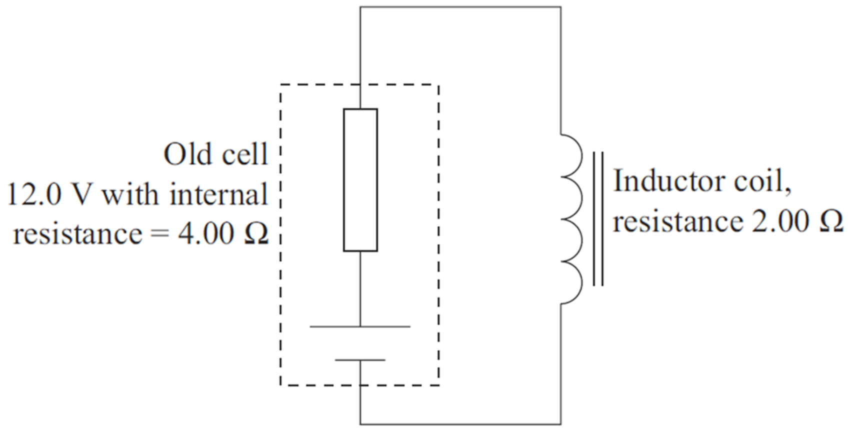
ELECTRICITY: BATTERIES AND KIRCHOFFS LAWS QUESTIONS

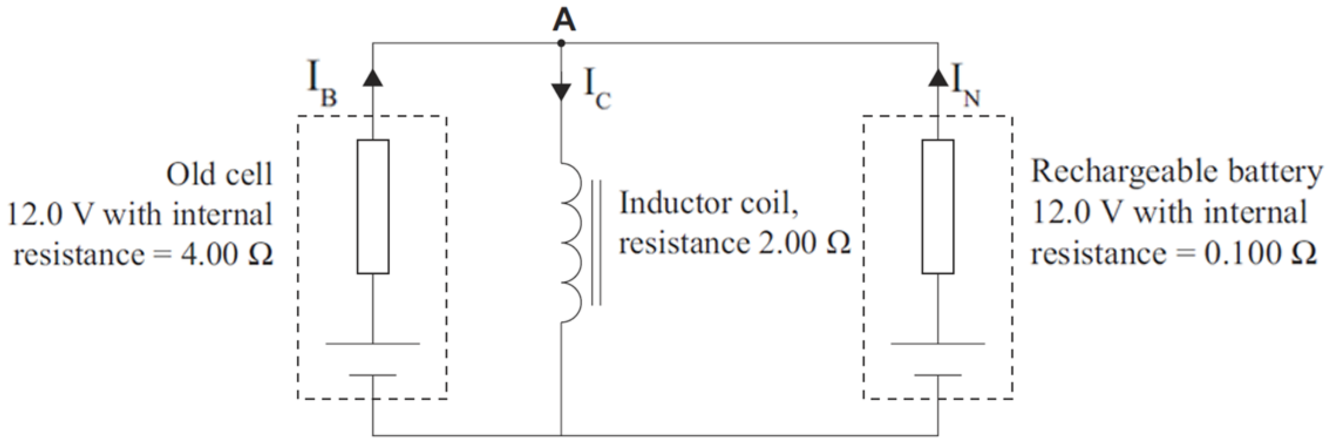
PORTABLE POWER (2010;1)

(a) A student connects an old cell to an inductor coil, as shown in the diagram.



Calculate the steady current that flows in the circuit.

(b) The student boosts the current by adding a re-chargeable battery with low internal resistance, as shown.



(i) Write an expression for the current at point **A**, in terms of the three currents labelled in the diagram.

(ii) A steady current of 5.58 A flows from the new cell. Using Kirchoff's Voltage Law, or otherwise, calculate the steady current through the inductor coil.

TORCH INVESTIGATION (2008;1)

Jess is investigating a torch to find out the characteristics of the battery and the lamp. The torch uses a filament lamp. The filament is a long coil of fine wire that heats up and glows when it carries sufficient current. For the purposes of calculation, assume that the resistance of the filament remains constant.

Jess measures the battery voltage when the lamp is switched off and finds the voltage to be 6.12 V. When Jess switches on the lamp, the voltage drops to 5.87 V. The current through the lamp is then 0.743 A.

(a) Name the term used for the potential difference measured when no current is drawn from the battery.

(b) Show that the working resistance of the lamp is 7.90 Ω.

