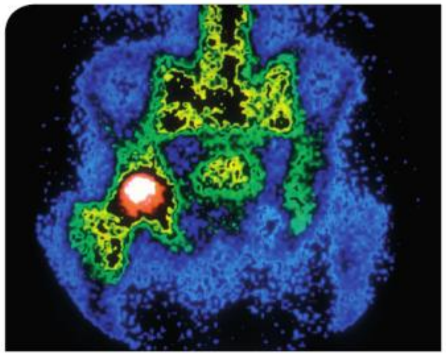
After each half-life the number of unstable nuclei halves.



The time taken for the activity to fall from 800 Bq to 400 Bq is the half life.
Half life = 9.5 -3.0 = 6.5s



Smoke Alarm



This gamma camera scan shows a bone tumour. The brighter the colour, the more radiation has been detected.

Rewind grid

This topic	This topic	9.6 Describing Atoms
Give the unit of activity of a radioactivity isotope. **1 point**	State what the activity of a radioactive isotope describes. **1 point**	Which two of the following particles have almost the same mass, atom, electron, neutron, proton **1 point**
A radioactive isotope has 1000 atoms that have not decayed. Calculate how many undecayed atoms will remain after a time of 3 half-lives? **3 points**	Explain what is meant by the half –life of a radioactive isotope. **3 points**	Explain why an atom is neutral. **3 points**
Explain the difference between exposure to radioactive substances by irradiation and contamination and the safety precautions that can be taken to protect people. **5 points**	Describe a simulation of radioactive decay to show how the activity of a radioactive substance deceases with time. **5 points**	Explain how alpha particle scattering shows that most of the mass of an atom is in the nucleus. **5 points**

ANSWERS

Becquerel (Bq)	The number of disintegrations each second or the number of unstable radioactive atoms that decay each second	Proton and neutron
A radioactive isotope has 1000 atoms that have not decayed. How many undecayed atoms will remain after a time of 3 half-lives? 1000 /2 =500 remain after1 half -life 500/2 = 250 remain after 2 half lives 250/2 =125 remain after 3 half lives Or$\frac{1}{2}$ x $\frac{1}{2}$ x $\frac{1}{2}$ =$\frac{1}{8}$ 1000/8 =125	Half life is the time it takes for half the unstable nuclei in a sample of radioactive isotope to decay Or the time it takes for the activity of a radioactive isotope to fall to half of its original value	An atom has an equal number of protons and electrons. The protons each have one positive charge and the electrons each have one negative charge. The positive and negative charges cancel out making the atom neutral
Irradiation is exposure to alpha ,beta or gamma radiation and stops when the person moves away from the source. People are protected from irradiation by keeping distant, using shields or wearing protective clothing. Contamination is due to coming into contact with radioactive sources or ingestion them. The effect is not removed unless the source of the radiation is removed. People are protected by wearing gloves, masks, protective clothing and washing if the radioactive substance is on the skin.	Describe a simulation to show that the activity of a radioactive substance deceases with time so that a graph can be plotted and a half-life found Use about 100 objects different on each side.,like coins. Weigh or count the objects Toss the objects on to paper remove those showing one side. Reweigh or count those left. Repeat until only a few left. Plot a graph of weight or counts of remaining objects against number of tosses. Draw the curve of best fit. Find the half- life by drawing a horizontal line at half the number or weight of object left (y axis) to line of best fit. Draw vertical line to x axis and read off the number of tosses.	Alpha particles are massive and according to the plum pudding model should pass through atoms. When Rutherford aimed alpha particles at gold atoms he found that most of the alpha particle went through the thin sheet of gold but a few alpha particles bounced back . This showed that most of the atom was empty space but there must be a very small, very heavy nucleus which would make the occasional alpha particle rebound.

Big Idea: Matter and Materials	Topic: 11.11 Nuclear Physics	Indicative hours: 5 SS

Prior knowledge

Students will need to be familiar with the knowledge covered in the Year 9 (P9.1 topic, Describing Atoms).

Topic overview

Students will discuss the advantages and disadvantages of nuclear power for generating electricity compared with the use of other fuels and methods.
The use of nuclear reactions as a source of energy will then be considered. Students learn that it is a controlled chain reaction in anuclear reactor that provides the energy for the generation of electricity in a nuclear power station and that the products of nuclear fission are radioactive. Nuclear fission is then compared with nuclear fusion as the process of energy generation in stars. The conditions required for nuclear fusion are also considered

Topic progression

Nuclear fission and nuclear fusion are studied in more detail in ilater in topic (Topic 11 Nuclear Radiation)which is examined in paper 2 of Edexcel A level Physics

Links to National Curriculum Programme of Study

- *nuclear fission, nuclear fusion and our sun's energy*

Links to Working Scientifically skills

elopment of scientific thinking

- Use a variety of models, such as representational, spatial, descriptive, computational and mathematical, to solve problems, make predictions and to develop scientific explanations and an understanding of familiar and unfamiliar facts.
- Appreciate the power and limitations of science, and consider any ethical issues that may arise.
- Explain everyday and technological applications of science; evaluate associated personal, social, economic and environmental implications; and make decisions based on the evaluation of evidence and arguments.
- Evaluate risks both in practical science and the wider societal context, including perception of risk in relation to data and consequences.

