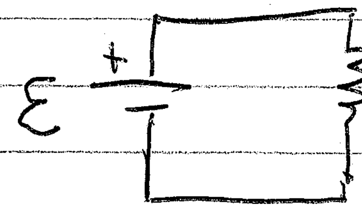
Phys 1402 2016-09-15 Lec 7

Basic Circuit w/ Ideal Battery



$V = IR$

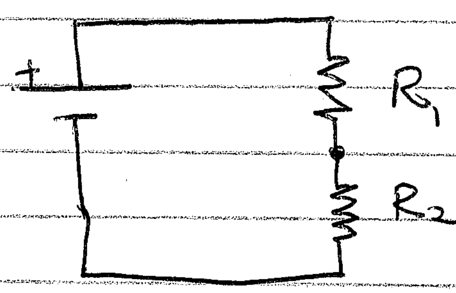
$V = \mathcal{E}$

$P = IV$

$\mathcal{E}$ = EMF = Voltage generated by battery.
R = Resistance of <u>Load</u>

Series Configuration

- The current leaving one device has no choice but to go into the next.



$I_1 = I_2 = I_{net}$

$V_1 + V_2 = V_{net}$

- In series, devices have the <u>same current.</u>

- In series, the energy gained/lost by each charge adds/subtracts.

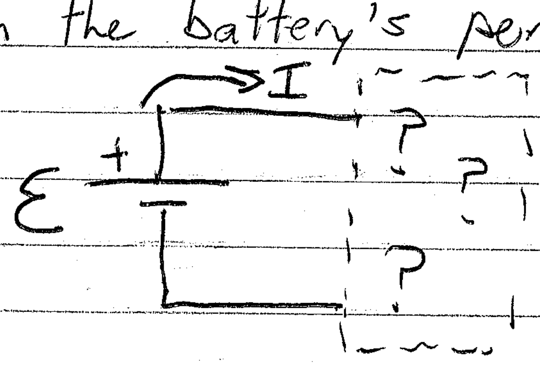
$$V_1 + V_2 = IR_1 + IR_2 = I(R_1 + R_2)$$

$$V_{net} = IR_{net}$$

$$\therefore R_{net} = R_1 + R_2$$

Resistance adds in series.

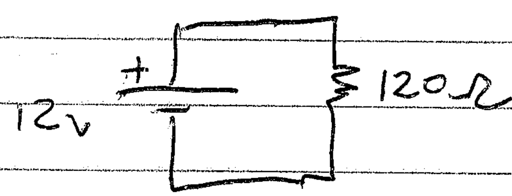
From the battery's perspective:

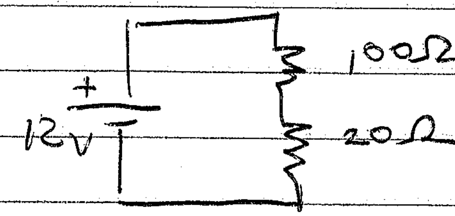


Ex: $\mathcal{E} = 12\ V$ $\qquad R_{net} = \frac{12V}{0.1A} = 120\Omega$

$I = 0.1\ A$

Equivalent Circuits





To analyze:

1. $I = \frac{12V}{120\Omega}$ in easy circuit.

2. $I = 0.1 A$ in the battery in <u>both</u>.

3. $V_1 = (0.1A)(100\Omega) = 10\ V$

   $V_2 = (0.1\ A)(20\Omega) = 2\ V$

"connected wire"

Note: $R_1 = 0$ in series does nothing

$R_1 = \infty$ in series forces $I = 0$.

"broken wire"

③

Internal Resistance - A realistic battery has some built-in series resistance.

- R_{int} increases the circuit resistance, making I smaller.
- R_{int} causes voltage loss in the battery, depending on I.

$$V_{net} = V_1 + V_2$$
$$\mathcal{E} = V_{int} + V_{ext}$$

$$\mathcal{E} - V_{int} = V_{ext}$$
$$\mathcal{E} - IR_{int} = V_{ext}$$

Ex: $\mathcal{E} = 120\ V$

$$\left.\begin{array}{l} R_{int} = 1\ \Omega \\ R_{ext} = 240\ \Omega \end{array}\right\} R_{net} = 241\ \Omega$$

$$I = \frac{V}{R} = \frac{120\ V}{241\ \Omega} = 0.498\ A$$

For the resistor $P = IV = (0.498)(119.5) = 59.5\ W$

$$V_{ext} = IR_{ext} = (0.498)(240) = 119.5\ V$$

- Ideal: $R_{int} = 0$ $\quad I = 0.5\ A$ $\quad P = 60\ W$
- I is a little smaller than ideal case.
- V_{ext} is a little smaller.
- P is a little smaller.

④

HW2-5

$$8.25 + 3.5 I_1 - 2.35 I_2 = 0$$

$$-2.2 I_1 + I_2 = 0$$

Simultaneous Equations
Manually, choose a method.
Method 1:

- Pick the easy eqn, solve for the easy variable.

$$I_2 = 2.2 I_1$$

- Substitute everywhere for this variable.

$$8.25 + 3.5 I_1 - 2.35 (2.2 I_1) = 0$$

Method 2: Find a way to add/subtract eqns to eliminate a variable.

$$(8.25)(2.2) + 3.5 I_1 (2.2) - 2.35 I_2 (2.2) = 0$$

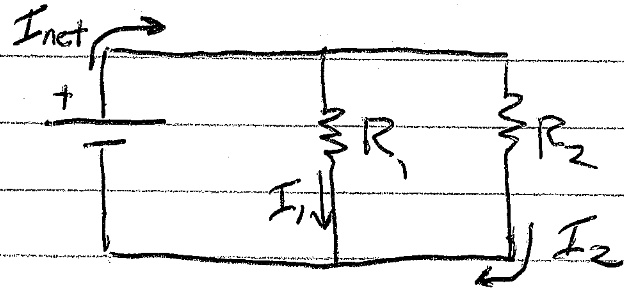
$$-2.2 I_1 (3.5) + I_2 (3.5) = 0$$

Add:

$$(8.25)(2.2) - 2.35 I_2 (2.2) + I_2 (3.5) = 0$$

Parallel Configuration

- The circuit provides different __branches__ for current to choose from.



$$I_1 + I_2 = I_{net}$$

$$V_1 = V_2 = V_{net}$$

- In Parallel, the current splits, and the branch currents add up to the total.
- The energy of each charge can only be lost in a single branch. No matter which branch is chosen, the voltage lost is the same.

$$I_1 + I_2 = I_{net}$$

$$\frac{V}{R_1} + \frac{V}{R_2} = \frac{V}{R_{net}}$$

$$\frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{R_{net}}$$

Resistors combine as inverses in parallel.