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**Knowledge Rich Curriculum Plan**

Science – Physics

Year 13



| **Science** **Year 13 Physics**  | **Unit:** Fields and Their Consequences |  |  |
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| **Lesson/Learning Sequence**  | **Intended Knowledge:***Students will know that…* | **Tiered Vocabulary**  | **Prior Knowledge:***In order to know this students, need to already know that…* |
| **Lesson:** **Fields** | * Students will know that a force field is a region in which a body will experience a non-contact force
* Students will know that force fields arise from interactions of mass, static charge and between moving charges
* Students will know how to represent force fields using diagrams
 | Force field: a region in which a body will experience a non-contact force | * ***Students need to already know that non-contact forces are forces that have an affect without the interacting objects touching***
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| **Lesson:** **Newton’s Law of Gravitation** | * Students will know that any object with mass will experience an attractive force if you put it in the gravitational field of another object
* Students will know that only object with a large mass have a significant effect.
* Students will know the force experienced by an object in a gravitational field is dependent on the gravitational constant, the 2 masses that are interacting and the distance between the two masses.
* Students will know how to solve problems using Newton’s law of gravitation equation
* Students will know that the law of gravitation is an inverse square law.
 |  | * ***Students need to already know gravity as a universal attractive force that acts between all matter***
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| **Lesson:** **Gravitational Field Strength** | * Students will know that when drawing force field diagrams the gravitational field lines are arrow showing the direction of the force the masses would feel in a gravitational field
* Students will know that Earth’s gravitational field is radial, so the lines of force meet at the centre of the Earth.
* Students will know the distance between the lines is linked with the relative strength of the force field.
* Students will know that close to Earth’s surface the field is almost uniform, and so the field lines are parallel and equally spaced.
* Students will know that gravitational field strength is the force per unit mass.
* Students will know that in a radial field gravitational field strength is inversely proportional to r2
* Students will know how to solve problems involving gravitational field strength equations
* Students will know how to represent the change in gravitational field strength with the distance between the objects.
 |  | * ***Students need to already know how to represent force fields using diagrams***
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| **Lesson:** **Gravitational Potential** | * Students will know that gravitational potential, V, at a point is the gravitational potential energy that a unit mass at that point would have.
* Students will know that gravitational potential is negative at the surface of a mass and increases with distance from the mass.
* Students will know that gravitational potential is negative because you have to do work against the gravitational field to move an object out of it.
* Students will know how to solve problems involving gravitational potential in a radial field.
* Students will know that gravitational field strength is calculated from the change in gravitational potential divided by the amount the distance changes
* Students will know that the gradient of a V vs r graph give the value for gravitational field strength at that point
* Students will know that the area under a g vs r graph gives the change in gravitational potential.
* Students will know that moving an object involves doing work against the force of gravity.
* Students will know that work done is equal to the mass of the object multiplied by the change in gravitational potential
* Students will know that equipotentials are lines that join all the same points that have the same potential.
* Students will know that equipotentials and field lines are perpendicular.
 | Equipotentials: lines in field diagrams that join all the same points that have the same potential. | * ***Students need to already know gravitational forces act between two objects with mass***
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| **Lesson:** **Orbits of Planets and Satellites** | * Students will know that T2 is proportional to r3
* Students will know how to derive the fact that T2 is proportional to r3
* Students will know that an orbiting satellite has kinetic energy and potential energy, and that its total energy is always constant.
* Students will know that an object in circular orbit has speed and distance remaining constant. This means that kinetic energy and potential energy are both constant.
* Students will know that in an elliptical orbit a satellite will speed up as its height decreases due to the total energy needing to be conserved. When the object is closer to the surface of the planet it has less potential energy, so kinetic energy must increase
* Students will know that a synchronous orbit is an orbit where the period of the orbiting object is the same as the rotational period of the orbited object.
* Students will know that geostationary satellites are always above the same point on Earth.
* Students will know that uses of geostationary orbits include TV and telephone signals.
* Students will know that low orbiting satellites are satellites which orbit between 180-2000 km
* Students will know that these satellites are cheaper as they required less energy to launch and less powerful transmitters.
* Students will know that low orbiting satellites are close enough to see Earth’s surface in a high level of detail.
* Students will know that the whole of Earth’s surface can be scanned using low orbiting satellites.
