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| **Lesson Number: 21.1** |
| **Lesson Title: Gravitational Field Strength** |
| **Specification Reference** | **3.7.2.1 / 3.7.2.2** |
| **Learning Objectives** |
| Gravity as a universal attractive force acting between all matterRepresentation of a gravitational field by gravitational field lines*g* as force per unit mass as defined by  |
| **Opportunities for Assessment** |
| Page 339 Questions |
| **Starter:** | Slide #1 allows an open discussion as to what is gravity – Note that Einstein’s theory of gravity is not covered in this course however some students may want to discuss it |
| **Main:** | Slide #2 outlines the probable outcomes of the discussionSlide #3 explains the mathematical derivation of the formula (from Newton’s second law) and units for gravitational field strength. Pupils sometime get confused about the units so slide #5 reiterates this.Slide #4 explains freefall and the idea that all objects fall at the same acceleration in a gravity field. Links can be made to Terminal Velocity in the Year 1 courseSlide #6 shows how the field lines are drawn around a planet and also compares to a uniform field as used on a planet surface (and in classroom experiments)Slide #7 explains some preconceptions that students have and should iron out any misunderstandings |
| **Plenary:** | Slide #8 is a summary of the key points |
| **Homework:** | Page 339 questions; Research the gravity on different planets |
| **Differentiation / Extension / S&C** |
| Research the gravity on different planets and how this varies with mass **and** radius |
| **Numeracy / Literacy** | **SMSC / Fundamental British Values** |
| Derivation of formula and unitsEquivalent units | Use of Newton’s second law and links to freefall. Use of estimations to use uniform fields for calculations. |
| **RESOURCES:** |
| NoneOptional - (*g* can be found by performing the pendulum experiment from Year 1 course) |
| **Risk Assessment** e.g. CLEAPSS card reference |
| None |
| **Working Scientifically (HSW)** |
| N/A |

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| **Lesson Number: 21.2** |
| **Lesson Title: Gravitational Potential** |
| **Specification Reference** | **3.7.2.2 / 3.7.2.3** |
| **Learning Objectives** |
| Understanding of definition of gravitational potential, including zero value at infinityUnderstanding of gravitational potential differenceWork done in moving mass *m* given by Δ*W* = *m*Δ*V*Equipotential surfacesIdea that no work is done when moving along an equipotential surfaceSignificance of the negative signGraphical representations of variations of *g* and *V* with *r**V* related to *g* by:  |
| **Opportunities for Assessment** |
| Page 342 questions |
| **Starter:** | Slide #1allows a discussion of rocket fuel, energy changes, does anything escape gravity? |
| **Main:** | Slide #2 links back to projectile motion from Year 1 to discuss the effect of increasing speed and hence kinetic energy on the height attained by a projectileSlide #3 Defines gravitational potential energy – students often struggle to understand why potential energy is zero at infinite distanceSlide #4 reaffirms the definition from the previous slide and tests their knowledge of unitsSlide #5 shows equipotentials – link to hill walking, gradients and DofE (Some OS maps might come in handy here if you have any)Slides #6 and #7 explain equipotentials and how they are not evenly spaced; this will therefore give rise to a changing gradient at different places – link back to contour lines and gradient from how close they are |
| **Plenary:** | Slide #8 is a summary |

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| **Homework:** | Page 342 questions, Research Isaac Newton and his Theory of Gravitation |
| **Differentiation / Extension / S&C** |
| Use of maps to find the gradient of slopes |
| **Numeracy / Literacy** | **SMSC / Fundamental British Values** |
| Use of formulae and gradients | DofE, route planning and gradients |
| **RESOURCES:** |
| Optional – OS Maps |
| **Risk Assessment** e.g. CLEAPSS card reference |
| None |
| **Working Scientifically (HSW)** |
| None |

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| **Lesson Number: 21.3** |
| **Lesson Title: Newton’s Law of Gravitation** |
| **Specification Reference** | **3.7.2.1, 3.7.2.4** |
| **Learning Objectives** |
| Gravity as a universal attractive force acting between all matter.Magnitude of force between point masses: where *G* is the gravitational constant.Orbital period and speed related to radius of circular orbit; derivation of *T*2 ∝ *r*3 |
| **Opportunities for Assessment** |
| Page 345 questions |
| **Starter:** | Slide #1 enables pupils to think about planning experiments and data collection – they may be surprised by how little data they need and that the mass of the planets and sun are not needed for this question |
| **Main:** | Slide #2 is an optional mathematical investigation; using logs the students can find the straight line of the relationship and hence find the missing powers. An alternative approach is to use excel to produce a graph and then use trial and error on the powers until a straight line appearsSlide #3 is an opportunity to discuss how all great scientists build their knowledge on the discoveries of those that came before them. Note the time it took to go from Kepler to Newton!Slide #4 describes the main points of Newton’s Law of Gravitation and gives pupils the opportunity to create a formula from ideas and relationshipsSlide #5 states the Gravitational Constant (discussions here could evolve into rotational speeds of galaxies and the search for Dark Matter) |
| **Plenary:** | Slide #6 is a summary |
| **Homework:** | Page 345 questions; research Isaac Newton and his theory of Gravitation |
| **Differentiation / Extension / S&C** |
| Research of Kepler’s Laws and their predictions |
| **Numeracy / Literacy** | **SMSC / Fundamental British Values** |
| * Use of formulae and relationships
* Understanding the inverse square law
 | Understanding the relative sizes of the planets and why Earth can be considered a point mass in calculations. Building on the ideas of scientists that have come before you. |
| **RESOURCES:** |
| None |
| **Risk Assessment** e.g. CLEAPSS card reference |
| None |
| **Working Scientifically (HSW)** |
| See page 345 “Cavendish’s measurement of *G*” |

Photo on slide #1 courtesy of [https://www.flickr.com/photos/11304375@N07/2818891443](https://www.flickr.com/photos/11304375%40N07/2818891443)

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| **Lesson Number: 21.4** |
| **Lesson Title: Planetary Fields** |
| **Specification Reference** | **3.7.2.1, 3.7.2.2, 3.7.2.3, 3.7.2.4** |
| **Learning Objectives** |
| Magnitude of force between point masses: where *G* is the gravitational constant.*g* as force per unit mass as defined by Understanding of definition of gravitational potential, including zero value at infinity.Understanding of gravitational potential difference.Work done in moving mass *m* given by Δ*W* = *m*Δ*V**V* in a radial field given by Significance of the negative sign.Graphical representations of variations of *g* and *V* with *r*.*V* related to *g* by: Escape velocity. |
| **Opportunities for Assessment** |
| Page 350 questions |
| **Starter:** | Slides #1 and #2 are a recap of gravitational fields and the formula to describe them |
| **Main:** | Slide #3 recaps the work done so far on calculating the gravitational field strength at different locations above the surface of a planetSlide #4 extends this idea and enables pupils to think about the graph to represent this formula. The next step is to consider the gravitational field strength below the surface of the Earth – Consider first the gravity in the centre of the Earth. An extension can be to calculate or prove the formula from “Inside a planet” on page 347 of the text bookSlides #5 and #6 enable the calculation of the gravitational potential on Earth’s surface (a nice extension here is to repeat this for the moon or Mars) and link to escape velocity calculations (Pupils can calculate the escape velocity of Earth and consider why rockets are always launched in the same direction that Earth is rotating)Slide #7 explains the differences in graph shapes between gravitational field strength and potential gradients, with distance from a planet’s surface |
| **Plenary:** | Slide #8 is a summary |

