George Stephenson High School SCIENCE KS4 Y10 P1 FORCES 1 Unit Overview

Unit:Y10 FORCES 1	Number of Lessons: 13
Students should: 2.10 Analyse velocity/time graphs to: a compare acceleration from gradients qualitatively b calculate the acceleration from the gradient (for uniform acceleration only) c determine the distance travelled using the area between the graph line and the time axis (for uniform acceleration only) 2.11 Describe a range of laboratory methods for determining the speeds of objects such as the use of light gates 2.12 Recall some typical speeds encountered in everyday experience for wind and sound, and for walking, running, cycling and other transportation systems 2.13 Recall that the acceleration, g, in free fall is 10 m/s^2 and be able to estimate the magnitudes of everyday accelerations 2.14 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) 2.15 Recall and use Newton's second law as: force (newton, N) = mass (kilogram, kg) × acceleration (metre per second squared, m/s^2) $F = m \times a$ 2.19 *Core Practical: Investigate the relationship between force, mass and acceleration by varying the masses added to trolleys* **TOPIC 15 FORCES AND MATTER (FROM SPEC)**	**The Big Picture (Progression):** **At KS2 pupils should already know:** Pushes and pulls Gravity, frictional forces (air and water), magnetic force, levers, pulleys and gears Contact and non-contact forces **At KS3 students should already know:** Particle theory Density Introduction to scalar and vector quantities N 1^{st} Law and resultant force Use s = d/t Draw and interpret d-t graphs **Future links and progression onto other KS4 units:** **<u>Y10 P3 Forces 2</u>** Particles and density and density **core practical** Gravitational field strength, mass and weight and associated equations Circular motion N 3^{rd} Law and equilibrium Momentum and large accelerations and force and associated equations Stopping distances and reaction time Electricity, magnetism and the motor effect **<u>Y11 Forces, Energy and Synoptic Links</u>** Links to Free Body Diagrams, Vectors and Interacting Forces (Newtons Laws) and energy transfer. **Progression onto KS5 Physics:** Kinematics, advanced mathematical application of Newton's Laws

Students should: 15.1 Explain, using springs and other elastic objects, that stretching, bending or compressing an object requires more than one force 15.2 Describe the difference between elastic and inelastic distortion 15.3 Recall and use the equation for linear elastic distortion including calculating the spring constant: force exerted on a spring (newton, N) = spring constant (newton per metre, N/m) × extension (metre, m) $F = k \times x$ 15.4 Use the equation to calculate the work done in stretching a spring: energy transferred in stretching (joule, J) = 0.5 × spring constant (newton per metre, N/m) × (extension (metre, m))^2 $E = \frac{1}{2} \times k \times x^2$ 15.5 Describe the difference between linear and non-linear relationships between force and extension 15.6 *Core Practical: Investigate the extension and work done when applying forces to a spring*	

Possible Key Learning Points	Skills	Prerequisites

L1 Speed L2 DT Graphs L3 Velocity & Acceleration (inc. Scalars & V... L4 VT Graphs L5 Resultant Forces & Newton's First Law L6 Newton's 2nd Law & Inertial Mass L7 CORE PRACTICAL - forces and motion L8-10 Springs **Interleaving:** Particles (atomic structure/atomic mass) link to 'mass' of objects and ideas of density linked to forces acting on an object. KS3 Fundamentals and Establishing forces topics cover many of these key principles	Literacy/Oracy accurate use of key words during class Q and A sessions and within written answers Numeracy Recording data in appropriate tables Plotting graphs – scales and axis Recall and use formula Rearrange to find alternative subject Use gradient to calculate speed and acceleration Recall and use units accurately Core Practical: F = ma (acceleration of a trolley down a ramp) Extension of a spring Creativity Application of key principles from topic Flipped Home Learning Interpersonal Team-work and communication skills during core practical	As above – KS1 and 2 prior learning: General understanding of a forces as a push or a pull. Forces act on objects Basic understanding of frictional forces including air and water resistance. Gravity and Magnetism as a non-contact force Gravity as a 'force' (not quite correct) linked to size of planets/solar system KS3 prior learning: Particle theory and density Scalar and vector quantities Speed (but not necessarily velocity) Relationship between speed, distance and time Drawing and interpreting d-t graphs
Subject Specific Language	Pedagogical Notes	Make it Stick /GREENZONE Activities

Force Weight (as a force due to gravity) Mass Newton (N) Kilogram/Gram (kg/g) Gravity Friction Scalar Vector Balanced force Unbalanced force Resultant force Air resistance Acceleration (m/s2) Velocity (m/s) Elasticity Elastic limit Spring constant	Forces is a topic that students will have been learning about from a very young age, exploring friction and gravity is some of the earliest learning children have. Be aware, they bring a lot of prior learning with them and some of it will be incorrect and very difficult to shift to more correct understanding of the key principles. Forces is difficult because, as with many scientific phenomena, you can't really see them, you can 'feel' them and you do experience them, so it is important to keep bringing the learning back to those tangible, concrete examples as you move from the concrete through to abstract learning. Forces act on all objects, at all times. Most students would say that an object that was still on the desk did not have any forces acting on it... or they might say gravity pulling it down, but not appreciate the upward force exerted by the table. Careful and well-planned questions to enable cognitive conflict is important throughout the unit to allow students to regularly question their pre-existing theories. As with most science topics, the amount of new terminology can be tricky. Students struggle to distinguish accurately between mass and weight, due to the inaccurate use of the word 'weight' in everyday life. They also struggle to fully describe resultant force and in particular when forces are balanced, and resultant force is zero and the idea of unbalanced forces changing the motion of an object (slow down/speed up). Stopping distance is often confused with stopping time. This is a persistent issue at KS4, so needs careful and consistent correction of terminology and clear explanations of 'distance travelled while thinking/braking'. Revisiting and correcting use of key terminology is essential throughout the unit. **<u>Assessments:</u>** Regular in class live marking throughout the unit	Starter for 5 (recall questions) Interleave particles topic – density Desirable difficulties including a variety of challenge options - 'chilli challenge' KAT and DIRT opportunities Metacognitive mediators to plan, monitor and evaluate own thinking processes Low stakes assessment through recall and interleaving approaches 5/3 and similar challenge tasks using the range of questions

	End of unit assessment 15 flash cards to learn via quizlet/paper copies Seen application question used in class to ensure students understand concepts and to demonstrate modeling and decoding of the question (metacognition) Final Assessment (30 marks) Section 1 – flash cards 10 marks (AO1) - PA Section 2 – seen application question 10 marks (AO2/3) - PA Section 3 – unseen application question (KAT to assess understanding of unit as a whole) 10 marks (AO2/3) - TA	
Reasoning opportunities and probing questions	Suggested Activities	Possible Misconceptions
What is a force? What forces can we see? What forces can't we see? Do we need forces to keep something moving/keep something still? Can anything float? What are the forces acting on a ball being thrown in the air? Can you describe Newtons 1st Law? What does it mean? How can you use N 1st law to describe the motion of an object that is still/moving at a constant speed/getting faster/getting slower? How can a free body diagram show us N 1st Law? Is anything weightless? What happens to you mass/weight if oyu go to the moon? Why does your weight change on the moon?	• Starter for 5 (fast 5 recall questions) each lesson • Placemat consensus • Oracy talk partners • Observing forces in the classroom. Identifying balanced and unbalanced forces. • Drawing Free Body diagrams • Calculating resultant forces and applying Newton's first law. • Investigating the relationship between mass and weight – collecting data/plotting graphs • Interpreting/describing distance time graphs • Plotting D-t graphs • Literacy – compare mass and weight • Designing and testing a bridge and a boat from limited resources. Applying key learning	Newton's first Law is in two parts, students find the 'continue to move at a constant speed' when forces are balanced counter intuitive. It 'feels' like the object should only be still or getting faster/slower. If something is moving there is only one force acting on the object in the direction of the movement Constant motion requires a constant force applied Confuse mass and weight Gravity as the force (weight is the force due to gravity actin on the mass of an object) There is no gravity in space Confusing forces and energy as the same thing Units for mass and gravity g and N Stopping distance as a time. Describing 'thinking distance' and 'braking distance' as the time taken to stop rather than the distance travelled. Heavier objects fall faster than lighter ones

Why does your mass stay the same, but your weight change if you went to the moon? What Why does it say ‘keep your distance’ on motorway signs? What would happen to the stopping distance if the road was wet? How would drinking alcohol/being tired effect the thinking distance? How would worn/damaged tyres effect the braking distance?	• Calculations involving s = d/t. Including rearranging if appropriate • Exactly guess the weight of the chocolate bar and you can keep it to enforce difference between weight and mass.	

