PHY 1120 - Dr. Rowley

Chapter 21 - Circuits

Summer 2020

Physics!

r/NoStupidQuestions
Posted by u/MrWaterplant • 13h

If kinetic energy is converted into thermal energy, how hard to I have to slap a chicken to cook it?

Learning Discussion

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Parker Ormonde
As your friendly neighborhood physics major, I decided to calculate this with a few assumptions.

The formula for converting between kinetic energy and thermal energy is 1/2mv^2=mcT

The average human hand weighs about 0.4kg, the average slap has a velocity of 11m/s (25mph), an average rotisserie chicken weighs 1kg (2lbs), has a specific heat capacity of 2720 J/kg*c, and let's assume the chicken has to reach a temperature of 205C (400F) for us to consider it cooked. The chicken will start off frozen, so 0C (32F)

1 average slap would generate a temperature increase of 0.0089 degrees Celsius. It would take 23,034 average slaps to cook the chicken.

To cook the chicken in one slap, you would have to slap it with a velocity of 1665.65 m/s or 3725.95 mph.

Just now Like Reply

EMF

- EMF - Electomotive “Force”
  - Electrical action produced by a non-electric source
  - In the case of batteries it is produced by chemical reactions within the battery cel. The size of the EMF is based on the electrochemistry of the cathode, anode, and electrolyte.

