15 Electrodynamics

Name_____

Reading: ELECTRIC SHOCK

AP/Inquiry Physics

Your body is controlled by electrical nerve impulses, so electric currents can disrupt normal bodily functions. It is the current that passes through your body, not the voltage across it, which determines the severity of the shock. The current can damage your organs, with the heart, brain, and spinal cord being particularly susceptible.

Ohm's Law gives the amount of current actually passing through the body as I=V/R. The resistance used varies with the situation. Internally, your blood and fluids are good conductors with a resistance of about 200 Ω. Externally, current must first pass through the skin (unless it is cut) and it typically has a much higher resistance. A calm person's dry skin may have a resistance of 500,000 Ω, while sweaty palms may have a resistance 10 to 50 times lower. (This is why a lie detector measures skin resistance along with other physiological factors.) A person standing in saltwater has a skin resistance of only 500 Ω.

Usually the electric current must pass through three series resistances: your skin (e.g. your nose), body fluids, and your skin again (e.g. your toes). Thus if your greasy nose has a resistance of 50,000 Ω, your blood has 200 Ω, and your sweaty feet have 10,000 Ω and you cross a 120 V household circuit, a current of (120 V) / (50,000 Ω + 200 Ω + 10,000 Ω) = 0.002 A will pass through you.

What would that do? A current greater than 1 mA (0.001 A) causes discomfort. Above 16 mA, you lose control of your muscles and they undergo contractions. Between 25 mA and 100 mA, you have difficulty breathing and eventually respiration stops. Between 100 mA and 200 mA, your heart stops pumping and undergoes uncoordinated contractions called ventricular fibrillation. Above 200 mA, irreversible heart damage occurs. So with a greasy nose and sweaty feet, the 2 mA current would cause discomfort.

Special thanks to Dr. Stewart Ryan of the University of Oklahoma

PROBLEMS SHOW YOUR WORK

1. Repairing his car in the rain, Mr. M puts his hands on the terminals of its 12.0 V battery. If his total resistance is 10,000 Ω, what current and effects will he experience?

2. Despondent over the latest test results, Mr. M sharpens his fingers and puts them in the slots of a 120 V wall outlet while bathing in saltwater. If his total resistance is 1,200 Ω, what current and effects will he experience?

15 Electrodynamics

Name_____

Reading: POWER AND APPLIANCES

AP/Inquiry Physics

You now know that the power an electrical device uses is predicted by multiplying the current passing through it by the voltage across it (P = IV). Below is a table of common appliances and their current and power requirements.

Appliance		Current (A)	Power (W)
Stereo system		0.3	36
60-W incandescent light bulb		0.5	60
Desktop computer		1.4	168
Televisions:	Average CRT	1.2	147
	Average LCD	1.6	193
	Average rear projection	1.7	208
	Average plasma	2.7	328
Drip coffee maker		3.5	420
Garage-door opener		4.5	540
Vacuum cleaner		5.4	648
2-door refrigerator (18 ft^3)		6.5	780
Steam iron		7	840
Toaster (2-slot)		7	840
Dishwasher		8.6	1032
Microwave oven		10	1200
Clothes washer		10	1200
Clothes dryer *		27	6480
Water heater *		37.5	9000
Electric stove (4-burner) and oven *		45.4	10900
Forced-air heater *		80.6	19344

* this appliance runs on a 240 V circuit instead of 120 V

Mostly taken from *The Physics Teacher*, Vol. 32, p. 511; TV data from CNET.com, 4/2007

Your home's electrical system is split into several parallel circuits. Each circuit is protected from shorts (where wires cross, causing low resistance and high current) or overloads (where too many appliances are turned on, causing high current) by a fuse or circuit breaker. The fuse melts or the circuit breaker switch turns off when the current exceeds a safe value.

A typical kitchen might have an electric oven, microwave, dishwasher, refrigerator, drip coffee maker, and four 60 W light bulbs. If all were operating, the current would be:

$$45.4\text{ A} + 10\text{ A} + 8.6\text{ A} + 6.5\text{ A} + 3.5\text{ A} + 2\text{ A} = 76\text{ A}.$$

That large a current would require very large wires, so the kitchen would likely run off two separate circuits. One 50 A, 240 V circuit would be for the oven. Another 35 A, 120 V circuit would serve the rest of the kitchen.

PROBLEM: How much power could be output from a 35 A, 120 V circuit?

SHOW YOUR WORK