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| **Homework:** | Page 350 questions |
| **Differentiation / Extension / S&C** |
| Sketching graphs of different equations e.g. (1/r2) and (1/r) |
| **Numeracy / Literacy** | **SMSC / Fundamental British Values** |
| Use of formulae, sketches of graphs | Use of physics to design multi-stage rockets and the problems / limitations with re-useable systems like the shuttle program |
| **RESOURCES:** |
| None |
| **Risk Assessment** e.g. CLEAPSS card reference |
| None |
| **Working Scientifically (HSW)** |
| See “Inside a planet” page 347 and “Multi-stage rockets” page 350 |

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| **Lesson Number: 21.5** |
| **Lesson Title: Satellite Motion** |
| **Specification Reference** | **3.7.2.4** |
| **Learning Objectives** |
| Orbital period and speed related to radius of circular orbitEnergy considerations for an orbiting satellite.Total energy of an orbiting satellite.Escape velocity.Synchronous orbits. |
| **Opportunities for Assessment** |
| Page 353 questions |
| **Starter:** | Slides #1 and #2 should outline preconceptions about orbits and enable a link to be made to centripetal force |
| **Main:** | Slide #3 recaps radial velocity calculations and links this into the satellite lesson. Optional higher level mathematics allows pupils to find the link to Kepler’s Third Law themselvesSlide #4 shows Kepler’s third law again as the final step in the precious work and extends pupils to qualitatively think about how you control the orbital period of a satelliteSlide #5 introduces geostationary satellites and the calculation of their heights. Note that the common student mistake is to forget to subtract the radius of the Earth from the final answer!Slides #5 and #6 go through the calculation (and derivation) of the energy formulae for satellites |
| **Plenary:** | Slide #7 is a summary |
| **Homework:** | Page 353 questions, research on different types of satellites (or a specific satellite) |
| **Differentiation / Extension / S&C** |
| Research into Keplar’s Laws of motion |
| **Numeracy / Literacy** | **SMSC / Fundamental British Values** |
| Use and derivation of gravitation formulae; drawing of 1/r graphs | Use of satellites in everyday lifeGeostationary satellites and military satellites and their orbits |
| **RESOURCES:** |
| None |
| **Risk Assessment** e.g. CLEAPSS card reference |
| None |
| **Working Scientifically (HSW)** |
| GPS systems and SatNav, page 352 “Vehicle Tracking” |

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| **Lesson Number: 22.1** |
| **Lesson Title: Field Patterns** |
| **Specification Reference** | **3.7.3.2** |
| **Learning Objectives** |
| Representation of electric fields by electric field lines. |
| **Opportunities for Assessment** |
| Page 361 questions |
| **Starter:** | Slides #1 and #2 form a recap from KS 3 and 4 about static electricity and field |
| **Main:** | Slide #3 recaps the gold leaf electroscope and it’s charging and discharging – a recommend demonstration (works better on dry days)Slide #4 explains the shuttling ball demonstration that can be performed here. Ensure you are aware of, and prevent the danger from, high voltage plates with this demonstration!Slides #5 - #8 are a basic drawing exercise of field patterns – an extension task is to link the point charges with the work on gravitational fields and also think about what the best possible properties would be to create perfect uniform fields (Infinitely large parallel plates) |
| **Plenary:** | Slide #9 is a summary |
| **Homework:** | Page 361 questions |
| **Differentiation / Extension / S&C** |
| Pupils can perform gold leaf experiments themselves and come to conclusions about how they work |
| **Numeracy / Literacy** | **SMSC / Fundamental British Values** |
| Recap of formula for current and charge | None |
| **RESOURCES:** |
| Demo 1:* Gold leaf electroscope
* Charging rod
* Cloth

Demo 2:* High voltage source (DC)
* Two parallel plates
* Conductive ball (Ping pong ball painted with conductive paint)
* Insulating cotton / string attached to ball
* Micro-ammeter and stop watch (Optional)
* Safety screen, high voltage leads
 |
| **Risk Assessment** e.g. CLEAPSS card reference |
| Demo 2 uses high voltage equipment and safeguards must be put in place to ensure neither student nor teacher will touch the plates directlyDC electricity only to be used with high voltage equipmentEnsure laboratory RCCD units are operating correctly prior to high voltage equipment being used |
| **Working Scientifically (HSW)** |
| See “Chips and Charge” on page 359 |

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| **Lesson Number: 22.2** |
| **Lesson Title: Electric Field Strength** |
| **Specification Reference** | **3.7.3.1, 3.7.3.2** |
| **Learning Objectives** |
| Permittivity of free space, Electric field strength.*E* as force per unit charge defined by Magnitude of *E* in a uniform field given by Derivation from work done moving charge between plates: *Fd* = *Q*Δ*V* |
| **Opportunities for Assessment** |
| Page 365 questions |
| **Starter:** | Slide #1 is an introduction to electric field strength – parallels may be drawn with previous work on gravitational fields. It is important that pupils *understand* what it is they are trying to measure and can quantify their answers by hypothesising the units |
| **Main:** | Slide #2 is an animated work through deriving the main formulaSlide #3 has the important main three bullet points needed when describing the field between parallel plates – students *should* be able to come up with these before seeing them!Slide #4 and #5 work through to derive the formula  Slide #6 is an extension into what the permittivity of free space is. Although the constant is needed, a definition is not nor is its derivation. |
| **Plenary:** | Slide #7 is a summary |
| **Homework:** | Page 365 questions; research on lightning and lightning conductors |
| **Differentiation / Extension / S&C** |
| Research on the permittivity of free space and its use in other physics constants (e.g. the speed of light) |
| **Numeracy / Literacy** | **SMSC / Fundamental British Values** |
| Derivation of formulae and units | None |
| **RESOURCES:** |
| None |
| **Risk Assessment** e.g. CLEAPSS card reference |
| None |
| **Working Scientifically (HSW)** |
| See “The lightning conductor” on page 363 |