Batteries - Structure

Batteries - Series

Batteries - Parallel

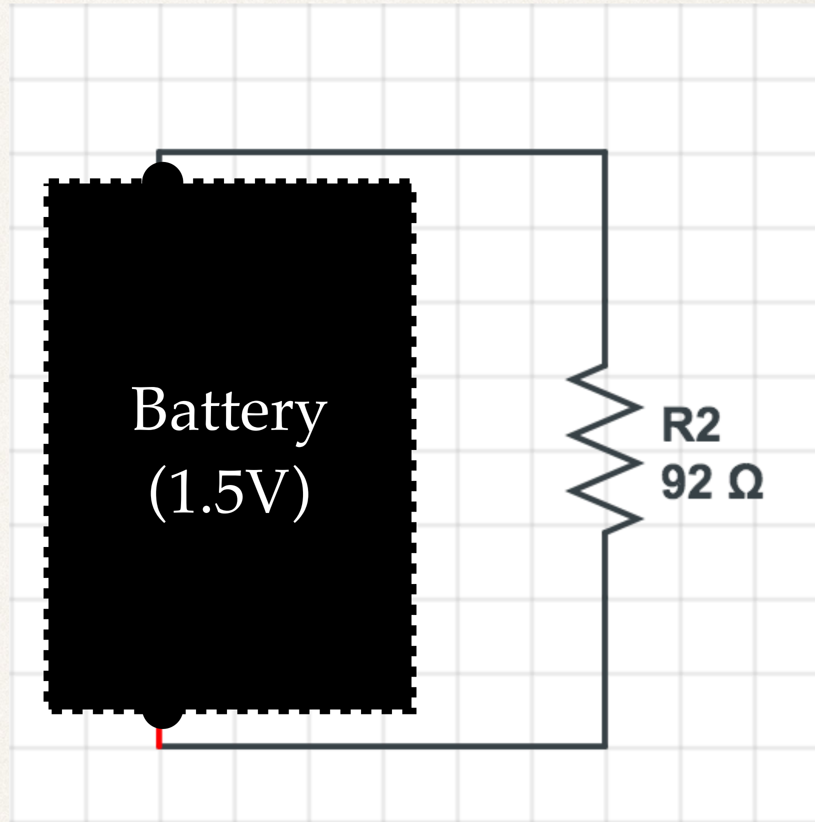
Ohm's Law, Revisited

$$V = (I)(R)$$

$$I = \frac{V}{R}$$

$$I = \frac{1.5\ \text{V}}{92\ \Omega}$$

$$I = 0.0163\ \text{A}$$



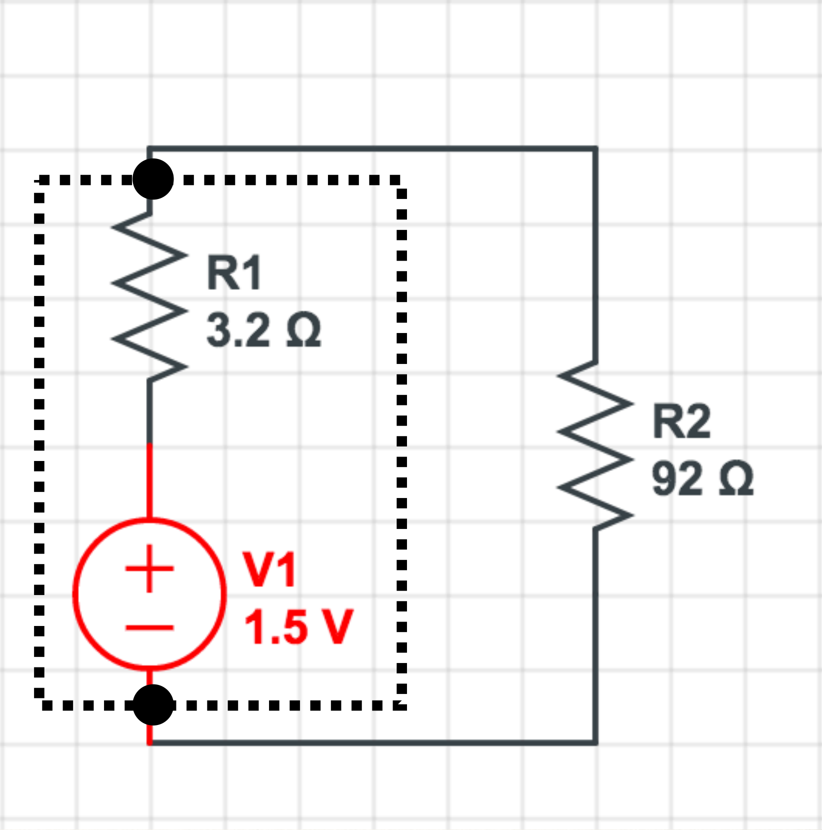
EMF

$$V = (I)(R)$$

$$V = EMF - (I)(r)$$