* Students will know that the escape velocity is the velocity a mass must travel at to escape the gravitational field.
* Students will know that at this point gravitational potential energy and kinetic energy must be equal.
* Students will know how to derive the escape velocity equation.
 | Synchronous orbit: an orbit where the period of the orbiting object is the same as the rotational period of the orbited object | * ***Students need to already know that gravity is the centripetal force acting on planets as they orbit the Sun***
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| **Lesson:** **Electric Fields and Coulomb’s Laws** | * Students will know that any object with a charge has an electric field around it.
* Students will know that electric fields can either attract or repel other charges.
* Students will know that if a charged object is a sphere you can assume all of its charge is at its centre.
* Students will know that Coulomb’s law gives the force of attraction between two point charges in a vacuum
* Students will know that Coulomb’s law is an inverse square law.
* Students will know that the size of the force depends on permittivity and the distance the two charges are from each other.
* Students will know that when drawing field diagrams for electric fields the arrows point in the direction a positive charge would move in.
* Students will know that air can be treated as a vacuum for calculations.
 |  | * ***Students need to already know that a force field is an area around an object where non-contact forces act***
* ***Students need to already know how to represent fields using diagrams***
* ***Students need to already know that the unit of charge is Coulombs***
* ***Students need to already know that like charges repel and opposite charges attract***
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| **Lesson:** **Electric Field Strengths** | * Students will know that electric field strength, E, is defined as the force per unit positive charge.
* Students will know how to solve problems involving electric field strength,
* Students will know that the units of E are newtons per coulomb.
* Students will know that a point charge as a radial field.
* Students will know that in a radial field, E is inversely proportional to r2
* Students will know that field strength decreases as you go further away from Q
* Students will know that a uniform electric field can be produced by connecting two parallel plates to the opposite poles of a battery.
* Students will know that the field strength is the same at all points between two plates in a uniform field.
* Students will know that in a uniform field, E is inversely proportional to the distance between the plates.
* Students will know that electric potential, V, is the electrical potential energy and a unit positive charge would have at that point.
* Students will know how to solve problems involving electric potential.
* Students will know that the magnitude of V is greatest at the surface of a charge, and zero at infinite distance away from the charge.
* Students will know that the gradient of a V vs r graph is equal to the electric field strength at that point.
* Students will know that potential difference is equal to the area under an electric field strength vs r graph.
* Students will know that electric potential difference is the energy needed ot move a unit charge.
* Students will know that the work done depends on the size of the charge and the size of the potential difference you’re moving it across.
* Students will know how to solve problems involving work done and potential differences.
* Students will know that a moving charged particle entering a uniform electric field at right angles would experience parabola movement.
* Students will know how to explain the trajectory of a moving charged particle entering a uniform electric field.
 |  | * ***Students need to already know how to represent electric fields***
* ***Students need to already know that the force felt between two point charges follows the inverse square line.***
* ***Students need to already know that equipotentials are points where the charges would have equal electric potential***
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| **Lesson:** **Gravitational fields vs electric fields** | * Students will know that both gravitational fields and electric fields are inverse squares.
* Students will know that forces caused by electric fields can be attractive or repulsive, whereas the forces caused by gravitational fields are attractive only.
* Students will know that the magnitude of forces caused by electric fields felt by subatomic particles are much larger than the forces caused by gravitational fields.
 |  | * ***Students need to already know that gravitational fields act between point masses***
* ***Students need to already know that gravitational fields follow the inverse square law.***
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| **Lesson:** **Capacitors** | * Students will know that capacitance is the amount of charge per unit potential difference.
* Students will know that the unit of capacitance is farad.
* Students will know that a capacitor is made up of two conducting plates separated by a gap/ dielectric
* Students will know that a dielectric is an insulating material made up of polar molecules.
* Students will know how that when no charge is applied to a dielectric the polar molecules all point in random directions
* Students will know that when a charge is applied to a dielectric the polar molecules all line themselves up.
* Students will know that when a capacitor is connected to a power source, positive and negative charge build up on the opposite plates, creating a uniform electric field.
* Students will know that permittivity is a measure of how difficult it is to generate an electric field in a certain material.
* Students will know that relative permittivity is the ratio of the permittivity of a material to the permittivity of free space.