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| **Lesson Number: 22.3** |
| **Lesson Title: Electric Potential** |
| **Specification Reference** | **3.7.3.3** |
| **Learning Objectives** |
| Understanding of definition of absolute electric potential, including zero value at infinity, and of electric potential difference.Work done in moving charge *Q* given by Δ*W* = *Q*Δ *V*Equipotential surfaces.No work done moving charge along an equipotential surface. |
| **Opportunities for Assessment** |
| Page 368 questions |
| **Starter:** | Slide #1 enables discussions about equipotentials in general. This example is isobars and pressure however if students struggle with this then use contours and height. |
| **Main:** | Slides #2 and #3 are simple definitions of the main areas of concern for this lesson. Links can be made to gravitational fields and their counterparts although care must be taken not to confuse students (mass vs charge must be made clear)Slide #4 is an important depiction of how moving charges require work to be done, a common examination idea.Slides #5 and #6 show the equipotentials in a uniform field, link this to the idea of work being done as a charge moves across them but not along themSlides #7 and #8 define potential gradients in electric fields and give the formulae required to calculate them. Again, links to contours and height are very useful here. |
| **Plenary:** | Slide #9 is a summary |
| **Homework:** | Page 368 questions |
| **Differentiation / Extension / S&C** |
| Get pupils to draw graphs of electric potentials with distance using cross sections from drawings done around non-uniform fields |
| **Numeracy / Literacy** | **SMSC / Fundamental British Values** |
| Formula use and calculations of gradients | N/A |
| **RESOURCES:** |
| Optional – Van de Graff generator |
| **Risk Assessment** e.g. CLEAPSS card reference |
| Electrical equipment, people with pace makers or similar items should not be close to the generator |
| **Working Scientifically (HSW)** |
| N/A |

Field line diagram courtesy of: By Sjlegg (Own work) [Public domain], via Wikimedia Commons

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| **Lesson Number: 22.4** |
| **Lesson Title: Coulomb’s Law** |
| **Specification Reference** | **3.7.3.1** |
| **Learning Objectives** |
| Force between point charges in a vacuum: Permittivity of free space, Appreciation that air can be treated as a vacuum when calculating force between charges.Comparison of magnitude of gravitational and electrostatic forces between subatomic particles.For a charged sphere, charge may be considered to be at the centre. |
| **Opportunities for Assessment** |
| Page 371 questions |
| **Starter:** | Slide #1 revisits the work done on field lines and equipotentials and extends them to point charges. Link to the equipotentials in a gravitational field around a planet |
| **Main:** | Slide #2 is simply historical data about Coulomb, this could be a homework idea for researchSlide #3 defines Coulomb’s Law, try and enable pupils to discover this formula for themselves. For more able group use the data on page 369 to draw a graph and then find the inverse square law themselves and hence the overall expression for force.Slide #4 defines the constant of proportionality and the permittivity of free space constantSlide #5 shows the pupils the differences in a the strength of gravity and electric forces |
| **Plenary:** | Slide #6 is summary |
| **Homework:** | Page 371 questions, Research Coulomb and his experiments |
| **Differentiation / Extension / S&C** |
| Enable more able pupils to discover the relationship between force and distance and hence define the formula themselves |
| **Numeracy / Literacy** | **SMSC / Fundamental British Values** |
| Formula and constant use, extensive use of units and scientific notation. Comparison between forces | Links between Newton’s laws and Coulomb’s law. Building upon past work and similar ideas. |
| **RESOURCES:** |
| None |
| **Risk Assessment** e.g. CLEAPSS card reference |
| None |
| **Working Scientifically (HSW)** |
| Why does Salt dissolve? Page 370 – research / discussion / links to Chemistry |

Slide #1 picture By Victor Blacus [CC BY-SA 3.0 (http://creativecommons.org/licenses/by-sa/3.0)], via Wikimedia Commons

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| **Lesson Number: 22.5** |
| **Lesson Title: Point charges** |
| **Specification Reference** | **3.7.3.1, 3.7.3.2, 3.7.3.3** |
| **Learning Objectives** |
| For a charged sphere, charge may be considered to be at the centre.Electric field strength.Magnitude of *E* in a radial field given by Magnitude of *V* in a radial field given by Graphical representations of variations of *E* and *V* with *r*.*V* related to *E* by Δ*V* from the area under graph of *E* against *r*. |
| **Opportunities for Assessment** |
| Page 374 questions |
| **Starter:** | Slide #1 enables a thought experiment on why we can consider planets and stars to be point masses and hence whether the same simplification can be done to charges – As an extended discussion protons and even neutrons have been shown to have charge differences across then due to their quarks |
| **Main:** | Slide# 2 extends the students understanding of electric field strength by combining with Coulomb’s LawSlide #3 recaps vector usage – this could take a full lesson if puils have forgotten their work on mechanics! – Extend this.as a discussion on what would happen to objects initially moving as they entered the field (needed for the syllabus) – Make an analogy with gravity and projectile motion from Year 1 (AS) Slides #4 and #5 show the differences between, and how to sketch, graphs for both field strength and potential against distance. The analogy between this and the gravity versions of them are important – knowing the difference between 1/*r* and 1/*r*2 is important hereSlide #6 shows how to use the area under a graph to find Δ*V* (i.e. work done per unit charge) – Students can get confused here and think they are finding the work done, and forget that it is per unit charge |
| **Plenary:** | Slide #7 is a summary |

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| **Homework:** | Page 374 questions |
| **Differentiation / Extension / S&C** |
| Drawing and sketching graphs of different functions and comparing them |
| **Numeracy / Literacy** | **SMSC / Fundamental British Values** |
| Sketching graphs and finding the area under a graph | None |
| **RESOURCES:** |
| Optional* Use a Van de Graff generator to show how discharge is quicker with a point (pin) than with a ball
 |
| **Risk Assessment** e.g. CLEAPSS card reference |
| Van de Graff generator should not be used close to sensitive electronic equipment including mobile phones and pacemakers |
| **Working Scientifically (HSW)** |
| None |

Image on slide #1:

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| **Lesson Number: 23.1** |
| **Lesson Title: Capacitance** |
| **Specification Reference** | **3.7.4.1** |
| **Learning Objectives** |
| Definition of capacitance:  |
| **Opportunities for Assessment** |
| Page 381 questions |
| **Starter:** | Slide #1 enables a discussion on how to store charge. Students may have preconceptions about cells that need to be revisited to assure them that these do not store charge. Discussions of how much charge flows down a lightning strike can be interesting. |
| **Main:** | Slides #2 and #3 describe the construction of a capacitor. Use two layers of aluminium foil and a sheet of thin plastic from a bin-liner between them to model thisSlide #4 explains how to charge a capacitor – Apply a High Voltage DC across the two sheets of foil and see them attract to each other Slide #5 enables the capacitance of a capacitor to be calculated from a graph of data, alternatively you can perform an experiment at constant current to obtain the data yourself (See page 380-381)Slide #6 explains why capacitors have a maximum charge that they can hold - (Optional, turn the p.d. up too high and the insulation will fail with loud cracks – turn the lights off to see sparks)Slide #7 is a list of common uses of capacitors – use this list as research for homework / presentations |
| **Plenary:** | Slide #8 is a summary |

