Using Ohm's Law

Ohm's Law reads

$$V = IR.$$

If we know the current and the resistance, we may find the potential difference (voltage) between the ends of the piece of wire. For example, suppose a circuit element has a resistance of 50.0 Ω and carries a current of 3.5 A (a). Then the potential difference between the ends of the piece of wire is

$$V = IR = (3.5 \text{ A}) \times (50.0\ \Omega) = 175 \text{ V}.$$

A greater resistance would have led to a greater potential difference. If the resistance were 200 Ω (b), the potential difference would have been

$$V = IR = (3.5 \text{ A}) \times (200.0\ \Omega) = 700 \text{ V}.$$

A greater current for the same resistance would also have meant a greater potential difference. If $I = 10.0$ A (c), then the potential difference is

$$V = IR = (10.0 \text{ A}) \times (50.0\ \Omega) = 500 \text{ V}.$$

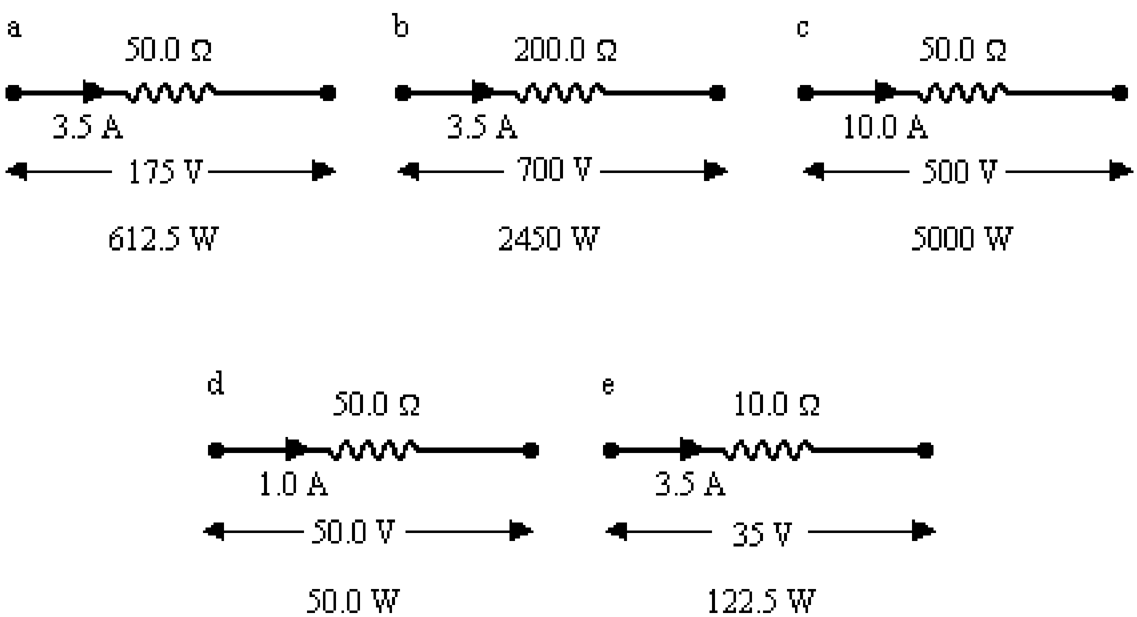

Fig. E04.3.1 Finding the voltage (potential difference) between ends of wires, and the amount of power dissipated. a. $I = 3.5$ A, $R = 50.0\ \Omega$ b. $I = 3.5$ A, $R = 200.0\ \Omega$ c. $I = 10.0$ A, $R = 50.0\ \Omega$ d. $I = 1.0$ A, $R = 50.0\ \Omega$ e. $I = 3.5$ A, $R = 10.0\ \Omega$

Similarly a smaller current, say $I = 1.0$ A (d), for the same resistance means a smaller potential difference

$$V = IR = (1.0 \text{ A}) \times (50.0\ \Omega) = 50.0 \text{ V}.$$

A smaller resistance R = 10.0 Ω, for the same current as in (a), 3.5 A (e) also means a smaller potential difference between the ends of the piece of wire,

$$V = IR = (3.5 \text{ A}) \times (10.0\ \Omega) = 35 \text{ V}.$$

Suppose we have a potential difference between two points of 100 V. If the current in the circuit element is 2.0 A, for example, we can determine the resistance to be

$$R = V/I = 100 \text{ V}/2.0 \text{ A} = 50.0\ \Omega.$$

A greater current flow will result if the resistance is smaller. For example, if the current in this circuit element having a potential difference of 100 V is 5.0 A, the resistance is lower:

$$R = V/I = 100 \text{ V}/5.0 \text{ A} = 20.0\ \Omega.$$

A smaller current flow will result when the resistance is greater. If the current in this same circuit element is 0.50 A, the resistance must have been

$$R = V/I = 100 \text{ V}/0.50 \text{ A} = 200.0\ \Omega.$$

Finally, if we know the potential difference between the ends of the piece of wire and the resistance, we can determine the current. Suppose a piece of wire has a potential difference between the ends of the wire of 100 V and has a resistance of 10.0 Ω. The current is

$$I = V/R = 100 \text{ V}/10.0\ \Omega = 10.0 \text{ A}.$$

Just as above, we can see that increasing the potential difference for a given resistance means a greater current, and increasing the resistance for a given potential difference means a smaller current. The contrary also is true: decreasing the potential difference for a given resistance means a smaller current, and decreasing the resistance for a given potential difference means a greater current.

Finding power

We know that power is given as

$$P = IV.$$

If Ohm's Law, $V = IR$, is also true, then we may find the power simply. Let us use the examples from the first paragraph above. The power used in each situation is

$$P = IV = (175 \text{ V}) \times (3.5 \text{ A}) = 612.5 \text{ W};$$

$$P = IV = (700 \text{ V}) \times (3.5 \text{ A}) = 2450 \text{ W};$$

$$P = IV = (500 \text{ V}) \times (10.0 \text{ A}) = 5000 \text{ W};$$

$$P = IV = (50.0 \text{ V}) \times (1.0 \text{ A}) = 50.0 \text{ W}; \text{ and}$$

$$P = IV = (35 \text{ V}) \times (3.5 \text{ A}) = 122.5 \text{ W, respectively}$$

If we know P and V we may determine I. Suppose in a circuit element that $V = 120$ V and $P = 1200$ W. Then

$$I = P/V = 1200 \text{ W}/120 \text{ V} = 10 \text{ A}.$$

We may now use Ohm's Law to determine the resistance of the circuit element:

$$R = V/I = 120 \text{ V}/10 \text{ A} = 12\ \Omega.$$

It is obvious in this case that if R had been known, the Joule heating relation $P = I^2R$ could have been used to determine I as

$$I = \sqrt{P/R} = \sqrt{1200 \text{ W}/12\ \Omega} = \sqrt{100 \text{ A}^2} = 10 \text{ A}.$$

As another example, consider a 10 W flashlight bulb. The two batteries that operate it produce a potential difference of 3.0 V. A current of

$$I = P/V = 10 \text{ W}/3.0 \text{ V} = 3.33 \text{ A}.$$

will flow, the resistance may be found as

$$R = V/I = 3.0 \text{ V}/3.33 \text{ A} = 0.90\ \Omega.$$

Note that the Joule heat equation is consistent:

$$P = I^2R = (3.33 \text{ A})^2 \times (0.90\ \Omega) = 10 \text{ W}.$$