* Students will know that relative permittivity is sometimes called the dielectric constant.
* Students will know how to calculate the capacitance of a capacitor using the dimensions of capacitor and the permittivity of the dielectric.
* Students will know that electrical energy is stored by capacitors.
* Students will know that the area under a graph of charge vs p.d. gives the energy stored.
* Students will know how to calculate energy store when given charge and p.d.
 | Relative permittivity: the ratio of the permittivity of a material to the permittivity of free space | * ***Students need to already know that charge is measured in coulombs and potential difference is measured in volts***
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| **Lesson:** **Charging and discharging** | * Students will know how to use the various energy calculations to measure the amount of electrical energy stored by a capacitor.
* Students will know that when a capacitor is connected to a power source it will build up charge
* Students will know that when the power source is disconnected from the capacitor the capacitor will become discharged
* Students will know that the time taken to charge or discharge a capacitor depends on the capacitance of the capacitor and the resistance of the circuit.
* Students will know how to calculate charge, potential difference and current as a capacitor charges and discharged
* Students will know that the time constant is = to RC.
* Students will know that the time constant is the time taken for the charge, potential difference or current of a discharging capacitor to fall to 37% of its value when fully charged, or the time taken for the charge or potential difference of a charging capacitor toe rise to 63% of its value when fully charged.
* Students will know that the larger the resistance in series with the capacitor, the longer it takes for it to discharge.
* Students will know that the time constant can be found using log-linear graphs of charge and time.
* Students will know how to calculate the time constant using log-linear graphs
* Students will know that the time taken to halve the potential difference, charge or current is = to 0.69RC
 |  | * ***Students need to already know that a capacitor is made up of two plates separated by a gap or a dielectric***
* ***Students need to already know how to calculate energy from charge and p.d***
* ***Students need to already know that capacitance is the amount of charge per unit potential difference***
* ***Students need to already know that resistance is measured in ohms***
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| **Lesson:** **Required Practical 9** | * Students will know how to investigate the charge and discharge of capacitors.
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| **Lesson:****Magnetic Fields** | * Students will know that conventional current flows from plus to minus.
* Students will know that when current flows in a wire a magnetic field is induced
* Students will know that a solenoid is a coil of wire, and that the field of a solenoid is similar to that of a bar magnet.
* Students will know that a current-carrying wire in an external magnetic field will feel a force. This is due to the field around the wire and the field from the magnets being added together.
* Students will know that the force is always perpendicular to both the current and the magnetic field.
* Students will know how to use Fleming’s left hand rule to determine the direction of the force.
* Students will know how to calculate the magnitude of the force.
 |  | * ***Students need to already know how to represent field diagrams***
* ***Students need to already know the magnetic field pattern for a bar magnet***
* ***Students need to already know that the arrows on a magnetic field line point from north to south***
* ***Students need to already know how to use the right hand grip rule and Fleming’s left hand rule***
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| **Lesson:****Required Practical 10** | * Students will know how to investigate how the force on a wire varies with flux density, current and length of wire using a top pan balance.
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| **Lesson:****Charged Particles in a Magnetic Field** | * Students will know how to calculate the magnitude of force felt by a charge moving in a magnetic field using the equation F = BQv
* Students will know that charged particles moving in a magnetic field are deflected in a circular path.
* Students will know how to use Fleming’s left hand rule to determine the direction the force of a moving charge would be felt (remembering that the index finger would represent the movement of a positive charge)
* Students will know how to complete calculations based on the circular motion of the charge.
* Students will know that the radius increases if the mass or velocity of a particle increases
* Students will know that the radius decreases if the strength of the magnetic field or the charge on the particle increases.
* Students will know that cyclotrons are particle accelerators
* Students will know that cyclotrons are made up of two hollow semi-circular electrodes with a uniform magnetic field applied perpendicular to the plane of the electrodes, with an alternating potential difference applied between the electrodes.
* Students will know that charged particles are fired into one of the electrodes, and the magnetic field makes them follow a circular path and leave the electrode.
* Students will know that the potential difference between the electrodes accelerates the particles across the gap, and because the speed is slightly higher the particle will follow a circular path with a larger radius. As the potential difference is reversed, the particle accelerates again between the electrodes. This process repeats as the particle spirals outwards, increasing in speed, before it exists the cyclotron.
 | Cyclotron: a particle accelerator | * ***Students need to already know that a charge moving in a magnetic field will experience a force***
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| **Lesson:** **Magnetic Flux** | * Students will know that magnetic flux density is the number of field lines per unit area.
