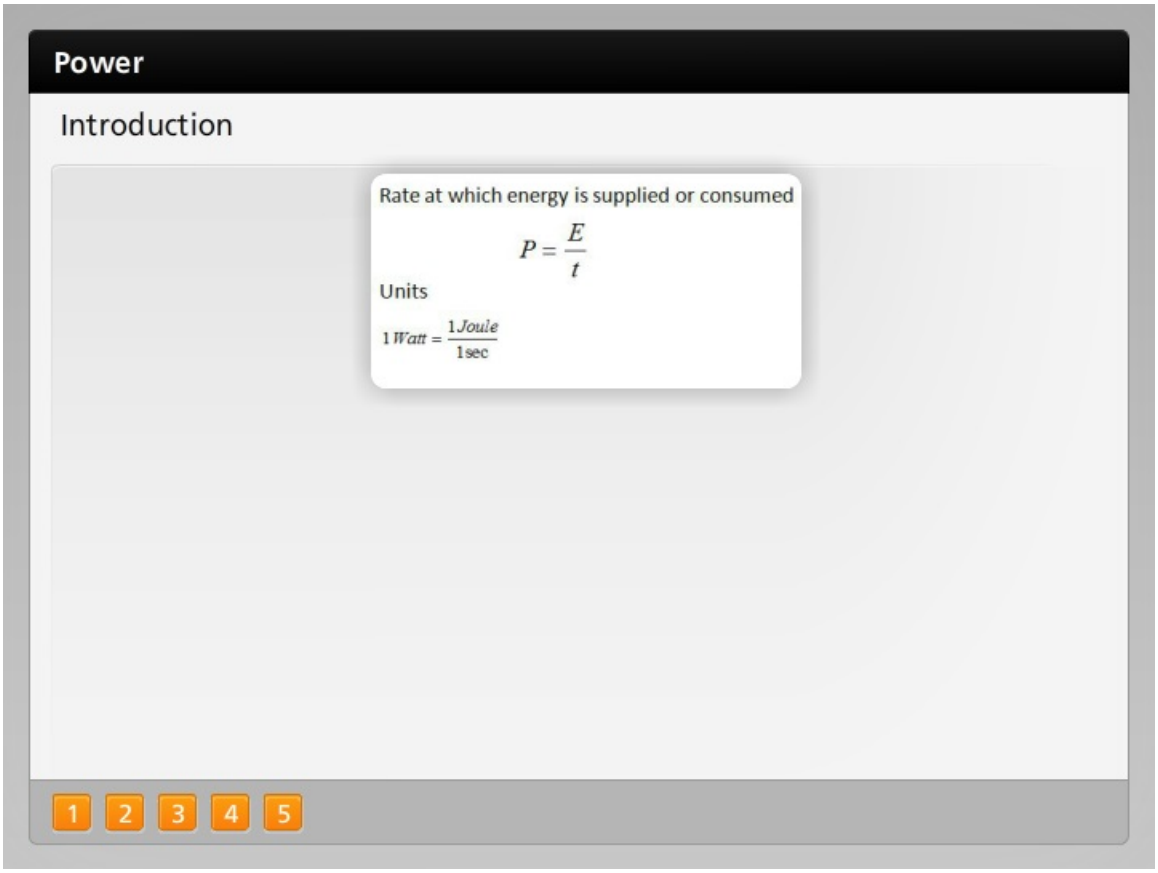
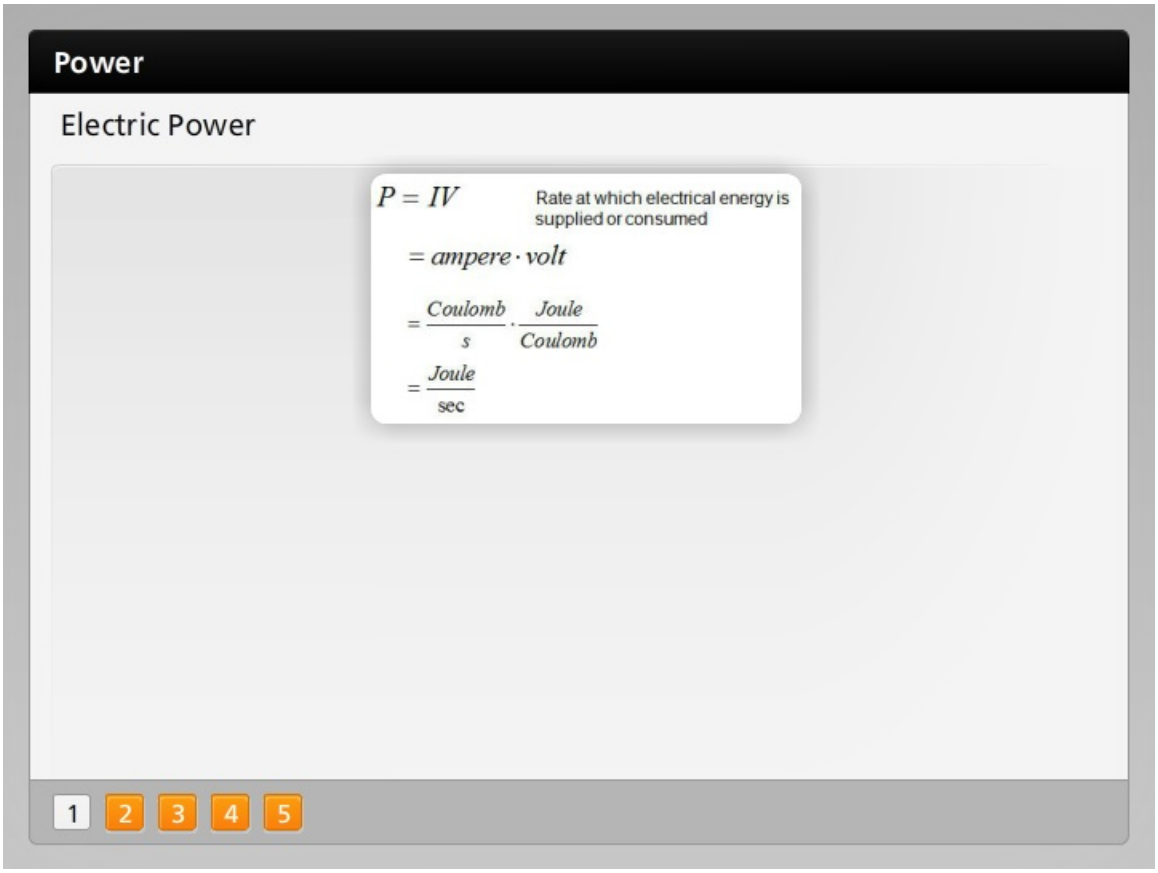
Module 7: Electricity - Currents and Circuits
Topic 3 Content: Power

