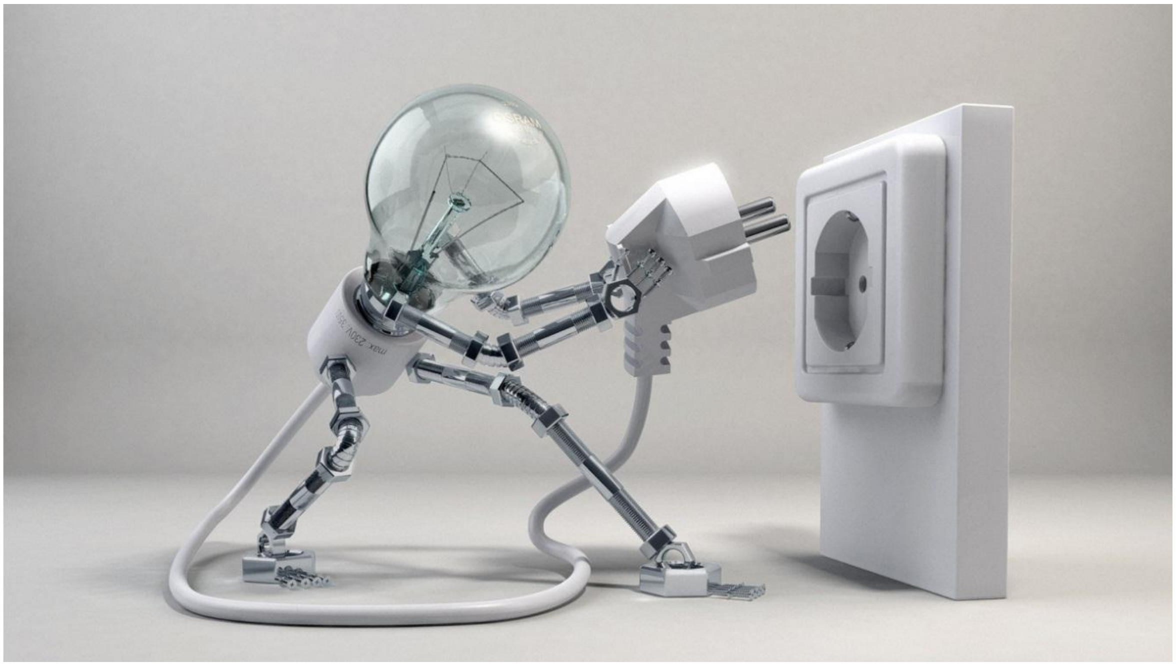
Level 2 Physics

Relevant past NCEA Exam questions for 91173

Electricity and Electromagnetism:



Relationships (taken directly from the Achievement standard 91173:

$E = \frac{V}{d}$ $F = Eq$ $\Delta E_p = Eqd$ $E_k = \frac{1}{2}mv^2$

$F = BIL$ $F = Bqv$ $V = BvL$

$I = \frac{q}{t}$ $V = \frac{\Delta E}{q}$ $V = IR$ $P = IV$ $P = \frac{\Delta E}{t}$

$R_T = R_1 + R_2 + \ldots$ $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots$

NZQA Exams, compiled by J Harris

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Subject Reference	Physics 2.6		
Title	Demonstrate understanding of electricity and electromagnetism		

Level 2 **Credits** 6 **Assessment** External

Subfield Science

Domain Physics

Status	Registered	**Status date**	17 November 2011
Planned review date	31 December 2014	**Date version published**	17 November 2011

This achievement standard involves demonstrating understanding of electricity and electromagnetism.

Achievement Criteria

Achievement	Achievement with Merit	Achievement with Excellence
• Demonstrate understanding of electricity and electromagnetism.	• Demonstrate in-depth understanding of electricity and electromagnetism.	• Demonstrate comprehensive understanding of electricity and electromagnetism.

Explanatory Notes

1 This achievement standard is derived from *The New Zealand Curriculum*, Learning Media, Ministry of Education, 2007, Level 7; and……

Assessment is limited to a selection from the following:

Static Electricity:

- uniform electric field
- electric field strength
- force on a charge in an electric field
- electric potential energy
- work done on a charge moving in an electric field.

DC Electricity:

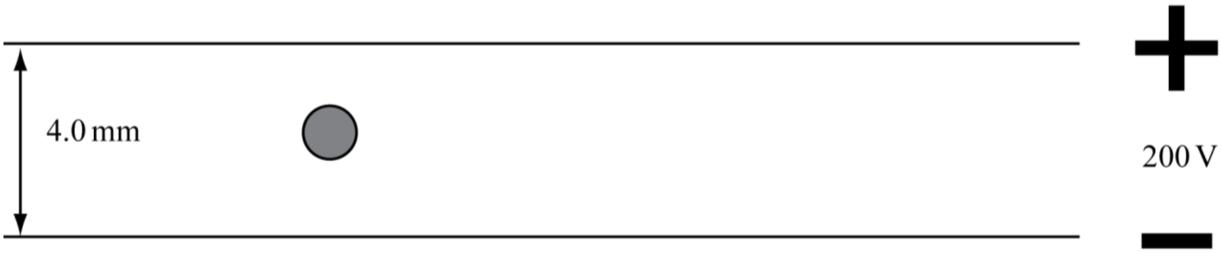
- parallel circuits with resistive component(s) in series with the source
- circuit diagrams
- voltage
- current
- resistance
- energy
- power.

Electromagnetism:

- force on a current carrying conductor in a magnetic field
- force on charged particles moving in a magnetic field
- induced voltage generated across a straight conductor moving in a uniform magnetic field.

QUESTION ONE: STATIC ELECTRICITY

The diagram below shows an electron that is introduced into the region between two parallel metal plates that are maintained at a potential difference of 200 V. The plates are separated by a distance of 4.0 mm.



(a) In terms of energy changes, describe what happens to the electron when it is:

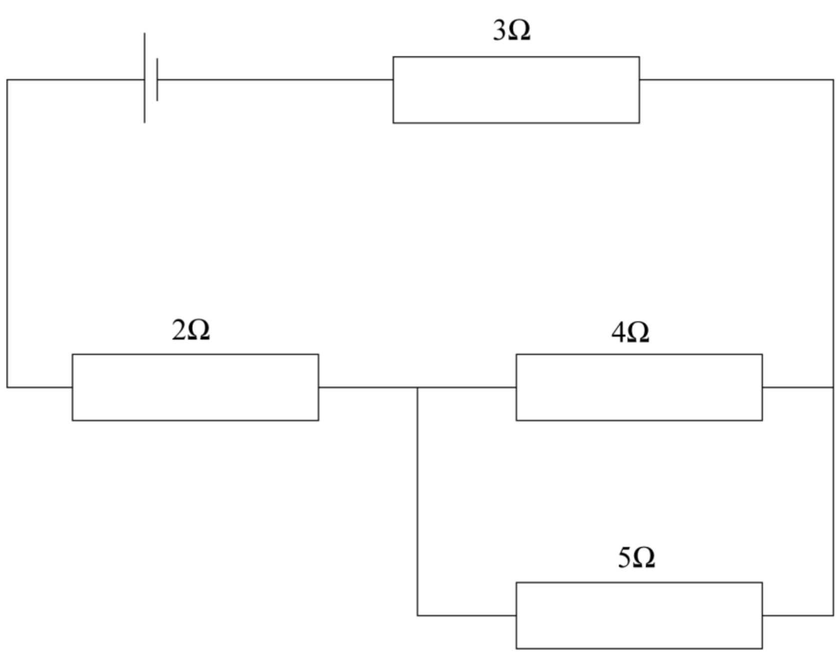
- free to move in the electric field
- forced to move against the electric field.

(b) The electron has a mass of 9.0×10^{-31} kg. The charge on the electron is -1.6×10^{-19} C.
The electron is released from the negative plate. Calculate the speed at which the electron reaches the positive plate as it accelerates towards it. In your answer, you should calculate the electric field strength.

(c) Comment on the size of the force experienced by the electron as it moves from the negative plate towards the positive plate.

QUESTION TWO: DC ELECTRICITY

The diagram below represents a circuit.



(a) Calculate the effective resistance of the circuit.

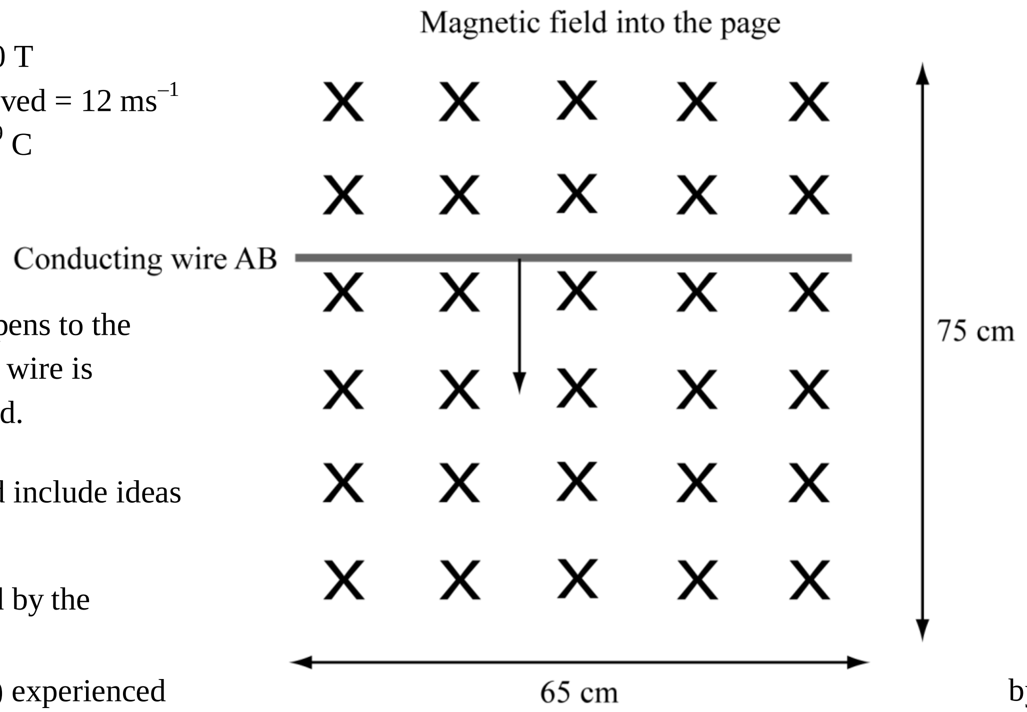
(b) Calculate the voltage across the 5 Ω resistor. The supply voltage is 9.0 V.