* Students will know that the total magnetic flux, Φ, passing through an area, A, perpendicular to a magnetic field, B, is defined as Φ = BA.
* Students will know that the unit for magnetic flux is Weber, Wb
* Students will know that emf is induced when there’s relative motion between a conducting rod and a magnetic field.
* Students will know that emf in a flat coil or solenoid is induced by moving the coil towards or away from the poles of a magnet, or by moving a magnetic towards or away from the coil.
* Students will know that emf is induced due to the magnetic field passing through a coil changing.
* Students will know that more turns on a coil of wire means a bigger emf will be induced.
* Students will know that the size of emf induced depends on the magnetic flux passing through the coil, the number of turns in the coil that cut the flux.
* Students will know that the product of the magnetic flux and number of turns (NΦ) is called the flux linkage.
* Students will know that for a coil cutting a magnetic field perpendicularly: NΦ = BAN
* Students will know that the rate of change in flux linkage tells us how strong the emf will be.
* Students will know how to use trig if the magnetic flux isn’t perpendicular to the area.
 | Weber: Unit of magnetic flux | * ***Students need to already know that magnetic flux density, B, is a measure of the strength of the magnetic field***
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| **Lesson:****Required Practical 11** | * Students will know how to investigate the effect on magnetic flux linkage of varying the angle between a search coil and magnetic field direction.
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| **Lesson:****Induction** | * Students will know that Faraday’s law states that the induced emf is directly proportional to the rate of change of flux linkage.
* Students will know that the size of emf can be calculated by plotting a graph of flux linkage against time.
* Students will know that the area under the graph of magnitude of emf against time gives the flux linkage
* Students will know that Lenz’s law states that the induced emf is always in a direction as to oppose the change that caused it.
* Students will know that emf is a vector quantity so has both direction and magnitude.
* Students will know that Lenz’s law helps explain how energy is conserved.
* Students will know that alternating potential difference is induced by rotating a coil of wire in a magnetic field.
* Students will know that flux linkage and induced voltage are 90o out of phase.
* Students will know how to complete calculations involving flux linkage, magnetic flux and angular speed.
 |  | * ***Students need to already know that emf can be induced by moving a coil through a magnetic field***
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| **Lesson:****Alternating Currents** | * Students will know that in a circuit involving alternating current, the potential difference across a resistance goes up and down in a regular pattern.
* Students will know that oscilloscopes can be used to display the voltage of an alternating current.
* Students will know how to interpret oscilloscope traces.
* Students will know that from an oscilloscope you can determine time period, peak voltage and peak to peak voltage.
* Students will know that to compare the voltage of an alternating current and direct current supply you need to look at the root mean square voltage of an ac supply.
* Students will know how to calculate root mean square voltage and current.
* Students will know that average power is equal to the product of root mean square voltage and root mean square current.
* Students will know that mains electricity supply is around 230 V, which is the root mean square voltage.
 |  | * ***Students need to already know that an alternating current is one that changes direction with time***
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| **Transformers** | * Students will know that transformers work as an alternating current flowing through a primary coil produces magnetic flux. This changing magnetic flux passes through the iron core to the secondary coil, where it induces an alternating voltage of the same frequency.
* Students will know how to use the transformer equation.
* Students will know that transformers are not 100% efficient as some power is lost in the transformer through eddy currents and heat generated by resistance in the coils.
* Students will know that eddy current are looping currents induced by the changing magnetic flux in the core. These create a magnetic field that acts against the field that induced them, reducing the field strength.
* Students will know that the effect of eddy currents can be reduced by laminating the core with layers of insulation
* Students will know that the heat generated by resistance of the coils can be reduced by using thick copper wire (which has low resistance).
* Students will know how to calculate the efficiency of a transformer
* Students will know how to calculate the maximum possible current/ p.d. output
* Students will know how to calculate how much power has been wasted in a transmission across the National Grid.
 |  | * ***Students need to already know that step up transformers increase potential difference, and step down transformers decrease potential difference.***
* ***Students need to already know that transformers are part of the National Grid***
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