George Stephenson High School SCIENCE KS4 Y10 P3 FORCES 2 Unit Overview

<table>
<tr><td>Unit:Y10 FORCES 2</td><td>Number of Lessons: 13</td></tr>
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FORCES TOPIC 2 (FROM SPEC)

2.15	Recall and use Newton's second law as: force (newton, N) = mass (kilogram, kg) × acceleration (metre per second squared, m/s^2) $F = m \times a$
2.16	Define weight, recall and use the equation: weight (newton, N) = mass (kilogram, kg) × gravitational field strength (newton per kilogram, N/kg) $W = m \times g$
2.17	Describe how weight is measured
2.18	Describe the relationship between the weight of a body and the gravitational field strength
2.19	*Core Practical: Investigate the relationship between force, mass and acceleration by varying the masses added to trolleys*
2.20	**Explain that an object moving in a circular orbit at constant speed has a changing velocity (qualitative only)**

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The Big Picture (Progression):
At KS2 pupils should already know:
Pushes and pulls
Gravity, frictional forces (air and water), magnetic force, levers, pulleys and gears
Contact and non-contact forces

At KS3 students should already know:
Particle theory
Density
Introduction to scalar and vector quantities
N 1st Law and resultant force
Use s = d/t
Draw and interpret d-t graphs

Future links and progression onto other KS4 units:
<u>**Y10 Forces 1**</u>
Forces and motion including D-t and V-t graphs and use of gradient to calculate acceleration.
Area under v-t graph to calculate distance and associated equations
N 1st and 2nd Law. Inertial mass and resultant forces and associated equations
Acceleration, mass and force **core practical**
Forces in springs. Spring constant and associated equations
Stretching a spring **core practical**

<u>**Y11 Forces, Energy and Synoptic Links**</u>
Links to Free Body Diagrams, Vectors and Interacting Forces (Newtons Laws) and energy transfer.

Progression onto KS5 Physics:
Kinematics, advanced mathematical application of Newton's Laws

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2.21	**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**	
2.22	**Explain that inertial mass is a measure of how difficult it is to change the velocity of an object (including from rest) and know that it is defined as the ratio of force over acceleration**	
2.23	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**	
2.24	**Define momentum, recall and use the equation:** **momentum (kilogram metre per second, kg m/s) = mass (kilogram, kg) × velocity (metre per second, m/s)** $p = m \times v$	
2.25	**Describe examples of momentum in collisions**	
2.26	**Use Newton's second law as:** **force (newton, N) = change in momentum (kilogram metre per second, kg m/s) ÷ time (second, s)** $F = \frac{(mv - mu)}{t}$	
2.27	Explain methods of measuring human reaction times and recall typical results	
2.28	Recall that the stopping distance of a vehicle is made up of the sum of the thinking distance and the braking distance	
2.29	Explain that the stopping distance of a vehicle is affected by a range of factors including: 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	
2.30	Describe the factors affecting a driver's reaction time including drugs and distractions	

2.31 Explain the dangers caused by large decelerations **and estimate the forces involved in typical situations on a public road** **TOPIC 9 – FORCES AND THEIR EFFECTS (FROM SPEC)** **Students should:** 9.1 Describe, with examples, how objects can interact a at a distance without contact, linking these to the gravitational, electrostatic and magnetic fields involved b by contact, including normal contact force and friction c producing pairs of forces which can be represented as vectors 9.2 Explain the difference between vector and scalar quantities using examples 9.3 **Use vector diagrams to illustrate resolution of forces, a net force, and equilibrium situations (scale drawings only)** 9.4 **Draw and use free body force diagrams** 9.5 **Explain examples of the forces acting on an isolated solid object or a system where several forces lead to a resultant force on an object and the special case of balanced forces when the resultant force is zero**	

Possible Key Learning Points	Skills	Prerequisites

L1 - Particles & Density L2 - Density Core Prac L3 Mass, Weight & Gravitational Field Stren... L4 Circular Motion L5 Newton's Third Law & Equilibrium L6 Momentum and calculating momentum L7 Change in momentum Newtons 2nd Law L8 Stopping distances and KAT L9 Reaction time Lz10 Large accelerations and forces **Interleaving:** Particles (atomic structure/atomic mass) link to 'mass' of objects and ideas of density linked to forces acting on an object Linking N1 and 2 laws and inter-linking F = ma with momentum. Mass and weight from KS3, units and definitions Scalar and vector quantities	Literacy/Oracy accurate use of key words during class Q and A sessions and within written answers Literacy KAT – compare Accurate spelling of key words Numeracy Recording data in appropriate tables Plotting graphs – scales and axis Recall and use formula Rearrange to find alternative subject Use gradient to calculate speed and acceleration Recall and use units accurately Core Practical: Density of solids and liquids Interpersonal Team-work and communication skills during core practical	As above – KS1 and 2 prior learning: General understanding of a forces as a push or a pull. Forces act on objects Basic understanding of frictional forces including air and water resistance. Gravity and Magnetism as a non-contact force Gravity as a 'force' (not quite correct) linked to size of planets/solar system
Subject Specific Language	Pedagogical Notes	Make it Stick /GREENZONE Activities

Force Weight (as a force due to gravity) Mass Newton (N) Kilogram/Gram (kg/g) Gravity Friction Balanced force Unbalanced force Resultant force Air resistance	Forces is a topic that students will have been learning about from a very young age, exploring friction and gravity is some of the earliest learning children have. Be aware, they bring a lot of prior learning with them and some of it will be incorrect and very difficult to shift to more correct understanding of the key principles. Forces is difficult because, as with many scientific phenomena, you can't really see them, you can 'feel' them and you do experience them, so it is important to keep bringing the learning back to those tangible, concrete examples as you move from the concrete through to abstract learning. Forces act on all objects, at all times. Most students would say that an object that was still on the desk did not have any forces acting on it... or they might say gravity pulling it down, but not appreciate the upward force exerted by the table. Careful and well-planned questions to enable cognitive conflict is important throughout the unit to allow students to regularly question their pre-existing theories. As with most science topics, the amount of new terminology can be tricky. Students struggle to distinguish accurately between mass and weight, due to the inaccurate use of the word 'weight' in everyday life. They also struggle to fully describe resultant force and in particular when forces are balanced, and resultant force is zero and the idea of unbalanced forces changing the motion of an object (slow down/speed up). Stopping distance is often confused with stopping time. This is a persistent issue at KS4, so needs careful and consistent correction of terminology and clear explanations of 'distance travelled while thinking/braking'. Revisiting and correcting use of key terminology is essential throughout the unit. **Assessments:**	Starter for 5 (recall questions) Interleave particles topic – density Desirable difficulties including a variety of challenge options - 'chilli challenge' KAT and DIRT opportunities Metacognitive mediators to plan, monitor and evaluate own thinking processes Low stakes assessment through recall and interleaving approaches 5/3 and similar challenge tasks using the range of questions

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What happens to you mass/weight if oyu go to the moon? Why does your weight change on the moon? Why does your mass stay the same, but your weight change if you went to the moon? What Why does it say 'keep your distance' on motorway signs? What would happen to the stopping distance if the road was wet? How would drinking alcohol/being tired effect the thinking distance? How would worn/damaged tyres effect the braking distance?	• Designing and testing a bridge and a boat from limited resources. Applying key learning • Calculations involving s = d/t. Including rearranging if appropriate • Exactly guess the weight of the chocolate bar and you can keep it to enforce difference between weight and mass.	Momentum interchangeable with energy Poor understanding that momentum is conserved, therefore difficulties using this is written and mathematical applications

