Power and Energy

- Power is an indication of how much work (the conversion of energy from one form to another) can be done in a specific amount of time; that is, *the rate of doing work*

$$\boxed{P = \frac{W}{t}}$$

Where : P is the power in Watts (W)
W is the energy in Joules (J)
t is the time in seconds (s)

Power and Energy

- Relating this to voltage and current

$$P = \frac{W}{t} = \frac{Q \cdot V}{t} = I \cdot V$$

Where :

P is the power in Watts (W)
W is the energy in Joules (J)
t is the time in seconds (s)

Q is the charge in Coulombs (C)
V is the voltage in Volts (V)
I is current in Amps (A)

Power and Energy

- Power can be delivered or absorbed as defined by the polarity of the voltage and the direction of the current (passive sign convention)
- Energy (W) lost or gained by any system is determined by:

$$W = P \cdot t$$

- Since power is measured in watts (or joules per second) and time in seconds, the unit of energy is the *watt-second* (Ws) or *joule* (J)

Power and Energy

- The watt-second is too small a quantity for most practical purposes, so the *watt-hour* (Wh) and *kilowatt-hour* (kWh) are defined as follows:

$$\text{Energy(Wh)} = \text{power(W)} \times \text{time(h)}$$

$$\text{Energy(kWh)} = \frac{\text{power(W)} \times \text{time(h)}}{1000}$$

Power and Energy

- Example: What is the cost of running a 110W stereo system for 4 hours at 9 cents/kWh?

$$\text{Energy (kWh)} = \frac{\text{power (W)} \times \text{time (h)}}{1000} = \frac{110\text{W} \cdot 4\text{h}}{1000} = 0.44\text{kWh}$$

$$\text{Cost} = 0.44\text{kWh} \cdot \frac{\$0.09}{\text{kWh}} = \$0.0396 \approx \$0.04$$

Power and Energy – Breakout #1

- A portable color TV draws 0.455 A at 9V. Find:

(a) The power rating in Watts

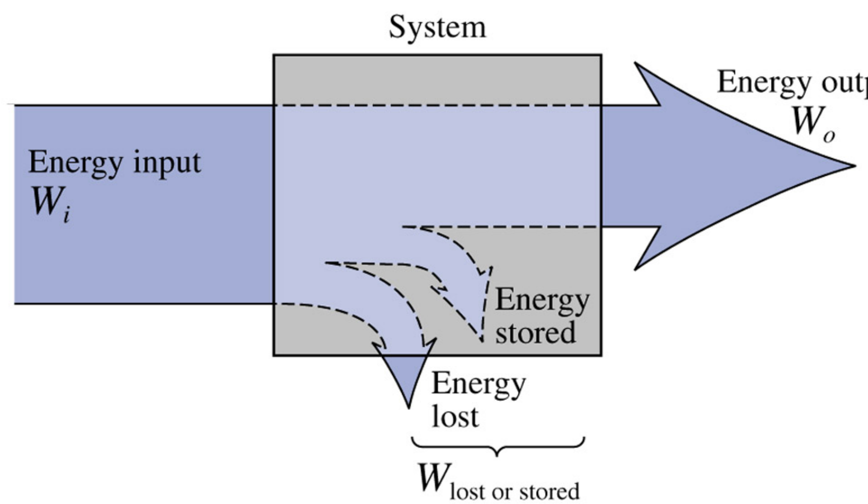
(b) The equivalent resistance of the TV

(c) The energy (in Joules) converted in 6 hours

Efficiency

- Conservation of energy requires that:

Energy input = Energy output + Energy lost and/or stored



$$\text{Efficiency} = \eta\,\% = \frac{W_0}{W_i} \cdot 100\,\%$$

Efficiency

- In terms of power (recall P = W/t):

$$W_i = W_0 + \left(W_L + W_S\right)$$

Becomes:

$$\frac{W_i}{t} = \frac{W_0}{t} + \frac{\left(W_L + W_S\right)}{t}$$

or

$$P_i = P_o + (P_L + P_S)$$

$$\text{Efficiency} = \eta\,\% = \frac{P_0}{P_i} \cdot 100\,\%$$

Efficiency

- Example: Find the efficiency of a motor that has an output of 0.5 hp and an input power of 450 W.

$$1\,\text{hp} \approx 746\,\text{W}$$

$$P_i = 450\,\text{W}$$

$$P_0 = 0.5\,\text{hp} \cdot 746\frac{\text{W}}{\text{hp}} = 373\,\text{W}$$

$$\eta\% = \frac{P_0}{P_i} \cdot 100\% = \frac{373\,\text{W}}{450\,\text{W}} \cdot 100\% = 82.9\%$$

Efficiency – Breakout #2

- The motor of a power saw is rated at 68.5% efficient. If 1.8 hp is required to cut a specific piece of lumber, what is the current drawn from a 120 V supply?

Efficiency – Breakout #3

- The overall efficiency of two systems in cascade is 72%. If the efficiency of the first is 0.9 (90%), what is the efficiency of the second (in percent)?
- Hint- For a cascaded system:

$$\eta_{\text{total}} = \eta_1 \cdot \eta_2 \cdot \eta_3 \ldots \cdot \eta_n$$