(c) Explain in detail whether the 3 Ω resistor OR the 5 Ω resistor will draw more power from the battery.

QUESTION THREE: ELECTROMAGNETISM

The conducting wire AB is moved in a magnetic field as shown in the diagram below.

Strength of magnetic field = 0.80 T
Speed with which the wire is moved = 12 ms^{-1}
Charge on electron = 1.6×10^{-19} C



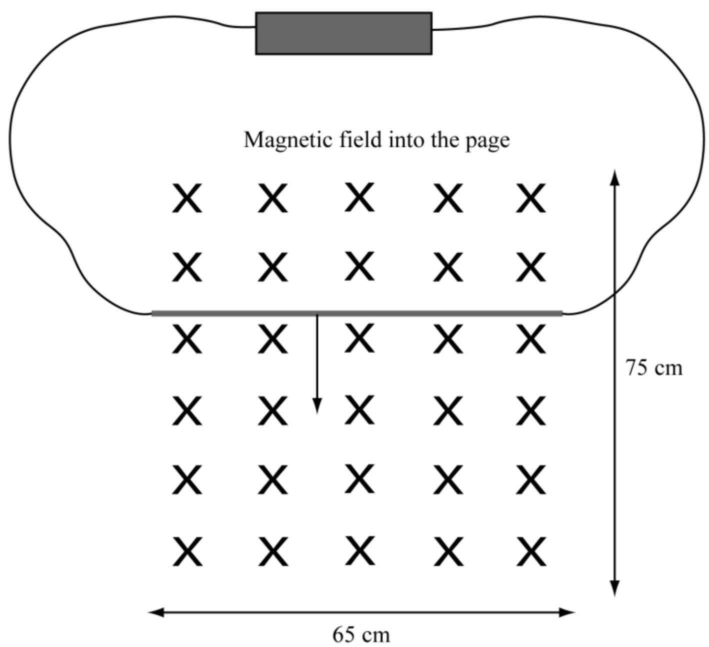
(a) Explain in detail what happens to the electrons in the wire as the wire is moved in the magnetic field.

In your answer, you should include ideas about:

- the force(s) experienced by the electrons in the wire
- the effect of the force(s) experienced by the electrons in the wire.

(b) Calculate the size of the induced voltage across the wire.

The wire is now connected to a resistor to make a complete circuit as shown in the diagram below. The resistance of the resistor and the wire = 4.5 Ω.



(c) Calculate the size of the current through the resistor as the wire is being moved in the magnetic field.

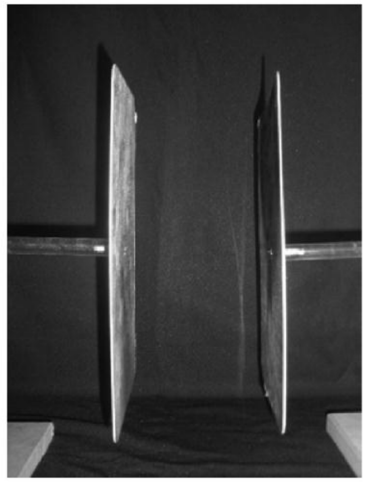
Draw an arrow on the diagram above to show the direction of the current through the resistor.

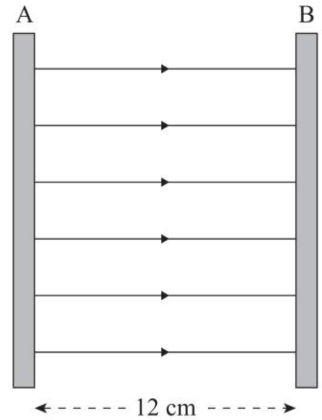
Year 12 Physics Electric Field & DC Circuits Unit Review

Equation		Symbol's **complete** name And SI unit	Situation where equation is most commonly used (or notes about this equation). Use your own paper
$E = \frac{V}{d}$	E		1
	V		
	d		
$F = Eq$	F		2
	E		
	q		
$\Delta E_p = Eqd$	ΔE_p		3
	E		
	d		
$I = \frac{q}{t}$	I		4
	t		
$V = \frac{\Delta E}{q}$	V		5
	ΔE		
$V = IR$	V		6
	I		
	R		
$P = IV$	P		7
$P = \frac{\Delta E}{t}$	P		8
	ΔE		
$R_T = R_1 + R_2 + \ldots$	R_T		9
$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots$	R_T		10

QUESTION 4: ELECTROSTATIC SWING *(NCEA 2011, Q1)*

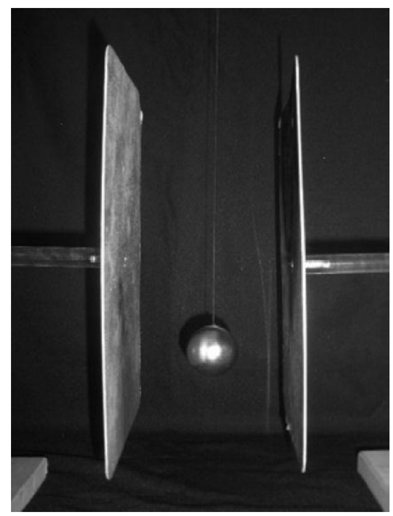
Sean is helping his physics teacher at the school open day. He connects two vertical metal plates to a Van de Graaff generator. The metal plates are shown in the picture below. They are 12 cm apart. The diagram on the right represents the electric field between the plates when the high voltage supply is turned on.





(a) State which plate (A or B) is positive. Give a reason for your answer. **[M]**

(b) State how the diagram shows that the electric field between the plates is uniform. **[A]**



(c) The strength of the **electric field** between the plates is 3.33×10^{6} V m^{-1}. Show that he **voltage** produced by the Van de Graaff generator is 400 kV. **[M]**

Sean has a metal ball with a mass of 2.5×10^{-2} kg suspended from a long thread. He puts the metal ball between the plates. It touches the **positive** plate and gains a charge of $+1.5 \times 10^{-10}$ C

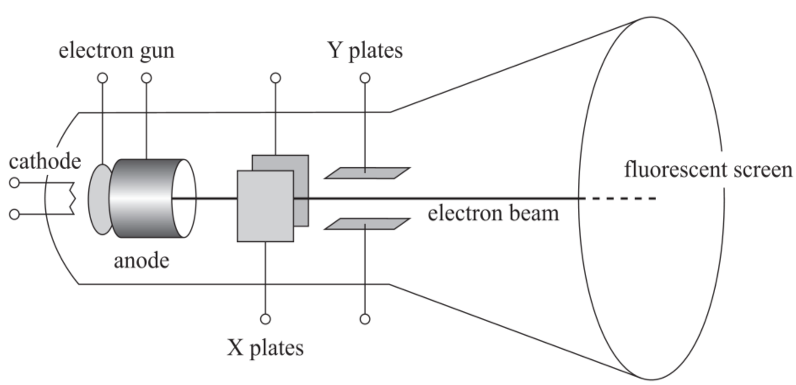
(d) Calculate the **speed** of the ball just before it hits the **negative** plate. **[E]**

(e) Describe the motion of the ball after it touches the negative plate. Explain your answer. **[E]**

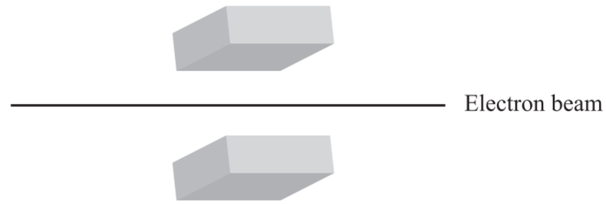
QUESTION 5: STATIC ELECTRICITY *(NCEA 2010, Q1)*

Charge on electron = -1.6×10^{-19} C, Mass of an electron = 9.0×10^{-31} kg

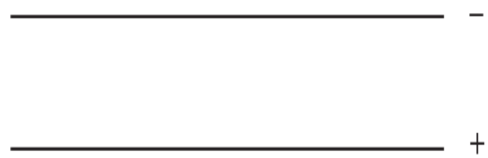
The oscilloscope is an electronic instrument widely used in making electrical measurements. Its main component is the cathode ray tube. The cathode ray tube is a vacuum tube in which electrons are accelerated and deflected by electric fields. The electrons are deflected in various directions by two sets of plates placed at right angles to each other in the neck of the tube.



The diagram below is a simplified diagram of the Y-plates in the cathode ray tube. These are two parallel metal plates. The two parallel metal plates are separated by a distance of 3.0 mm. The plates are maintained at a potential difference of 20 V.



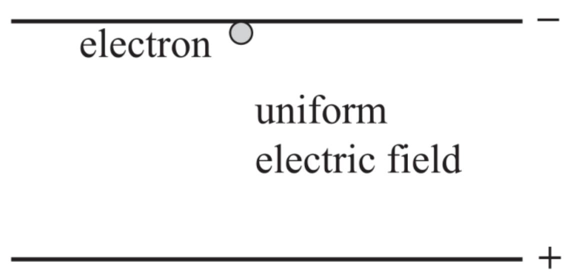
(a) On the diagram to the right, draw arrows to represent the shape and direction of the electric field between the plates. [A]



(b) Show that the electric field strength in the region between the plates is 6.7×10^{3} V m^{-1}. **[M]**

(c) State another unit for electric field strength. **[A]**

An electron is released with zero velocity from the negative plate as shown in the diagram to the right.



(d) Describe what happens to the electron once it is released, in terms of **[M]**

i. the energy changes
ii. the motion of the electron.

