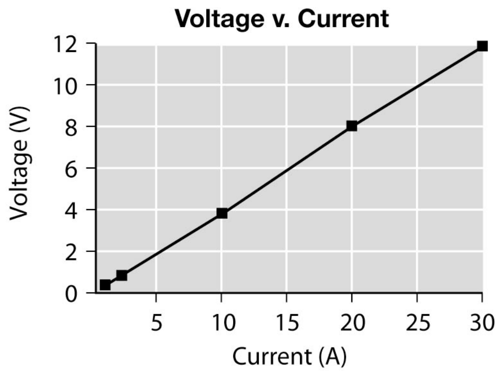
Section 11.7: Electrical Resistance

Mini Investigation: Determining Unknown Resistance, page 523

A. Graphs may vary. Sample graph:



$$\begin{aligned} \text{slope} &= \frac{\Delta V}{\Delta I} \\ &= \frac{0.72\ \text{V} - 0.24\ \text{V}}{2.0\ \text{A} - 0.8\ \text{A}} \\ &= \frac{0.48\ \text{V}}{1.2\ \text{A}} \\ \text{slope} &= 0.4\ \text{V/A} \end{aligned}$$

The unknown resistance is 0.4 Ω.

B. Answers may vary. Sample answer:
A 100 Ω resistor would give values ranging from 2-15 V and 0.2 A to 0.15 A. Note: the ammeter should be of an appropriate scale. The percent difference is typically around 5 %.

C. Answers may vary. Sample answer:
The other student's graph had the same shape as mine. Both graphs show a linearly proportional relationship, but each had a different slope.

Tutorial 1 Practice, page 525

1. Given: $V = 120$ V; $I = 6.5$ A

Required: R

Analysis: $R = \frac{V}{I}$

Solution:
$$\begin{aligned} R &= \frac{V}{I} \\ &= \frac{120\ \text{V}}{6.5\ \text{A}} \\ R &= 18\ \Omega \end{aligned}$$

Statement: The resistance of the toaster element is 18 Ω.

2. Given: $A = 450$ A; $V = 12$ V

Required: R

Analysis: $R = \frac{V}{I}$

Solution:
$$\begin{aligned} R &= \frac{V}{I} \\ &= \frac{12\ \text{V}}{450\ \text{A}} \\ R &= 0.027\ \Omega \end{aligned}$$

Statement: The resistance of the car starter is 0.027 Ω.

Section 11.7 Questions, page 526

1. (a) Given: $R = \frac{V}{I}$.

Rearranging:
$$\begin{aligned} R &= \frac{V}{I} \\ R \times I &= \frac{V}{\cancel{I}} \times \cancel{I} \\ IR &= V \\ \frac{\cancel{R}I}{\cancel{R}} &= \frac{V}{R} \\ I &= \frac{V}{R} \end{aligned}$$

The equation solved for current is $I = \frac{V}{R}$.

(b) Given: $R = \frac{V}{I}$.

Rearranging:
$$\begin{aligned} R &= \frac{V}{I} \\ R \times I &= \frac{V}{\cancel{I}} \times \cancel{I} \\ V &= IR \end{aligned}$$

The equation solved for voltage is $V = IR$.

2. Given: $V = 9.0$ V; $I = 160$ mA

Required: R

Analysis: $R = \frac{V}{I}$

Solution: Convert the current to amperes to get the answer in ohms:

$$\begin{aligned} I &= 160\ \cancel{\text{mA}} \times \frac{1\ \text{A}}{1000\ \cancel{\text{mA}}} \\ I &= 0.16\ \text{A} \end{aligned}$$

$$\begin{aligned} R &= \frac{V}{I} \\ &= \frac{9.0\ \text{V}}{0.16\ \text{A}} \\ R &= 56\ \Omega \end{aligned}$$

Statement: The resistance of the portable fan is 56 Ω.

3. Given: $V = 9.0$ V; $R = 100\ 000\ \Omega$

Required: I

Analysis: $R = \frac{V}{I}$

$I = \frac{V}{R}$

Solution: $I = \frac{V}{R}$

$= \frac{9.0\text{ V}}{100\ 000\ \Omega}$

$I = 9 \times 10^{-5}$ A

Statement: The current going through the skin would be 9×10^{-5} A.

4. Given: $V = 120$ V; $R = 1000\ \Omega$.

Required: I

Analysis: $R = \frac{V}{I}$

$I = \frac{V}{R}$

Solution: $I = \frac{V}{R}$

$= \frac{120.0\text{ V}}{1000\ \Omega}$

$I = 0.1$ A

Statement: The current going through the skin would be 0.1 A.

5. Given: $R = 8.0\ \Omega$; $V = 5.2$ V

Required: I

Analysis: $R = \frac{V}{I}$

$I = \frac{V}{R}$

Solution: $I = \frac{V}{R}$

$= \frac{5.2\text{ V}}{8.0\ \Omega}$

$I = 0.65$ A

Statement: The current going to the speaker is 0.65 A.