Introduction



You probably remember the definition of power. In mechanical systems we described power as the rate at which energy is supplied or consumed or the rate of doing work. This is expressed as p equals e divided by t. The unit of power is the watt, and one watt is equal to one joule per second.

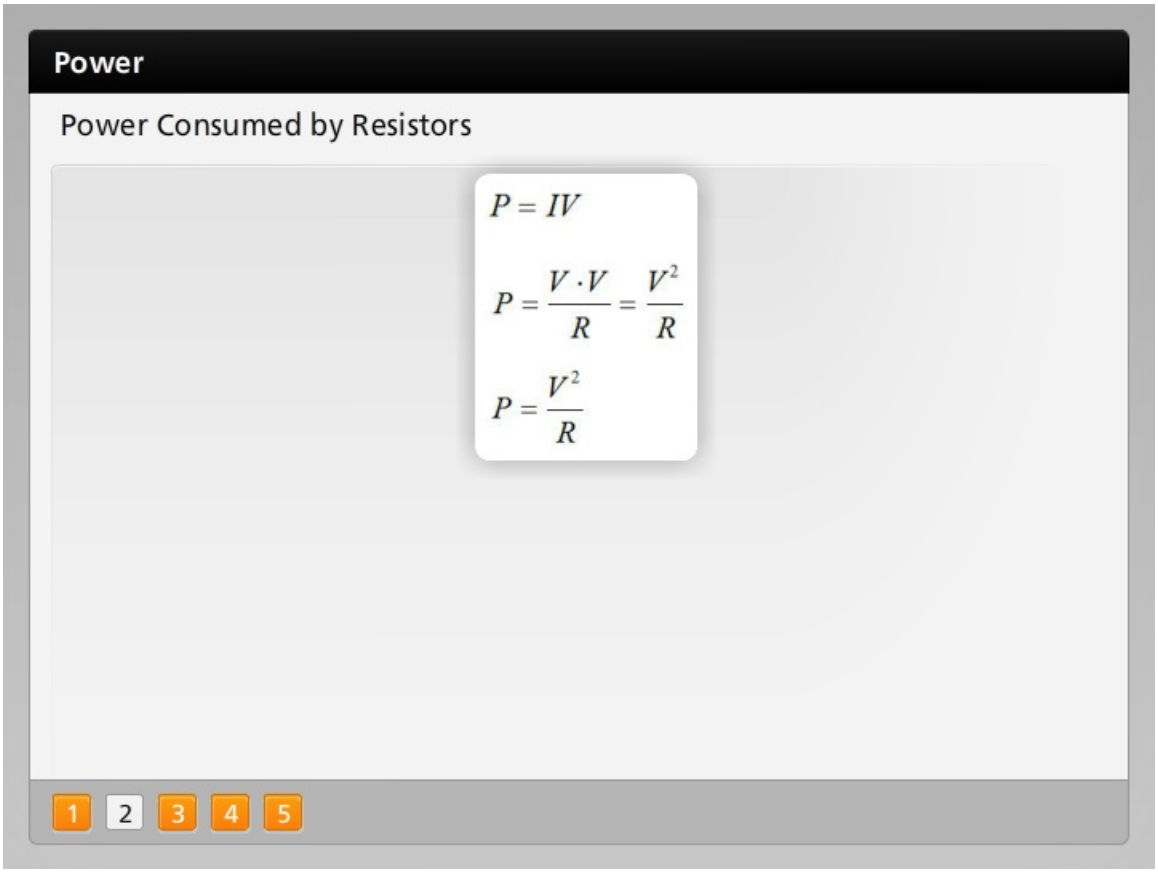
Electric Power



In electric systems, power is the rate at which electric energy is supplied or consumed. To calculate power for electric systems we need a new equation. Power is equal to current times voltage.

Let's verify that electric power has the same unit, the watt, as mechanical power. If we substitute ampere for current and volt for voltage, we get ampere times voltage, which really does not tell us much. So we need to break ampere and volt down using their definitions. One ampere is a coulomb per second and one volt is a joule per coulomb. Then we can see that the coulombs will cancel out and we will be left with joule per second. And a joule per second is a watt. So we see that electric power and mechanical power are both measured in watts.