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| **Homework:** | Page 381 questions; research the uses of capacitors |
| **Differentiation / Extension / S&C** |
| Research the uses of capacitors, discuss the effect on current over time as the capacitor charges |
| **Numeracy / Literacy** | **SMSC / Fundamental British Values** |
| Formula use, new units (Farads) and prefixes | Uses of capacitors |
| **RESOURCES:** |
| Demo:* Two layers of aluminium foil (approx. 50cm x 50cm)
* 1 layer of think plastic (bin – liner) 60cm x 60cm
* High Voltage DC supply
* High voltage leads x2 and crocodile clips

Optional* Capacitors with ratings written on
* 1.5V cell x2
* Voltmeter (digital)
* Charge meter
 |
| **Risk Assessment** e.g. CLEAPSS card reference |
| High voltage danger – only use DC, keep pupils and staff away from the aluminium sheets, check classroom RCCD unit prior to lesson |
| **Working Scientifically (HSW)** |
| Uses of capacitors (Slide #7 and page 381) |

Images courtesy of:

Slide #1 - <https://commons.wikimedia.org/wiki/File%3AMultiple_Lightning_Strikes.jpg> from <http://www.photolib.noaa.gov/>

Slide #2 - Wikipedia (Public Domain)

Slide #3 - http://pgfplots.net/tikz/examples/cylinder-spiral/

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| **Lesson Number: 23.2** |
| **Lesson Title: Energy stored in a charged capacitor** |
| **Specification Reference** | **3.7.4.1, 3.7.4.3** |
| **Learning Objectives** |
| Definition of capacitance: Interpretation of the area under a graph of charge against pd. |
| **Opportunities for Assessment** |
| Page 383 questions |
| **Starter:** | Slide #1 should enable pupils to revise their formulae knowledge from AS level and recent lessons on charges and fields |
| **Main:** | Slide #2 works slowly through defining the main formulae for this lesson. Be careful to ensure pupils understand that the vertical axis p.d. is the p.d. on the plates **not** the charging p.d. – Pupils often struggle knowing which formula to use so practice with selecting them is crucial hereSlide #3 has a key learning point that 50% of the energy is wasted. Even if pupils do not understand why this occurs it is critical that they remember it as a simple rule.Slide #4 explains a simple experiment to measure the energy dissipated by a charged capacitor. If joule-meters are not available then monitoring current flow over time and plate p.d. can yield results that will give an estimate. |
| **Plenary:** | Slide #5 is summary |
| **Homework:** | Page 383 questions, research lightning |
| **Differentiation / Extension / S&C** |
| Links to thunderstorms; discussion of energy and area under a graph |
| **Numeracy / Literacy** | **SMSC / Fundamental British Values** |
| Area under a graph, selection of formulae | Energy stored in devices, application of physics |
| **RESOURCES:**Sets of: |
| * Joule-meter
* 1.5V bulb and holder
* Capacitor (Variety can be used although larger capacitance work better)
* Low voltage supply (DC)
 |
| **Risk Assessment** e.g. CLEAPSS card reference |
| None (Very large capacitors and 12V supply can be dangerous e.g. car ignition systems) due to large discharges |
| **Working Scientifically (HSW)** |
| Lightning and energy calculations – page 383 |

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| **Lesson Number: 23.3** |
| **Lesson Title: Charging and discharging a capacity through a fixed resistor** |
| **Specification Reference** | **3.7.4.4** |
| **Learning Objectives** |
| Graphical representation of charging and discharging of capacitors through resistors.Corresponding graphs for *Q*, *V* and *I* against time for charging and discharging.Time constant *RC*.Calculation of time constants including their determination from graphical data.Time to halve, *T*½ = 0.69*RC*Quantitative treatment of capacitor discharge, Use of the corresponding equations for *V* and *I*.Quantitative treatment of capacitor charge,  |
| **Opportunities for Assessment** |
| Page 387 questions |
| **Starter:** | Slide #1 enables discussion of the shape of a graph looking at discharge from a capacitor, students should be able to realise that it will be exponential decay |
| **Main:** | Slides #2 - #4 go through the simple graph shapes and the extraction from a curved graph of the time constant – Note that AQA do **not** use **Tau** as a time constant however to completeness the PowerPoints start from this and move onto *RC*Slide #5 poses a hinge question – depending on the student’s use of natural logs the next few slides are a recap / teaching aid of logsSlides #6 - #8 are a quick teaching of logs and exponential decay formulaeSlide #9 is the main slide that derives the formulae for exponential decay in capacitor, it has some animation so check it works on your screenSlides #10 - #12 extend to charging a capacitor (note the change in the formula for the growth curve) and also link to half-life and total time to discharge (Essential exam points)The next lesson is the required practical (number 9) so planning this or extending this lesson into a discussion of the equipment needed is appropriate |
| **Plenary:** | Slide #13 is a summary |

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| **Homework:** | Page 387 questions, research of the uses of a time constant in physics, planning required practical |
| **Differentiation / Extension / S&C** |
| Derivation of natural log formulae |
| **Numeracy / Literacy** | **SMSC / Fundamental British Values** |
| Formula use and derivationExponential decay curves and growth formulae | Use of decay constant in everyday physics, application of *RC* circuits |
| **RESOURCES:** |
| None |
| **Risk Assessment** e.g. CLEAPSS card reference |
| None |
| **Working Scientifically (HSW)** |
| None |

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| **Lesson Number: 23.3a** |
| **Lesson Title: Investigation of the charge and discharge of capacitors****Required Practical 9** |
| **Specification Reference** | **3.7.4.4** |
| **Learning Objectives** |
| Graphical representation of charging and discharging of capacitors through resistors.Corresponding graphs for *Q*, *V* and *I* against time for charging and discharging.Time constant *RC*.Calculation of time constants including their determination from graphical data.Quantitative treatment of capacitor discharge, Use of the corresponding equations for *V* and *I*.Quantitative treatment of capacitor charge,  |
| **Opportunities for Assessment** |
| Assessing the practical aspect of the lesson**Skills Assessment (Required practical 3)**AT (b),(f),(g),(h),(k) – Note that “h” requires oscilloscope usage and would best suit a demo in another lesson |
| **Starter:** | Recap capacitor charging and discharge from last lesson (Slides #1 and #2) |
| **Main:** | Slide #3 explains to students that their teacher will decide how much dependence they are given in this experiment. See pages 61 and 62 of the AQA practical handbook for Physics for full detailsSlide #4 outlines the assessed skills that will be looked at by the teacher. Students should keep these in mind and ensure that their teacher watches them perform these skills during the practical.Depending on the outcomes that the teacher wishes to assess, the pupils can either be given a method to follow or a lesson can be used as a full research and planning sessionThe experiment needs to be performed. See pages 96 to 99 of the practical handbook for A-Level Physics for full details. |
| **Plenary:** | Go over the experiment and the results; write up the experiment in full; discuss the assessing of the skills and the outcome assessed by the teacher. |

