

## Energy and Power

In physics, *energy* is a property of objects, transferable among them via fundamental interactions, which can be converted in form but not created or destroyed. Energy can be used to do **work** or can be expelled into the environment in the form of **heat**. The joule (J) is the SI unit of energy, based on the amount transferred to an object by the mechanical work of moving it 1 meter against a force of 1 newton.

Power is the rate at which energy is transferred. It is thus the time derivative of energy. We usually denote it with the symbol,  $p$ .

$$p = \frac{dw}{dt} (W)$$

The unit of power is a Watt, which is equivalent to a Joule per second (J/s).

Note the previously given definitions of current and voltage:

$$v = \frac{dw}{dq} (V)$$

$$i = \frac{dq}{dt} (A)$$

Note that if you multiply the two:

$$v \cdot i = \frac{dw}{dq} \cdot \frac{dq}{dt} = \frac{dw}{dt} (W)$$

Thus, we see that

$$p = v \cdot i$$

Thus, multiplying the instantaneous voltage across a device with the instantaneous current gives us the instantaneous power being consumed or supplied by that device.

### Passive Sign Convention

By convention, when trying to determine if a device or component (or sub-circuit) is consuming or supplying power (i.e. if power is flowing into or out of the device), we first define a voltage and current as per the figure below (i.e. we define a current  $i$  which enters the (+) side of the voltage,  $v$ ).

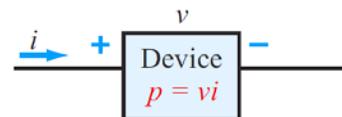
Once these values are found, then we calculate

$$p = v \cdot i$$

If  $p > 0$  then power is being delivered to the device

If  $p < 0$  then power is being supplied by the device

#### Passive Sign Convention



$p > 0$  power delivered to device  
 $p < 0$  power supplied by device

\*Note that  $i$  direction is defined as entering (+) side of  $v$ .