(e) Calculate the velocity with which the electron reaches the positive plate after travelling a distance of 3.0 mm. **[E]**

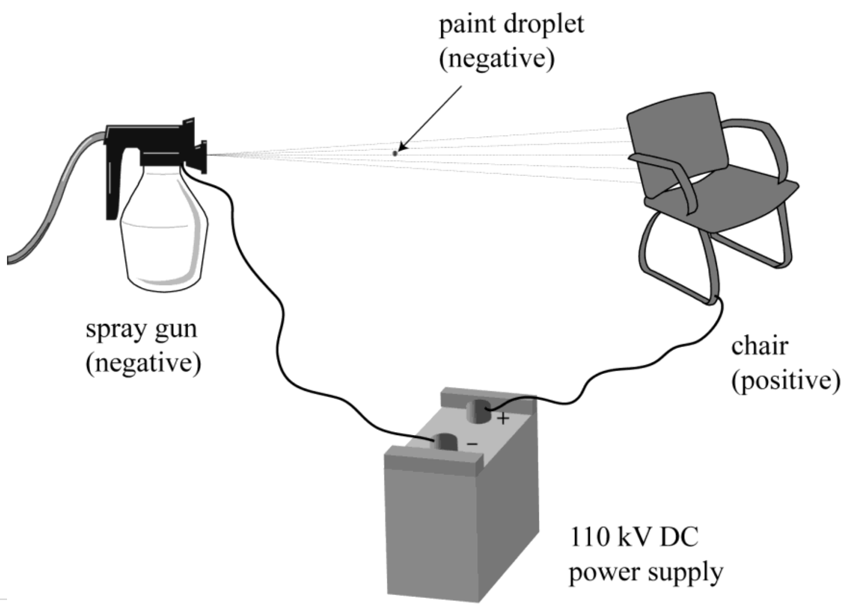
QUESTION 6: SPRAY PAINTING *(NCEA 2005, Q1)*

Spray painting involves firing fine droplets of liquid paint at the object to be sprayed. One problem is that many of the droplets miss the object. A solution to this problem is to use electrostatics.

The electrostatic spray painter in the diagram below shows how a metal chair can be painted. The negative terminal of the power supply is connected to the spray gun so the paint droplets become charged.

The positive terminal of the power supply is connected to the chair. This creates an electric field between the spray gun and the chair, and the charged paint droplets are repelled from the gun and attracted to the chair.

(You should assume the electric field is uniform.) The charge on one electron is: -1.60×10^{-19} C.



(a) Draw an **arrow** on the diagram above to show the direction of the electric field between the spray gun and the chair. **[A]**

(b) One particular paint droplet has 3.0×10^6 electrons added to it. **Show** that it has a total charge of -4.8×10^{-13} C. **[A]**

(c) The spray gun and chair are 0.65 m apart. The voltage between the spray gun and the chair is 110 kV. Calculate the **size** of the **force** acting on the paint droplet described in Question 1(b). **[E]**

(d) Explain clearly what will happen to the force acting on the paint droplets if the spray gun is moved **closer** to the chair. **[E]**

(e) Calculate the **change** in electrical potential energy of this paint droplet as it travels from the spray gun to the chair. **[M]**

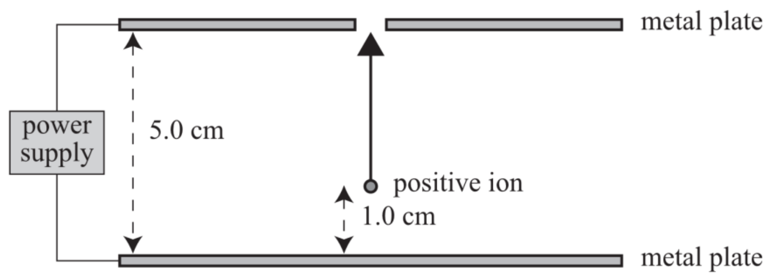
(f) State what is meant by the term **electric current**. **[A]**

(g) The spray gun fires out 6.5×10^5 paint droplets every minute. The average charge on each paint droplet is -8.0×10^{-13} C. Calculate the size of the electric current from the spray gun. **[M]**

QUESTION 7: MASS SPECTROMETER *(NCEA 2009, Q1)*

Sean is in the physics lab using a mass spectrometer to measure the mass of an unknown atom. In the mass spectrometer, an electron is removed from an atom, producing a positive ion. The positive ion is then accelerated by a constant electric field between two metal plates.

A positive ion is created 1.0 cm above the bottom plate, as shown in the diagram below. The positive ion then accelerates towards the top plate. The ion has a charge of $+1.6 \times 10^{-19}$ C.



(a) On the diagram above, what is the direction of the electric field between the plates? **[A]**

(b) The current between the plates is 3.5×10^{-6} A. How many positive ions reach the top plate in one minute? **[M]**

(c) Explain what happens to the size of the electric force on the positive ion as it moves towards the top plate. **[M]**

(d) Explain what happens to the maximum velocity of the positive ion if the power supply voltage is increased. **[E]**

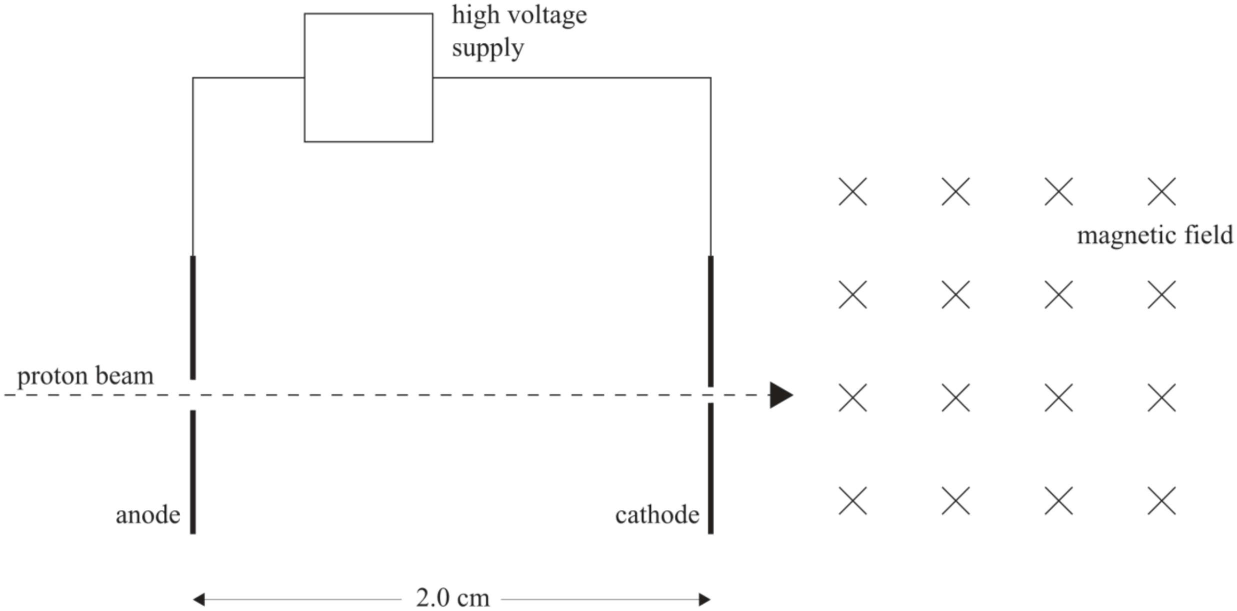
(e) The electric force on the ion is 3.20×10^{-15} N. Calculate the strength of the electric field between the plates. **[A]**

(f) Show that the maximum velocity of the positive ion if it moves from the position shown to the top plate is 6.9×10^4 m s^{-1}. The mass of the ion is 5.31×10^{-26} kg. **[E]**

QUESTION 8: THE PARTICLE ACCELERATOR *(NCEA 2007, Q1)*

A particle accelerator is a machine designed to accelerate charged particles to very high speeds. In one type of accelerator, **protons** are accelerated by an electric field and then deflected by a magnetic field. The diagram below shows part of the particle accelerator. **Protons** pass through the hole in the anode, and are accelerated towards the cathode. The **protons** pass through the hole in the cathode and travel to the right.

The distance between the anode and cathode is 2.0 cm.
The charge on a proton is $+1.6 \times 10^{-19}$ C.
The mass of a proton is 1.67×10^{-27} kg.



(a) Draw an arrow on the above diagram to show the **direction** of the **electric field** between the anode and the cathode. **[A]**

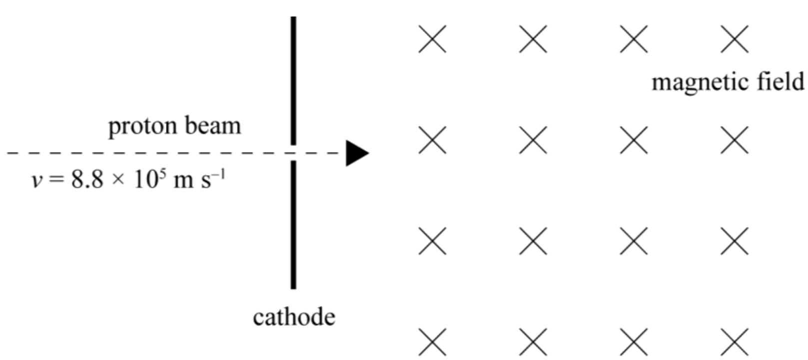
(b) Describe the change in the **type of energy** of the proton as it moves from the anode to the cathode. **[A]**

(c) A proton passes through the anode at 6.2×10^5 m s^{-1}, and passes through the cathode at 8.8×10^5 m s^{-1}. Show that the strength of the electric field is 100 000 V m^{-1}. **[E]**

(d) State a unit for electric field strength other than V m^{-1}. **[A]**

(e) Calculate the **voltage** between the anode and the cathode. **[A]**

When the protons pass through the hole in the cathode, they enter a magnetic field as shown in the diagram below. The direction of the magnetic field is into the page.
Magnetic field strength = 3.5 mT.

