Set 16: Circuits and Ohm's Law

16.1	(a)	$R = \frac{V}{I} = \frac{2.55\ V}{0.012\ A} = 213\ \Omega$
	(b)	$I = \frac{V}{R} = \frac{3.42\ V}{147\,000\ \Omega} = 2.33 \times 10^{-5}$ A or 23.3μA
	(c)	$I = \sqrt{\frac{P}{R}} = \sqrt{\frac{1.6\ W}{2000\ \Omega}} = 0.0283$ A or 28.2 mA
16.2		V = I x R = 0.007 A x 8000 Ω = 56.0 V
16.3		$R = \frac{V}{I} = \frac{14\ V}{0.5\ A} = 28.0\ \Omega$
16.4		V = I x R = 0.32 A x 4.7 Ω = 1.50 V
16.5	(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 x 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 x V = 10 A x 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.
16.6	(a)	R_{max} per metre of cable $= \frac{18.1\ \Omega}{1000\ m} = 0.0181\ \Omega\ m^{-1}$ for 36m of cable, R_{max} = 36 x 0.0181 Ω m^{-1} = 0.65 Ω at 20 °C
	(b)	$I = \frac{V_{max}}{R} = \frac{415\ V}{0.65\ \Omega} = 638\ A$
16.7	(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 = 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.
16.8		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.
16.9	(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)	$R = \frac{V}{I} = \frac{12\ V}{0.035\ A} = 343\ \Omega$