Note-A-Rific: Power

In everyday electrical devices like heaters, stoves, blow dryers, and such, electricity is turned into thermal energy.

- Light bulbs and heating filaments in household devices range from about 1Ω to a few hundred ohms.
- Although in some cases heat is not the intended result (light bulbs), we always need to take into account the thermal energy they release.
- The electrical energy is turned into thermal energy because all those electrons wiggling around are going to be bumping into things.
  - When you have a lot of current, or high resistance, there are lots of those collisions, so lots of thermal energy is given off.

Remember from a previous section that we had a formula for relating electricity to energy changing forms…

$$V = \frac{\Delta E}{q} \rightarrow \Delta E = Vq \quad \text{(Equation 1)}$$

But from way back in Science 10 we had a formula for the power as energy is changed from one form to another.

$$P = \frac{\Delta E}{t} \quad \text{(Equation 2)}$$

P = Power measured in Watts (W), the equivalent of J/s
ΔE = change in energy measured in Joules (J)
t = time measured in seconds (s)

- This formula tells you that power is the rate at which energy is changed from one form to another.
  - For example, a 60W bulb changes electrical energy into light and thermal energy at a rate of 60 Joules per second.

We can now play around a bit with this formula…

- First substitute Equation 1 into Equation 2 to get…

$$P = \frac{Vq}{t} \quad \text{(Equation 3)}$$

- Now recall that we have a formula for the current flowing through a circuit…

$$I = \frac{q}{t} \quad \text{(Equation 4)}$$

- We can simplify Equation 3 since it has Equation 4 in it. This gives us…

$$\mathbf{P = I\,V}$$

- This will be one of the main formulas you will use when calculating power in an electrical circuit.

Example: A household appliance draws a 0.50A current. What is its power?
Household power lines run at 120 V, so we can use that in our calculation.
P = I V = (0.5A)(120V) = 60W
The appliance runs at 60 W.

There are two other commonly used formulas for power that you need to be ready to use…

$$P = \frac{V^2}{R} \quad \text{and} \quad P = I^2 R$$

Power Costs

Most household appliances and lighting runs off of electricity obtained from a power generating station.

- Just like any other business they have to keep track of how much of their product you use, so they can figure out how much to charge you.
- Power companies could measure your electrical energy use in Joules, which would make perfect sense to a physicist.
    - Unfortunately this would mean you, the consumer, would get bills charging you for using **millions** of Joules of energy each month.
    - Most people don't like to see numbers that big on bills, no matter what they have to pay.
    - Power companies devised a system that lets people know how much energy they use, in a much more compact, easy to understand number.

The unit they devised is the **kilowatt hour**. (kWh)

- It is still a unit of energy, just like Joules.
- It's based on the formula ΔE = P t
- If you measure the power an appliance uses in kilowatts, and measure how long it runs for in hours, you would get units of

$$\Delta E = P\,t$$
$$= \text{kilowatt (hours)}$$
$$\Delta E = \text{kilowatt hours}$$

Notice that if we had simplified stuff down to watts and seconds, we would have the standard SI unit for energy, Joules.

$$\Delta E = P\,t$$
$$= 1 \text{ kilowatt (1 hour)}$$
$$= 1000\text{W (3600s)}$$
$$\Delta E = 3.6 \times 10^6 \text{ J}$$

- So one kilowatt hour equals 3.6×10^6 J of energy.

Your power bill is based on the cost of 1 kW h of electricity.

- Here in Alberta that number usually sits at around 5¢ / kWh

Take a look at the sample problems on page 664 of your text.