6. Given: $I = 2.07$ A; $R = 8.05\ \Omega$

Required: I

Analysis: $R = \frac{V}{I}$

$V = IR$

Solution: $V = IR$

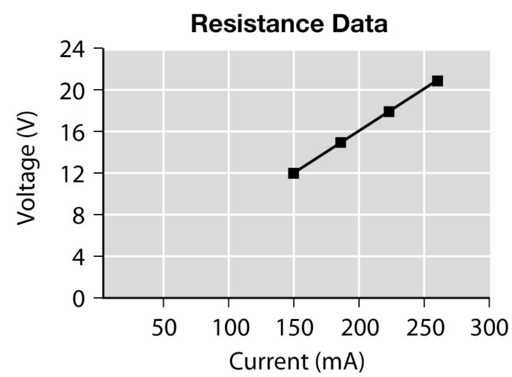
$= (2.07\text{ A})(8.05\ \Omega)$

$V = 16.7$ V

Statement: The voltage of the charger is 16.7 V.

7. Answers may vary. Sample answer:
Electrical resistance is a term that describes a measure of how able an electric current is to travel through a material. The higher the resistance, the less able an electric current is to travel through a material.

8.



The slope of the line connecting the data points represents the resistance. For example, the line passes through the data points (12 V, 151 mA) and (18 V, 226 mA). First convert the current to amperes to find the resistance in ohms:

$I_1 = 151\cancel{\text{mA}} \times \frac{1\text{ A}}{1000\cancel{\text{mA}}}$

$I_1 = 0.151$ A

$I_2 = 226\cancel{\text{mA}} \times \frac{1\text{ A}}{1000\cancel{\text{mA}}}$

$I_2 = 0.226$ A

The two data points (12 V, 0.151 A) and (18 V, 0.226 A) can be used to find the slope:

$\text{slope} = \frac{\text{rise}}{\text{run}}$

$m = \frac{\Delta V}{\Delta I}$

$= \frac{18\text{ V} - 12\text{ V}}{0.226\text{ A} - 0.151\text{ A}}$

$m = 80\ \Omega$

So the resistance is 80 Ω.

9. Ohm's law can be stated as an equation as $R = \frac{V}{I}$. For any value for the current, I, on the graph, the load represented by the blue line has a greater voltage than the load represented by the red line. From the equation $R = \frac{V}{I}$, for a constant current, a higher voltage indicates a higher resistance. So the blue line represents the higher value of resistance.

10. The student has incorrectly connected the ohmmeter in series instead of in parallel, and has incorrectly connected the ohmmeter to an operating circuit instead of a circuit that is switched off.

11. Answers may vary. Sample answer:
A situation where electrical resistance is desirable is in an electric circuit that has fine wires and devices sensitive to high currents, since high electrical currents could damage the wires or devices, and a high resistance means that electrical currents do not flow easily.
A situation where electrical resistance is undesirable is in the transmission of electrical energy through wires from a power plant to consumers, since resistance in the wire will cause some of the electrical energy flowing through the wire to be converted into thermal energy, which will be wasted.

12.

Current	Voltage (V)	Resistance (Ω)
25 mA	12	**480**
1.2 A	**610**	510
375 μA	0.25	**670**
3.6 A	120	33
1.0 mA	1.5	1500

Row 1: Convert current to amperes to get the answer in volts per ampere, or ohms:

$$I = 25\,\cancel{\text{mA}} \times \frac{1\text{ A}}{1000\,\cancel{\text{mA}}}$$

$$I = 0.025\text{ A}$$

$$R = \frac{V}{I}$$

$$= \frac{12\text{ V}}{0.025\text{ A}}$$

$$R = 480\ \Omega$$

The resistance is 480 Ω.

Row 2:

$$R = \frac{V}{I}$$

$$V = IR$$

$$= (1.2\text{ A})(510\ \Omega)$$

$$V = 610\text{ V}$$

The voltage is 610 V.

Row 3: Convert current to amperes to get the answer in volts per ampere, or ohms:

$$I = 375\,\cancel{\mu\text{A}} \times \frac{1\text{ A}}{1\times 10^{6}\,\cancel{\mu\text{A}}}$$

$$I = 3.75\times 10^{-4}\text{ A}$$

$$R = \frac{V}{I}$$

$$= \frac{0.25\text{ V}}{3.75\times 10^{-4}\text{ A}}$$

$$R = 670\ \Omega$$

The resistance is 670 Ω.

Row 4:

$$R = \frac{V}{I}$$

$$I = \frac{V}{R}$$

$$= \frac{120\text{ V}}{33\ \Omega}$$

$$I = 3.6\text{ A}$$

The current is 3.6 A.

Row 5:

$$R = \frac{V}{I}$$

$$I = \frac{V}{R}$$

$$= \frac{1.5\text{ V}}{1500\ \Omega}$$

$$I = 1.0\times 10^{-3}\text{ A}$$

Convert current to microamperes:

$$I = 1.0\times 10^{-3}\,\cancel{\text{A}} \times \frac{1000\text{ mA}}{1\,\cancel{\text{A}}}$$

$$I = 1.0\text{ mA}$$

The current is 1.0 mA