Q and A

# Q1

Kylie measures the potential difference and current in a circuit.
[a] The potential difference across a resistor is 2.55 V when the current through the resistor is 120 mA. Calculate the resistance of this component.
[b] A resistor is marked as 147 kΩ and has 3.42 V across it. Calculate the current through this resistor.
[c] A 2.0 kΩ resistor has a power rating of 1.6 W. Calculate the maximum current it will tolerate.

(a) $$R = \frac{V}{I} = \frac{2.55\ \text{V}}{0.012\ \text{A}} = 213\ \Omega$$

(b) $$I = \frac{V}{R} = \frac{3.42\ \text{V}}{147\,000\ \Omega} = 2.33 \times 10^{-5}\ \text{A or } 23.3\ \mu\text{A}$$

(c) $$I = \sqrt{\frac{P}{R}} = \sqrt{\frac{1.6\ \text{W}}{2000\ \Omega}} = 0.0283\ \text{A or } 28.2\ \text{mA}$$

# Q2

A telephone receiver has a resistance of $8.0 \times 10^3\ \Omega$, and it uses a current of 7.0 mA. What potential difference must the exchange supply to make the receiver work properly?

$$V = I \times R = 0.007\ A \times 8000\ \Omega = 56.0\ V$$

# Q3

A technician has to replace the indicator lights in a stereo amplifier. Each light operates on 14.0 V and draws a current of 500 mA. Calculate the resistance of such a light.

$$R = \frac{V}{I} = \frac{14\ V}{0.5\ A} = 28.0\ \Omega$$

# Q4

Your nephew, Tom, finds a toy car, but the battery is missing. You read the label on the car's motor. It states the motor uses 320 mA and has a resistance of 4.7 Ω. What potential difference battery would you advise Tom to use in his car?

$$V = I \times R = 0.32\ A \times 4.7\ \Omega = 1.50\ V$$

# Q5

The resistance of metals increases as the temperature of the metal increases.

[a] Does the current through the metal element of a bar heater increase or decrease as the element heats up? Explain your reasoning.

[b] What happens inside the heating element that causes the resistance to increase as its temperature rises?

[c] Calculate the resistance of a 240 V bar heater that passes 10 A once it is at its normal operating temperature.

[d] Calculate the power consumption of the a 240 V heater that passes 10 A at its normal operating temperature.

[e] During a ‘brown-out’ the electricity supply to your house might drop to 170 V. How will this affect the resistance and power consumption of the heater?

# Q5 continued

(a) Since V is constant, then according to Ohm's Law (I is inversely proportional to R), if the resistance increases then the current should decrease. However, in practice, in order to maintain the operating power rating of the heater ($P = I \times V$), electrical energy will be consumed at a greater rate in an attempt to keep the current the same – the heater has to work harder.

(b) The atoms and free electrons will increase their vibration as the temperature increases so the free electron flow through the lattice will encounter greater opposition, therefore the resistance increases.

(c) $R = \frac{V}{I} = \frac{240\ V}{10\ A} = 24.0\ \Omega$

(d) $P = I \times V = 10\ A \times 240\ V = 2400\ W$ – electrical energy is consumed at a rate of $2.4\ kJ\ s^{-1}$

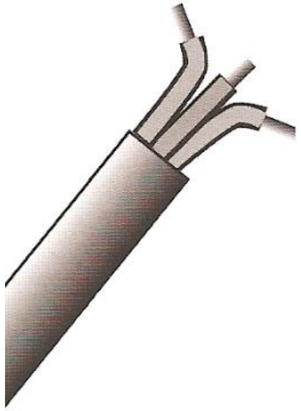
(e) If the voltage drops then so will the operating current, therefore the heater will not work as effectively. This means that it will not get as hot so its resistance will decrease. It will obviously consume less energy.

# Q6

The figure (*left*) shows a three-core general-purpose domestic electrical cable, which electricians use in electrical wiring in a house. The manufacturers design the cable for use with 240 V, but it is still safe at 415 V. The standard for such a cable states that one kilometre of any of the three conductors must have a resistance of not more than 18.1 Ω at 20 °C.

[a] Calculate the maximum resistance of one of the conductors in the cable if it runs 36.0 m from the meter board to a power outlet in a house.

[b] Calculate potential difference that has to be applied across 36.0 m of this cable to maintain a current of 1.00 A through it.