Unit: GCSE Physics Combined P5 Energy	**Number of Lessons:** 18
Key Principles Students should begin to conceptualize the phenomenon of energy and energy conservation Students should be able to draw and analyses energy diagrams [including Sankey Diagrams) and solve mathematical problems from these Students should be able to recall, rearrange and solve using the KE and GPE equations and state the units of energy Students should understand the meaning behind efficiency and be able to solve efficiency calculations Students should be able to calculate payback times and evaluate insulation methods Students should be confident with the simple changes of state and the energy transfers involved. Students may relate this to endo and exothermic reactions. Students should be familiar with the methodology behind the Latent Heat and Specific Heat Capacity Core Practical's and be able to solve calculations Students should understand the role of particles in creating pressure in gases and the role of volume and temperature Students should be familiar with different units of temperature and converting between them (Celsius and Kelvin) Students should be able to compare renewable and non-renewable energy resources and evaluate the benefits and drawbacks of both Students should be confident analyzing data regarding energy use and future trends	**The Big Picture (Progression): At KS2 pupils should already have been taught to:** - Understand electricity as a 'type' of energy - Construct simple electrical circuits - Describe everyday uses of electricity - Understand light as a 'type' of energy - misconception - Understand sound as a 'type' of energy - misconception - Suggest scientific ideas as hypotheses - Follow the scientific process to plan investigations and gather evidence to draw conclusions **Links to other FUNDAMENTALS units:** - Forces - can result in energy transfers - Energy - Particles – kinetic energy and random movement of particles **Links to progression into ESTABLISHING units:** - Waves as a transfer of energy without matter - Heating and cooling as heating is a transfer of thermal energy causing an increase in temperature - Reactions 2 – endothermic/exothermic reactions involving transfer of thermal energy - Respiration – release of chemical and thermal energy - Forces and Energy - relationship between balancing forces and energy transfers - Magnetism – as a store of energy **Links with other KS4 Units** - **C3 – States of Matter and Mixtures** – Solids, Liquids and Gases and Changing States - **C4 – Fuels and Hydrocarbons** – Non-Renewable Fuels - **C6 – Earth Science** - Non-Renewable Fuels and Global Warming - **C10 – Chemical Energy Changes –** Endothermic and Exothermic Changes - **P2 Waves –** Waves as a form of energy transfer - **P4 EM Spec –** Waves as a form of energy transfer - **P10 Forces, Energy and Synoptic Links –** Energy - **P9 Magnetism and Induction –** Magnetism/Electricity as a store of energy

Possible Key Learning Points	**Skills**	**Prerequisites**

Key Learning Principles	Key Skills Learnt	Students should already be aware of the KS2 content outlined above such as:
- State stores of energy - Describe basic energy transfers in a system - Describe renewable and non-renewable sources of energy - Compare sources of energy - Evaluate sources of energy - Describe how energy is transferred between stores - Understand and recall the law of energy conservation - Calculate KE and GPE and recall the equations used - Understand the different units of temperature and how to convert between them - Understand the role of temperature and volume in the pressure of gases - Understand the energy changes which occur during changes of state - Calculate energy costs and payback times - Compare different types of insulation - Calculate efficiency - Understand the different between specific latent heat and specific heat capacity - Complete the specific latent heat and heat capacity core practicals - Interpretation of energy diagrams (e.g. Sankey) - Make links to careers with energy resources **Interleaving** - Y7 Fundamentals Forces - Y7 Fundamentals Particles - Y7 Fundamentals Energy - Y8 Establishing Waves - Y8 Establishing Heating and cooling - Y8 Establishing Reactions 2 - Y8 Establishing Respiration - Y8 Establishing Forces and - Y8 Establishing Magnetism - C3 – States of Matter and Mixtures - C4 – Fuels and Hydrocarbons - C6 – Earth Science - C10 – Chemical Energy Changes	- Written literacy & Oracy: Understand and use unit-specific vocabulary accurately with correct spelling - Understand how to apply energy stores to different scenarios - Understand how to describe energy transfers with clear sequencing - Understand how to draw energy transfer diagrams - Understand how to calculate efficiency as a percentage - Understand how to evaluate - Understand how investigate to evaluate fuel sources - Understand how to draw a results table and conclusions from personal evidence - Practical skills during core practicals - Independency for home learning to be assessed in-lesson	- Is aware of basic abstract concept of energy - Awareness of different devices using different amounts of energy - Can form hypotheses based upon prior understanding - Can compare sets of data to draw conclusions - Can draw links between rate of temperature increase and energy transfer - Aware of basic laboratory safety when using open flames - Calculate simple percentages

- P2 Waves - P4 EM Spec - P10 Forces, Energy and Synoptic Links - P9 Magnetism and Induction		
Subject Specific Language	Pedagogical Notes	Make it Stick Activities
Energy Joules Conservation Store / Transfers Dissipation Gravitational Potential Energy Kinetic Energy Sankey Diagram Mass Speed / Velocity Insulate Conduction / Convection Efficiency Payback Time Specific Latent Heat Specific Heat Capacity Melting / Freezing / Subliming / Evaporating / Condensing Bonds Joulemeter Pressure Temperature Volume Renewable and Non-Renewable Global Warming / Climate Change Greenhouse Gases Fossil Fuels Finite / Infinite Turbine / Generator	Learning of the concept of energy and stores is absent in specification at KS2, with core emphasis on electrical energy. At KS3 students became familiar with the acronym HEPMACK to recall the types of energy stores and should be familiar with the phrase "[_______] store of energy" (e.g. chemical store of energy) and should be trained to avoid saying "chemical energy" as this enforces the misconception that the different stores of energy are in fact different substances which is not the case. An energy store of some kind is necessary for something to happen. Energy is hard to teach both because it is an abstract idea that is difficult to define, and because there are many contradictions between the everyday and scientific usage of the word energy. Children generally think about energy in terms of: • human activity – I'm tired because I have run out of energy or I can run very fast because I have a lot of energy • health – as in 'exercise is good for you because it builds up your energy' and 'when we run out of energy we need medicine and vitamins' • food and fuels – some objects and materials contain a lot of energy that can be used up to help us move about and to make other things happen. Students often confuse ideas of energy with ideas of force, work or power. The most common misunderstanding students have about energy is that, like food or a fuel, it gets used up. A good model, if used carefully, for thinking about energy is as a quasi-material substance that can be transferred from place to place. This is used by The Institute of Physics is using orange liquid, poured from beaker to beaker to represent the transfer of energy between different beakers (or stores) and the conversation of energy law. With this method energy can	Tips for Teachers to Help Learning 'Stick' • Short AO1 fact recall 'flashcard' questions throughout e.g. starter • Continuous interleaving of class targets/core principles into AO1 fact recall questions e.g. HEPMACK energy stores • Focus on active learning methods such as the fuel investigation • Embed visual learning through use of device carousel • Continuous live-marking for immediate personal feedback, including stretch and challenge where appropriate • Create 'desirable difficulties' such as calculating efficiencies as percentages and energy costs • Incorporate frequent, low stakes testing throughout, such as 'pens in pots' and 'hot seat' • Encourage collaboration and responsibility through strategies such as 'pens in pots' and 'hot seat' • Provide opportunities for elaboration, reflection after KAT and DIRT lesson after assessment • Explain to students how to troubleshoot their own problems. Don't do it for them – "Have you tried X?"

	usefully be imagined as an invisible, intangible substance that is never created or used up, which can be stored in a number of different ways, and which can be transferred between different energy stores by several different mechanisms (note: Light and sound are not stores of energy as they cannot be captured to be used at a later date). Re-visiting is recommended to maintain knowledge of stores and application questions. This might be through emphasis on HEPMACK with routine interleaving tests and quizzes throughout the scheme to support students struggling to retain this new terminology. A nice article on teaching energy can be found here – definitely worth a read: https://www.stem.org.uk/sites/default/files/pages/downloads/BEST_Article_Teaching%20energy.pdf **Assessments:** **Literacy Key Assessed Task possibilities:** Main KAT is found in the Data Analysis Lesson and aims to develop the skill of data handling and using graphs in exam questions which is a popular choice for energy resources in exams. ' Alternative options might include: Evaluate the advantages and disadvantages of renewable energy resources and non-renewable energy resources. Work is to be marked *via* coded-marking and feedback to be completed by students in green pen. This assessment is vital in ensuring all pupils understand the key learning outlined at KS2 and reviewed in more detail in lessons 1-3. TA. **End of Topic Assessment Lesson 16/17** 32 Mark Total - Section 1: Quizlet Flashcards (AO1) – 15 Marks - Section 2: Seen Applications Questions (AO2/3) – 9 Marks - Section 3: Unseen Application Questions (AO2/3) – 8 Marks	
Reasoning opportunities and probing questions	Suggested Activities	Possible Misconceptions