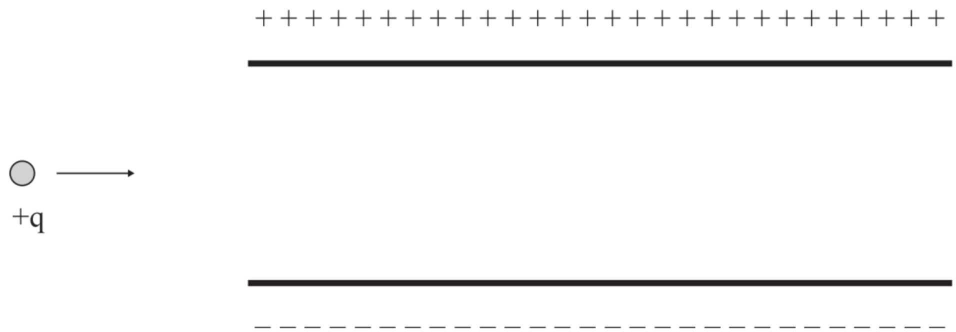


(f) State the **direction** of the force acting on the proton as it enters the magnetic field. **[A]**

(g) Calculate the **size** of the magnetic force acting on the proton in the magnetic field.
Write your answer to the correct number of **significant figures**. **[A]**

QUESTION 9: CHARGED PARTICLES *(NCEA 2008, Q1)*

A velocity sorter is an apparatus that can be used to obtain a stream of charged particles, all travelling with the same velocity. The diagram below shows a simplified velocity sorter. A stream of protons is made to pass between two parallel charged plates.

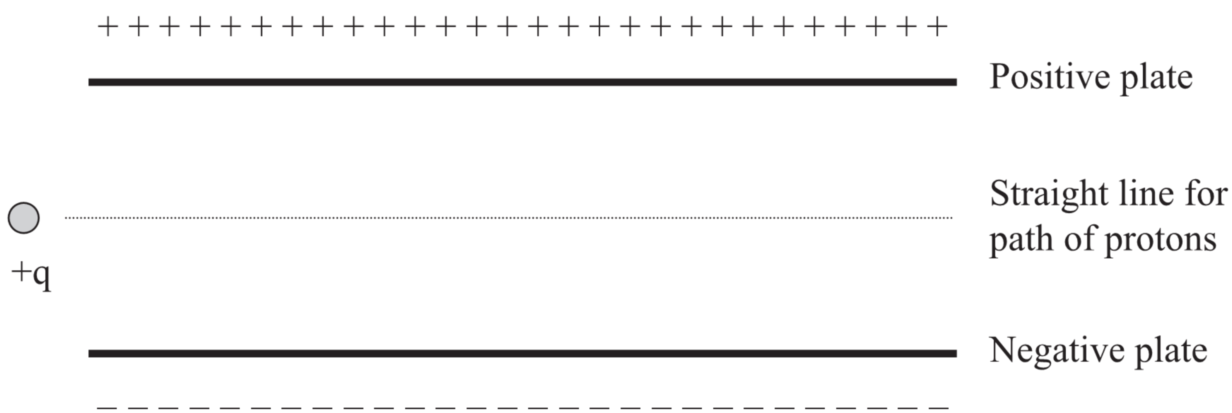


(a) On the diagram, **use arrows** to draw the electric field between the plates **[M]**

(b) On the same diagram, draw the path of the proton in the field. **[A]**

(c) **Explain why** the proton follows this path. **[M]**

In order for the protons to travel in a **straight line**, a velocity sorter also has a magnetic field.



(d) The proton is travelling through a magnetic and electric field. State the direction of the magnetic field that would allow the protons to go in a straight line. Choose your answer from: **[A]**

towards the top of the page	*towards the bottom of the page*
left	*right*
into the page	*out of the page.*

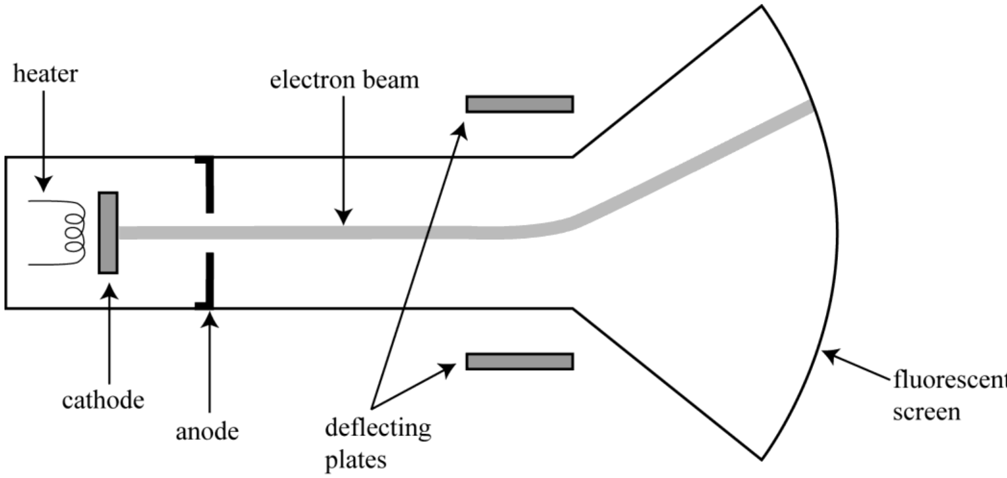
(e) Explain the effect (if any) of the speed of the proton on the size of the **electric force**, and on the size of the **magnetic force** acting on the proton. **[E]**

(f) The voltage between the plates is 220 V. The plates are 5.0 cm apart. Calculate the size of the **electric force** on the proton. Charge on proton = 1.60×10^{-19} C. Give your answer to the correct number of significant figures. **[E]**

(g) 3.5×10^{15} protons enter the field in 10 s. Calculate the size of the current. **[M]**

QUESTION 10: CATHODE RAY TUBE *(NCEA 2006, Q2)*

The diagram below shows the path of an **electron** moving through a cathode ray tube.



(a) On the diagram, label the positive deflecting plate "+". **[A]**

(b) On the diagram above draw arrows to represent the **electric field** formed between the **deflecting plates. [M]**

(c) The deflecting plates are maintained at a voltage of 45 V, and are 8.0 mm apart. Show that the **electric field strength** between the plates is 5625 V m^{-1}. **[A]**

(d) Use TWO appropriate formulae from the list at the front of this paper to derive TWO different units for electric field strength, E. **[M]**

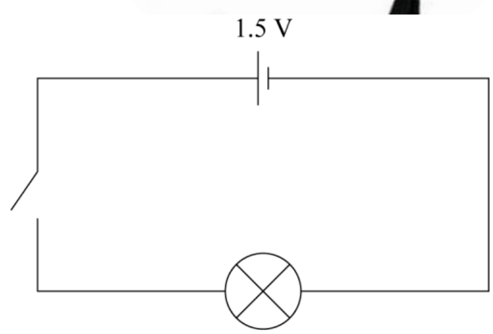
(e) The charge on an electron is 1.6×10^{-19} C. Calculate the **electric force** on an electron between the plates. **[A]**

(f) **Explain** why the electron is losing **electric potential energy** while it is moving from the cathode (negative electrode) to the anode. **[E]**

DC:

QUESTION 11: CAMP TORCH *(NCEA 2006, Q1)*

Tom was out camping one weekend. He had taken some spare 1.5 volt cells with him. The diagram below shows the circuit diagram for Tom's torch.



(a) How many joules of **energy** does the cell supply to each coulomb of charge that flows out of the cell? **[A]**

(b) When the cell is switched on, the resistance of the lamp is 5.00 Ω. Calculate the **current** flowing through the lamp. **[A]**

(c) State the meaning of the term **resistance** in terms of electron flow. **[A]**

(d) One evening, Tom used the torch for 3 minutes. **Calculate** the number of coulombs of charge that flowed through the **lamp** in 3 minutes. **[M]**

QUESTION 12: CLAIRE'S CAR LIGHTS *(NCEA 2011, Q3)*

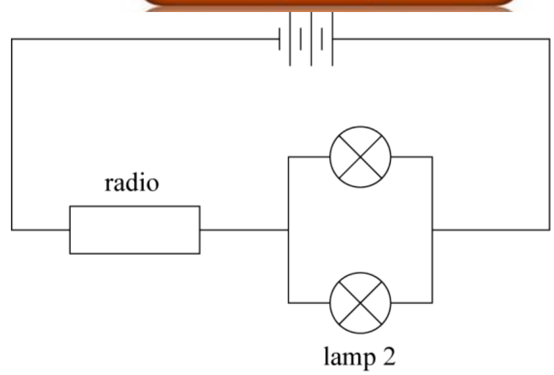
Claire has a light bulb inside her car. The light bulb is labelled "12 V 5 W", and it is connected to
the car's 12 V battery.

(a) Describe what the label means. **[A]**

(b) Calculate the size of the current in the light bulb when it is switched on. **[A]**

QUESTION 13: CAMP RADIO *(NCEA 2006, Q1)*

Tom wanted to use his radio as well as have lights on in his tent. He used three of his 1.5 V cells and connected the circuit as shown below.



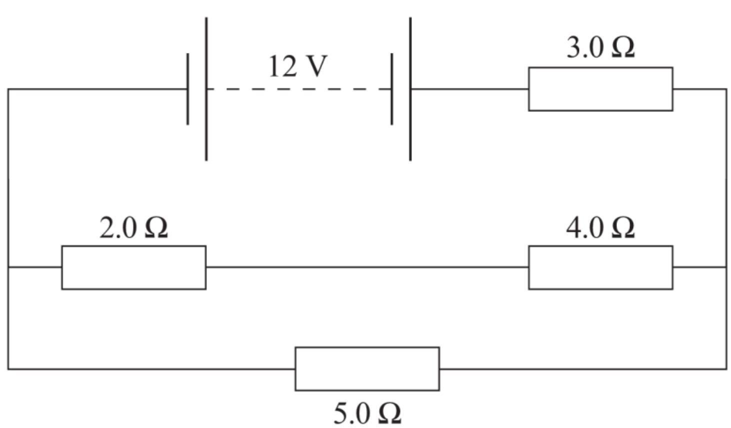
(a) Calculate the **total voltage** supplied by the cells. **[A]**
The resistance of each lamp is now 4.00 Ω and the resistance of the radio is 14.0 Ω.

