**7. MAGNETISM and ELECTROMAGNETISM**

1. Permanent and induced magnetism, magnetic forces and fields
2. The motor effect
3. Induced potential, transformers and the National Grid (physics only) (HT only)

|  |  |  |  |
| --- | --- | --- | --- |
|  | R | A | G |
| **4.7 Magnetism and electromagnetism** |  |  |  |
| *4.7.1 Permanent and induced magnetism, magnetic forces and fields* |  |  |  |
| **4.7.1.1 Poles of a magnet** |  |  |  |
| 1. The poles of a magnet are the places where the magnetic forces are strongest.
2. When two magnets are brought close together they exert a force on each other.
3. Two like poles repel each other. Two unlike poles attract each other. Attraction and repulsion between two magnetic poles are examples of non-contact force.
4. A permanent magnet produces its own magnetic field.
5. An induced magnet is a material that becomes a magnet when it is placed in a magnetic field. Induced magnetism always causes a force of attraction. When removed from the magnetic field an induced magnet loses most/all of its magnetism quickly.
6. Students should be able to describe:
* the attraction and repulsion between unlike and like poles for permanent magnets
* the difference between permanent and induced magnets.
 |  |  |  |
| **4.7.1.2 Magnetic fields** |  |  |  |
| 1. The region around a magnet where a force acts on another magnet or on a magnetic material (iron, steel, cobalt and nickel) is called the magnetic field.
2. The force between a magnet and a magnetic material is always one of attraction.
3. The strength of the magnetic field depends on the distance from the magnet. The field is strongest at the poles of the magnet.
4. The direction of the magnetic field at any point is given by the direction of the force that would act on another north pole placed at that point.
5. The direction of a magnetic field *line* is from the north (seeking) pole of a magnet to the south (seeking) pole of the magnet.
6. A magnetic compass contains a small bar magnet. The Earth has a magnetic field. The compass needle points in the direction of the Earth’s magnetic field.
7. Students should be able to:
* describe how to plot the magnetic field pattern of a magnet using a compass
* draw the magnetic field pattern of a bar magnet showing how strength and direction change from one point to another
* explain how the behaviour of a magnetic compass is related to evidence that the core of the Earth must be magnetic.
 |  |  |  |

|  |  |  |  |
| --- | --- | --- | --- |
| *4.7.2 The motor effect* |  |  |  |
| **4.7.2.1 Electromagnetism** |  |  |  |
| 1. When a current flows through a conducting wire a magnetic field is produced around the wire.
2. The strength of the magnetic field depends on the current through the wire and the distance from the wire.
3. Shaping a wire to form a solenoid increases the strength of the magnetic field created by a current through the wire. The magnetic field inside a solenoid is strong and uniform.
4. The magnetic field around a solenoid has a similar shape to that of a bar magnet. Adding an iron core increases the strength of the magnetic field of a solenoid. An electromagnet is a solenoid with an iron core.

Students should be able to:1. describe how the magnetic effect of a current can be demonstrated
2. draw the magnetic field pattern for a straight wire carrying a current and for a solenoid (showing the direction of the field)
3. explain how a solenoid arrangement can increase the magnetic effect of the current.

(Physics only) Students should be able to interpret diagrams of electromagnetic devices in order to explain how they work. |  |  |  |
| **4.7.2.2 Fleming’s left-hand rule (HT only)** |  |  |  |
| 1. When a conductor carrying a current is placed in a magnetic field the magnet producing the field and the conductor exert a force on each other. This is called the motor effect.
2. Students should be able to show that Fleming’s left-hand rule represents the relative orientation of the force, the current in the conductor and the magnetic field.
3. Students should be able to recall the factors that affect the size of the force on the conductor.
4. For a conductor at right angles to a magnetic field and carrying a current:
* $force=magnetic flux density x current x length$
* $F=B x I x l$

force, *F*, in newtons, Nmagnetic flux density, *B*, in tesla, Tcurrent, *I*, in amperes, A (amp is acceptable for ampere)length,$ l$, in metres, m |  |  |  |
| **4.7.2.3 Electric motors (HT only)** |  |  |  |
| 1. A coil of wire carrying a current in a magnetic field tends to rotate.
2. This is the basis of an electric motor.
3. Students should be able to explain how the force on a conductor in a magnetic field causes the rotation of the coil in an electric motor.
 |  |  |  |
| **4.7.2.4 Loudspeakers (physics only) (HT only)** |  |  |  |
| 1. Loudspeakers and headphones use the motor effect to convert variations in current in electrical circuits to the pressure variations in sound waves.
2. Students should be able to explain how a moving-coil loudspeaker and headphones work.
 |  |  |  |

|  |  |  |  |
| --- | --- | --- | --- |
| *4.7.3 Induced potential, transformers and the National Grid (physics only) (HT only)* |  |  |  |
| **4.7.3.1 Induced potential (HT only)** |  |  |  |
| 1. If an electrical conductor moves relative to a magnetic field or if there is a change in the magnetic field around a conductor, a potential difference is induced across the ends of the conductor. If the conductor is part of a complete circuit, a current is induced in the conductor. This is called the generator effect.
2. An induced current generates a magnetic field that opposes the original change, either the movement of the conductor or the change in magnetic field.
3. Students should be able to recall the factors that affect the size of the induced potential difference/induced current.
4. Students should be able to recall the factors that affect the direction of the induced potential difference/induced current.
5. Students should be able to apply the principles of the generator effect in a given context.
 |  |  |  |
| **4.7.3.2 Uses of the generator effect (HT only)** |  |  |  |
| 1. The generator effect is used in an alternator to generate AC and in a dynamo to generate DC.

Students should be able to:1. explain how the generator effect is used in an alternator to generate A.C. and in a dynamo to generate D.C.
2. draw/interpret graphs of potential difference generated in the coil against time.
 |  |  |  |
| **4.7.3.3 Microphones (HT only)** |  |  |  |
| 1. Microphones use the generator effect to convert the pressure variations in sound waves into variations in current in electrical circuits.
2. Students should be able to explain how a moving-coil microphone works.
 |  |  |  |

|  |  |  |  |
| --- | --- | --- | --- |
| **4.7.3.4 Transformers (HT only)** |  |  |  |
| 1. A basic transformer consists of a primary coil and a secondary coil wound on an iron core.
2. Iron is used as it is easily magnetised.
3. The ratio of the potential differences across the **p**rimary and **s**econdary coils of a transformer *V***p** and *V***s** depends on the ratio of the number of turns on each coil, *n***p** and *n***s**.
* $\frac{V\_{p}}{V\_{s}}= \frac{n\_{p}}{n\_{s}}$

potential difference, *V***p** and *V***s** in volts, VIn a step-up transformer *V***s** > *V***p**In a step-down transformer *V***s** < *V***p**d) If transformers were 100 % efficient, the electrical power output would equal the electrical power input and so *V*s × *I*s = *V*p × *I*pWhere *V*s × *I*s is the power output (secondary coil) and *V*p × *I*p is the power input (primary coil).(power input and output, in watts, W)Students should be able to:e) explain how the effect of an alternating current in one coil in inducing a current in another is used in transformersf) explain how the ratio of the potential differences across the two coils depends on the ratio of the number of turns on eachg) calculate the current drawn from the input supply to provide a particular power outputh) apply the equation linking the potential difference and number of turns in the two coils of a transformer to the currents and the power transfer involved and relate these to the advantages of power transmission at high potential differences. |  |  |  |