What is energy? What is an energy store? Where do you get your energy from? What does it mean if you are running out of energy? Why are light and sound not described as energy stores? Where does energy go? Why is energy conservation a law? Can you give an example of an energy store? E.g. skateboarder skating = kinetic Can you give an example of an energy transfer? E.g. skateboarder skating downhill = GPE to kinetic Where might energy be dissipated? E.g. Skateboarder skating = heat on ground If energy is conserved, how are we running out? Which fuel/device is the best? What makes this fuel/device more efficient? Which energy resource is most appropriate under a certain circumstance e.g. why are solar panels not the most appropriate for the Arctic? What is a fuel? How can you investigate the most efficient fuel/device? How does a fuel generate electricity in your home? Why do we continue to use non-renewable energy resources?	- Y7 Fundamentals Energy Stores, Transfers & HEPMACK Review - Students drawing their own energy transfer pathway diagrams for an array of examples - KE and GPE Practice Questions and HL - Graph Paper Sankey Diagrams if Time - Efficiency and Payback Calculations Practice - Layers of Insulation Practical and Experimental Write Up - Specific Heat Capacity Core Practical - Particles in Motion Home Learning (Flipped) - Pressure in Gases Demos (Expanding Balloon and Hot Water or Collapsing Can) - Renewable Fuels Speed Dating and Marketplace - Data Analysis KAT	There are different types of energy Energy can be created Energy can be destroyed Energy is lost/disappears Energy is force There are different types of energy Sound is a type of energy Light is a type of energy Heat is the same as temperature Kilojoules and joules are the same Energy in humans is kinetic Gravitational potential energy is only relative to height from the ground Energy is only associated with movement Energy is a product of an activity Energy is running out and therefore not conserved Fossil fuels turn into electricity

George Stephenson High School Unit Overview

Unit: KS4 Y11 Combined Science: Physics P2 Waves	**Number of Lessons:** 8

Key Principles

Students should:		Maths skills
4.1	Recall that waves transfer energy and information without transferring matter	
4.2	Describe evidence that with water and sound waves it is the wave and not the water or air itself that travels	
4.3	Define and use the terms frequency and wavelength as applied to waves	
4.4	Use the terms amplitude, period, wave velocity and wavefront as applied to waves	
4.5	Describe the difference between longitudinal and transverse waves by referring to sound, electromagnetic, seismic and water waves	
4.6	Recall and use both the equations below for all waves: wave speed (metre/second, m/s) = frequency (hertz, Hz) × wavelength (metre, m) $v = f \times \lambda$ wave speed (metre/second, m/s) = distance (metre, m) ÷ time (second, s) $v = \frac{x}{t}$	1a, 1b, 1c, 1d 2a 3a, 3b, 3c, 3d
4.7	Describe how to measure the velocity of sound in air and ripples on water surfaces	2g
4.10	Explain how waves will be refracted at a boundary in terms of the change of direction **and speed**	1c 3c 5b
4.11	**Recall that different substances may absorb, transmit, refract or reflect waves in ways that vary with wavelength**	
4.17	*Core Practical: Investigate the suitability of equipment to measure the speed, frequency and wavelength of a wave in a solid and a fluid*	2g

Specification points 4.8, 4.9, 4.12, 4.13, 4.14, 4.15 and 4.16 are in the GCSE in Physics only.

The Big Picture (Progression): At KS2 pupils should already have been taught to:

- Recall that light reflects from surfaces
- Recall that sounds are made via vibrations
- Understand that materials / mediums allow sounds to pass
- Recognize patterns between pitch and objects which produce sounds
- Recognize the relationship between volume and vibration strength
- Recognize sounds get fainter as distance from source increases

At KS3 Pupils should already have been taught to:

Y8 Establishing Waves

- Recognise light and sound/mechanical act as energy stores and /or transfers
- Recall that waves transfer energy and not matter
- Compare transverse and longitudinal waves and give examples (light vs. sound)
- Label a transverse wave
- Describe how waves can be reflected and refracted at boundaries
- Recall that frequency is measured in Hertz (Hz) and how this relates to pitch
- Recall that sound requires a medium to travel but light does not
- Recall and substitute values with the wave equation (v=fλ)
- Describe how the ear works with reference to sounds
- Be able to explain light travels in straight lines with reference to pin hole cameras and the eye
- Understand that light diffracts into the colours of the spectrum

	- Recall the speed of light **Future links and progression onto other KS4 UNITS** - **P2 – Forces 2** - Particles and Density - **B2 – Cells** - Magnification and Ripple Tank Core Practical - **P4 – EM Spectrum** - Transverse Waves and the EM Spectrum - **P6 – Radioactivity** - Gamma Waves and Ionization **Progression onto KS5 Physics requires an in-depth understanding of Wave Mechanics and Mathematics**

Possible Key Learning Points	Skills	Prerequisites
Key Learning Principles - Recall the two types of waves (transverse and longitudinal) with examples - Define a wave - Describe and explain how colors form under white light and filters - Compare and contrast transverse and longitudinal waves - Identify and label transverse and longitudinal waves - Recall, substitute and rearrange the	**Key Skills Learnt** - Literacy / Oracy: To understand and use new unit specific vocabulary effectively - Draw tables of results and produce suitable graphs to display data - Formulate conclusions based on evidence collected - Develop fine motor skills and practical safety when using light equipment - Use a protractor correctly - Improved logic and problem-solving	**Students should already:** - Be aware of basic laboratory safety - Hold basic numeracy skills such as negative numbers, using a calculator and competency with simple mathematical processes (add, subtract, divide, multiply) - Have key literacy skills such as suitable reading age - Be aware of the purpose of the curriculum and its links with Y8 Establishing and KS4 - Recognise light and sound/mechanical act as

wave equation v=fλ and v=x/t - Define and calculate the frequency of waves - Calculate and describe a wave period - Explain why refraction occurs relating to density, medium and wave fronts - Describe what TIR is and how this relates to optical fibres - Become aware of careers links in the field of electrical engineering - ***Physics Core Practical 2****: Investigate the suitability of equipment (e.g. wave tank / ripple machine / metal rod) to measure the speed, frequency and wavelength of a wave in a solid and a fluid* - ***Physics Core Practical 3***: *Investigate refraction in rectangular glass blocks in terms of the interaction of electromagnetic waves with matter* - **Interleaving:** Y7 Fundamentals Particles Y7 Fundamentals Energy Y8 Establishing Waves KS4 P3 – Forces 2 KS4 B2 – Cells & Magnification	skills - Complete technical ray diagrams to demonstrate reflection and refraction - Teamwork and communication in practical work - Numeracy: Solving Equations via substitution and rearranging - Use and recall key units correctly - Using standard form and significant figures - Independent learning during research-based home learning	energy stores and /or transfers - Recall that waves transfer energy and not matter - Compare transverse and longitudinal waves and give examples (light vs. sound) - Label a transverse wave - Describe how waves can be reflected and refracted at boundaries - Recall that frequency is measured in Hertz (Hz) and how this relates to pitch - Recall that sound requires a medium to travel but light does not - Recall and substitute values with the wave equation (v=fλ) - Describe how the ear works with reference to sounds - Be able to explain light travels in straight lines with reference to pin hole cameras and the eye - Understand that light diffracts into the colours of the spectrum - Recall the speed of light
Subject Specific Language	Pedagogical Notes	Make it Stick Activities

Wave Energy Medium Vibration / Oscillation Reflected Refracted Transverse Longitudinal Peak / Crest Trough Amplitude Frequency Hertz (Hz) Wavelength Compression Rarefaction Density Ripple Tank Lambda Velocity Parallel Perpendicular Total Internal Reflection Wave Period Kinetic Wave Front Ray Incident Ray Emergent / Refracted Ray Angle of Incidence / Angle of Refraction Normal EM / Electromagnetic Waves Fiber Optics Critical Angle Snells Law (Stretch and Challenge Only)	Following on from Y8 Establishing Waves students will arrive at GCSE with a good foundation the key terminology used in this topic: I suggest beginning by asking students to wave at you and introducing key terminology such as "oscillations around a fixed point". You could take this further asking pupils to sit back-to-back and displaying for pupils to describe: https://www.youtube.com/watch?v=yJQRTQJL7jQ This allows you to introduce terms such as high frequency and low amplitude before recapping the structure of transverse waves. Again waves is a difficult topic to conceptualize and therefore it is recommended you spend some time with the slinky spring demos and continue to utilize these in different lessons. You can attach a peg/sticky label to the spring to show the "transfer only energy" principle or use the jelly baby wave machine. You can also tape together a metal spring and plastic spring to show speed of waves in different densities later in the module. https://youtu.be/VE520z_ugcU Note: Students will often request to use the slinky springs themselves but I would deter you from doing this as they easily get tangled. The amount of new terminology and equations to recall is difficult for students so utilize flash card quizzes and mini-plenaries when possible (see 'make it stick'). Again pupils also struggle to remember the equation and distinguish between the different	Tips for Teachers to Help Learning 'Stick' • Oracy discussions • Slinky Spring Demos • Map From Memory • Sage and Scribe • Wave Labeler Differentiated Tasks • 6 Mark Exam Questions + Peer Assessment • Chili Challenges • Ripple Tank Demos • Refraction Illusions • Look Cover Complete • Refraction Class Practical • Words to Pictures • Listen Right • Flipped HL Independent Learning • Green Zone • TIR Stretch and Challenge • Pens in Pots • Quizlet Flashcards