Power Consumed by Resistors

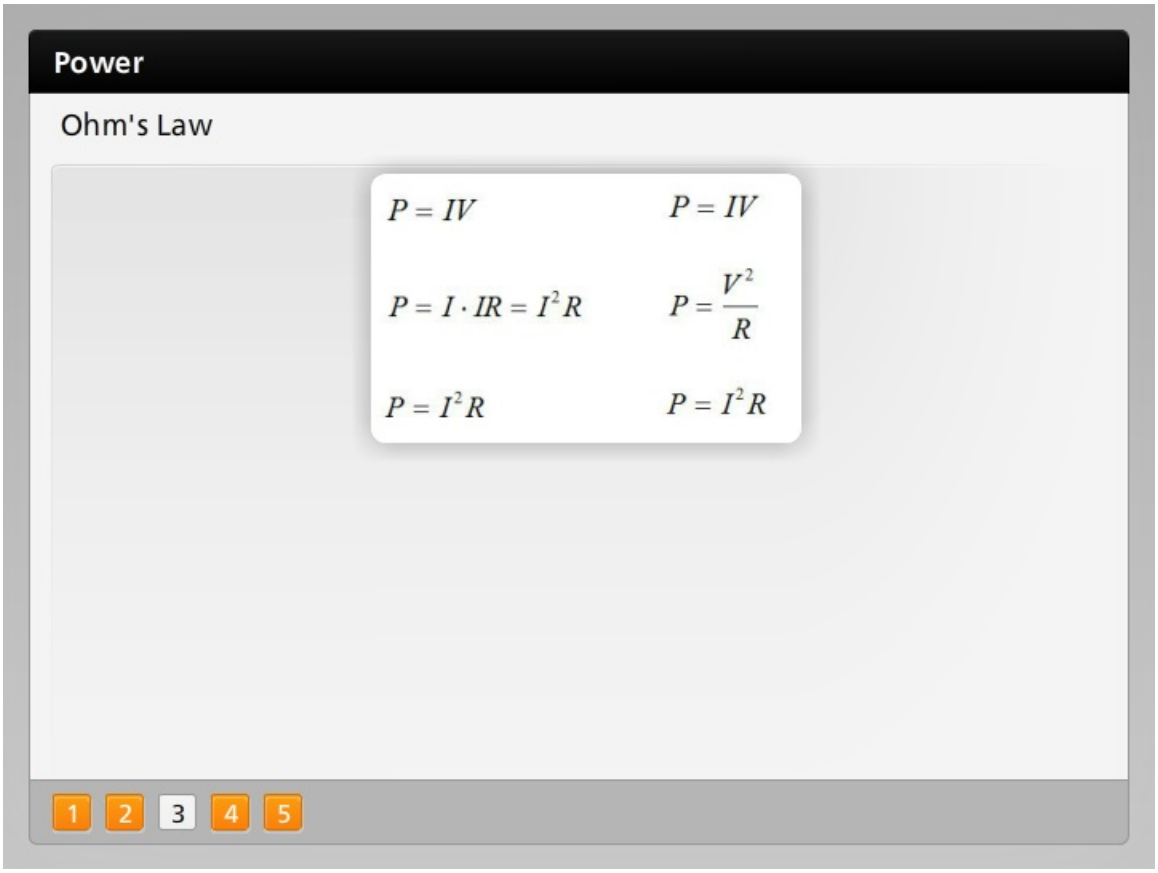


Resistors convert electrical energy to thermal energy or heat. This is often referred to as energy dissipated by a resistor. The dictionary definition of dissipated is "irreversibly lost". Why is this term used? The heat energy is transferred to the surroundings, which makes air molecules move faster. But this energy cannot be easily used for other purposes. We want to be able to find out how much energy is dissipated in a resistor.

The equation we have now for power, power equals current times voltage, could be used to find the energy dissipated in the resistor. However, sometimes we may not know V or I, so we want to have other ways to find power. By using Ohm's Law, we can substitute for V or I and have other formulas to find power.

Let's use the version of Ohm's Law that is solved for I and substitute it. Remember that the I equals V divided by R; since the insect sees the vulture over the rabbit. This simplifies to P equals v squared over R.