Scientific vocabulary, quantities

use scientific vocabulary, terminology and definitions

Details of practicals	Misconceptions	Future Ready
• set up dominos to model chain reaction	Confusion between the words 'fission' and 'fusion'. Students should draw labelled diagrams of each process and discuss why one is used in reactors and the other is not to help embed the differences.	Digital superusers can… KS4 step 8 Identify IT requirements and use several applications to resolve a task and KS4 step 9 Research and present information in a well designed, visually effective presentation Demonstrate effective ways to communicate and share research findings when researching a different type of system generating power for the national grid.

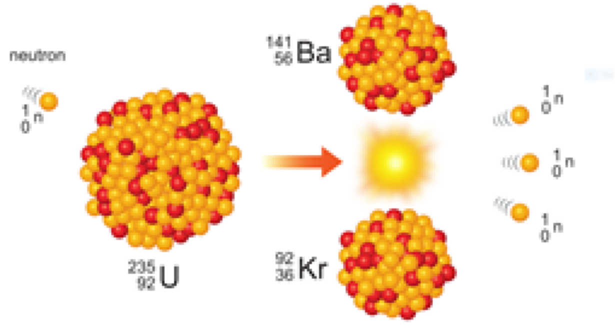
Literacy ideas and terminology	Broadening curriculum
Ideas: Discuss the advantages of generating power using nuclear fusion to reducing the effects of climate change. ***Key words:*** ***Tier 1:*** *temperature, pressure, energy* ***Tier 3:*** *nucleus, fission, fusion, daughter nuclei, chain reaction, nuclear reactor, uranium, control rod, moderator, proton, neutron*	***Pearson scientist of the months:*** *Chien-Shiung Wu (Physics, Female, Chinese-American)nuclear physicist Lise Meitner (Physics, Female, Austrian-Swedish) Theory of nuclear fission* ***Other notable scientists:*** *Discovery of nuclear fission(1938) Otto Hahn, Fritz Strassmann, Theory of nuclear fission Otto Frish, First nuclear reactor core (1942) Enrico Fermi* *Joint European Torus Project (JET) to create usable energy from nuclear fusion (Culham laboratory Oxford shire), ITER (France)* ***STEM careers:*** *forensic scientist geoscientist journalist lab technician*

Learning objectives	Teaching ideas/ links to resources	Indicative success criteria
Nuclear Reactions *(spec points: 6.36 – 6.46)* • Understand the processes of nuclear fission and fusion. (P) • Understand that nuclear fission and fusion release energy that can be used to generate electricity. (P) • Understand the advantages and disadvantages of using nuclear energy in generating electricity. (P) • Know that nuclear fission can lead to a chain reaction which is controlled in a nuclear reactor. (P) • Know that fusion is the energy source of stars such as our Sun. (P)	• Students each groups each group researches a different type of system generating power for the national grid. Group presentation of advantages and disadvantages, class discussion • Students model the chain reaction using domino topples. Mouse traps and ping pong balls see Ultimate Chain Reaction (You tube) • Use nuclear reactor diagram for students to label and explain the uses for each part. • Practice nuclear equations to show the products of nuclear reactions • Discussion of nuclear fusion as the energy source of the stars • Nuclear equations for nuclear fusion • Research in groups, differences between fission and fusion(chart) ,reasons for high temperatures and pressures needed for fusion, JET project, ITER	• Evaluate the advantages and disadvantages of nuclear power for generating electricity, including the lack of carbon dioxide emissions, risks, public perception, waste disposal and safety issues (AO2) • Recall that nuclear reactions, including fission, fusion and radioactive decay, can be a source of energy (AO1) • Explain how the fission of U-235 produces two daughter nuclei and the emission of two or more neutrons, accompanied by a release of energy (AO1) • Explain the principle of a controlled nuclear chain reaction (AO1) • Explain how the chain reaction is controlled in a nuclear reactor, including the action of moderators and control rods (AO2)

• Understand that the conditions needed for fusion make it difficult to produce a practical and economic power station. (P)	project, reasons for very strong magnetic fields(Torus), is fusion practical as a power generator. Report back to class *GCSE resource links: Active Learn SP6k, SP6l, SP6m*	• Describe how thermal (heat) energy from the chain reaction is used in the generation of electricity in a nuclear power station (AO2) • Recall that the products of nuclear fission are radioactive (AO1) • Describe nuclear fusion as the creation of larger nuclei resulting in a loss of mass from smaller nuclei, accompanied by a release of energy, and recognise fusion as the energy source for stars (AO1) • Explain the difference between nuclear fusion and nuclear fission (AO1) • Explain why nuclear fusion does not happen at low temperatures and pressures, due to electrostatic repulsion of protons (AO1) • Relate the conditions for fusion to the difficulty of making a practical and economic form of power station (AO2)

