

Next:

- Power and Energy
- Passive sign convention
- Voltage and current sources
- Electrical Resistance (Ohm's Law)

Objectives:

- know and be able to use the definition of power and energy
- be able to use passive sign convention to calculate power for ideal basic circuit element given its voltage and currents
- Understand the symbols for and the behavior of the following ideal basic circuit elements:
 - independent voltage and current sources
 - dependent voltage and current sources
 - resistors
- Be able to state Ohm's Law and use it to calculate voltage, current, and power

Power & Energy

Power and energy calculation are important.

practical devices have limitation on the amount of power they can handle (voltage and current calculations by themselves are not sufficient.)

Power is the time rate of expanding or absorbing energy, mathematically

$$p = \frac{dw}{dt}$$

p = the power [watts]

w = the energy [joules]

t = the time [seconds]

The power associated with the flow of the charge follows directly from the definition of voltage and current

$$p = \frac{d\omega}{dt} = \underbrace{\frac{d\omega}{dq}}_{v} \cdot \underbrace{\frac{dq}{dt}}_i$$

$$p = v i$$

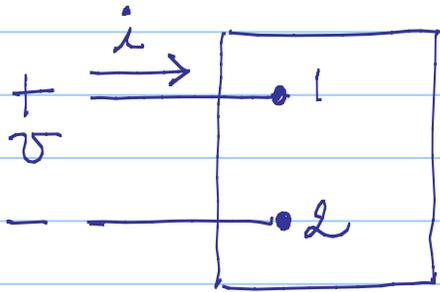
power equation

p = the power [Watts]

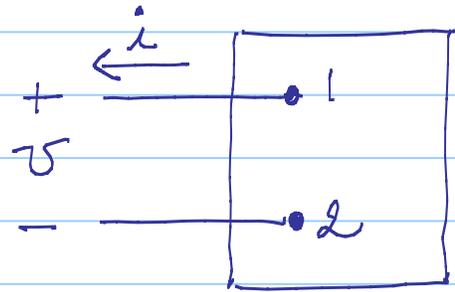
v = the voltage [volts]

i = the current [amperes]

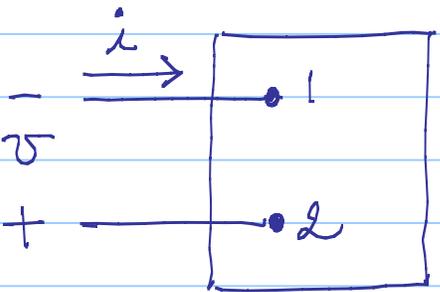
power associated with basic circuit element is simply the product of the current in the element and the voltage across the element.



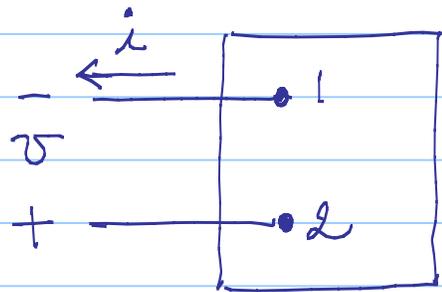
$$p = v i$$



$$p = -v i$$



$$p = -v i$$



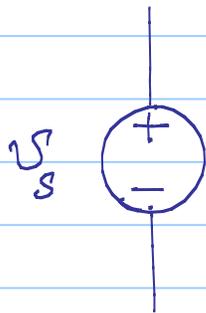
$$p = v i$$

⇒ Interpreting algebraic sign of power

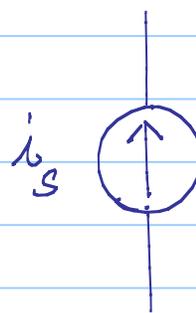
- If the power is positive, power is being delivered to the circuit inside the box
- If the power is negative, power is being extracted to the circuit inside the box

Voltage and Circuit Sources

- Ideal voltage source is a circuit element that maintains a prescribed voltage across its terminals regardless of the amount of current flowing in those terminals.
- Ideal current source is a circuit element that maintains a prescribed current through its terminals regardless of the amount of voltage across those terminals.
- Independent source — establish voltage or current in a circuit without relying on voltages or currents elsewhere in the circuit.



Ideal Independent
Voltage source



Ideal Independent
Current source

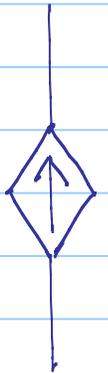
- A dependent source - establish voltage or current whose value depends on voltage or current elsewhere in the circuit. (sometimes referred to as controlled sources)

$$v_s = \mu v_x$$



ideal dependent
voltage-controlled
voltage source

$$i_s = \alpha v_x$$

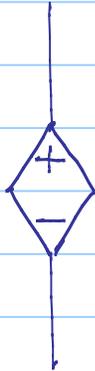


ideal dependent
voltage-controlled
current source

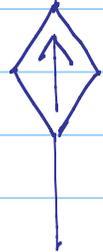
μ - dimensionless

α - amperes/volt

$$v_s = \rho i_x$$



$$i_s = \beta i_x$$



ideal dependent
current-controlled
voltage source

ρ - volts / ampere

ideal dependent
current-controlled
current source

β - dimensionless

Electric Resistance (Ohm's Law)

Resistance - the capacity of materials to impede the flow of the current (or more specifically, flow of the electric charge)

- moving electrons make up electric current interacting with and being resisted by the atomic structure of the materials through which they are moving
- In the course of these interaction some amount of electric energy is converted to thermal energy and dissipated in the form of heat. (while this effect may be undesirable, many useful electric device take advantage of resistance heating including stoves, toasters, hair dryers, and space heaters)



the circuit symbol for a resistor

- Most materials exhibit measurable resistance to the current. Metals such as copper and aluminium have small values of resistance, making them a good choices for wiring.

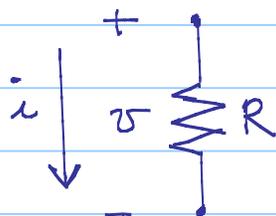
Relation of the current in the resistor to the terminal voltage.

$$v = iR \quad \text{Ohm's Law}$$

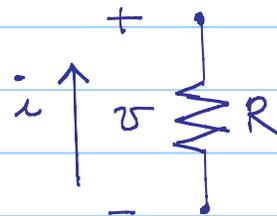
v = the voltage [volts]

i = the current [amperes]

R = resistance [Ohms]



$$v = iR$$



$$v = -iR$$

$$p = v i$$

$$= (iR) i$$

$$= i^2 R$$

$$p = -v i$$

$$= -(-iR) i$$

$$= i^2 R$$

- This demonstrates that regardless of the voltage or current direction, power at the terminal of the resistor is always positive!

$$p = i^2 R$$

power in a resistor
in terms of current.

$$p = \frac{v^2}{R}$$

power in a resistor
in terms of voltage.

reciprocal of resistance is called conductance
measured in siemens (S)

$$G = \frac{1}{R} \quad [S]$$

↑ sometimes \mathcal{U}

$$p = \frac{i^2}{G}$$

$$p = i^2 G$$