	units and symbols (e.g. λ = wavelength). Try this catchy song for wave equation which I find goes a long way to embedding it into memory: https://www.youtube.com/watch?v=EzU79Egl3-c&t=1s Many students will likely still struggle with rearranging the equations and should be guided away from using triangles to do this. Triangles should be introduced closer to the exam if necessary for foundation pupils. However, most pupil's especially higher tier should be expected to do this mathematically. This module contains two core practical's using the light equipment and ripple tank. The ripple tank isn't great and I would often use a video to demonstrate this. If you do use it – project waves the ceiling for a clearer view. However, note a nice link to B2 Cells and Magnification here. How much bigger is the image than the actual size? Nice video example: https://www.youtube.com/watch?v=OY0lXHPo_nM The refraction core practical works best if done in stages 'copy the teacher' style for lower ability classes or by giving higher ability classes a full demo of how to do it before starting. Just giving pupils instructions will produce undesirable results. Some students will still surprisingly struggle to use a protractor and I often split my mixed ability classes into two groups to accommodate both of the above ideas. Note: as the room needs to be dark – try to plan ahead for this lesson so that it is	

	completed at the most suitable time for your classroom environment. **<u>Assessments:</u>** **Frequency in-class Live Marking throughout Unit** **Key Assessed Task** Two options: - Lesson 2: Compare the properties of longitudinal and transverse waves giving examples of each (6 marks) - Lesson 4: Describe how the speed of waves could be determined using a ripple tank (6 marks) I recommend doing both during the scheme but reserving one as TA KAT and using the other as a SA/PA Exam Question. The TA KAT is to be marked *via* coded-marking and feedback to be completed by students in green pen. This assessment is vital in ensuring all pupils understand the key learning outlined at KS3/4. **End of Topic Assessment Lesson 10** 35 Mark Total - Section 1: Quizlet Flashcards (AO1) – 15 Marks (PA) - Section 2: Seen Applications Questions (AO2/3) – 10 Marks (PA) - Section 3: Unseen Application Questions (AO2/3) – 10 Marks (TA)	
Reasoning opportunities and probing questions	Suggested Practical Activities	Possible Misconceptions

What colour would [___] appear under [____] light / filter? How is a transverse wave similar to a hand wave? Compare transverse and longitudinal waves How can the speed of sound be determined using this equipment? What careers involve light? How might TIR be used in the home? What examples of refraction / reflection can you think of? When we studied density in 'Y8 Heating and Cooling' what did it means? When we say the bus to town from the Killingworth Centre comes frequently - what do we mean? How could be make this experiment more accurate and eliminate human error? What would the wave form look like for a pneumatic drill vs. a bee	- A review of standard form and significant figures - Refraction Core Practical - Ripple Tank Core Practical - Slinky Demos - Plastic + Metal Slinky Density Demo - Candle in Water Illusion: https://www.youtube.com/watch?v=gIC6DbWtc9g *You can also use a CD case https://www.youtube.com/watch?v=E5SFUCF7_mo - You could get pupils to calculate speed of a slinky wave (v=x/t) or via v=fλ with a slow motion camera - TIR Core Practical Extension Task	Particles or matter moves along a wave The existence of sound particles Loudness and pitch are the same Sounds are heard and seen at the same time Hitting something hardest increases its pitch In telephones for example sounds travel though the wire rather than electrical energy Sounds move faster in air than solids When light passes though a filter the colour is added Paint mixing and light mixing result in similar effects (e.g. Yellow is a primary colour) Coloured objects make coloured shadows Speed and velocity are the same thing Refraction and Reflection confusion Only shiny surfaces reflect light Black is a colour of light

George Stephenson High School Unit Overview

<table>
<tr><th>Unit: KS4 Y11 Combined Science: Physics P7 – Electricity in the Home</th><th>Number of Lessons: 7</th></tr>
<tr><td>
Key Principles
Students can recall, substitute and rearrange using the E=IVT equation
Students can recall the common electrical terms, their units and their symbols (e.g. Q=charge=coulombs)
Students can explain how voltage relates to charge and energy in a simple circuit
Students can recall, substitute and rearrange the equations for power P=E/T, P=IV and $P=I^2R$
Students can describe how energy is transferred from batteries and the A.C. mains to electrical components (e.g. heaters or motors)
Students can compare AC and DC current giving examples
Students can call the frequency and voltage of UK domestic supply (50Hz / 230V)
Students can describe the role of each wire in a plug and how to identify it
Students can explain why fuses and circuit breakers are often present in circuits with relation to safety
Students can explain why safety devices such as fuses and switches are often connected to the live wire of domestic circuits
Students can recall the potential differences between the live, neutral and Earth mains wires.
Students can explain the dangers of connections between the live, neutral and Earth wires
Students can describe with examples the relationship between the power ratings for domestic electrical applications and the changes in energy stores when they are in use
</td><td>
The Big Picture (Progression): At KS2 pupils should already have been taught to:
- Identify common electrical appliances
- Construct simple circuits
- Name components in electrical circuits
- Identify simple problems with circuits such as switch position
- Recognize conducting and insulating materials via testing
- Make links between voltage and its effect in circuits / bulbs
- Utilize simple circuit symbols
- Understand electricity is a type of energy

At KS3 Pupils should already have been taught to:
- Draw and label the structure of the atom
- Conceptualize the phenomenon of electricity and what it is before beginning the topic. A ‘zoom’ into what is happening in an electrical wire and the current that flows.
- Recall electrical component symbols and electrical units of amps, volts, ohms and what they are a measure of. The students should also think of voltage as potential difference with an explanation of change in voltage.
- Recall the rules in terms of current and voltage for series and parallel circuits.
- Develop an understanding of what is meant by resistance- i.e. the ‘slowing’ of the current.
- Use the formula V=IR [substitution]
- Understanding how heat conduction in metals works Y8 ESTABLISHING – HEATING & COOLING

Future links and progression onto other KS4 UNITS
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</table>

	- **P7 – Electricity in the Home** - [AC vs. DC, Power Equations: E=IVt, P=E/t, P=IV, P=I2R, Wiring a Plug, Fuses and Circuit Breakers] - **P9 – Magnetism and Induction** - Transformers, Electromagnetism, Motor Effect - **C1 – Key Concepts** - Atomic Structure - **C11 – Electrolysis** - Application of Electricity in Separating Metals **Progression onto KS5 Physics requires an in-depth understanding of Electrical Principles and Mathematics**

Possible Key Learning Points	Skills	Prerequisites
Key Learning Principles Pupils should be able to quickly recall the equations E=IVT, P=E/T, P=IV and $P=I^2R$, substitute figures, rearrange and solve electrical calculations Unit and symbol recall for Power, Current, Voltage, Resistance, Energy, Charge and Time Define 1 Joule, 1 Volt, 1 Coulomb, 1 ohm, 1 watt and 1 Amp and how they relate to each other. Understand that when an electrical charge goes through a change in potential difference energy is transferred between stores	**Key Skills Learnt** - Literacy / Oracy: To understand and use new unit specific vocabulary effectively - Understand how to draw circuit symbols and circuit diagrams - Draw tables of results and produce suitable graphs to display data - Formulate conclusions based on evidence collected - Develop fine motor skills and practical safety when using electrical equipment - Improved logic and problem-solving skills to fix circuit issues - Teamwork and communication in practical work and hats model - Numeracy: Solving Equations via substitution and rearranging - Use and recall key units correctly	**Students should already:** - Be aware of basic electrical safety - Be able to construct simple circuits from circuit symbols and name its component - Be able to make simple links between the number of batteries (i.e. voltage) and its effect on the circuit - Be able to compare different materials based on electrical conductivity - Hold basic numeracy skills such as negative numbers, using a calculator and competency with simple mathematical processes (add, subtract, divide, multiply) - Have key literacy skills such as suitable reading age - Draw and label the structure of the atom