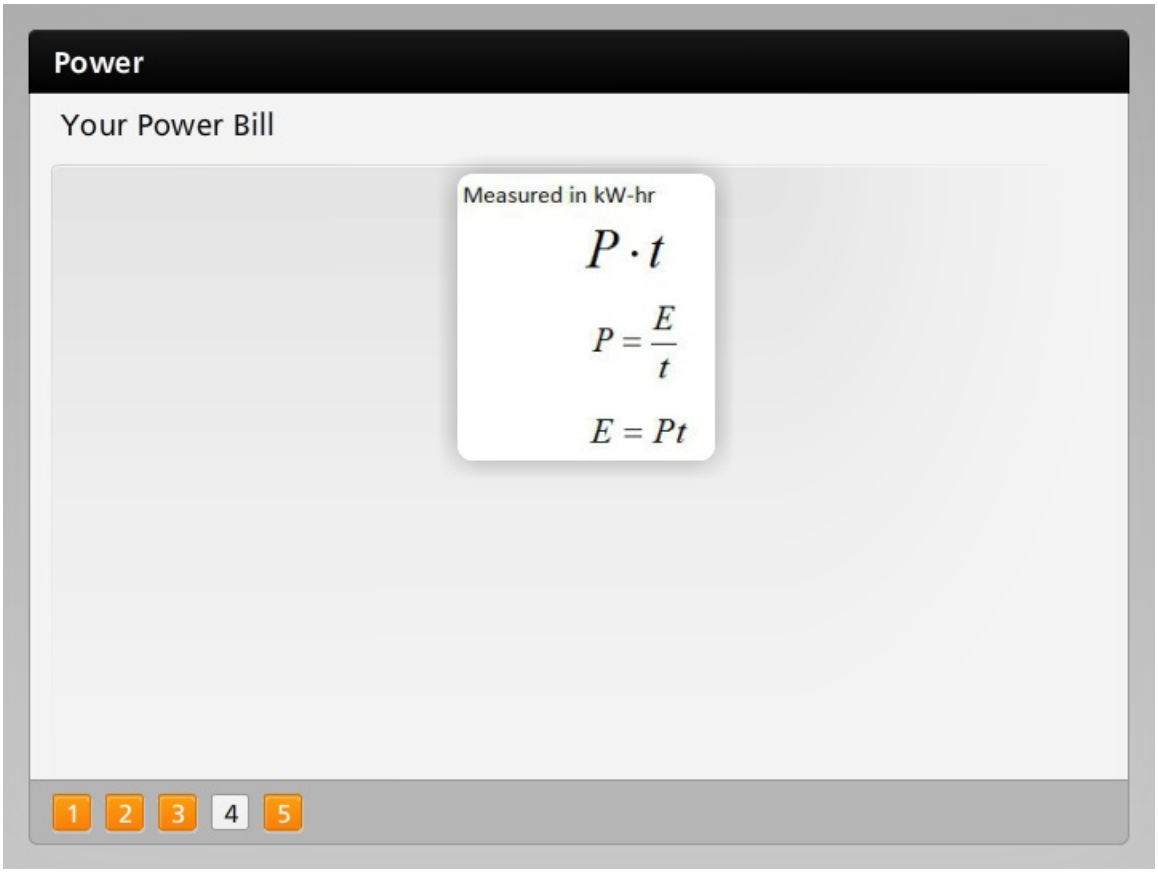
Ohm's Law



Let's use the version of Ohm's Law that is solved for V and substitute it. Remember that V equals I times R, since the vulture sees the insect next to the rabbit. Simplifying, this becomes p equals I squared R. Electrical engineers will use the term I squared R losses to refer to the energy dissipated in a resistor. This equation is where that expression comes from.

So, now you have three different ways to figure out power. Which one you use depends on which quantities you know.