3 core cable

# Q6 continued

(a) $R_{max}$ per metre of cable $= \dfrac{18.1\,\Omega}{1000\,\text{m}} = 0.0181\,\Omega\,\text{m}^{-1}$

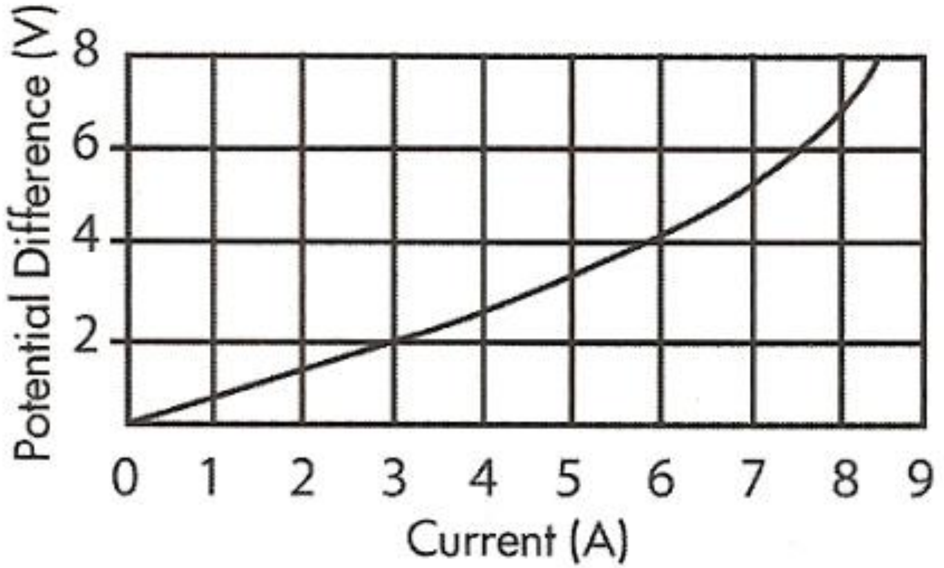
for 36m of cable, $R_{max} = 36 \times 0.0181\,\Omega\,\text{m}^{-1} = 0.65\,\Omega$ at 20 °C

(b) $R = \text{gradient of linear section of the graph} = \dfrac{V}{I} = \dfrac{4\,\text{V}}{6\,\text{A}} = 0.67\,\Omega$

(c) As voltage increases, the current also increases but at a reduced rate – the slope of the curve has an increasing gradient. This suggests that the resistance of the component is increasing.

# Q7

In an experiment on electrical circuits, the technician represented the data collected in the graph (*below*).




[a] Over which current range does the component act as an ohmic conductor?
[b] Calculate the resistance of the component in the ohmic region.
[c] Explain what happens to the resistance of the component at higher currents.
[d] What could cause such a change in resistance?

# Q7 continued

(a) The component's I-V characteristic is linear up to 6 A, so it acts as an ohmic conductor from 0 – 6 A.

(b) $$R = \text{gradient of linear section of the graph} = \frac{V}{I} = \frac{4\ V}{6\ A} = 0.67\ \Omega$$

(c) As voltage increases, the current also increases but at a reduced rate – the slope of the curve has an increasing gradient. This suggests that the resistance of the component is increasing.

(d) This is probably caused by an increase in temperature within the component.

# Q8

Why is it that the electricity does not kill birds when they perch on high voltage transmission lines?

Current requires a potential difference to flow, however when birds sit on a high voltage transmission line, the potential difference between the bird's legs is negligible. They are effectively sitting on an isolated electrical system. If the birds were grounded, then the potential difference would be much higher, current would flow and they would be killed. However the air between the lines and the ground provides adequate insulation to prevent this happening.

# Q9

A lie detector measures the sweat rate of subjects by detecting changes in their skin resistance. Persons under stress normally produce more sweat, so lie-detector operators assume subjects will sweat more when they tell lies.

[a] Would a lie detector register increased or decreased skin resistance as a typical subject starts to tell a lie? Explain why you chose your answer.

[b] The detector shows this change in resistance as a needle movement, which traces a line on paper. What would this resistance change cause to happen to the current driving the needle motor?

[c] If the potential difference across the detector is 12 V and the current through the detector is 35 mA, what is the resistance of the person's skin?

# Q9 continued

(a) Decrease in skin resistance. Sweat contains a high concentration of salts and so has a high concentration of ions (charged particles), which conduct electricity in solutions.

(b) A decrease in resistance implies an increase in current, since according to Ohm's Law, I is inversely proportional to R. This would result in greater movement / deflection of the needle.

(c) $$R = \frac{V}{I} = \frac{12\ \text{V}}{0.035\ \text{A}} = 343\ \Omega$$