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| **Homework:** | Write up the experiment |
| **Differentiation / Extension / S&C** |
| Assistance / guidance on the planning of the experiment can be altered for group’s ability |
| **Numeracy / Literacy** | **SMSC / Fundamental British Values** |
| Use of natural logs and exponential formulae | Team work in a practical lessonUnderstanding other people’s opinions and ideas in the planning of the experiment |
| **RESOURCES:**PRACTICAL 9 - AQA Notes and Method – (1 copy unless specified additional methods) |
| Per group:* Stop-clock
* electrolytic capacitors ( suitable values: 1000µF, 2200µF, 4700µF)
* resistors (0.25W carbon film, values in the range 10kΩ to 100kΩ)
* battery 3V, 6V or 9V
* digital voltmeter, range 0 – 10V
* SPDT (single pole double throw) switch
* connecting leads
 |
| **Risk Assessment** e.g. CLEAPSS card reference |
| Ensure that capacitors are connected the correct polarity when chargingResistors can get hot if a current is accidently run through them instead of charging a capacitor |
| **Working Scientifically (HSW)** |
| Assessed practical and write-up |

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| **Lesson Number: 23.4** |
| **Lesson Title: Dielectrics** |
| **Specification Reference** | **3.7.4.2** |
| **Learning Objectives** |
| Dielectric action in a capacitor Relative permittivity and dielectric constant.Students should be able to describe the action of a simple polar molecule that rotates in the presence of an electric field. |
| **Opportunities for Assessment** |
| Page 391 questions |
| **Starter:** | Slide #1 links back to static electricity and inducing a dipole effect in neutral molecules |
| **Main:** | Slide #2 shows how a dielectric fits between the plates and what its function isSlides #3 and #4 explain the calculation of the dielectric constant as well as some examplesSlide #5 contains important exam points on capacitor design and then defines the formula based on them – note that the permittivity of free space is epsilon noughtSlide #6 is a brief outline of the three main polarisation methods – see page 390 of the course book for more details (possible research homework)Slide #7 highlights the order in which the three mechanisms decrease in an alternating field |
| **Plenary:** | Slide #8 is a summary |
| **Homework:** | Page 391 questions, research polarisation mechanisms |
| **Differentiation / Extension / S&C** |
| Discuss the idea of inertia and why the polarisation mechanisms decrease in the order that they do |
| **Numeracy / Literacy** | **SMSC / Fundamental British Values** |
| Formula use and ratios | Capacitor applications and design, linking physics to engineering |
| **RESOURCES:** |
| Optional – An old capacitor, large style, opened up to see the construction |
| **Risk Assessment** e.g. CLEAPSS card reference |
| None |
| **Working Scientifically (HSW)** |
| Page 391 – capacitor applications |

Photo on slide #1 courtesy of <https://www.flickr.com/photos/patdavid/4455723092>

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| **Lesson Number: 24.1** |
| **Lesson Title: Current-carrying conductors in a magnetic field** |
| **Specification Reference** | **3.7.5.1** |
| **Learning Objectives** |
| Force on a current-carrying wire in a magnetic field: *F* = *BIl* when field is perpendicular to current.Fleming’s left hand rule.Magnetic flux density B and definition of the tesla. |
| **Opportunities for Assessment** |
| Page 399 questions |
| **Starter:** | Slide #1 asks students to think of any possible link between electric and magnetic fields. They may realise that electromagnetism or motors incorporate both areas of physics |
| **Main:** | Slide #2 explains that moving charges create magnetic fieldsDemonstrate the plotting compasses being effected by a current carrying wireSlide #3 is interesting in that pupils get confused as to whether the North pole of the Earth is a north seeking or South seeking poleSlide #4 explains the motor force acting on a wireDemonstration – place a wire from a low voltage unit (2-4V) between a pair of attracting magnets. See the wire move when the power is switched on – Optional use AC to watch the wire shudderSlide #5 is a bit of extension – the maths for angular intercepts of current and magnetism are not needed for A-LevelSlides #6 - #8 define the unit of the Tesla as well as giving some examplesSlide #9 explains Flemming’s left-hand ruleSlide #10 explains the torque effect in a motor – link to any previous work on motors and moments |
| **Plenary:** | Slide #11 is a summary |

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| **Homework:** | Page 399 questions; research the electric motor and its history, research Tesla |
| **Differentiation / Extension / S&C** |
| Extend the idea of motor force beyond the syllabus to include any angle |
| **Numeracy / Literacy** | **SMSC / Fundamental British Values** |
| Units and formulae | Nikola Tesla and his research, arguments about AC / DC safety for houses |
| **RESOURCES:** |
| Demonstrations:* LV supply
* Insulated wire (approx. 1m)
* Bar magnets x2 and holder (U shaped)
* Plotting compass
 |
| **Risk Assessment** e.g. CLEAPSS card reference |
| Wires can get hot, do not exceed 4V, internal fuses can go on LV packs if used for more than a few seconds as this demonstration is a short circuit |
| **Working Scientifically (HSW)** |
| “The electric motor” page 398 |

Pictures courtesy of:

Slides #1, #7 and #9 – Wikipedia

Slide #2 - [https://www.flickr.com/photos/121935927@N06/13580502213](https://www.flickr.com/photos/121935927%40N06/13580502213)

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| **Lesson Number: 24.1a** |
| **Lesson Title: Investigation of the of the relationship between the force, magnetic flux density, current and length of wire using a top pan balance****Required Practical 10** |
| **Specification Reference** | **3.7.5.1** |
| **Learning Objectives** |
| Force on a current-carrying wire in a magnetic field: *F* = *BIl* when field is perpendicular to current. |
| **Opportunities for Assessment** |
| Assessing the practical aspect of the lesson**Skills Assessment (Required practical 3)**AT (a),(b),(f) |
| **Starter:** | Recap magnetic flux and motor force from last lesson (Slides #1 and #2) |
| **Main:** | Slide #3 explains to students that their teacher will decide how much dependence they are given in this experiment. See pages 100-102 of the AQA practical handbook for Physics for full detailsSlide #4 outlines the assessed skills that will be looked at by the teacher. Students should keep these in mind and ensure that their teacher watches them perform these skills during the practical.Depending on the outcomes that the teacher wishes to assess, the pupils can either be given a method to follow or a lesson can be used as a full research and planning sessionThe experiment needs to be performed. See pages 100-104 of the practical handbook for A-Level Physics for full details. |
| **Plenary:** | Go over the experiment and the results; write up the experiment in full; discuss the assessing of the skills and the outcome assessed by the teacher. |