(b) Calculate the **total resistance** of the circuit. Express your answer to the correct number of significant figures. **[M]**

(c) Calculate the **voltage** across lamp 2. **[E]**

QUESTION 14: DC ELECTRICITY *(NCEA 2010, Q2)*

Frank is out camping. He has just one 12 V battery with him. He connects various low voltage devices to this battery, as shown in the diagram.

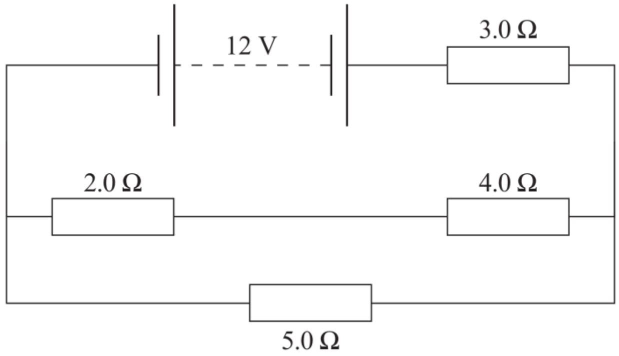


(a) Calculate the effective resistance of the circuit. **[E]**

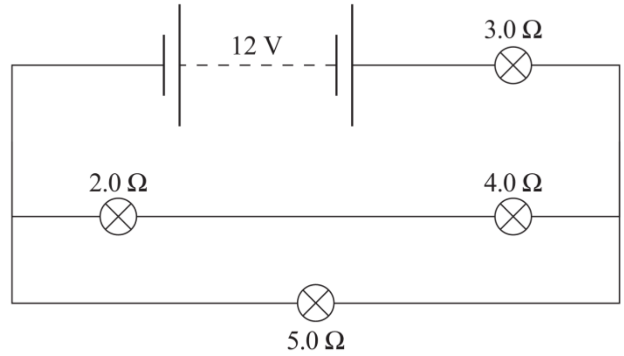
(b) Calculate the current through the 3.0 Ω resistor. **[A]**

(c) Calculate the current through the 5.0 Ω resistor. **[E]**

As it starts getting dark, Frank replaces all the devices with lamps of resistances similar to those of his low voltage devices at that temperature.



Old circuit

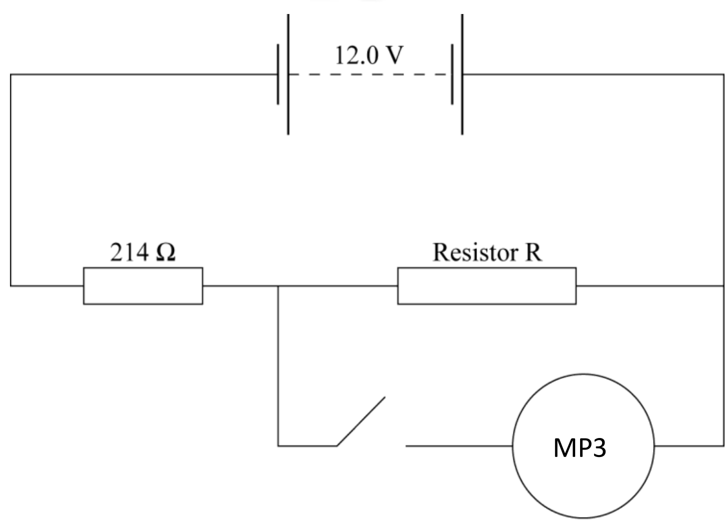


New circuit

(d) Discuss which of the TWO lamps (3.0 Ω lamp or the 4.0 Ω lamp) in the above circuit will be brighter. You may use calculations to support your answer. **[E]**

QUESTION 15: THE MP3 PLAYER *(NCEA 2007, Q2)*

Ella has a battery-operated MP3 player that she wants to connect to her car battery. The voltage of her car battery is **12.0 V** and her CD player is marked **"4.5 V, 25 mA"**. She knows she cannot connect it directly to the car battery, so she decides to connect it in a circuit as shown in the diagram below. The switch is **initially closed**.



(a) Calculate the resistance of the CD player. **[M]**

(b) Calculate the **voltage** across the 214 Ω resistor if the CD player has the correct voltage across it when the **switch** is **closed**. **[A]**

(c) Show that the appropriate value of **resistor R** is 450 Ω. **[E]**

Ella now **opens** the switch.

(d) Explain what happens to the voltage across the 214 Ω resistor when she **opens** the switch. **[E]**

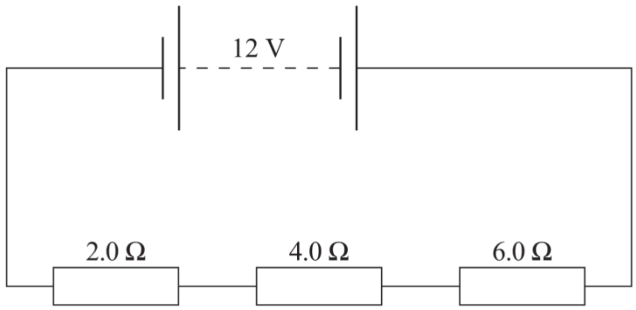
(e) The switch remains open. Explain which resistor produces more heat in a given time. **[E]**

(f) Ella does not have a 450 Ω resistor, but she does have three 300 Ω resistors. Draw a diagram to show how she could connect the three 300 Ω resistors to give a total of 450 Ω. **[A]**

QUESTION 16: ELECTRIC CIRCUITS *(NCEA 2009, Q2)*

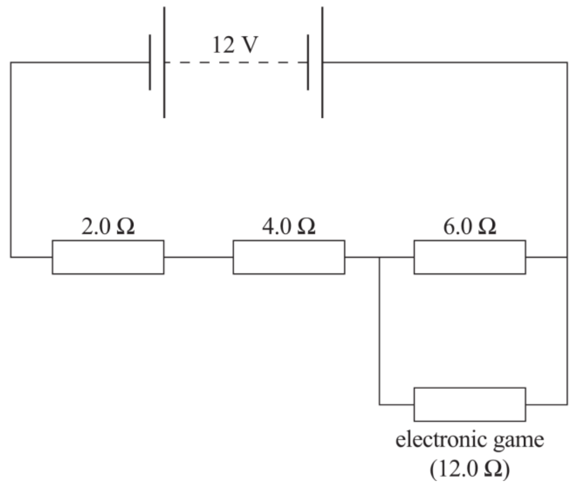
Sean has a yacht with a 12 V power supply. He has various low voltage devices that he wants to run off the power supply. He connects three resistors in series with the power supply as shown in the diagram below.

(a) Calculate the current through the circuit. **[A]**



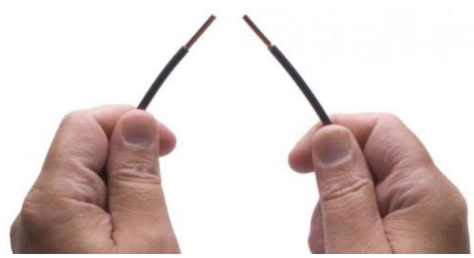
(b) Sean connects an electronic game with a resistance of 12.0 Ω in parallel with the 6.0 Ω resistor. Calculate the voltage across the electronic game. **[E]**

Question 1b:

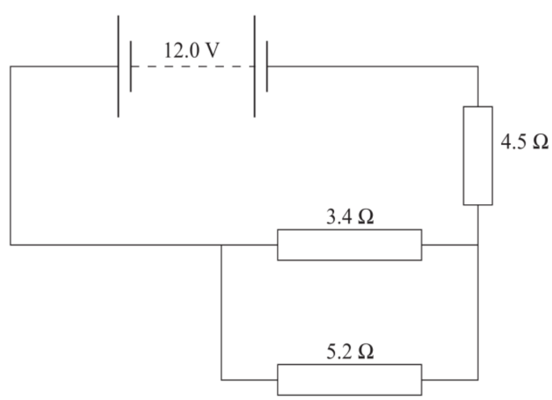


(c) Sean switches the electronic game to "standby mode". This causes the resistance of the electronic game to increase. Explain how this affects the voltage across the 4.0 Ω resistor. **[E]**

QUESTION 17: ELECTRIC CIRCUITS *(NCEA 2008, Q2)*



Martha and Mere connected the following circuit using several resistors and a power supply.



(a) How much energy does the battery give to each Coulomb of charge? **[A]**

(b) Show that the total resistance in this circuit is 6.56 Ω. **[M]**

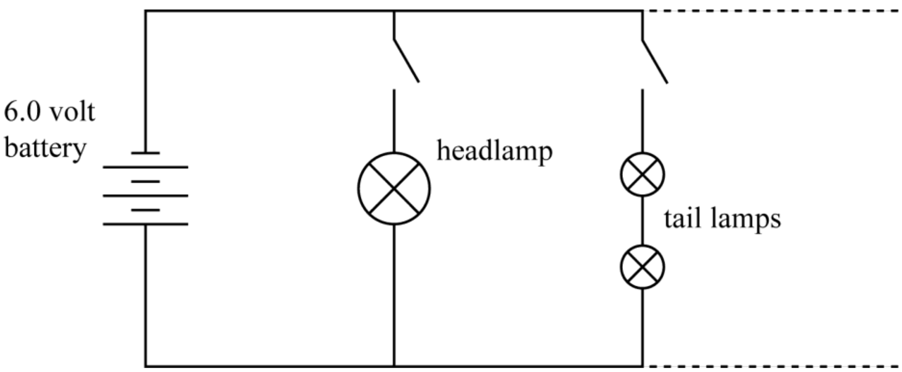
(c) Calculate the current through the 4.5 Ω resistor. **[A]**

(d) Show that the voltage across the 3.4 Ω resistor is 3.8 V. **[M]**

(e) State the voltage across the 5.2 Ω resistor. Give reasons for your answer. **[M]**

QUESTION 18: MIKE'S MOTORBIKE *(NCEA 2005, Q2)*

Mike is restoring an old motorbike. The wiring is damaged and he decides to replace it. His sister Moana designs a lighting circuit and draws a wiring diagram. Part of it is shown below. Mike then connects the lighting circuit on the motorbike. All the lamps are designed to operate at 6.0 V.



