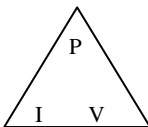


Name: _____ Date : _____

Electrical Power & Energy

Power

Remember that power is the rate of work done, or the rate of change in energy. The concept of power was covered for mechanical power earlier this year. At the time, we said: $Power = \frac{Work}{time}$. However, **power** in electricity is related to **current** and **voltage**.

The concepts:	$Power = Current \times Voltage$
Abbreviations:	$P = I \times V$ 
The SI Units:	Watts (W) = Amperes (A) × Volts (V)

Power ratings on devices (ex: a **75-Watt** light bulb) generally tell how much power is needed to make the appliance work. Devices are also generally designed to work with a specific **voltage**. In the USA, the standard voltage for an electrical outlet is 120 V.

So, a 75 W light bulb in the USA would require 0.625 A of current to work:

$$I = \frac{P}{V} = \frac{75 \text{ W}}{120 \text{ V}} = 0.625 \text{ A}$$

Practice Problems

- How much current flows through a 170 W hair iron plugged into a 220 V outlet? (220 V is a common voltage used in Europe.)
- If the hair iron draws less current, then it is less effective at its job, and if it draws less than 0.55 A of current, it just does not work at all (not enough to make it work). Will the 170 W iron work in the USA, where the voltage is 120 V?

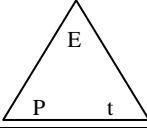
Energy

Power is just a **rate** of energy consumption (work performed). The **amount** of energy consumed depends on both the power and how long that power is used:

$$\text{Energy (Joules)} = \text{Power (Watts)} \times \text{time (seconds)}$$

With electricity, we often use kilowatts (kW) for power and hours (h) for time. This is done for the same reason why we use kilograms instead of grams: the numbers end up being more comfortable when we use this larger units.

If we calculate energy using kilowatts for power and hours for time, then we end up with energy units of *kilowatt-hours* (kWh) instead of Joules. The kilowatt-hour is the unit of energy used by the electric companies when they send you your electric bills.

The concepts:	$\text{Energy (E)} = \text{Power (P)} \times \text{time (t)}$
Abbreviations:	$E = P \times t$ 
The SI Units:	kilowatt-hours (kWh) = kilowatts (kW) × hours (h)

Practice Problems

- 3) How much energy does a 350 W television use if it is used for 3 hours? Express your answer in kWh.

- 4) If the cost of electricity is $\frac{\$0.25}{\text{kWh}}$, how much money does it cost to watch TV for 3 hours? (Same TV as above, so its power rating is 350 W.)

Answers to Practice Problems

- 1) How much current flows through a 170 W hair iron plugged into a 220 V outlet? (220 V is a common voltage used in Europe.)

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

$$I = \frac{170 \text{ W}}{220 \text{ V}} = 0.77 \text{ A}$$

- 2) If the hair iron draws less current, then it is less effective at its job, and if it draws less than 0.55 A of current, it just does not work at all (not enough to make it work). Will the 170 W iron work in the USA, where the voltage is 120 V?

Here, find out how much current it **will** draw in the USA, and then compare the value you get with the 0.55 A minimum value needed to make the hair iron work.

$$I_{USA} = \frac{P}{V_{USA}} = \frac{170 \text{ W}}{120 \text{ V}} = 1.42 \text{ A}$$

Since $1.42 \text{ A} > 0.55 \text{ A}$ it most certainly will draw enough current to work! However, at this point, the risk is that it will draw **too much** current, and will cause the hair iron to catch fire!

Because there is more current, there will now be more friction in the wires of the hair iron as the increased number of electrons try to rush through. The amount of extra friction will cause quite an increase in temperature, and may even set the wires on fire!

- 3) How much energy does a 350 W television use if it is used for 3 hours? Express your answer in kWh.

First, convert the 350 W to 0.350 kW. This is the same method of SI unit conversion that you already know.

$$\text{energy} = 0.350 \text{ kW} \times 3 \text{ h} = 1.05 \text{ kWh}$$

- 4) If the cost of electricity is $\frac{\$0.25}{\text{kWh}}$, how much money does it cost to watch TV for 3 hours? (Same TV as above, so its power rating is 350 W.)

First, solve for the amount of energy that the TV will use in 3 hours. See #3), above.

You can set up a proportion for this one:

$$\frac{\$0.25}{1 \text{ kWh}} = \frac{\$x}{1.05 \text{ kWh}}$$

$$\$0.25 \times 1.05 \text{ kWh} = \$x \times 1 \text{ kWh}$$

$$\$0.2625 \text{ kWh} = \$x \times 1 \text{ kWh}$$

$$\frac{\$0.2625 \text{ kWh}}{1 \text{ kWh}} = \$x = \$0.26$$