Compare and contrast AC and DC current Recall UK mains frequency and voltage Describe how to wire a plug and how to identify each wire by colour Explain why wires are copper based an insulated by relating to current and conductivity Explain the importance of the Earth wire in safety Describe how a fuse works Compare and contrast fuses and RCDs ***Core Practical****: None* **Interleaving:** Y7 Fundamentals Particles Y7 Fundamentals Energy Y8 Establishing Electricity and Magnetism P7 – Electricity in the Home P9 – Magnetism and Induction C1 – Key Concepts and Atomic Structure C11 – Electrolysis	- Using standard form and significant figures - Independent learning during research-based home learning	- Conceptualize the phenomenon of electrical current as flowing electrons - Students should finish this unit competent in their knowledge of the electrical units of amps, volts, ohms and what they are a measure of. The students should also think of voltage as potential difference with an explanation of change in voltage. - Students should be aware of the rules in terms of current and voltage for series and parallel circuits. - Students should develop an understanding of what is meant by resistance- i.e. the 'slowing' of the current. - Students should also use the formula V=IR. - Explain how conduction of heat occurs in metals - Be aware of the purpose of the curriculum and its links with Y8 Establishing and KS4
Subject Specific Language	Pedagogical Notes	Make it Stick Activities

Current / Amps Voltage / Potential Difference / Volts Resistance / Ohms Charge / Coulomb Power / Watt Electron Series / Parallel Circuit Battery Wire Voltmeter / Ammeter Energy Stores Energy Transfers Insulator / Conductor Coulombs / Charge Fuse Live / Earth / Neutral Frequency Circuit Breakers / RCDs / RCCB Alternating Current (AC) Direct Current (DC)	Electricity is a topic that students will have been learning about from a very young age in KS2 and developed significantly during Y7 FUNDEMENTALS ELECTRICITY. Students will bring a lot of prior learning with them and some of it will STILL be incorrect and very difficult to shift to more correct understanding of the key principles. Electricity is a difficult scientific principle to grasp as it cannot be visualized inside a wire or a device. It is therefore essential to continually link back to more tangible content such as the 'Hats Model' in Fundamentals Electricity (I suggest this is repeated as Lesson 1 of the scheme). Incorporating and revisiting key models such as the 'HEPMACK energy stores' principles, 'Hats' Model' and the 'Factory example' throughout the scheme will develop higher level understanding of electrical flow, energy and charge. The amount of new terminology and equations to recall is difficult for students. Pupils also struggle to distinguish between the different electrical units and symbols involved (e.g. Q = charge). Re-visiting key flashcards is essential to developing knowledge. Try to use quick quizzes and interleaved learning throughout. See 'Make it Stick' examples. Students often take great interest in this topic when it can be directly related to their own life and safety in the future; short personal anecdotes or news stories may be useful. Many students will likely still struggle with	Tips for Teachers to Help Learning 'Stick' • Focus on active learning methods such as the Hats Model of Electricity at the start of the scheme using good questioning to recap KEY PRINCIPLES in Y7 FUNDEMENTALS ELECTRICITY • Whiteboard Quizzes • Flash card starters interleaved throughout • Card sort (electrical units and symbols) • Equations exam practice • Flipped HL lesson 3 (give out lesson 1?) • Sage and Scribe (AC/DC) • Wiring a plug practical [optional] • Words to pictures • Green zone plenary exam questions • Double bubble • Which fuse to use thinking task • Plenary multiple choice • Fuses vs. RCCBs KAT

	rearranging the equations and should be guided away from using triangles to do this. Triangles should be introduced closer to the exam if necessary for foundation pupils. However, most pupils' especially higher tier should be expected to do this mathematically. __Assessments:__ **Frequency in-class Live Marking throughout Unit** **Key Assessed Task** Towards the end of the scheme (Fuses and RCDs lesson) students should be expected to choose and answer one of the following: **Grade 3** – What is a fuse and why are they needed? **Grade 5**- Explain how a fuse protects you when there is a fault. **Grade 7**- Explain what a RCCB is and evaluate its use compared to a fuse. Work is to be marked *via* coded-marking and feedback to be completed by students in green pen. This assessment is vital in ensuring all pupils understand the key learning outlined at KS3/4. TA. **End of Topic Assessment Lesson 6 or 7 depending on if a revision lesson is used** 35 Mark Total - Section 1: Quizlet Flashcards (AO1) – 15 Marks (PA) - Section 2: Seen Applications Questions (AO2/3) – 10 Marks (PA) - Section 3: Unseen Application Questions	

	(AO2/3) – 10 Marks (TA)	
Reasoning opportunities and probing questions	Suggested Activities	Possible Misconceptions
What would electricity look like as it travels through a wire? What is current? How can it be measured? Why is current shared in a parallel circuit? How does a cell / battery store potential energy? How do resistance, voltage and current link? What is a coulomb? What is charge and how is it different to current? What is the different between a heat insulator and an electrical one? Evaluate the factory model of electricity Why are resistors important electrical components? Why do some circuits contain fuses and others circuit breakers (RCDs) Why did AC become the dominating form of electricity in the modern national grid? Why is it important that wires in circuits are colour coded in all newly built appliances by law? Why do you think one of the wires is stripped? Yellow/Green. Why do you think the old colours of red,	- Building simple circuits from circuit diagrams leant at KS2 - Reviewing the hats model of electrical current from Y7 FUNDEMENTALS - A review of standard form and significant figures - Wiring a plug - Calculating the resistance of fuses using voltmeters and ammeters / power packs	All heat conductors are also electrical conductors That electricity is stored in batteries That electrons are not found within a wire not connected to a circuit That electrical sockets leak electricity when not plugged into something That wires have “sparks” inside of them That all batteries are the same Electrons flow fast in a circuit Electricity is Weightless Electricity and Electrical Energy are the same thing Electrical current is the flow of a substance called current Electrical energy flows all the way around the circuit (in a circle) That electricity is used up in a circuit High levels of resistance is a bad thing Fuses and Circuit breakers are used in dangerous appliances only Heating in circuits is always bad Positively charges objects gain protons Voltage flows through components Every appliance in my home will be wired correctly using stripped, brown and blue wires. Double insulated appliances are always safe

green and black were changed to brown, stripped and blue? How does a fuse "blow"?		

George Stephenson High School SCIENCE KS4 Circuits Unit Overview

Unit: KS4 Y11 Combined Science: Physics P8 - Circuits	**Number of Lessons:** 13
Key Principles (From Specification) Students should fully conceptualize the phenomenon of electricity and what is actually occurring in a circuit at a particle level. Students should finish this unit competent in their knowledge of the electrical units of amps, volts, ohms and what they are a measure of Pupils should be able to quickly recall the required electrical equations (e.g. E=VQ, Q=IT or V=IR), substitute figures and rearrange the equations to solve electrical calculations. Students should be familiar with using standard form and significant figures when providing answers to numerical questions Students should be able to assemble electrical circuits from circuit diagrams and use circuits to collect reads for voltage and current with a multimeter. Students should be able to quickly recall electrical symbols and draw both series and parallel electrical circuits Pupils should learn the uses of Thermisters, Diodes and LDRs within circuit and identify them from IV graphs. Students should be able to describe an experiment to collect data in order to draw IV graphs for key electrical equipment (e.g. filament bulb) as well as describe the shapes of such graphs and explain the reasons behind them. Students should be aware of the rules in terms of current and voltage for series and parallel circuits. Students should develop an understanding of what is meant by resistance Students should finally be able to explain what is meant by 'Charge' and how this relates to energy stores and transfers in circuits.	**The Big Picture (Progression): At KS2 pupils should already have been taught to:** - Identify common electrical appliances - Construct simple circuits - Name components in electrical circuits - Identify simple problems with circuits such as switch position - Recognize conducting and insulating materials via testing - Make links between voltage and its effect in circuits / bulbs - Utilize simple circuit symbols - Understand electricity is a type of energy **At KS3 Pupils should already have been taught to:** - Draw and label the structure of the atom - Conceptualize the phenomenon of electricity and what it is before beginning the topic. A 'zoom' into what is happening in an electrical wire and the current that flows. - Recall electrical component symbols and electrical units of amps, volts, ohms and what they are a measure of. The students should also think of voltage as potential difference with an explanation of change in voltage. - Recall the rules in terms of current and voltage for series and parallel circuits. - Develop an understanding of what is meant by resistance- i.e. the 'slowing' of the current. - Use the formula V=IR [substitution] - Understanding how heat conduction in metals works Y8 ESTABLISHING – HEATING & COOLING **Future links and progression onto other KS4 UNITS**

