

**Motors and Generators – Overview****HSC Topic 2****Topic:** Motors and Generators**Year:** HSC**Context:** Electricity use at home and in industry**PFA:** Applications & Uses (P3), Society & Environment (P4)**Knowledge:** Energy (P7), Waves (H8), Fields (H9), EM (H10)**Values:** P16**Skills:** H1 – H5

Modern industrialised society is geared to using electricity. Electricity has characteristics that have made it uniquely appropriate for powering a highly technological society. There are many energy sources that can be readily converted into electricity. In Australia, most power plants burn a fuel, such as coal, or use the energy of falling water to generate electricity on a large scale. Electricity is also relatively easy to distribute. Electricity authorities use high-voltage transmission lines and transformers to distribute electricity to homes and industries around each state. Voltages can be as high as  $5 \times 10^5$  volts from power stations but by the time this reaches homes, the electricity has been transformed to 240 volts. While it is relatively economical to generate electric power at a steady rate, there are both financial and environmental issues that should be considered when assessing the long-term impact of supplying commercial and household power.

The design of a motor for an electrical appliance requires consideration of whether it will run at a set speed, how much power it must supply, whether it will be powered by AC or DC and what reliability is required. The essentials of an electric motor are the supply of electrical energy to a coil in a magnetic field causing it to rotate.

The generation of electrical power requires relative motion between a magnetic field and a conductor. In a generator, mechanical energy is converted into electrical energy while the opposite occurs in an electric motor.

The electricity produced by most generators is in the form of alternating current. In general AC generators, motors and other electrical equipment are simpler, cheaper and more reliable than their DC counterparts. AC electricity

can be easily transformed into higher or lower voltages making it more versatile than DC electricity.

## **Motors and Generators – Concept Map**

HSC Topic 2

## Motors and Generators – Outcomes

## HSC Topic 2

### Big Idea 1: Motors use the effect of forces on current-carrying conductors in magnetic fields

	<ul style="list-style-type: none"> <li>▪ discuss the effect on the magnitude of the force on a current-carrying conductor of variations in:               <ul style="list-style-type: none"> <li>– the strength of the magnetic field in which it is located</li> <li>– the magnitude of the current in the conductor</li> <li>– the length of the conductor in the external magnetic field</li> <li>– the angle between the direction of the external magnetic field and the direction of the length of the conductor.</li> </ul> </li> </ul>
	<ul style="list-style-type: none"> <li>▪ describe qualitatively and quantitatively the force between long parallel current-carrying conductors:           </li> </ul> $\frac{F}{l} = k \frac{I_1 I_2}{d}$
	<ul style="list-style-type: none"> <li>▪ define torque as the turning moment of a force using: <math>\tau = Fd</math></li> </ul>
	<ul style="list-style-type: none"> <li>• identify that the motor effect is due to the force acting on a current-carrying conductor in a magnetic field</li> </ul>
	<ul style="list-style-type: none"> <li>• describe the forces experienced by a current-carrying loop in a magnetic field and describe the net result of the forces</li> </ul>
	<ul style="list-style-type: none"> <li>• describe the main features of a DC electric motor and the role of each feature</li> </ul>
	<ul style="list-style-type: none"> <li>• identify that the required magnetic fields in DC motors can be produced either by current-carrying coils or permanent magnets</li> </ul>
	<ul style="list-style-type: none"> <li>▪ solve problems using:           </li> </ul> $\frac{F}{l} = k \frac{I_1 I_2}{d}$
	<ul style="list-style-type: none"> <li>▪ perform a first-hand investigation to demonstrate the motor effect</li> </ul>
	<ul style="list-style-type: none"> <li>▪ solve problems and analyse information about the force on current-carrying conductors in magnetic fields using:</li> </ul>

	$F = BIl\sin\theta$
	<ul style="list-style-type: none"> <li>▪ solve problems and analyse information about simple motors using: <math>\tau = nBIA\cos\theta</math></li> </ul>
	<ul style="list-style-type: none"> <li>▪ identify data sources, gather and process information to qualitatively describe the application of the motor effect in: <ul style="list-style-type: none"> <li>– the galvanometer</li> <li>– the loudspeaker</li> </ul> </li> </ul>

