Phys 2426 2014-09-17 Lecture 6

DC Circuits

Battery - causes voltage

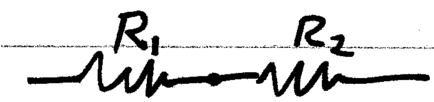
Resistance - Links voltage & current

$$V = I R$$

- I — current thru the resistor
- V — voltage across the resistor

Series - no "fork" between components

Ex:



The same current goes thru each
Charges lose some energy in each.

Series: $V_{net} = V_1 + V_2 + \cdots$

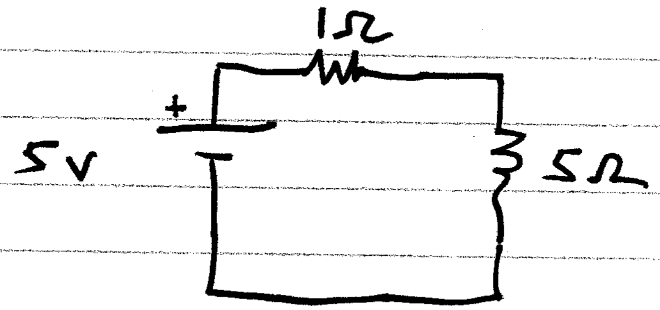
$$= IR_1 + IR_2 + \cdots$$
$$= I(R_1 + R_2 + \cdots)$$

$$V_{net} = I R_{eq}.$$

Series: $R_{eq} = R_1 + R_2 + \cdots$

②

Ex:



$$R_{eq} = 1\Omega + 5\Omega = 6\Omega$$

$$I = \frac{V_{net}}{R_{eq}} = \frac{5v}{6\Omega} = 0.87\ A$$

Across each part

$$V_1 = IR_1 = 0.87\ V$$
$$V_5 = IR_5 = 4.13\ V$$

This can model a battery w/ internal resistance

$$R_{int} = 1\Omega$$
$$R_{ext} = 5\Omega$$

$$V_{tot} = V_{out} + IR_{int}$$

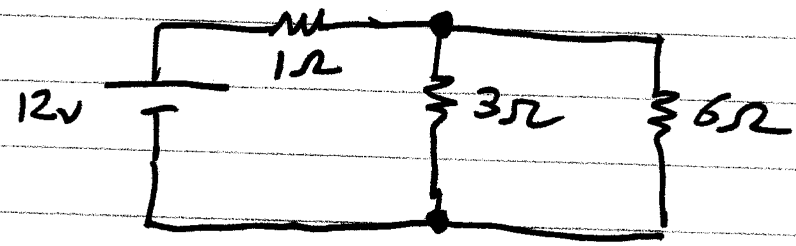
↗ Full EMF of batt — ↑ Operating Voltage — ↖ Wasted

$$(5v) = (4.13v) + (0.87v)$$

EMF = Voltage = Electromotive Force

Parallel Circuit

- A parallel section starts with a fork in the wire & ends when the wires come back together.



The 3Ω and 6Ω are in parallel

$$I_{tot} = I_3 + I_6$$

$$V_3 = V_6$$

A given charge gains 12v in the battery.
It Loses some voltage in the 1Ω resistor.
Then it Loses the rest of its voltage in
Either the 3Ω
Or the 6Ω.

Parallel Equivalent R:

$$I_{tot} = I_1 + I_2 + \ldots$$
$$= V/R_1 + V/R_2 + \ldots$$
$$= V(1/R_1 + 1/R_2 + \ldots)$$
$$I_{tot} = V/R_{eq}$$

$$1/R_{eq} = 1/R_1 + 1/R_2 + \ldots$$

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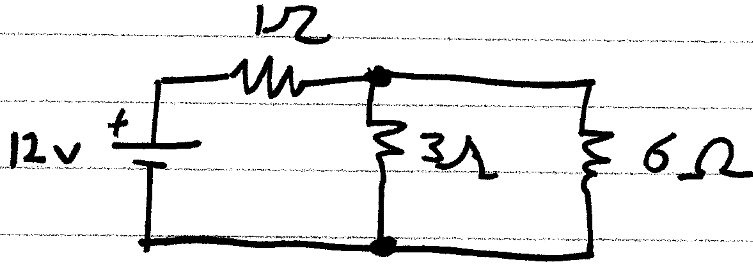
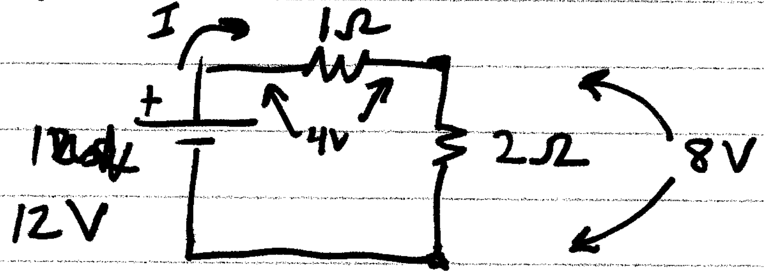


