90523

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SUPERVISOR'S USE ONLY

NEW ZEALAND QUALIFICATIONS AUTHORITY
MANA TOHU MĀTAURANGA O AOTEAROA

Level 3 Physics, 2012

90523 Demonstrate understanding of electrical systems

9.30 am Tuesday 27 November 2012
Credits: Six

Check that the National Student Number (NSN) on your admission slip is the same as the number at the top of this page.

You should attempt ALL the questions in this booklet.

Make sure that you have Resource Booklet L3–PHYSR.

In your answers use clear numerical working, words and/or diagrams as required.

Numerical answers should be given with an SI unit, to an appropriate number of significant figures.

If you need more room for any answer, use the extra space provided at the back of this booklet.

Check that this booklet has pages 2–10 in the correct order and that none of these pages is blank.

YOU MUST HAND THIS BOOKLET TO THE SUPERVISOR AT THE END OF THE EXAMINATION.

ASSESSOR'S USE ONLY	Achievement Criteria	
Achievement	**Achievement with Merit**	**Achievement with Excellence**
Identify or describe aspects of phenomena, concepts or principles.	Give descriptions or explanations in terms of phenomena, concepts, principles and/or relationships.	Give explanations that show clear understanding in terms of phenomena, concepts, principles and/or relationships.
Solve straightforward problems.	Solve problems.	Solve complex problems.
Overall level of performance		

You are advised to spend 55 minutes answering the questions in this booklet.

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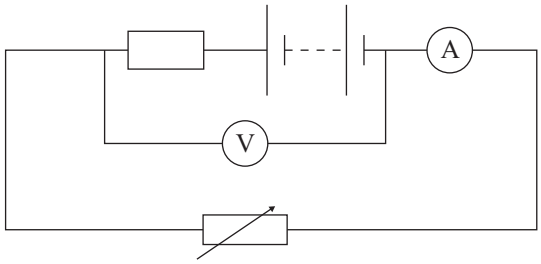
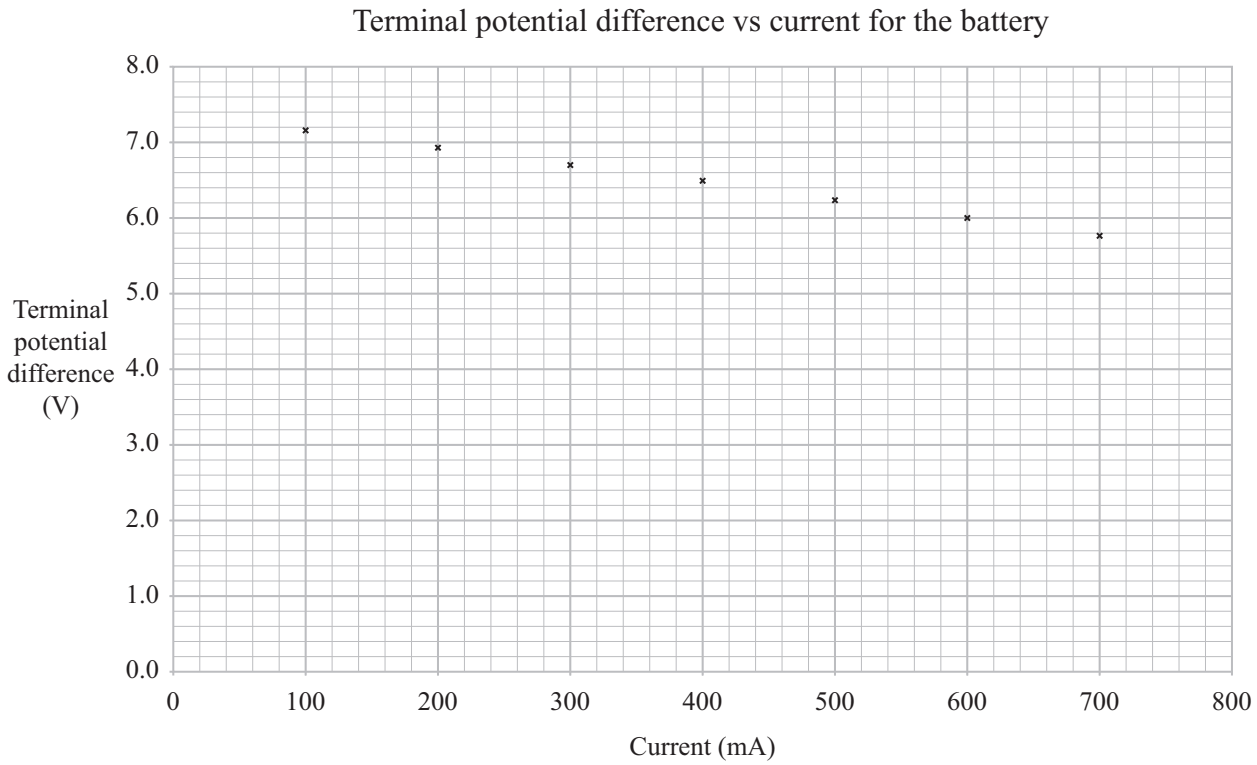
QUESTION ONE: THE BATTERY

Hugo has bought a remote-controlled car. He removes the battery from the car and connects it to a variable load that allows him to control the current.



