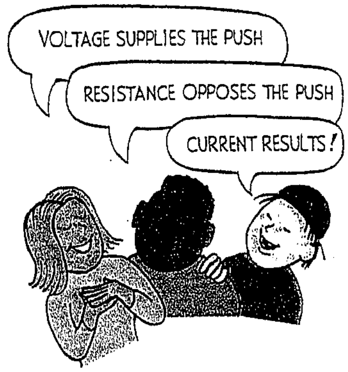
34.6 Ohm's Law and Electric Shock



What causes electric shock in the human body—current or voltage? The damaging effects of shock are the result of current passing through the body. From Ohm's law, we can see that this current depends on the voltage applied, and also on the electric resistance of the human body.

The resistance of your body depends on its condition and ranges from about 100 ohms if you're soaked with salt water to about 500 000 ohms if your skin is very dry. If you touched the two electrodes of a battery with dry fingers, the resistance your body would normally offer to the flow of charge would be about 100 000 ohms. You usually would not feel 12 volts, and 24 volts would just barely tingle. If your skin were moist, on the other hand, 24 volts could be

Table 34.1
Effect of Various Electric Currents on the Body

Current in amperes	Effect
0.001	Can be felt
0.005	Painful
0.010	Involuntary muscle contractions (spasms)
0.015	Loss of muscle control
0.070	If through the heart, serious disruption; probably fatal if current lasts for more than 1 second

Questions

1. If the resistance of your body were 100 000 ohms, what would be the current in your body when you touched the terminals of a 12-volt battery?
2. If your skin were very moist so that your resistance was only 1000 ohms, and you touched the terminals of a 24-volt battery, how much current would you draw?

Answers

1. The current in your body, quite harmless, would be

$$\text{current} = \frac{\text{voltage}}{\text{resistance}} = \frac{12\ \text{V}}{100\ 000\ \Omega} = 0.000\ 12\ \text{A}$$

2. You would draw $\frac{24\ \text{V}}{1000\ \Omega}$, or 0.024 A, a dangerous amount of current!

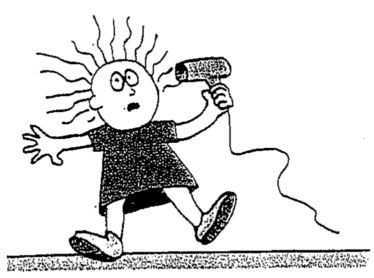


Figure 34.7 ▲
Handling a wet hair dryer can be like sticking your fingers into a live socket.

quite uncomfortable. Table 34.1 describes the effects of different amounts of current on the human body.

Many people are killed each year by current from common 120-volt electric circuits. If you touch a faulty 120-volt light fixture with your hand while you are standing on the ground, there is a 120-volt "electric pressure" between your hand and the ground. The soles of your shoes normally provide a very large resistance between your feet and the ground, so the current would probably not be enough to do serious harm. But if you are standing barefoot in a wet bathtub connected through its plumbing to the ground, the resistance between you and the ground is very small. Your overall resistance is lowered so much that the 120-volt potential difference may produce a harmful current through your body.

Drops of water that collect around the on/off switches of devices such as a hair dryer can conduct current to the user. Although distilled water is a good insulator, the ions in ordinary water greatly reduce the electric resistance. These ions are contributed by dissolved materials, especially salts. There is usually a layer of salt left from perspiration on your skin, which when wet lowers your skin resistance to a few hundred ohms or less. Handling electric devices while taking a bath is extremely dangerous.

Figure 34.8 ▲
The bird can stand harmlessly on one wire of high potential, but it had better not reach over and grab a neighboring wire! Why not?

You have seen birds perched on high-voltage wires. Every part of their bodies is at the same high potential as the wire, and they feel no ill effects. For the bird to receive a shock, there must be a *difference* in electric potential between one part of its body and another part. Most of the current will then pass along the path of least electric resistance connecting these two points.

Suppose you fall from a bridge and manage to grab onto a high-voltage power line, halting your fall. So long as you touch nothing else of different potential, you will receive no shock at all. Even if the wire is thousands of volts above ground potential and even if you hang by it with two hands, no charge will flow from one hand to the other. This is because there is no appreciable difference in electric potential between your hands. If, however, you reach over with one hand and grab onto a wire of different potential, ZAP!!

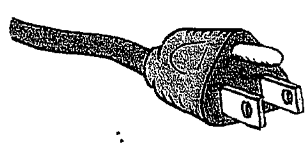


Figure 34.9 ▲
The third prong connects the body of the appliance directly to ground. Any charge that builds up on an appliance is therefore conducted to the ground.

Mild shocks occur when the surfaces of electric appliances are at an electric potential different from that of the surfaces of other nearby devices. If you touch surfaces of different potentials, you become a pathway for current. Sometimes the effect is more than mild. To prevent this problem, the outsides of electric appliances are connected to a ground wire, which is connected to the round third prong of a three-wire electric plug (Figure 34.9). All ground wires in all plugs are connected together through the wiring system of the house. The two flat prongs are for the current-carrying double wire. If the live wire accidentally comes in contact with the metal surface of an appliance, the current will be directed to ground rather than shocking you if you handle it.

One effect of electric shock is to overheat tissues in the body or to disrupt normal nerve functions. It can upset the nerve center that controls breathing. In rescuing victims, the first thing to do is clear them from the electric power supply with a wooden stick or some other nonconductor so that you don't get electrocuted yourself. Then apply artificial respiration.