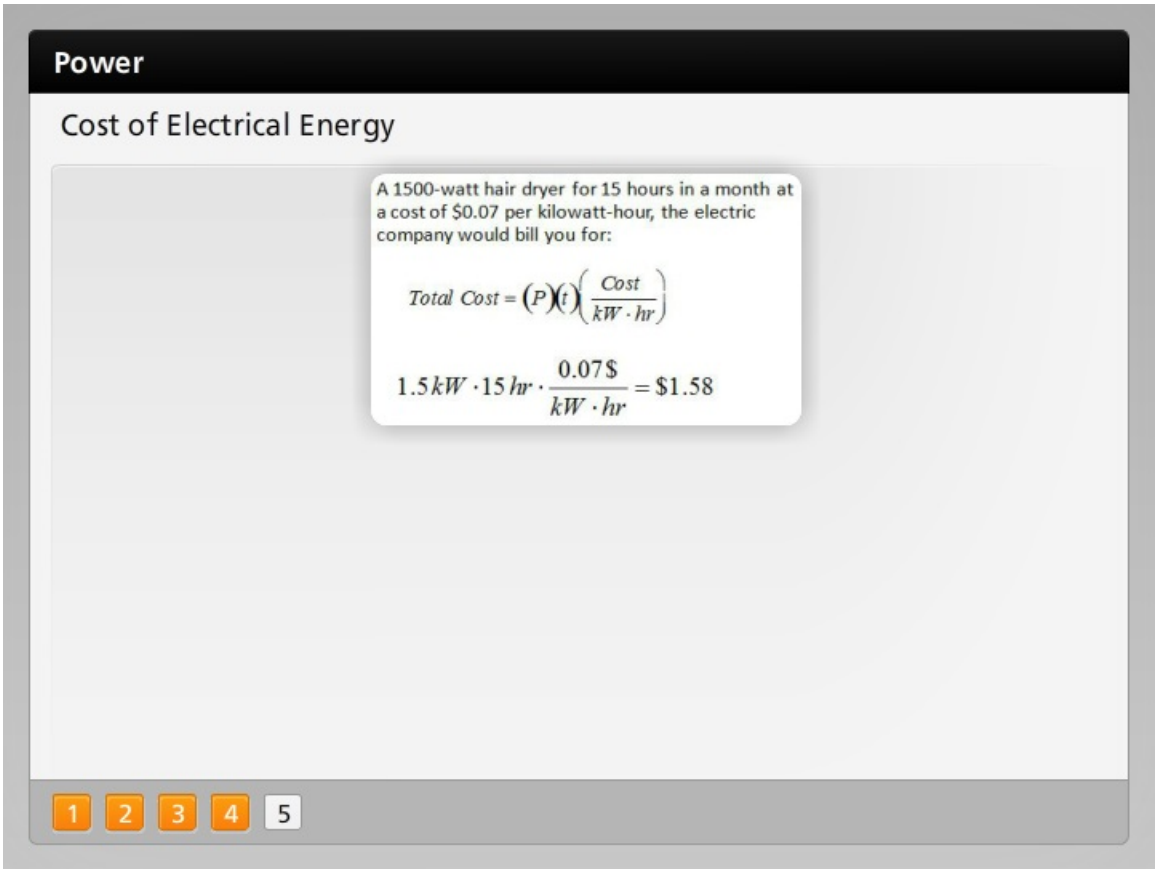
Your Power Bill



You might have heard your parents talk about the electric power bill or the power company. Knowing that power is a rate of energy consumption, should the power company charge for power or something else? The power company really charges you for the amount of energy you consume, not the rate at which you consume it. How can you figure out how much it costs to run appliances?

The units on your power bill are kilowatt hours. Let's think about what a kilowatt times an hour is. Kilowatt is a unit of power, and an hour is a unit of time. So, kilowatt hour represents power times time. Since power is energy divided by time, energy is equal to power times time. So, the power company really is billing you for energy, not power.