Equiv of 3Ω and 6Ω:

$$R_{36} = \left(\frac{1}{3} + \frac{1}{6}\right)^{-1} = 2\,\Omega$$

Equiv Circuit



$$I = \frac{12\,V}{3\,\Omega} = 4A$$

↑ 1Ω + 2Ω

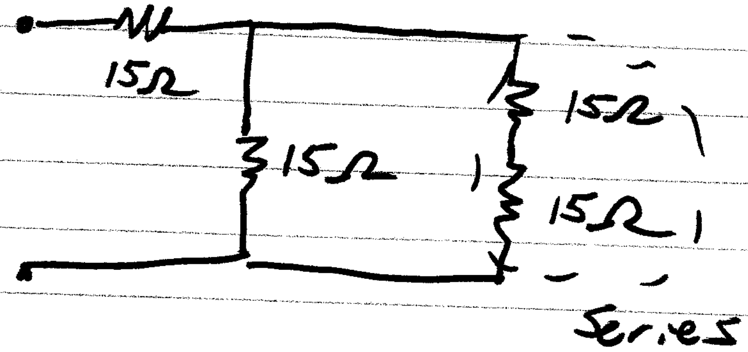
The same 4A flows thru the batt in the original circuit.

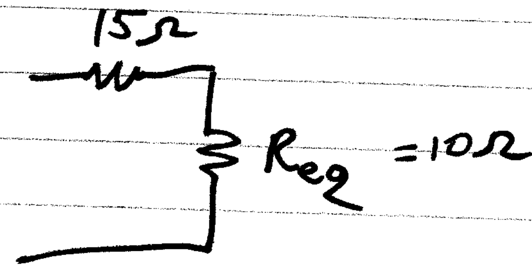
$$V_1 = 4\,V$$

$$V_3 = 8\,V = V_6$$

$$I_3 = \frac{8\,V}{3\,\Omega} = 2.67\,A \qquad I_6 = \frac{8\,V}{6\,\Omega} = 1.33\,A$$

(E)





More Complicated Circuits : Kirchoff's Laws

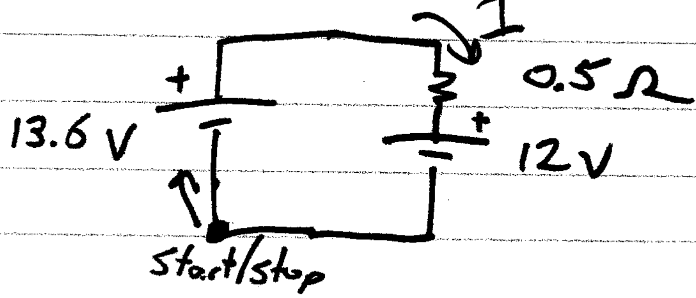
Current: At a junction

$$\sum I_{in} = \sum I_{out}$$

Voltage: For any Loop :

$$\sum_{loop} \Delta V = 0 \qquad \sum_{loop} V_{rises} = \sum_{loop} V_{drops}$$

Battery Charger



We can follow a loop around the circuit:

Alternator : $\Delta V = +13.6\ V$

Resistance : $\Delta V = -IR = -I\,(0.5\Omega)$

negative because voltage drops across ~~thru~~ a resistor.

Battery : $\Delta V = -12\ V$

$$\sum_{loop} \Delta V = 0 \longrightarrow (13.6V) - I(0.5\Omega) - (12V) = 0$$

$$I = \frac{13.6 - 12}{0.5\Omega} = 3.2\ A$$

Applying Kirchoff's Laws

Method 1: Assign a variable for current in each branch.

$I_1, I_2, I_3, \ldots$

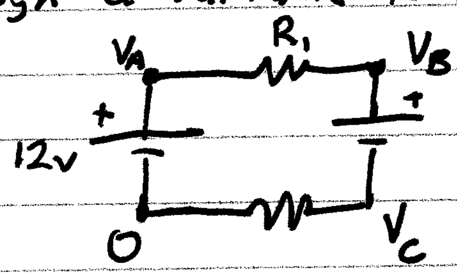
Current Law is easy: $I_1 = I_2 + I_3$
(Or something like that.)

Voltage Law has $\pm V_{batt}$ and $\pm I_i R_A$ terms in it.

Solve for I's as the unknowns (usually).

Method 2: Node Voltage Equations.

Assign a variable to the voltage @ each node.



Voltage Law automatically satisfied.
Current Law uses current thru resistors

$$I_A = (V_B - V_A)/R_1$$

Batteries Link voltage variables

$$V_A - 0 = 12V$$

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Method 3: Mesh Currents

Beware: the current in any wire or resistor is <u>not</u> one of the variables that is being solved for.