(a) The headlamp has a resistance of 1.2 Ω when it is switched on. **Show** that the electric current through the headlamp is 5.0 A. **[A]**

(b) Calculate the power output of the headlamp when it is operating normally. Give the correct unit with your answer. **[A]**

(c) Explain clearly what will happen to the current in the headlamp in the short time after its switch is first closed. **[E]**

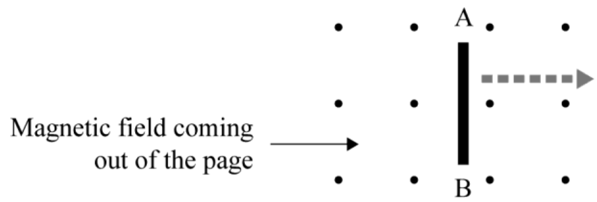
(d) The battery is producing 6.0 A when both switches are closed. Calculate the **resistance** of each tail lamp, assuming that they are identical. **[E]**

Year 12 Physics Magnetic Fields, Forces & Induced Voltage Unit Review

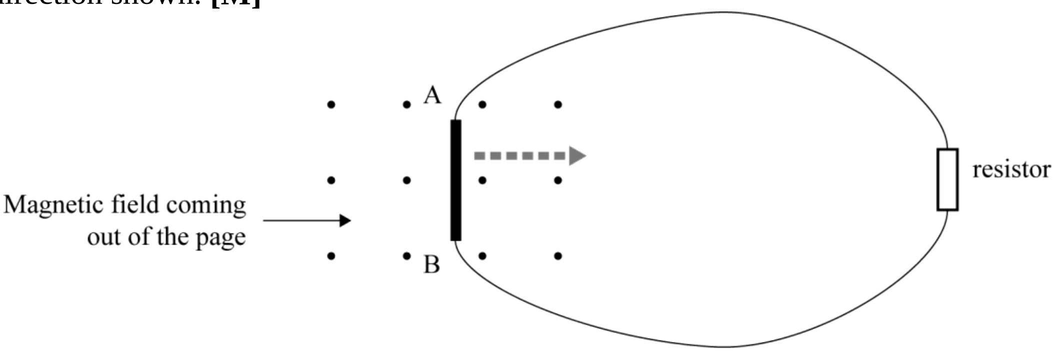
Equation		Symbol's **complete** name And SI unit	Situation where equation is most commonly used (or notes about this equation). Use your own paper
$V = IR$	V		1
	I		
	R		
$P = IV$	P		2
	I		
	V		
$F = BIL$ or $F = BIL(\sin\theta)$	F		3
	B		
	I		
	L		
	θ		
$F = Bqv$	V		4
	q		
	v		
$V = BvL$	V		5
	v		
	L		

QUESTION 19: ELECTROMAGNETISM *(NCEA 2006, Q3)*

A metal rod AB is pushed from left to right so that it cuts across the magnetic field, as shown in the following diagram.



(a) Explain clearly in terms of movement of electric charge, what would happen as the rod starts moving in the direction shown. **[M]**



The rod is then connected by two wires to a resistor to a make a complete circuit.

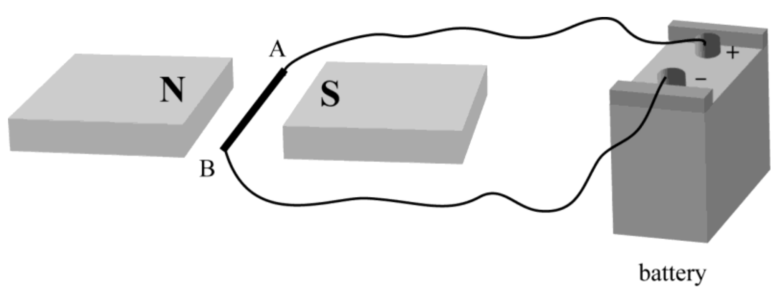
(b) Explain what would now happen as the rod is moved through the magnetic field while the resistor remains stationary. In your explanation, include the direction of any charge flow. **[E]**

(c) Calculate the **current** that would flow through the resistor, using the following information: **[E]**

- Resistance of resistor = 2.0 Ω
- Strength of magnetic field = 0.80 T
- Length of rod in the magnetic field = 10.0 cm
- Speed with which the rod is being moved = 4.0 m s^{-1}

The metal rod, AB, is now connected to a battery, and placed between the poles of two magnets, as shown in the diagram below.

(d) Draw an arrow on the diagram to show the **direction** of the **magnetic field** produced by the magnets. **[A]**



(e) Using one of the terms: "left, right, up, down, into the page, out of the page", identify the direction of the **magnetic force** on the rod. **[A]**

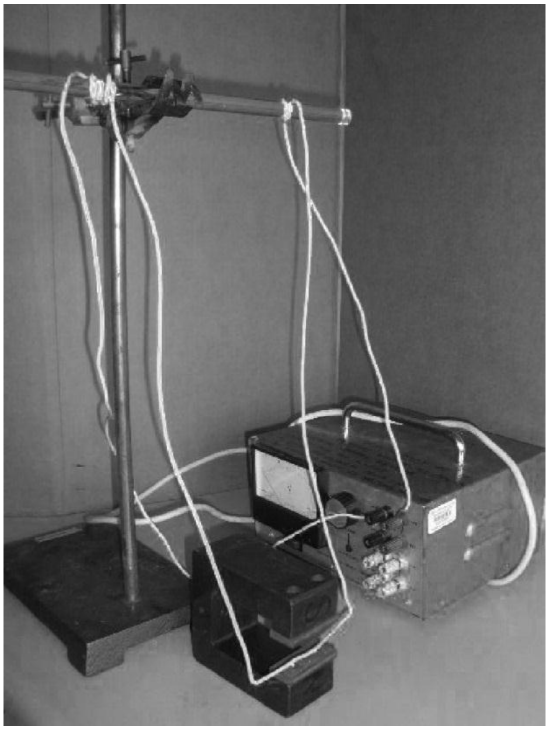
(f) Explain clearly why the rod experiences a magnetic force in the direction you have stated in (e). **[E]**

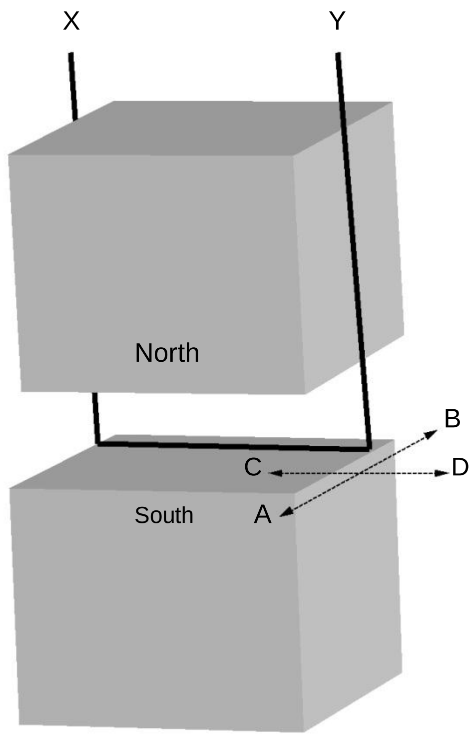
(g) Calculate the size of the magnetic force experienced by the rod, using the information given below. Write your answer to the correct number of significant figures. **[A]**

- Strength of the magnetic field = 0.90 T
- Current = 3.20 A
- Length of rod in the field = 10.0 cm

QUESTION 20: ELECTROMAGNETIC SWING *(NCEA 2011, Q2)*

Sean sets up a demonstration called the electromagnetic swing. It comprises a wire loop hanging between two magnetic poles, as shown in the picture below. The magnetic field strength is 2.0 T. The left side of the loop (X) is connected to the negative terminal of a battery.

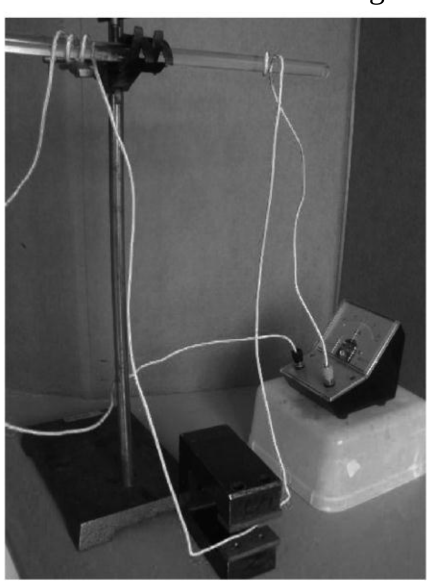


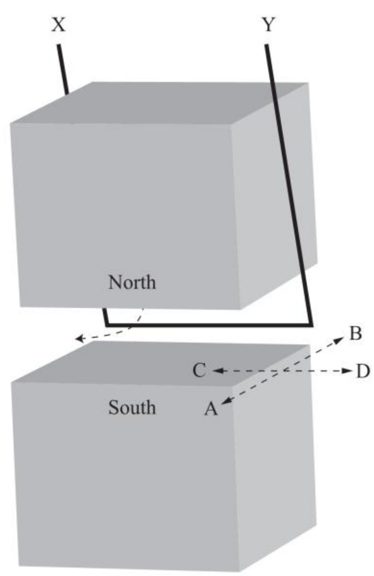


(a) Describe and explain what happens when Sean closes the switch. **[E]**

(b) The circuit including the wire loop has a resistance of 1.8 Ω. The battery voltage is 6.0 V. The force on the wire is 0.25 N. Show that the length of the horizontal wire is 3.8 cm **[E]**

Sean replaces the battery with a sensitive voltmeter. He pulls the loop back and releases it so that it swings through the magnetic field as shown in the diagram below.