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| **Homework:** | Write up the experiment |
| **Differentiation / Extension / S&C** |
| Assistance / guidance on the planning of the experiment can be altered for group’s ability |
| **Numeracy / Literacy** | **SMSC / Fundamental British Values** |
| Use of formula ***F=BIL*** | Team work in a practical lessonUnderstanding other people’s opinions and ideas in the planning of the experiment |
| **RESOURCES:**PRACTICAL 10 - AQA Notes and Method – (1 copy unless specified additional methods) |
| Per group:* A 25cm length of straight bare copper wire of thickness 1.5mm, for example
* Low voltage variable DC supply (eg 0-6V)
* Ammeter (eg 0-10A with 0.1A precision or better)
* Two crocodile clips
* Two clamps on stands
* Three connecting leads
* Four magnadur magnets with a metal cradle
* An electronic top pan balance with precision 0.1g or better
* 30cm ruler
 |
| **Risk Assessment** e.g. CLEAPSS card reference |
| Wires can get hot, do not exceed 4V, internal fuses can go on LV packs if used for more than a few seconds as this demonstration is a short circuit |
| **Working Scientifically (HSW)** |
| Assessed practical and write-up |

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| **Lesson Number: 24.2** |
| **Lesson Title: Moving charges in a magnetic field** |
| **Specification Reference** | **3.7.5.2** |
| **Learning Objectives** |
| Force on charged particles moving in a magnetic field, *F* = *BQv* when the field is perpendicular to velocity.Direction of force on positive and negative charged particles. |
| **Opportunities for Assessment** |
| Page 402 questions |
| **Starter:** | Slide #1 allows the students to discuss and think about extending the previous lesson on current carrying conductors to individual particles |
| **Main:** | Slide #2 introduces the Maltese cross experiment – Demonstrate this now using a bar magnet (Ensure the N-S are labelled in the magnet)Slide #3 is a quick explanation of the motor force on particles and hints at some homework research (CERN) that could be setSlide #4 is a picture courtesy of CERN of a high energy collision in a magnetic fieldSlide #6 derives the formula for particles *F=BQv*Slide #7 is an extension slide, not needed for A-level |
| **Plenary:** | Slide #8 is a summary |

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| **Homework:** | Page 402 questions, research CERN and cyclotrons, research Hall probes |
| **Differentiation / Extension / S&C** |
| Extending the maths to any angle using trigonometric functions |
| **Numeracy / Literacy** | **SMSC / Fundamental British Values** |
| Use and derivation of formula | CERN, particle physics and the collaboration of scientists and governments |
| **RESOURCES:** |
| Demonstration:* Maltese cross experiment and high voltage power supply
* Bar magnet with North / South labelled
 |
| **Risk Assessment** e.g. CLEAPSS card reference |
| High voltage is dangerous – precautions must be taken to ensure that nobody can touch the live metal, use high voltage insulated wiresTest the laboratory RCCD system prior to using high voltage equipment |
| **Working Scientifically (HSW)** |
| “Hall Probe” on page 401 |

Pictures courtesy of:

Slide #1 – Wikipedia

Slide #2 by Chris Burks Chetvorno (Own work) [Public domain], via Wikimedia Commons

Slide #4 by Lucas Taylor / CERN (http://cdsweb.cern.ch/record/628469) [CC BY-SA 3.0 (http://creativecommons.org/licenses/by-sa/3.0)], via Wikimedia Commons

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| **Lesson Number: 24.3** |
| **Lesson Title: Charged particles in circular orbits** |
| **Specification Reference** | **3.7.5.2** |
| **Learning Objectives** |
| Force on charged particles moving in a magnetic field, *F* = *BQv* when the field is perpendicular to velocity.Direction of force on positive and negative charged particles.Circular path of particles; application in devices such as the cyclotron. |
| **Opportunities for Assessment** |
| Page 405 questions |
| **Starter:** | Slide #1 enables a discussion about CERN and the projects done there – circular paths are needed both to steer the particles and to analyse the results |
| **Main:** | Slide #2 introduces the idea that particles will follow circular orbits in magnetic fields. The diagram also allows the use of Flemming’s left hand rule to describe the motion of the charges. Note the circle and dot represents the magnetic field coming out of the pictureSlide #3 is a mathematical derivation of the formula to calculate the radius of the circle described by a charged particle moving in a magnetic fieldSlides #4 and #5 explain two uses of this technology; the aurora on planet Earth are a nice research topic |
| **Plenary:** | Slide #6 is a summary |
| **Homework:** | Page 405 questions; research CERN and particle accelerators |
| **Differentiation / Extension / S&C** |
| Extended research on why particles make spirals in accelerator experiments |
| **Numeracy / Literacy** | **SMSC / Fundamental British Values** |
| Derivation of formula | CERN and other experiments that require international collaboration and team work |
| **RESOURCES:** |
| Optional Demo:* Helmholtz coils demonstration
 |
| **Risk Assessment** e.g. CLEAPSS card reference |
| Helmholtz coils use high voltages and precautions must be made to ensure live circuitry cannot be touched, including the use of fully insulated high voltage wiresThe laboratory RCCD system should be tested prior to high voltage equipment being used. |
| **Working Scientifically (HSW)** |
| Page 404 – The cyclotron / Mass Spectrometer |

Pictures courtesy of:

Slide #1 – Ryan Boyles, CERN - [https://www.flickr.com/photos/136478526@N02/22386330902](https://www.flickr.com/photos/136478526%40N02/22386330902)

Slide #2 – Wikipedia

Slide #5 - Devon Fyson [Public domain or Public domain], via Wikimedia Commons

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| **Lesson Number: 25.1** |
| **Lesson Title: Electromagnetic Induction** |
| **Specification Reference** | **3.7.5.4** |
| **Learning Objectives** |
| Applications such as a straight conductor moving in a magnetic field. |
| **Opportunities for Assessment** |
| Page 412 questions |
| **Starter:** | Slide #1 recaps the components of a dynamo or motor |
| **Main:** | Slide #2 explains the components in more detail and how to increase the output of a dynamo or motor (in reverse)Demonstrate the bar magnet in a coil of wire with a micro-ammeter hereSlides #3 - #4 explain the differences between a motor and a dynamoSlide #5 can be used to set homework in researching Michael Faraday – it also highlights the importance of scientific research for research sake; nobody knows what CERN will discover or more importantly what those discoveries will be used for hundreds of years in the future.Slide #6 introduces Flemming’s Right-hand rule – recap the left-hand rule if necessary |
| **Plenary:** | Slide #7 is a summary |