	- **P7 – Electricity in the Home** - [AC vs. DC, Power Equations: E=IVt, P=E/t, P=IV, P=I2R, Wiring a Plug, Fuses and Circuit Breakers] - **P9 – Magnetism and Induction** - Transformers, Electromagnetism, Motor Effect - **C1 – Key Concepts** - Atomic Structure - **C11 – Electrolysis** - Application of Electricity in Separating Metals **Progression onto KS5 Physics requires an in-depth understanding of Electrical Principles and Mathematics**

Possible Key Learning Points	Skills	Prerequisites
Key Learning Principles Pupils should be able to quickly recall the Q=IT, V=IR and E=QV equation, substitute figures, rearrange and solve electrical calculations Explain that electric current is the rate of flow of charge and the current in metals is a flow of electrons Explain that potential difference (voltage) is the energy transferred per unit charge passed and hence that the volt is a joule per coulomb Explain how changing the resistance in a circuit changes the current and how this can be achieved using a variable resistor	**Key Skills Learnt** - Literacy / Oracy: To understand and use new unit specific vocabulary effectively - Understand how to draw circuit symbols and circuit diagrams - Draw tables of results and produce suitable graphs to display data - Formulate conclusions based on evidence collected - Develop fine motor skills and practical safety when using electrical equipment - Improved logic and problem-solving skills to fix circuit issues - Teamwork and communication in practical work and hats model - Numeracy: Solving Equations via substitution and rearranging - Use and recall key units correctly	**Students should already:** - Be aware of basic electrical safety - Be able to construct simple circuits from circuit symbols and name its component - Be able to make simple links between the number of batteries (i.e. voltage) and its effect on the circuit - Be able to compare different materials based on electrical conductivity - Hold basic numeracy skills such as negative numbers, using a calculator and competency with simple mathematical processes (add, subtract, divide, multiply) - Have key literacy skills such as suitable reading age - Draw and label the structure of the atom

Draw and use electric circuit diagrams using appropriate electrical symbols Describe the differences between series and parallel circuits Calculate the currents, potential differences and resistances in series circuits Explain how current cause heating. Link current in a metal to the increase in resistance Recall that a voltmeter is connected in parallel and that an ammeter is connected in series Explain why, if two resistors are in series, the net resistance is increased, whereas with two in parallel the net resistance is decreased Explain how current varies with potential difference and how this relates to resistance using IV graphs Describe how the resistance of a light-dependent resistor (LDR) varies with light intensity Describe how the resistance of a thermistor varies with change of temperature Become aware of careers links in the field of electrical engineering ***Core Practical****: Construct and test electrical circuits to: Investigate the relationship between potential difference, current and resistance for a resistor and a filament*	- Using standard form and significant figures - Independent learning during research-based home learning	- Conceptualize the phenomenon of electrical current as flowing electrons - Students should finish this unit competent in their knowledge of the electrical units of amps, volts, ohms and what they are a measure of. The students should also think of voltage as potential difference with an explanation of change in voltage. - Students should be aware of the rules in terms of current and voltage for series and parallel circuits. - Students should develop an understanding of what is meant by resistance- i.e. the 'slowing' of the current. - Students should also use the formula V=IR. - Explain how conduction of heat occurs in metals - Be aware of the purpose of the curriculum and its links with Y8 Establishing and KS4

lamp **Interleaving:** Y7 Fundamentals Particles Y7 Fundamentals Energy Y8 Establishing Electricity and Magnetism P7 – Electricity in the Home P9 – Magnetism and Induction C1 – Key Concepts and Atomic Structure C11 – Electrolysis		
Subject Specific Language	Pedagogical Notes	Make it Stick Activities
Current / Amps Voltage / Potential Difference / Volts Resistance / Ohms Electron Series / Parallel Circuit Battery Wire Voltmeter / Ammeter Energy Stores Energy Transfers Insulator / Conductor Coulombs / Charge Diode Light Dependent Resistor [LDRs] Thermisters IV-Graphs	Electricity is a topic that students will have been learning about from a very young age in KS2 and developed significantly during Y7 FUNDEMENTALS ELECTRICITY. Students will bring a lot of prior learning with them and some of it will STILL be incorrect and very difficult to shift to more correct understanding of the key principles. Electricity is a difficult scientific principle to grasp as it cannot be visualized inside a wire or a device. It is therefore essential to continually link back to more tangible content such as the 'Hats Model' in Fundamentals Electricity (I suggest this is repeated as Lesson 1 of the scheme). Incorporating and revisiting key models such as the 'HEPMACK energy stores' principles, 'Hats' Model' and the 'Factory example' (L1 Slide 12) throughout the scheme will develop higher level understanding of electrical flow, energy and charge. To demonstrate that electrons do not flow at the speed of light, but actually very slowly, you could fill a hose pipe or similar with marbles and insert one into one end. This demonstrates that the effect of flowing charge is	Tips for Teachers to Help Learning 'Stick' • Focus on active learning methods such as the Hats Model of Electricity at the start of the scheme using good questioning to recap KEY PRINCIPLES in Y7 FUNDEMENTALS ELECTRICITY • Create 'desirable difficulties' such as the Core Practical. Allow students to cognitively struggle and do not spoon feed ideas (e.g. draw your own result table) • Provide constructive feedback after the KAT via coded marking • Incorporate frequent, low stakes testing of flashcards during starter and plenary activities • Provide opportunities for elaboration, reflection after KAT and DIRT lesson after assessment • Explain to students how to troubleshoot their own problems when making circuits. Don't do it for them – "Have you tried [this]?" • Pens in Pots • Chili Challenges • Green Zone challenges to figure out rules for parallel and series circuits • Whiteboard Quizzes

	instantaneous, but the original marble or electron is not moving very quickly at all. The amount of new terminology and equations to recall is difficult for students. Pupils also struggle to distinguish between the different electrical units and symbols involved (e.g. Q = charge). Re-visiting key flashcards is essential to developing knowledge. Try to use quick quizzes and interleaved learning throughout. See ‘Make it Stick’ examples. Students will also struggle to successfully build their own circuits due to faulty equipment. We recommend spending some time showing pupils how to troubleshoot key issues. Many students will likely still struggle with rearranging the equations and should be guided away from using triangles to do this. Triangles should be introduced closer to the exam if necessary for foundation pupils. However, most pupil’s especially higher tier should be expected to do this mathematically. **<u>Assessments:</u>** **Frequency in-class Live Marking throughout Unit** **Key Assessed Task** Towards the end of the scheme students should be expected to: “Evaluate the factory model of electricity”	

	This could be completed at any point after Lesson 5. Work is to be marked *via* coded-marking and feedback to be completed by students in green pen. This assessment is vital in ensuring all pupils understand the key learning outlined at KS3/4. TA. **End of Topic Assessment Lesson 10** 35 Mark Total - Section 1: Quizlet Flashcards (AO1) – 15 Marks (PA) - Section 2: Seen Applications Questions (AO2/3) – 10 Marks (PA) - Section 3: Unseen Application Questions (AO2/3) – 10 Marks (TA)	
Reasoning opportunities and probing questions	Suggested Activities	Possible Misconceptions
What would electricity look like as it travels through a wire? What is current? How can it be measured? Why is current shared in a parallel circuit? How does a cell / battery store potential energy? How do resistance, voltage and current link? What is a coulomb? Why is this useful unit? How can a citrus fruit create voltage? What is charge and how is it different to current? Why do birds sit on electrical cables in the winter? What is the different between a heat insulator and an electrical one? How is electricity like the hats model? Evaluate the hats model of electricity Evaluate the factory model of electricity How could an LDR/Thermister be used in the home?	- Building simple circuits from circuit diagrams leant at KS2 - Reviewing the hats model of electrical current from Y7 FUNDEMENTALS - A review of standard form and significant figures - Core Practical [essential] - Analyzing images of bad electrical safety - Let students explore with LDRs and thermisters in the classroom or outdoors. - Building batteries from different types of fruit - Using and rearranging equations review - Collecting experimental data to produce your own IV graphs for filament bulbs and resistors - Drawing IV graphs form data provided	All heat conductors are also electrical conductors That electricity is stored in batteries That electrons are not found within a wire not connected to a circuit That electrical sockets leak electricity when not plugged into something That wires have "sparks" inside of them That all batteries are the same Electrons flow fast in a circuit Electricity is weightless Electricity and Electrical Energy are the same thing Electrical current is the flow of a substance called current Electrical energy flows all the way around the circuit (in a circle) That electricity or charge is used up in a circuit High levels of resistance is a bad thing Fuses and Circuit breakers are used in dangerous appliances only Heating in circuits is always bad Positively charges objects gain protons Voltage flows through components