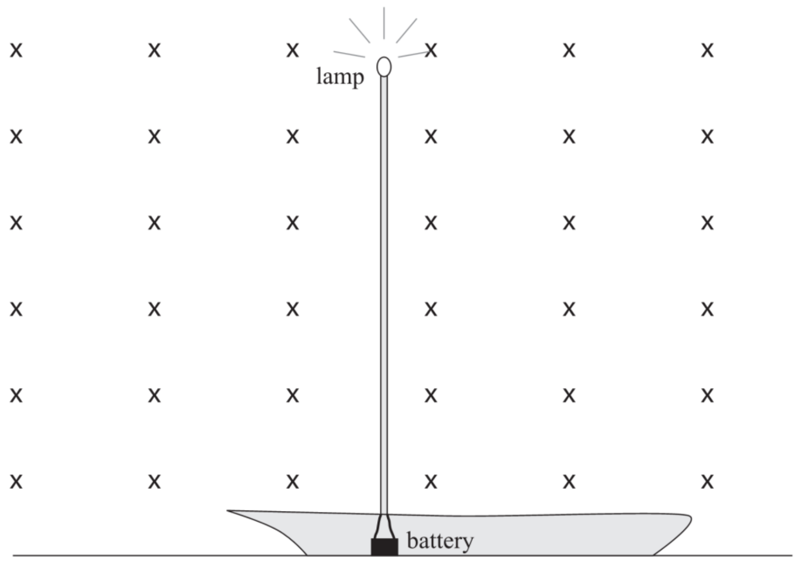


(c) Name the type of particle that moves inside the wire, and state the direction that it moves as a result of the loop's motion. **[A]**

(d) At one time the induced voltage is 11 mV. Calculate the speed of the wire at this time. **[M]**

QUESTION 21: MAGNETIC FIELDS *(NCEA 2009, Q3)*

Sean's yacht has an 8.0 m high mast with a light on top. Two wires connect the 12 V battery to the lamp (nothing else is connected to the battery). The total resistance of the wires and lamp is 18.0 Ω. The horizontal component of the earth's magnetic field is 4.0×10^{-4} T. The charge on an electron is 1.6×10^{-19} C.



The yacht is stationary.

(a) State the direction of the magnetic force acting on the wire that is connected to the negative terminal of the battery. **[A]**

(b) Calculate the size of the magnetic force acting on ONE wire **[E]**

(c) Will the magnetic force on the two connecting wires produce a net force on the yacht? Explain your answer. **[E]**

The yacht now moves forward.

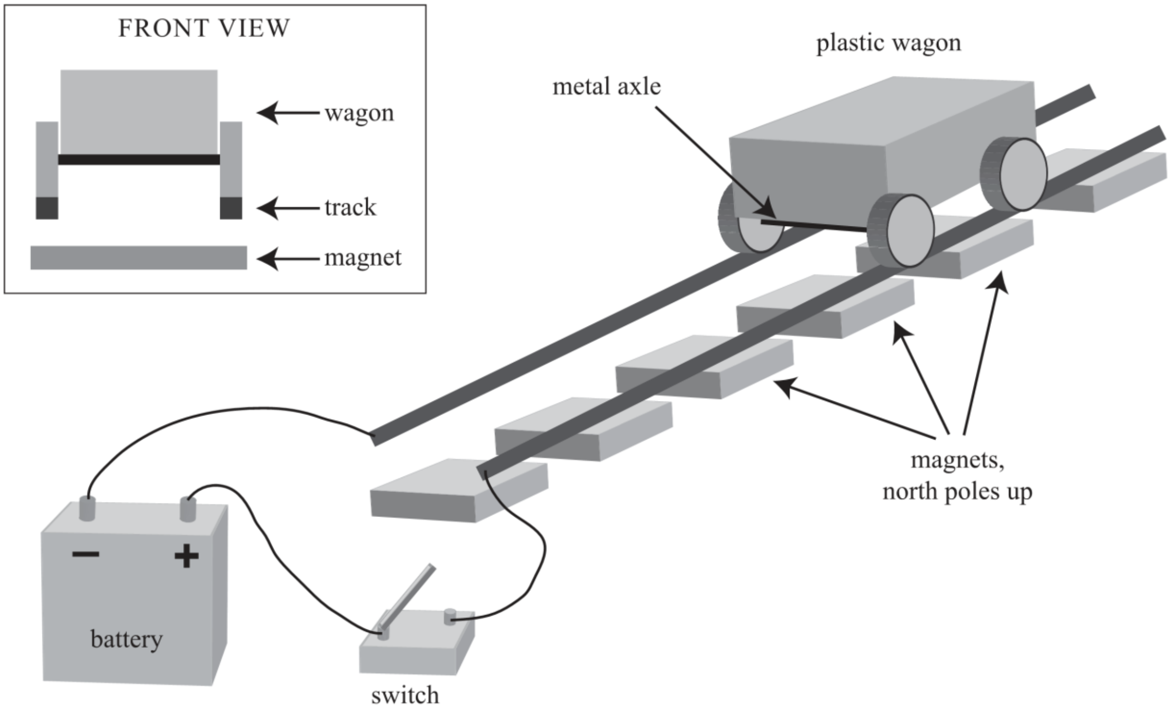
(d) Sean switches the light off. Is there a voltage induced in the wire as the yacht moves forward? Explain your answer. **[M]**

(e) Calculate the size of the magnetic force acting on a single electron if the yacht moves at 3.0 m s^{-1} perpendicular to the magnetic field. **[A]**

QUESTION 22: THE MODEL RAILWAY *(NCEA 2007, Q3)*

Tana is playing with a model railway. He wants to make one of the plastic wagons move without an electric motor. He places a row of magnets under (but not touching) the horizontal tracks, with the north poles pointing up. He then connects the tracks to a battery and puts a wagon on the tracks. The wheels, axles and track conduct electricity.

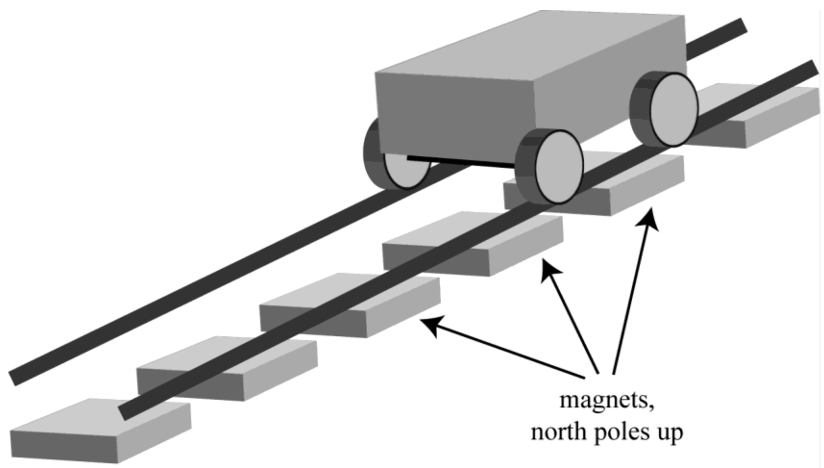
The magnets produce a uniform magnetic field of 0.25 T.
The tracks are 35 mm apart.
The resistance of the circuit is 0.55 Ω.



(a) Explain what causes the wagon to move when the switch is closed. **[M]**

(b) Draw an arrow on the diagram above to show the **direction** of the **electromagnetic force** on the wagon. **[A]**

(c) When the switch is closed, the size of the electromagnetic force on the wagon due to the **two axles** is 0.052 N. Calculate the **battery voltage**. **[E]**

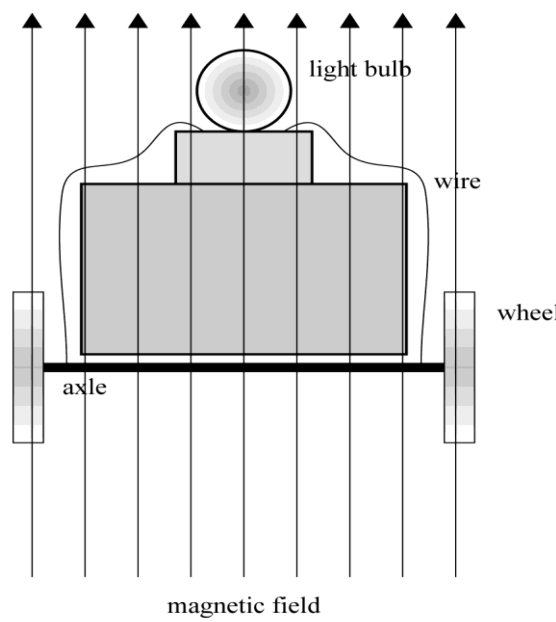


Tana disconnects the battery, then gives the carriage a horizontal push.

(d) Calculate the **induced voltage** across each axle when the carriage is travelling at 0.29 m s^{-1}. Write your **answer in mV**. **[M]**

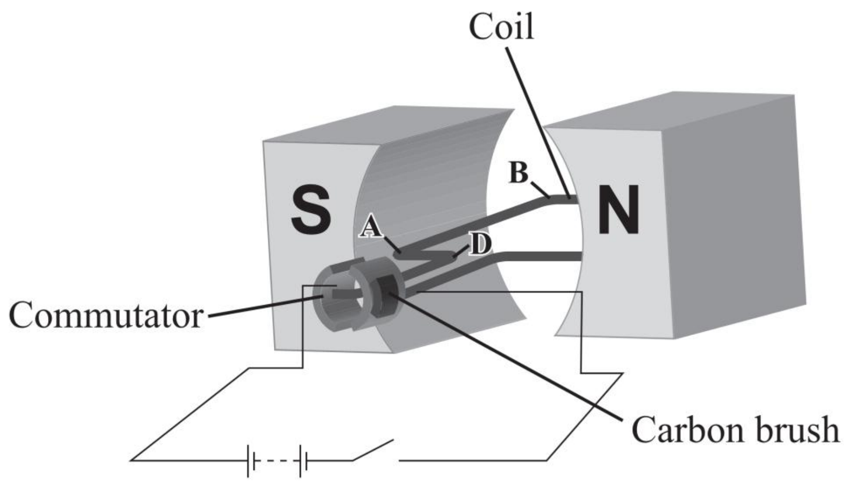
(e) Explain clearly why one end of the axle becomes **negatively** charged. **[M]**

(f) Tana wants to use the induced voltage to light a lamp. With the battery still disconnected, he puts a low-power lamp on the carriage and connects it to the axles as shown below. Explain what will happen in the **circuit** of the **lamp** and **axle**, as the wagon cuts across the magnetic field. **[E]**



QUESTION 23: THE ELECTRIC MOTOR *(NCEA 2010, Q3)*

The diagram below is a simplified electric motor.