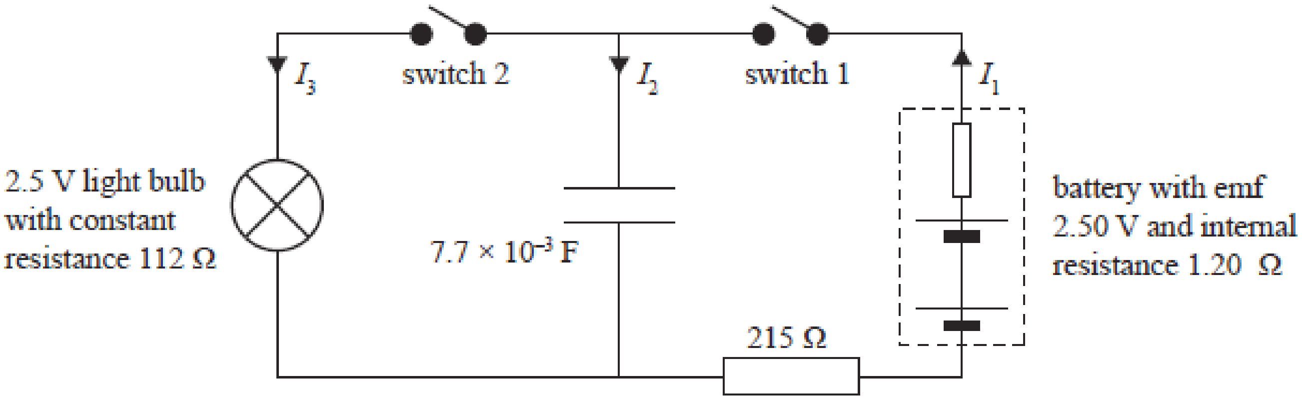
(c) Show that the internal resistance of the battery is 0.336 Ω.

(d) Describe and explain what would be observed if a battery with a higher internal resistance was used in the torch (Assume that the resistance of the lamp remains constant).

(e) Calculate the current that travels through the battery if a second identical lamp is connected in parallel with the first lamp.

CAPACITORS AND LOOPED CIRCUITS (2007;1)

The following circuit was set up to model the operation of a camera flash.



With switch 2 open, switch 1 is closed and the capacitor starts to charge.

(b) Write a Kirchhoff's voltage equation for the closed loop to calculate the initial current in the circuit (the voltage across the capacitor will initially be zero).

The capacitor is then discharged. With switch 2 still closed, switch 1 is now closed to re-charge the capacitor.

(c) Write a Kirchhoff's current equation for the circuit while the capacitor is charging.

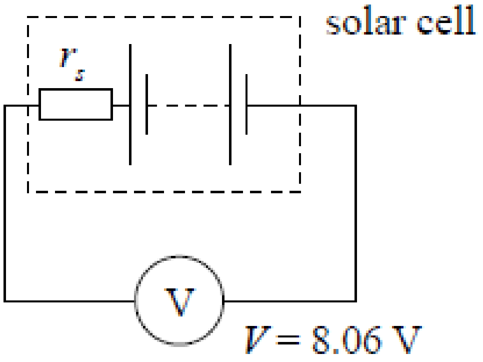
(d) Show that the terminal voltage of the battery, when the capacitor has finished charging, is 2.49 V (the current through the capacitor will now be zero).

(e) When the capacitor is charged, the voltage across the 215 Ω resistor is 1.64 V. Calculate the voltage across the capacitor.

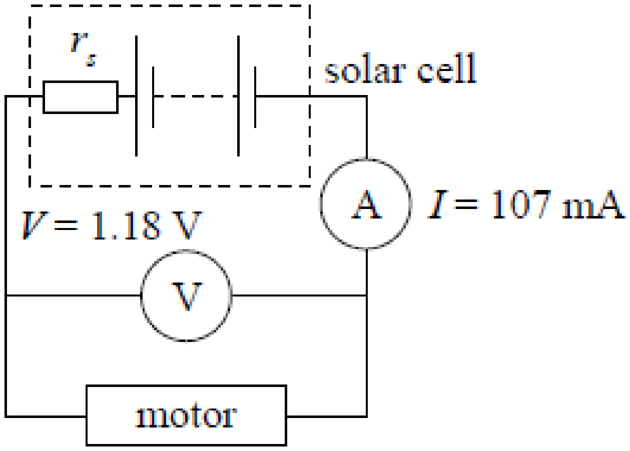
SOLAR RACING (2005;1)

As part of a technology challenge Tui and Richard are building a solar powered model car. They plan to use a solar cell connected to a small motor to drive the car.

They have been told that the internal resistance, r_s,of a solar cell is relatively large and so, before they start, they decide to investigate the electrical properties of the solar cell.
First they connect the solar cell to a voltmeter with no other components and find the voltage is 8.06 V.