## Big Idea 2: The relative motion between a conductor and magnetic field is used to generate an electrical voltage

	<ul style="list-style-type: none"> <li>• outline Michael Faraday's discovery of the generation of an electric current by a moving magnet</li> </ul>
	<ul style="list-style-type: none"> <li>▪ define magnetic field strength B as magnetic flux density</li> </ul>
	<ul style="list-style-type: none"> <li>▪ describe the concept of magnetic flux in terms of magnetic flux density and surface area</li> </ul>
	<ul style="list-style-type: none"> <li>• describe generated potential difference as the rate of change of magnetic flux through a circuit</li> </ul>
	<ul style="list-style-type: none"> <li>• account for Lenz's Law in terms of conservation of energy and relate it to the production of back emf in motors</li> </ul>
	<ul style="list-style-type: none"> <li>• explain that, in electric motors, back emf opposes the supply emf</li> </ul>
	<ul style="list-style-type: none"> <li>• explain the production of eddy currents in terms of Lenz's Law</li> </ul>
	<ul style="list-style-type: none"> <li>• perform an investigation to model the generation of an electric current by moving a magnet in a coil or a coil near a magnet</li> </ul>
	<ul style="list-style-type: none"> <li>▪ plan, choose equipment or resources for, and perform a first-hand investigation to predict and verify the effect on a generated electric current when: <ul style="list-style-type: none"> <li>- the distance between the coil and magnet is varied</li> <li>- the strength of the magnet is varied</li> <li>- the relative motion between the coil and the magnet is varied</li> </ul> </li> </ul>
	<ul style="list-style-type: none"> <li>• gather, analyse and present information to explain how induction is used in cooktops in electric ranges</li> </ul>

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|  | <ul style="list-style-type: none"> <li>gather secondary information to identify how eddy currents have been utilised in electromagnetic braking</li> </ul> |
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### **Big Idea 3:** Generators are used to provide large scale power production

	<ul style="list-style-type: none"> <li>describe the main components of a generator</li> </ul>
	<ul style="list-style-type: none"> <li>describe the differences between AC and DC generators</li> </ul>
	<ul style="list-style-type: none"> <li>discuss the energy losses that occur as energy is fed through transmission lines from the generator to the consumer</li> </ul>
	<ul style="list-style-type: none"> <li>assess the effects of the development of AC generators on society and the environment</li> </ul>
	<ul style="list-style-type: none"> <li>account for Lenz's Law in terms of conservation of energy and relate it to the production of back emf in motors</li> </ul>
	<ul style="list-style-type: none"> <li>explain that, in electric motors, back emf opposes the supply emf</li> </ul>
	<ul style="list-style-type: none"> <li>explain the production of eddy currents in terms of Lenz's Law</li> </ul>
	<ul style="list-style-type: none"> <li>plan, choose equipment or resources for, and perform a first-hand investigation to demonstrate the production of an alternating current</li> </ul>
	<ul style="list-style-type: none"> <li>gather secondary information to discuss advantages/disadvantages of AC and DC generators and relate these to their use</li> </ul>
	<ul style="list-style-type: none"> <li>analyse secondary information on the competition between Westinghouse and Edison to supply electricity to cities</li> </ul>
	<ul style="list-style-type: none"> <li>gather and analyse information to identify how transmission lines are:             <ul style="list-style-type: none"> <li>insulated from supporting structures</li> <li>protected from lightning strikes</li> </ul> </li> </ul>

### **Big Idea 4:** Transformers allow generated voltage to be either increased or decreased before it is used

	<ul style="list-style-type: none"> <li>describe the purpose of transformers in electrical circuits</li> </ul>
	<ul style="list-style-type: none"> <li>compare step-up and step-down transformers</li> </ul>
	<ul style="list-style-type: none"> <li>identify the relationship between the ratio of the number of turns in the primary and secondary coils and the ratio of primary to secondary voltage</li> </ul>
	<ul style="list-style-type: none"> <li>explain why voltage transformations are related to conservation of energy</li> </ul>
	<ul style="list-style-type: none"> <li>explain the role of transformers in electricity sub-stations</li> </ul>
	<ul style="list-style-type: none"> <li>discuss why some electrical appliances in the home that are connected to the mains domestic power supply use a transformer</li> </ul>
	<ul style="list-style-type: none"> <li>discuss the impact of the development of transformers on society</li> </ul>
	<ul style="list-style-type: none"> <li>perform an investigation to model the structure of a transformer to demonstrate how secondary voltage is produced</li> </ul>
	<ul style="list-style-type: none"> <li>solve problems and analyse information about transformers using:           <math display="block">\frac{V_p}{V_s} = \frac{n_p}{n_s}</math> </li> </ul>
	<ul style="list-style-type: none"> <li>gather, analyse and use available evidence to discuss how difficulties of heating caused by eddy currents in transformers may be overcome</li> </ul>
	<ul style="list-style-type: none"> <li>gather and analyse secondary information to discuss the need for transformers in the transfer of electrical energy from a power station to its point of use</li> </ul>

### **Big Idea 5:** Motors are used in industries and the home usually to convert electrical energy into more useful forms of energy

	<ul style="list-style-type: none"> <li>describe the purpose of transformers in electrical circuits</li> </ul>
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	<ul style="list-style-type: none"><li>• perform an investigation to demonstrate the principle of an AC induction motor</li></ul>
	<ul style="list-style-type: none"><li>• gather, process and analyse information to identify some of the energy transfers and transformations involving the conversion of electrical energy into more useful forms in the home and industry</li></ul>