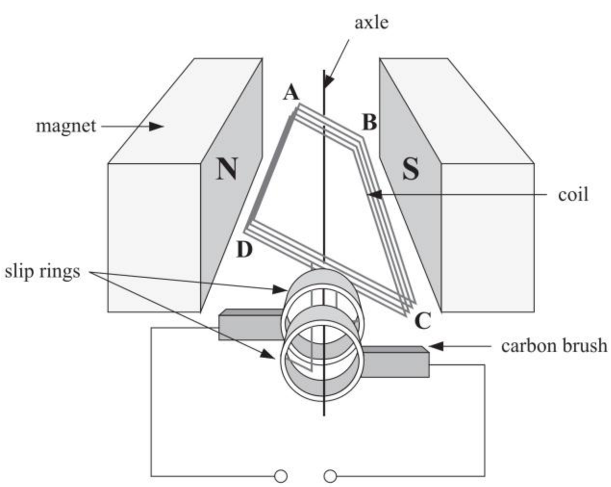
- Length AB of the coil = 12 cm
  Strength of magnetic field = 0.75 T
- Voltage across the terminals of the battery = 12 V
- Total resistance of all the wires including the coil = 4.5 Ω

(a) Calculate the size of the magnetic force on AB, which has 100 turns of wire. **[E]**

(b) Explain why the part of the wire labelled AD, which is 5.0 cm long, will not experience a magnetic force while at the position shown in the diagram above. **[A]**

(c) State TWO changes that can be made in order to make the coil spin faster. **[A]**

QUESTION 24: Generator *(NCEA 2008, Q3)*



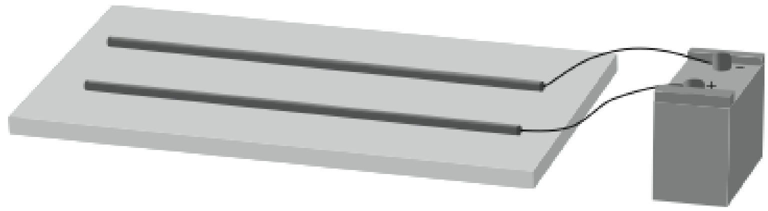
The diagram above shows a wind-powered generator in a yacht. It comprises a rectangular coil of wire that is rotated in a magnetic field.

The width (AB) of the coil = 6.4 cm
The length (AD) of the coil = 14.6 cm
The strength of the magnetic field = 0.75 T
Speed of the long side of the coil = 20.0 cm s^{-1}
Number of turns of coil = 100 turns

(a) Calculate the maximum induced voltage across **one loop**. **[M]**
(b) Describe three ways in which the size of the induced voltage across the length of the coil can be increased. **[A]**

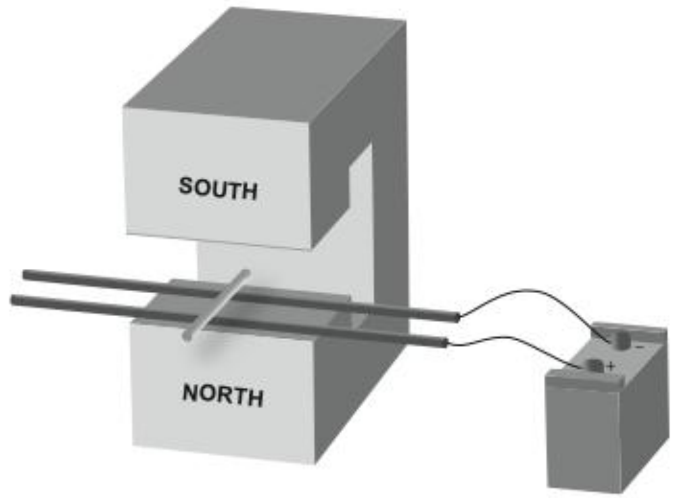
QUESTION 25: INDUCTION *(NCEA 2004, Q3)*

David's teacher Mr Manu asked him to set up an experiment to show the force acting on a conductor in a magnetic field. David put two horizontal, parallel metal rails on a wooden table and connected them to a battery as shown.



(a) State why the battery did not produce a current. **[A]**

David then put an aluminium rod across the rails and placed the rod and rails between the poles of a magnet as shown to the right.



(b) On the above diagram:

(i) Draw an arrow to show the direction of the magnetic field between the rails. Label this arrow '**field**'. **[A]**

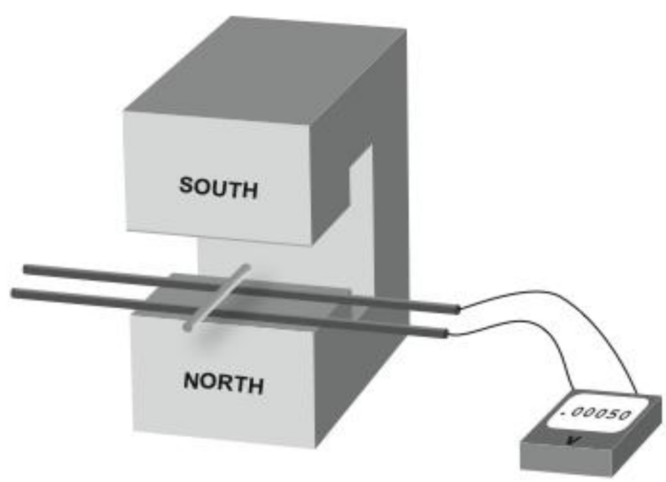
(ii) Draw an arrow to show the direction of the electromagnetic force on the aluminium rod. Label this arrow '**force**'. **[M]**

(c) Explain what caused the aluminium rod to experience an electromagnetic force. **[E]**

(d) Use the data below to calculate the size of the electromagnetic force on the aluminium rod. **[E]**

- Battery voltage = 12 V
- Total resistance of circuit = 2.5 Ω
- Distance between rails = 6.0 cm
- Length of aluminium rod = 8.0 cm
- Magnetic Field strength = 0.15 T

David then removed the battery and replaced it with a sensitive voltmeter. He pushed the aluminium rod so it rolled along the rails while maintaining electrical contact. At one time the voltmeter reads 5.0×10^{-4} V.



(e) Calculate the speed of the aluminium rod as it rolled along the rails. **[M]**

(f) David observed that as the aluminium rod approached the magnet, it slowed down when the current was produced. Explain clearly why it slowed down. **[E]**

Level 2 Exotic Electricity and Magnetism Matching

1. alternating current	a) gives off light when current passes through them but use very little voltage
2. ammeter	b) where iron or moving charged particles experience a force
3. ampere	c) tool for measuring the rate of change of charge
4. armature	d) wire wound around and around
5. carbon	e) generator that uses friction to build up very high potentials
6. circuit	f) region in which a charged object experiences a force
7. conventional current	g) the size of the force on a charge is proportional to the distance squared and the other charge
8. coulomb	h) where the number of positive and negative charges are equal or not present at all
9. coulomb's law	i) generation of voltage across a wire
10. current	j) rate of movement of charge
11. diode	k) term for the number of wrappings of wire in solenoid
12. direct current	l) where lines of force or action are parallel and equally spaced
13. electric field	m) first to measure the size of the charge on a single electron
14. electric field lines	n) rate of doing work
15. electric potential energy	o) stored by moving a charge against an electric field
16. electromagnet	p) when lines of force or action move away (or into) in every direction from central point
17. electromagnetic induction	q) electrons travel the other way
18. electrons	r) quantity that requires a direction
19. emf	s) steady flow of electrons in one direction only
20. galvanometer	t) when heat energy is used to cause atoms to shake off their electrons
21. generator	u) does not alter the ability to retard the movement of electrons
22. graphite	v) quality of material to retard movement of electrons or ions
23. heat	w) SI unit of the rate of movement of charge
24. induction	x) what every resistor produces
25. joules	y) difference in voltage between parts of a circuit
26. light dependent resistor	z) produces electric current from rotating coil inside magnetic field
27. light emitting diode	aa) SI unit of the magnetic field strength
28. magnetic field	bb) voltages and currents produced by changing magnetic fields
29. Milikan	cc) complete conductive path for
	electrons to return to power source
30. neutral	dd) produced when a current passes through a solenoid
31. neutron	ee) SI unit of rate of change of work
32. ohm	ff) very sensitive tool for measuring the rate of charge moving
33. ohmic conductor	gg) common term for potential difference
34. ohm's law	hh) process of transforming energy form one form to another
35. potential difference	ii) SI unit of quality of material to retard movement of electrons
36. potential divider	jj) uses two resistors to divide up an input voltage and make a smaller output voltage
37. potentiometer	kk) circuit with only one path for charged particles to return to power source
38. power	ll) positively charged nucleon
39. proton	mm) SI unit of energy
40. radial field	nn) used to control voltage (volume or tone controls in radios or amplifiers)
41. resistance	oo) changes ability to retard electron flow dependent on temperature
42. right hand slap rule	pp) orbit the nucleons
43. series	qq) SI unit for charge
44. solenoid	rr) used for brushes in motor for lubrication and conductivity
45. tesla	ss) changes ability to retard electron flow dependent on light intensity
46. thermistor	tt) material found in most common resistor type
47. thermonic emission	uu) semiconductor that allows current to flow one direction
48. turns	vv) uncharged nucleons
49. uniform field	ww) alternate term for coil of wire in motor
50. Van der Graaf	xx) map out the path a small positive test charge would move
51. vector	yy) relationship between voltage, resistance and current
52. voltage	zz) type of current produced in generators
53. voltmeter	aaa) a source voltage
54. watt	bbb) instrument for measuring potential difference
55. work	ccc) relates magnetic field, current and force on wire