Cost of Electrical Energy

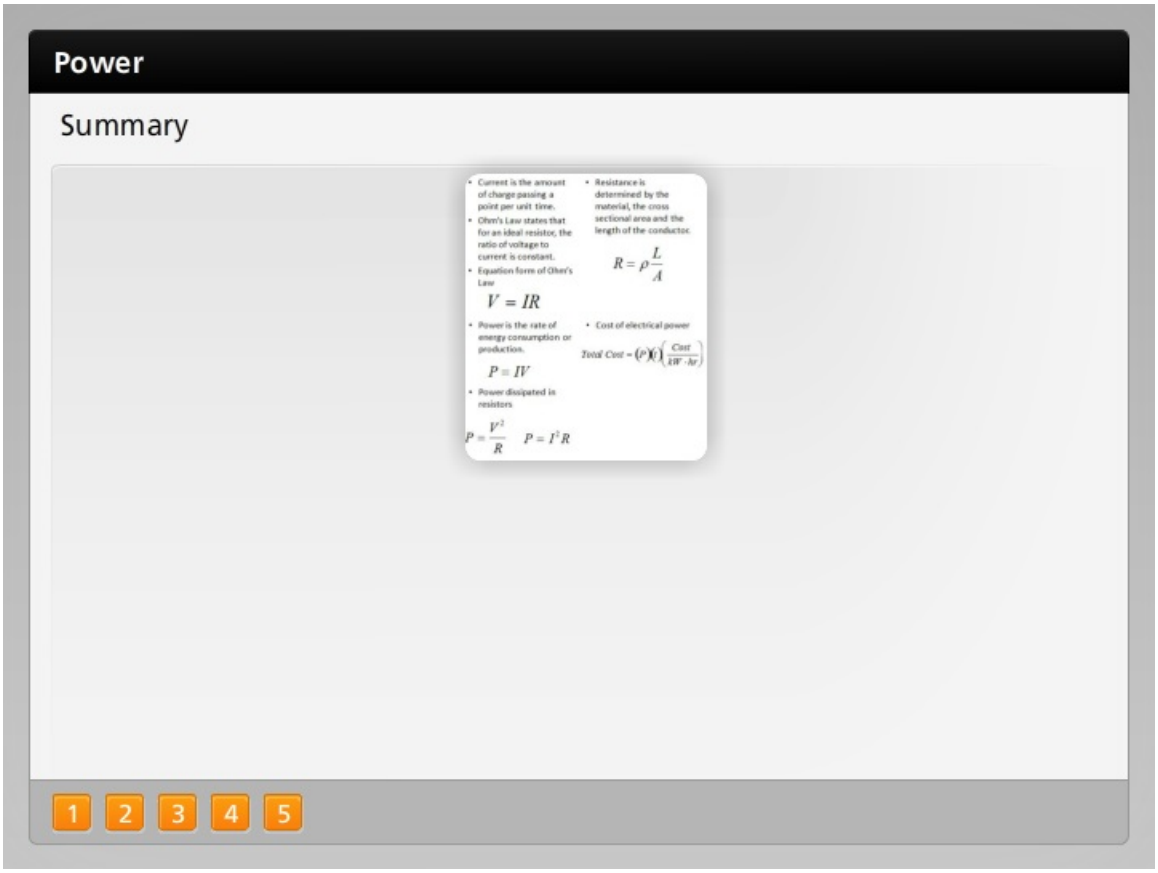


So how much does it cost to operate a hair dryer? Let's assume that your hair dryer uses one thousand five hundred watts, and that you use it for about thirty minutes a day, or fifteen hours a month. If the power company charges seven cents per kilowatt hour, how much will your bill be?

The general procedure for calculating the cost of electric energy is to multiply the number of kilowatts of power used by the time in hours, then multiply that result by the cost of each kilowatt hour.

In this example, the power of the hair dryer is given in watts. So first we have to convert the watts to kilowatts by dividing by one thousand. Then multiply by the hours and by the cost of each kilowatt hour. The result is the cost of using that appliance. In this case the hair dryer costs about one dollar and fifty eight cents a month to use.

Summary



In summary, in this unit you have learned that: Current is the amount of charge passing a point per unit time. Ohm's Law states that for an ideal resistor, the ratio of voltage to current is constant. In equation form, Ohm's Law is written as V equals I times R.

Resistance is determined by the material, the cross sectional area and the length of the conductor. In equation form, this is written as resistance equals resistivity times length divided by area.

Power is the rate of energy consumption or production and is calculated by multiplying current and voltage. Power is dissipated in resistors. The amount of power dissipated can be found from two equations: power equals voltage squared over resistance and power equals current squared times resistance.

You can figure out how much your electricity usage costs by multiplying power times time times the cost per kilowatt hour.