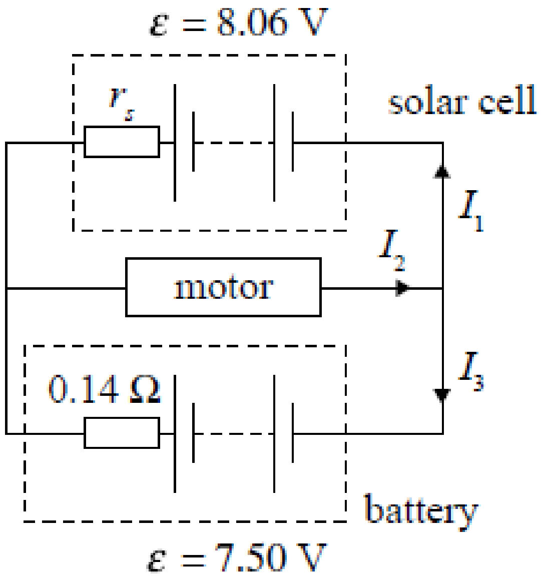


Then they connect the solar cell to the motor. They measure the voltage across the terminals of the cell to be 1.18 V, and the current to be 107 mA.



(a) Show that, in this circuit, the internal resistance of the solar cell is 64.3 Ω.

The arrangement does not make the motor go. Richard suggests they use a battery to drive the motor and then, when the motor isn't going, use the solar cell to charge the battery. A diagram of this arrangement is shown below.



(b) Explain why this arrangement is more likely to make the motor go.

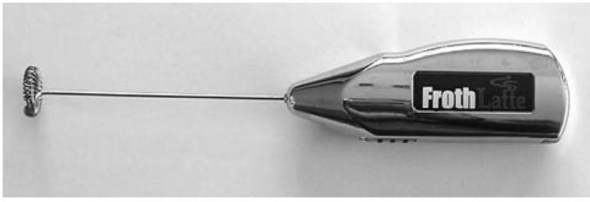
(c) State, in words, Kirchhoff's Voltage Law.

In the circuit above, I_1 = 0.029 A, I_2 = 0.674 A and I_3 = 0.645 A.

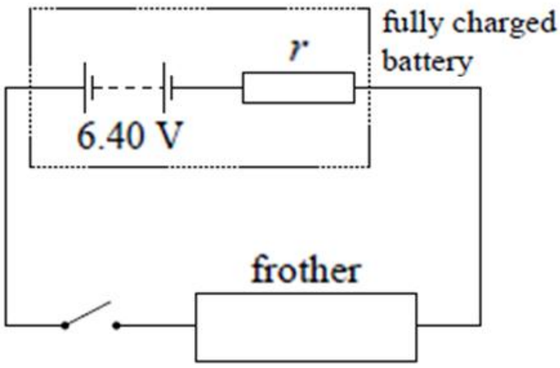
(d) Calculate the internal resistance, r_s, of the solar cell when connected in this circuit.

CAPPUCCINO ESSENTIALS (2004;1)

Jodi has a battery-operated rotary whisk that makes frothy milk for her coffee.



The electrical circuit of the frother is shown below; the motor that drives the frother is shown as a resistor. The battery has an emf of 6.40 V, and when fully charged it has internal resistance r.



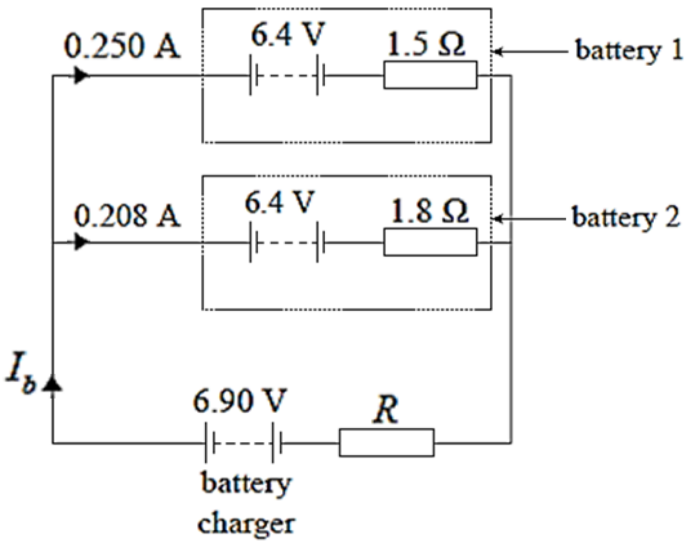
At maximum speed the power output of the frother is 4.5 W and this is achieved when the voltage across it is 6.25 V.

(a) Calculate the current through the frother when it is operating at maximum speed.

The frother operates at maximum speed when the battery is fully charged

(b) Calculate the internal resistance, r, of the fully charged battery.

After some time, the frother slows down because the battery is becoming flat. Jodi removes the battery and starts to recharge it, together with another battery that is also flat. The internal resistance of the battery Jodi removed is now 1.5 Ω and the internal resistance of the second flat battery is 1.8 Ω. The battery charger has a voltage of 6.90 V. The initial current through battery 1 is 0.250 A and through battery 2 is 0.208 A. The diagram shows the recharging circuit.



(c) Calculate the current, I_b, through the battery charger.

(d) Calculate the resistance, R, of the resistor.