$$EMF - (I)(r) = (I)(R)$$

$$EMF = (I)(R) + (I)(r)$$



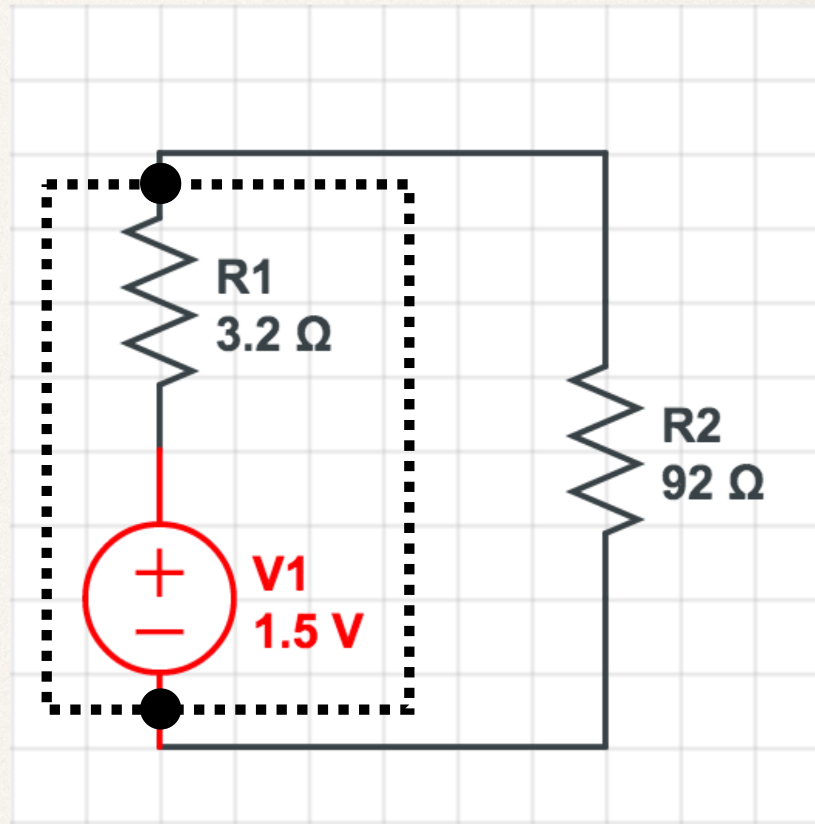
EMF

$$EMF = (I)(R) + (I)(r)$$

$$EMF = (I)(R + r)$$

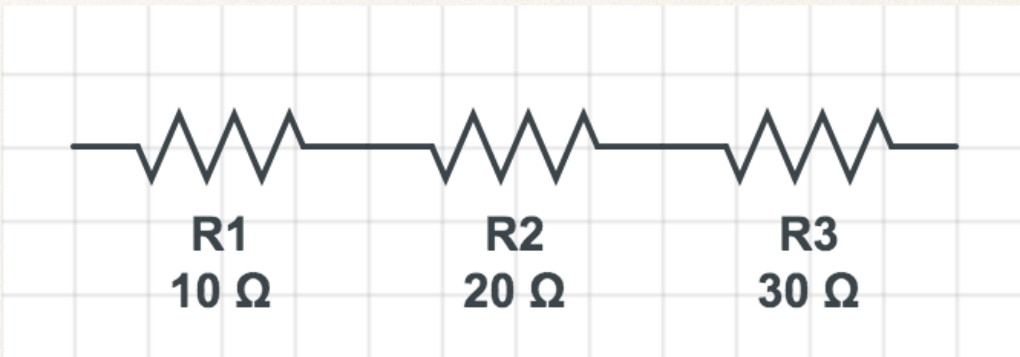
$$(I) = \frac{EMF}{(R + r)}$$

$$(I) = \frac{1.5\ \mathrm{V}}{(92\ \Omega + 3.2\ \Omega)} = 0.0158\ \mathrm{A}$$