Exemplification of mastery

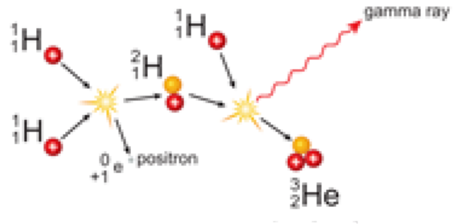
Nuclear Fission



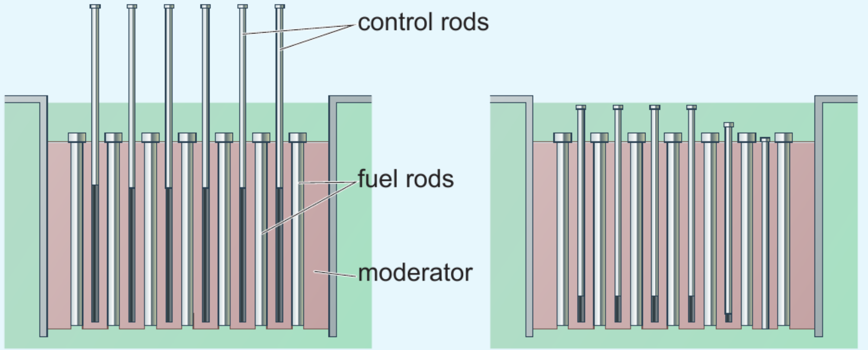
Why is this the start of a chain reaction?

Ans. The three neutrons produced each split an atom and each split produces three more neutrons

Nuclear Fusion

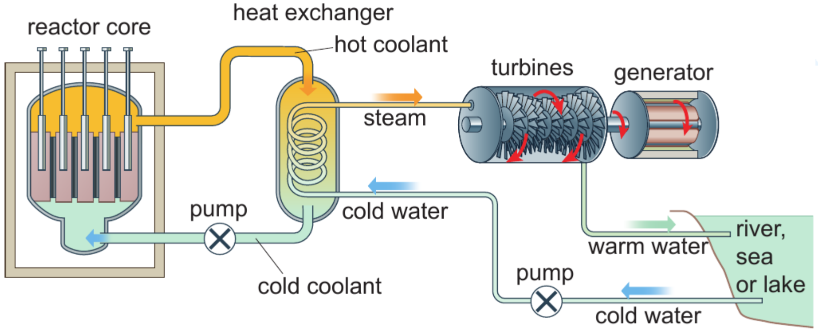


There is a loss of mass in this reaction.What does the lost mass become? Ans. energy



Not many of the neutrons from fission reactions are absorbed by the control rods so the chain reaction can proceed quickly and a lot of energy is released.

Most of the neutrons from fission reactions are absorbed by the control rods so the chain reaction will slow down.



Radioactive fuels are used to generate electricity in nuclear power stations.

Rewind grid

This topic	This topic	11.10 Dangers and uses of radioactivity
State how many daughter nuclei are produced by nuclear fission. **1 point**	Name the element that must be in a star for nuclear fission to take place. **1 point**	State why radioactive tracers, used for medical diagnosis, emit gamma rays and not alpha or beta. **1 point**
Explain the purpose of a nuclear reactor in a nuclear power station. **3 points**	Explain why there must be high temperatures and pressures for nuclear fusion to occur **3 points**	Explain why radioactive tracers used in medical diagnosis should have a short half-life. **3 points**
Explain how the moderator and control rods are used in a nuclear reactor. **5 points**	Explain where the energy produced by nuclear fusion comes from. **5 points**	Explain how a PET scanner works and why the radioactive isotope used must be produced nearby. **5 points**

ANSWERS

Two.	Hydrogen	Only gamma rays pass through the body and can be detected outside the body
The nuclear reactor generates heat which comes from the kinetic energy of the fragments produced. The energy is used to heat water to make super-heated steam which drives a turbine which turns a generator and produces electricity	To make hydrogen nuclei move fast enough to overcome the electrostatic repulsion of two hydrogen nuclei (protons) which both carry a positive charge so that the hydrogen nuclei can combine	The intensity of the radioactivity will reduce faster and cause less damage to other parts of the body
The moderator is used to slow down the neutrons because slower neutrons are more likely to be absorbed by uranium nuclei and continue the chain reaction. The control rods contain elements that absorb neutrons and control the rate at fission takes place. The control rods are inserted between the fuel rods and raised or lowered to absorb more or less neutrons.	The mass of the hydrogen atoms is greater than the mass of the helium atom which is produced by nuclear fission. The loss of mass of the hydrogen atoms is released as energy and this process provides the energy of the stars.	A radioactive isotope is injected into the person. When electrons in cells strike positrons from the isotope gamma rays are emitted which can be detected outside the body. Tumours take in more of isotope and therefore produce more gamma rays and the position of the cancer can then be found The isotope used only has a short half –life so to make its use effective it has to be used quickly