Hugo then measures the terminal potential difference using the voltmeter, and plots his results on a graph.



(a) Calculate the size of the resistance that Hugo uses to draw a current of 500 mA.

Resistance = _____

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(b) Use the graph to estimate the EMF of the battery.

Explain your answer.

EMF = _____

(c) Use the graph to calculate the internal resistance of the battery.

Explain your answer.

Internal resistance = _____

(d) Hugo puts the battery in the car and plays with the car until it is running noticeably slower. He then removes the battery again and repeats the experiment, measuring the terminal potential difference and the current.

Draw a line on the graph to show the relationship between the terminal potential difference and current from this used battery.

Explain why you have placed the line where you have.

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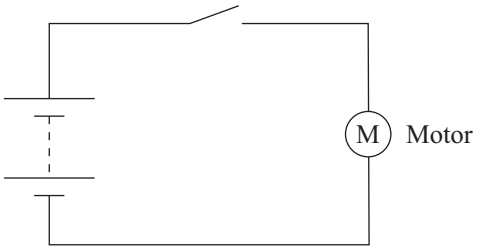
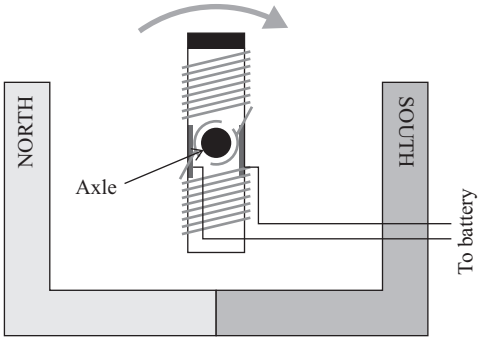
QUESTION TWO: THE MOTOR

When Hugo presses a button on the car's remote control, a switch closes to allow current to flow in the coil of the motor. This causes the coil to rotate, which makes the car's wheels turn.





adapted from http://static.ddmcdn.com/gif/motor-labels.gif

The motor has a very simple design – the current in the coil causes it to rotate in the magnetic field between the two magnets, as shown in the diagram.

As the coil rotates, a "back EMF" is produced in the coil.

(a) Explain how this back EMF will increase the life of the battery.

In your answer you should:

- explain why an EMF will be induced in the coil as it turns
- explain how this EMF will change as the coil rotates faster
- explain the effect of this EMF on the current drawn from the battery.

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The examination continues on the following page.