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| **Homework:** | Page 412 questions; Research the life of Michael Faraday |
| **Differentiation / Extension / S&C** |
| Extended discussion on the opinions of research; do goals limit research? |
| **Numeracy / Literacy** | **SMSC / Fundamental British Values** |
| N/A | Research and funding implications |
| **RESOURCES:** |
| Demonstration:* Bar magnet
* Coil of wire
* Micro-ammeter

Optional Demo:* Dynamo / motor on a circuit board with a crank to turn
* Bulb and connecting wires
 |
| **Risk Assessment** e.g. CLEAPSS card reference |
| None |
| **Working Scientifically (HSW)** |
| N/A |

Pictures courtesy of:

Slides #1 and #3 – Wikipedia

Slide #4 – Patrik Nygen: <https://www.flickr.com/photos/lattefarsan/18189497353>

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Slide #6 by Douglas Morrison DougM (en.wiki) [GFDL (http://www.gnu.org/copyleft/fdl.html) or CC-BY-SA-3.0 (http://creativecommons.org/licenses/by-sa/3.0/)], via Wikimedia Commons

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| **Lesson Number: 25.2** |
| **Lesson Title: The laws of electromagnetic induction** |
| **Specification Reference** | **3.7.5.3 / 3.7.5.4** |
| **Learning Objectives** |
| Magnetic flux defined by where *B* is normal to *A*.Flux linkage as where *N* is the number of turns cutting the flux.Flux and flux linkage passing through a rectangular coil rotated in a magnetic field: flux linkageFaraday’s and Lenz’s laws.Magnitude of induced emf = rate of change of flux linkage  |
| **Opportunities for Assessment** |
| Page 416 questions |
| **Starter:** | Slide#1 recaps previous work (KS3, KS4) on solenoids |
| **Main:** | Slides #2 - #4 show a method for applying Lenz’s law to working out the current direction that is induced in a solenoid due to the insertion of a magnet – There are many methods for doing this but this system of lettering seems to lodge in students minds easiest!Demonstration dropping the Neodymium magnet to be done after slide #2Demonstration showing reversing current to be done after slide #4Slides #5 - #10 are step by step work-through of the formulae and derivation of each. A useful activity is to get pupils to start listing all the ways of calculating each variable and then testing each other on the units (Volts, Tesla, Webber) of each one. |
| **Plenary:** | Slides #11 and #12 are the summary |

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| **Homework:** | Page 416 questions, research electric cars and regenerative braking systems |
| **Differentiation / Extension / S&C** |
| Discussion and self-creation of Lenz’s law from ideas about Solenoids |
| **Numeracy / Literacy** | **SMSC / Fundamental British Values** |
| Numerous formulae and units for magnetic flux, flux density flux linkage and *emf* | N/A |
| **RESOURCES:**Demonstration: |
| * Small Neodymium magnet
* Copper pipe (or any non-magnetic metal pipe) about 1m long and slightly larger diameter than the magnet

Demonstration:* Bar magnet
* Coil of wire
* Micro-ammeter
 |
| **Risk Assessment** e.g. CLEAPSS card reference |
| None however Neodymium magnets are brittle and should not be allowed to drop onto the floor |
| **Working Scientifically (HSW)** |
| “Regenerative braking” page 414 |

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Slides #1, #2 - By Svjo (Own work) [CC BY-SA 3.0 (http://creativecommons.org/licenses/by-sa/3.0)], via Wikimedia Commons

Slide #3 (Coil) - By Zureks (Own work) [Public domain], via Wikimedia Commons

Slide #3 (Magnet) - Wikipedia

Slide #4 (Right hand grip rule) - By The original uploader was Schorschi2 at German Wikipedia (Eigene Zeichnung) [Public domain or Public domain], via Wikimedia Commons

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| **Lesson Number: 25.3** |
| **Lesson Title: The alternating current generator** |
| **Specification Reference** | **3.7.5.4** |
| **Learning Objectives** |
| Magnitude of induced emf = rate of change of flux linkage Applications such as a straight conductor moving in a magnetic field.emf induced in a coil rotating uniformly in a magnetic field:Sinusoidal voltages and currents only; root mean square, peak and peak-to-peak values for sinusoidal waveforms only.Use of an oscilloscope as a dc and ac voltmeter, to measure time intervals and frequencies, and to display ac waveforms.No details of the structure of the instrument are required but familiarity with the operation of the controls is expected. |
| **Opportunities for Assessment** |
| Page 419 questions |
| **Starter:** | Slide #1 is an introduction to AC current – This is a good opportunity to use the oscilloscope to display a low voltage AC current trace, students require this skill in the required practical (Technique *h*) |
| **Main:** | Slides #2 - #4 go through the mathematics of the main formulae; it is useful on slide #4 t draw a sine wave on the board and show how the rate of change of cos is a sine waveSlide #5 explains a DC generator – link to the use of a split commutator in a DC motorSlide #6 and #7 explains the phases in the UK mains and the 3 phase system |
| **Plenary:** | Slides #8 and #9 are summaries |

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| **Homework:** | Page 419 questions; research the three phase alternator and the National Grid |
| **Differentiation / Extension / S&C** |
| Discussion on the DC from an LV unit |
| **Numeracy / Literacy** | **SMSC / Fundamental British Values** |
| Formulae and gradients of waves | National Grid and its effect on human life over the last 100 years |
| **RESOURCES:** |
| Demonstration:* Oscilloscope
* Low voltage AC power pack
 |
| **Risk Assessment** e.g. CLEAPSS card reference |
| None |
| **Working Scientifically (HSW)** |
| Power station alternators and three phase systems (Page 419) |

Pictures courtesy of:

Slide #5 – Wikipedia <https://upload.wikimedia.org/wikipedia/commons/d/da/Waveform_fullwave_rectifier.png>

Slide #7 - By User:J JMesserly modification of original svg by User:SiriusA (File:3-fas-spänningar.svg) [CC BY 3.0 (http://creativecommons.org/licenses/by/3.0) or Public domain], via Wikimedia Commons