Why must an ammeter be placed in series? Why must a voltmeter be placed in parallel? Why are resistors important electrical components? Why do some circuits contain fuses and others circuit breakers (RCDs)		That electrons are provided to a circuit/wire when the electricity is “switched on” / ”plugged in”

<table>
<tr><th>Unit: Y10 Physics: EM Spectrum</th><th>Number of Lessons: 5</th></tr>
<tr><td>Key Principles (from NC):
electromagnetic waves, velocity in vacuum; waves transferring energy; wavelengths and frequencies from radio to gamma-rays
production and detection, by electrical circuits, or by changes in atoms and nuclei
uses in the radio, microwave, infra-red, visible, ultra-violet, X-ray and gamma ray regions, hazardous effects on bodily tissues.</td><td>The Big Picture (Progression): At KS2 pupils should already have been taught to:
recognise that they need light in order to see things and that dark is the absence of light
notice that light is reflected from surfaces
recognise that light from the sun can be dangerous and that there are ways to protect their eyes
recognise that light appears to travel in straight lines
use the idea that light travels in straight lines to explain that objects are seen because they give out or reflect light into the eye
explain that we see things because light travels from light sources to our eyes or from light sources to objects and then to our eyes
Links to FUNDAMENTALS UNITS:
Energy
Links to other ESTABLISHING UNITS:
Waves
Heating and Cooling
Magnets and Electromagnets
Links to prior KS4 UNITS
Waves

Future links and progression onto KS4 UNITS
Energy, Radioactivity, Magnetism and Induction</td></tr>
</table>

<table>
<tr><th>Possible Key Learning Points</th><th>Skills</th><th>Prerequisites</th></tr>
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<td>
<table>
<tr><th>Students should:</th><th>Maths skills</th></tr>
<tr><td>5.7 Recall that all electromagnetic waves are transverse, that they travel at the same speed in a vacuum</td><td></td></tr>
<tr><td>5.8 Explain, with examples, that all electromagnetic waves transfer energy from source to observer</td><td></td></tr>
<tr><td>5.9 Core Practical: Investigate refraction in rectangular glass blocks in terms of the interaction of electromagnetic waves with matter</td><td></td></tr>
<tr><td>5.10 Recall the main groupings of the continuous electromagnetic spectrum including (in order) radio waves, microwaves, infrared, visible (including the colours of the visible spectrum), ultraviolet, x-rays and gamma rays</td><td></td></tr>
<tr><td>5.11 Describe the electromagnetic spectrum as continuous from radio waves to gamma rays and that the radiations within it can be grouped in order of decreasing wavelength and increasing frequency</td><td>1a, 1c
3c</td></tr>
<tr><td>5.12 Recall that our eyes can only detect a limited range of frequencies of electromagnetic radiation</td><td></td></tr>
<tr><td>5.13 Recall that different substances may absorb, transmit, refract or reflect electromagnetic waves in ways that vary with wavelength</td><td></td></tr>
<tr><td>5.14 Explain the effects of differences in the velocities of electromagnetic waves in different substances</td><td>1a, 1c
3c</td></tr>
<tr><td>5.20 Recall that the potential danger associated with an electromagnetic wave increases with increasing frequency</td><td></td></tr>
<tr><td>5.21 Describe the harmful effects on people of excessive exposure to electromagnetic radiation, including:
a microwaves: internal heating of body cells
b infrared: skin burns
c ultraviolet: damage to surface cells and eyes, leading to skin cancer and eye conditions
d x-rays and gamma rays: mutation or damage to cells in the body</td><td></td></tr>
</table>
<table>
<tr><th>Students should:</th><th>Maths skills</th></tr>
<tr><td>5.22 Describe some uses of electromagnetic radiation
a radio waves: including broadcasting, communications and satellite transmissions
b microwaves: including cooking, communications and satellite transmissions
c infrared: including cooking, thermal imaging, short range communications, optical fibres, television remote controls and security systems
d visible light: including vision, photography and illumination
e ultraviolet: including security marking, fluorescent lamps, detecting forged bank notes and disinfecting water
f x-rays: including observing the internal structure of objects, airport security scanners and medical x-rays
g gamma rays: including sterilising food and medical equipment, and the detection of cancer and its treatment</td><td></td></tr>
<tr><td>5.23 Recall that radio waves can be produced by, or can themselves induce, oscillations in electrical circuits</td><td></td></tr>
<tr><td>5.24 Recall that changes in atoms and nuclei can
a generate radiations over a wide frequency range
b be caused by absorption of a range of radiations</td><td></td></tr>
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Key Skills Learnt

The ability to recall all names of groupings of the electromagnetic spectrum, in order
Numeracy: use of standard form to compare the wavelengths of EM waves
Identify uses of each group of EM waves
Link properties of EM waves to their uses
Identify hazards associated with each grouping of EM waves

</td>
<td>
Students should already:

Be able to identify a transverse wave
Accurately label parts of a transverse wave
Know that waves are either refracted, reflected, transmitted, or absorbed by different mediums
Know that a vacuum is an absence of matter
Understand that energy can be transferred via radiation
Know that visible light is made up of different wavelengths of light, which are different colours
Know that visible light is detected by the eyes.
Have a limited knowledge of other parts of the EM spectrum (e.g. students should be familiar with x-ray or radio) – although they will probably be unaware that these are part of the EM spectrum prior to this topic.
Have a limited knowledge of some uses of the EM spectrum

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</tr>
<tr><th>Subject Specific Language</th><th>Pedagogical Notes</th><th>Make it Stick Activities</th></tr>
</table>

Electromagnetic Wave Wavelength Frequency Radiation Reflection Refraction Transmitted Absorbed Radio Microwave Infra-red Visible light Ultraviolet X-ray Gamma Oscillation	EM Spectrum is a short topic, and is heavily focused on AO1 in that there are many facts which need to be retained in order for students to be successful in learning this topic well. Students will probably be unaware that the different groupings are part of the EM spectrum, even though they will be familiar with most of the groups. For example all students should know the term microwave but will associate it with a use, cooking food, rather than knowing that the term refers to the waves produced. The topic of the EM spectrum can be rather a difficult one for learners to grasp. Many fail to appreciate that the different regions are essentially the same as visible light, albeit with the waves having different frequencies and hence wavelength. It is essential that before starting this topic that students have been reintroduced to the 'anatomy' of a transverse wave, so that they are familiar with the basic terms of wavelength and frequency before commencing the topic. Since students will already be aware of the real life applications of many groups, there are plenty of opportunities to ask questions to probe understanding. Learning about one of the groups in more detail in order to peer teach has proved a good exercise with classes in the past. For the dangers of the EM spectrum, there is a card sort which should help students to identify that the higher the frequency the more energy transferred by a wave, and generally the more harmful to health they are. For higher tier, students must also recognise that oscillations in electrical circuits can produce radio waves and vice versa, this is a good opportunity to interleave with electromagnetism and discuss other interactions with electricity. **Assessments:** **End of Topic Assessment Lesson 8** 30 Mark Total • Section 1: Quizlet Flashcards (AO1) – 10 Marks • Section 2: Seen Applications Questions (AO2/3) – 10 Marks • Section 3: Unseen Application Questions (AO2/3) – 10 Marks	Tips for Teachers to Help Learning 'Stick' • Interleaving with other units (particularly waves which has recently been covered) • Mini-plenary tasks • Demonstration of reactions • Carousel/marketplace type activities • Flash cards • Real life applications of EMS embedded • Flipped HL on discovery of IR and UV • Literacy task on mobile phone usage • Mini quizzes
Reasoning opportunities and probing questions	Suggested Activities	Possible Misconceptions

What is a wave? What would a wave look like if we shortened/lengthened the wavelength? What would a wave look like if we increased amplitude? How does a microwave work? How do you hear the radio in your car? Why do we get images from x-rays (specifically get students to think in terms of absorb, transmit, reflect, refract)		Each type of EM wave has a specific wavelength and frequency (rather than a range) Confusing sound and EM waves EM waves travel via vibrations of particles in the air All waves need a medium to trave through Radio waves are sound waves Only light waves travel at the speed of light Different wavelengths of light have different energy and therefore different speeds. A radio wavelength is a sound wave not part of the electromagnetic spectrum. Black does not reflect any light and/or white does not absorb any light. Only shiny materials reflect light. Water does not reflect or absorb light but light can go through it. The distance that light travels depends on the amount of energy that light has