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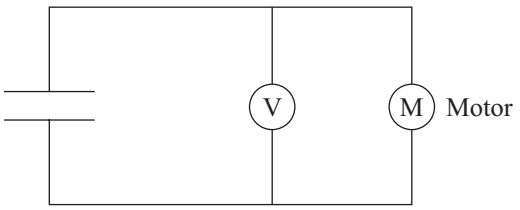
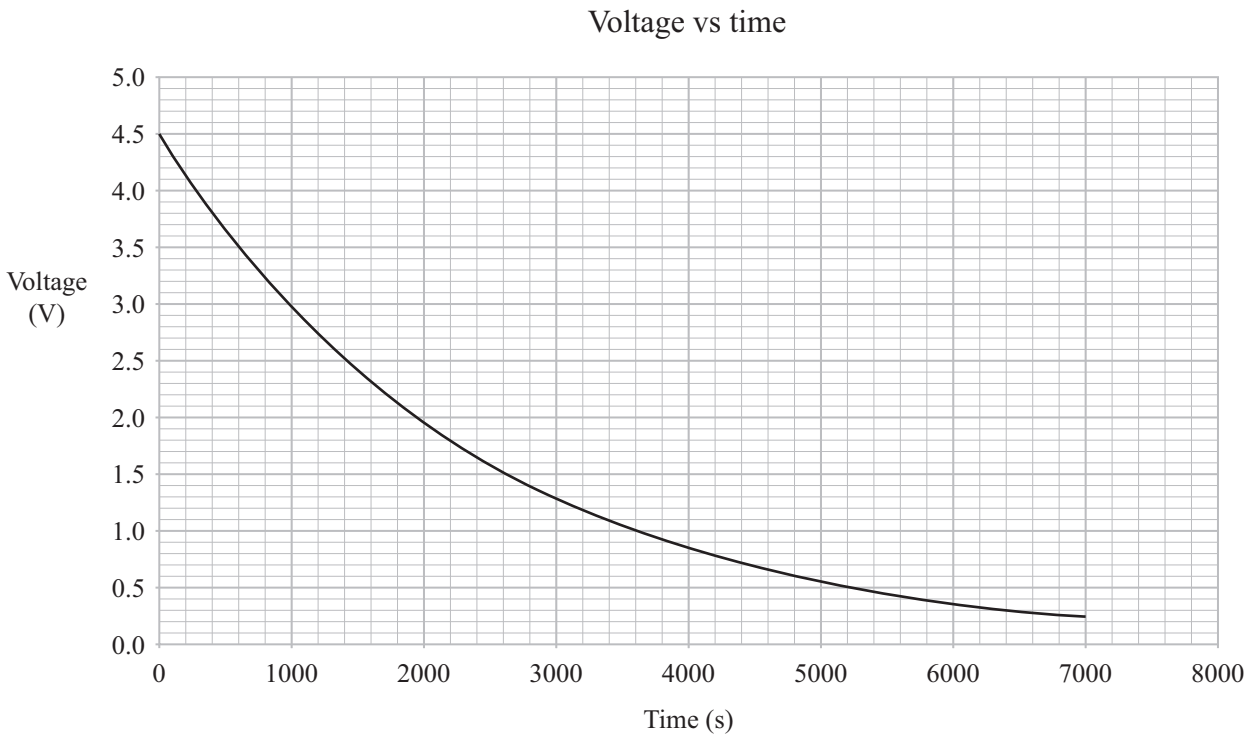
Hugo decides to use a capacitor instead of a battery to power his remote-controlled car. He knows that capacitors have no internal resistance and can be recharged. Hugo uses a 500 F capacitor in place of the battery. The capacitor is charged to 4.5 V, and then connected to the car's motor, as shown.



A voltmeter is placed in the circuit.

The following graph of voltage vs time is produced as the motor runs.



(b) Show that the effective resistance of the car's motor is approximately 4.8 Ω.

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(c) Calculate the size of the capacitance required to triple the time constant and draw a new curve on the graph opposite to show the effect of doing this.

Capacitance _____

(d) Describe, using words or by sketching a circuit diagram, how this new capacitance could be achieved with 500 F capacitors.

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QUESTION THREE: THE RECEIVER

The car's remote control sends out radio waves of frequency 27.0 MHz (27.0×10^6 Hz). Hugo starts investigating the cars's radio receiver by removing an inductor coil of inductance 1.00×10^{-6} H.

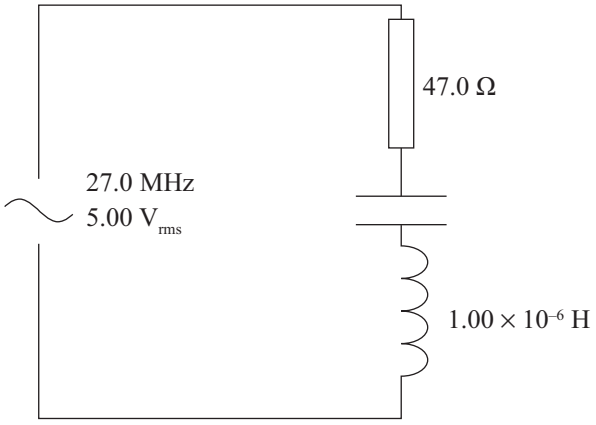
(a) Show that the reactance of the inductor at this frequency is 170 Ω.

Hugo connects the inductor in series with a 47.0 Ω resistor.

(b) Calculate the rms current through the resistor when this arrangement is connected to a 5.00 V_{rms} AC supply oscillating at 27.0 MHz.

rms current = _____

(c) A capacitor can be added in series to cause this circuit to resonate.



By stating the conditions under which resonance occurs, calculate the capacitance needed to bring the circuit to resonance at this frequency.

Capacitance = _____

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(d) When two radio controlled cars are sold as a set, the second controller uses a 49.0 MHz wave to avoid interference between the two radio signals.

Explain why a circuit built to resonate at 27.0 MHz does not respond to a 49.0 MHz signal.

As part of your answer, determine the current in the circuit in part (c) when the supply frequency is 27.0 MHz and when the supply frequency is 49.0 MHz.

Current in circuit when the supply frequency is 27.0 MHz = _____

Current in circuit when the supply frequency is 49.0 MHz = _____

Extra paper if required.
Write the question number(s) if applicable.

QUESTION NUMBER

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