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| **Lesson Number: 25.4** |
| **Lesson Title: Alternating current and power** |
| **Specification Reference** | **3.7.5.5** |
| **Learning Objectives** |
| Sinusoidal voltages and currents only; root mean square, peak and peak-to-peak values for sinusoidal waveforms only. Application to the calculation of mains electricity peak andpeak-to-peak voltage values.Use of an oscilloscope as a dc and ac voltmeter, to measure time intervals and frequencies, and to display ac waveforms.No details of the structure of the instrument are required but familiarity with the operation of the controls is expected. |
| **Opportunities for Assessment** |
| Page 422 questions |
| **Starter:** | Slide #1 enables the recap and discussion of AC supply and also sine waves and the key words amplitude, frequency, peak, trough, time period |
| **Main:** | Slides #1 - #3 go through the general AC supply units and measurements. Slide #4 shows an oscilloscopeSlides #5 - #7 go through the use of an oscilloscope and test the pupil’s ability to use one to get meaningful data. – Note that if these were not used in the required practical or a student was off then write up this experiment and it can be used as technique (h)Slides #8 and #9 explain the mathematical use of *root mean squared* calculations and applies them to AC potential difference and current – the calculation of 230V here often answers questions posed earlier about why we say the mains is 230V but it peaks at 325V |
| **Plenary:** | Slide #10 is a summary |

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| **Homework:** | Page 422 questions |
| **Differentiation / Extension / S&C** |
| Development and history of the main electrical system; DC vs AC arguments for mains electricity |
| **Numeracy / Literacy** | **SMSC / Fundamental British Values** |
| Root mean squared calculationsReading from an oscilloscope | Health and safety of AC electricity |
| **RESOURCES:** |
| Group sets of:* Low voltage power supply (AC)
* Connecting leads (for oscilloscope)
* Oscilloscope
 |
| **Risk Assessment** e.g. CLEAPSS card reference |
| No dangers however use only 2V with oscilloscopes |
| **Working Scientifically (HSW)** |
| N/A |

Pictures courtesy of:

Slide #1 – Wikipedia

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| **Lesson Number: 25.5** |
| **Lesson Title: Transformers** |
| **Specification Reference** | **3.7.5.6** |
| **Learning Objectives** |
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| **Opportunities for Assessment** |
| Page 424 questions |
| **Starter:** | Slide #1 is a recap of transformers and their uses and limitations, note that pupils who did not do further physics at GCSE will have no prior knowledge of calculations |
| **Main:** | Slides #2 and #3 describe the design of a transformer – do not dwell too long on the picture as it appears again in slide #6Slides #4 - #6 derive the transformer formula and the picture on slide #6 enables discussion / examples to be created to practice it’s useDemonstration:* Connect a bulb (low voltage, low power) in a holder to a wire 2m in a loop
* Connect a wire (2m) from positive to negative of an Low Voltage power supply set to 2V
* Coil both wires around U shaped laminated cores
* Turn on the power supply (this will make one core an electromagnet) and clip the cores together – the bulb should light up
* Repeat with differing numbers of coils in the secondary coil

Slides #7 - #9 go through the efficiency of a transformers and designs that assist in making them almost 100% efficient. Slide #9 also explains why transformers draw very little current when plugged in but not used to power something. – Extension, ask pupils why this is and see if they can work it outSlide #10 explains why the National Grid uses step up transformers and recaps the formula for the power of an AC supply as an example |
| **Plenary:** | Slide #11 is a summary |

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| **Homework:** | Page 424 questions |
| **Differentiation / Extension / S&C** |
| Inside a phone charger / use of diodes page 423 converting AC to DC |
| **Numeracy / Literacy** | **SMSC / Fundamental British Values** |
| Transformer formulaUse of ratios | AC / DC safety and chargers in the home |
| **RESOURCES:** |
| Demonstration:* Low voltage power supply (AC)
* 2m insulated wires
* Low voltage, low power bulb in holder connected to a loop of wire (2m)
* 2 x U-shaped laminated iron cores
 |
| **Risk Assessment** e.g. CLEAPSS card reference |
| None although the primary coil is a short circuit so keep to 2V and turn off when not in use; trip switch in LV power supply may trip out. |
| **Working Scientifically (HSW)** |
| AC to DC transformers / National Grid |

Pictures courtesy of:

Slide #3, #6 & #7 – Wikipedia

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| **Lesson Number: 25.5a** |
| **Lesson Title: Investigation, using a search coil and oscilloscope, the effect on the magnetic flux linkage of varying the angle between a search coil and magnetic field direction****Required Practical 11** |
| **Specification Reference** | **3.7.5.3** |
| **Learning Objectives** |
| Magnetic flux defined by where *B* is normal to *A*.Flux linkage as where *N* is the number of turns cutting the flux.Flux and flux linkage passing through a rectangular coil rotated in a magnetic field: flux linkageFaraday’s and Lenz’s laws.Magnitude of induced *emf* = rate of change of flux linkage  |
| **Opportunities for Assessment** |
| Assessing the practical aspect of the lesson**Skills Assessment (Required practical 11)**AT (a),(b),(f),(h) |
| **Starter:** | Recap oscilloscope use and magnetic flux linkage previous lessons (Slides #1 and #2) – Note that this experiment links to lesson 25.2 however waiting until the end of the chapter ensures they have had as much practice as possible with oscilloscopes first |
| **Main:** | Slide #3 explains to students that their teacher will decide how much dependence they are given in this experiment. See pages 105-106 of the AQA practical handbook for Physics for full detailsSlide #4 outlines the assessed skills that will be looked at by the teacher. Students should keep these in mind and ensure that their teacher watches them perform these skills during the practical.Depending on the outcomes that the teacher wishes to assess, the pupils can either be given a method to follow or a lesson can be used as a full research and planning sessionThe experiment needs to be performed. See pages 105-109of the practical handbook for A-Level Physics for full details. |
| **Plenary:** | Go over the experiment and the results; write up the experiment in full; discuss the assessing of the skills and the outcome assessed by the teacher. |

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| **Homework:** | Write up the experiment |
| **Differentiation / Extension / S&C** |
| Assistance / guidance on the planning of the experiment can be altered for group’s ability |
| **Numeracy / Literacy** | **SMSC / Fundamental British Values** |
| Use of formula  | Team work in a practical lessonUnderstanding other people’s opinions and ideas in the planning of the experiment |
| **RESOURCES:**PRACTICAL 11 - AQA Notes and Method – (1 copy unless specified additional methods) |
| Per group:* oscilloscope
* large circular coil
* Stand (or support) for circular coil
* Low voltage 50Hz AC supply (or AF signal generator)
* Connecting leads
* protractor
* Axial or lateral search coil
* Stand, boss and clamp to support search coil
 |
| **Risk Assessment** e.g. CLEAPSS card reference |
| Ensure that the voltage supply matches the requirements of the coil to avoid damage to the equipment through heating – turn off when not in use. |
| **Working Scientifically (HSW)** |
| Assessed practical and write-up |