Series and Parallel

- Series - No path choice

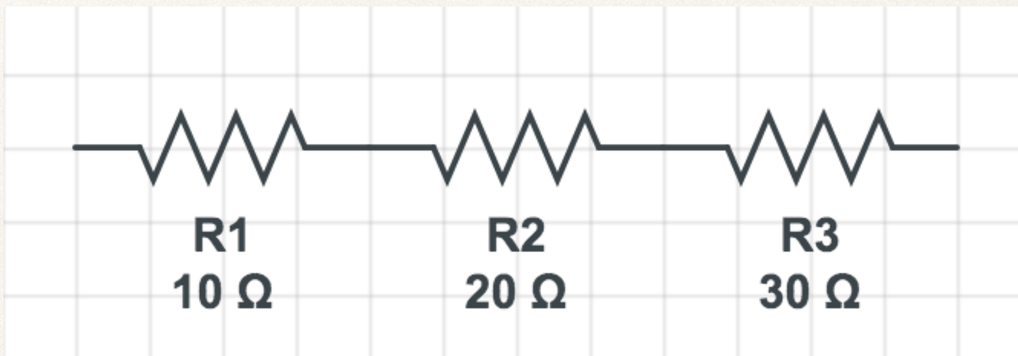


$$R_{eq} = \sum R_i$$

$$R_{eq} = R_1 + R_2 + R_3 + \ldots$$

Series and Parallel

- Series - No path choice



$$R_{eq} = 10\ \Omega + 20\ \Omega + 30\ \Omega$$

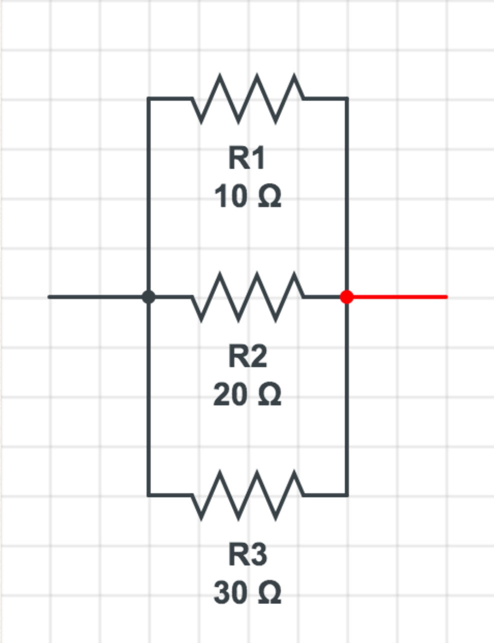
$$\boxed{R_{eq} = 60\ \Omega}$$

Series and Parallel

- Parallel - Multiple paths for electricity to flow

$$\frac{1}{R_{eq}} = \sum \frac{1}{R_i}$$

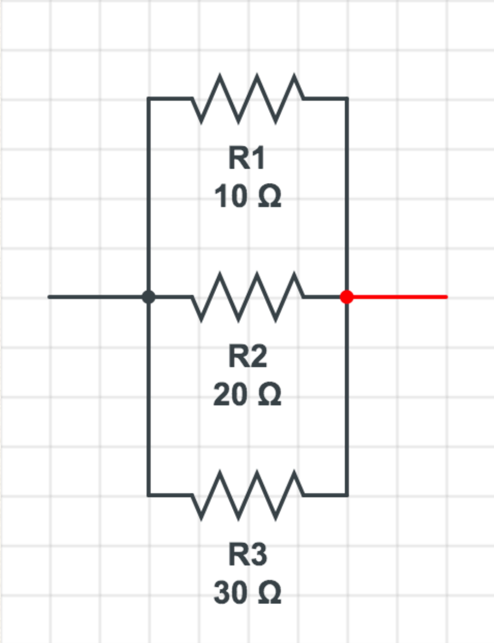
$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots$$



Series and Parallel

- Parallel - Multiple paths for electricity to flow

$$\frac{1}{R_{eq}} = \frac{1}{10\ \Omega} + \frac{1}{20\ \Omega} + \frac{1}{30\ \Omega}$$

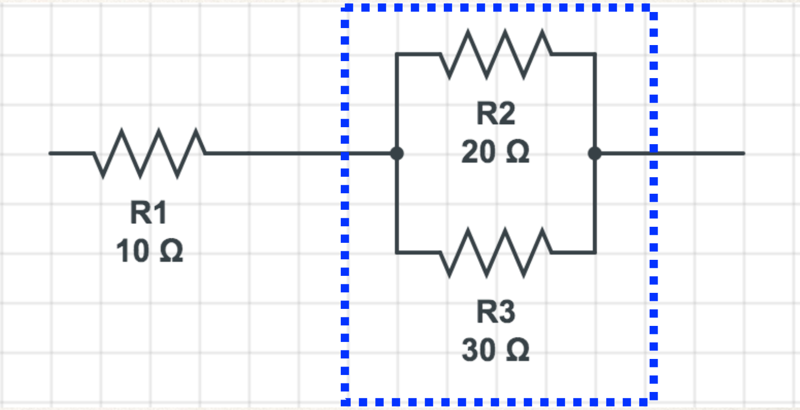


$$\frac{1}{R_{eq}} = \frac{6}{60\ \Omega} + \frac{3}{60\ \Omega} + \frac{2}{60\ \Omega} = \frac{11}{60\ \Omega}$$

$$R_{eq} = \frac{60\ \Omega}{11} = \boxed{5.45\ \Omega}$$

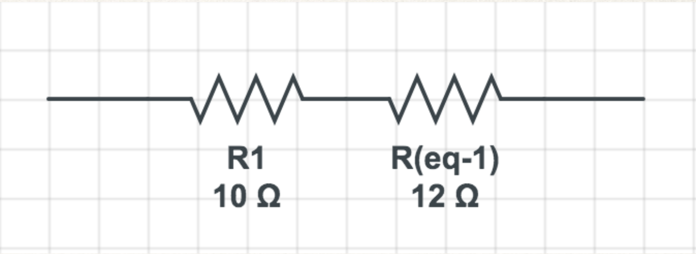
Series and Parallel

$$\frac{1}{R_{eq_1}} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{20\ \Omega} + \frac{1}{30\ \Omega}$$



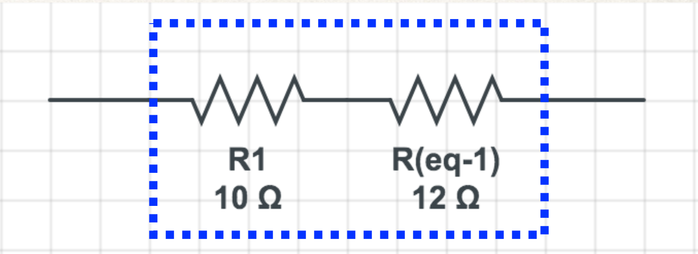
$$\frac{1}{R_{eq_1}} = \frac{5}{60\ \Omega}$$

$$\boxed{R_{eq_1} = 12\ \Omega}$$

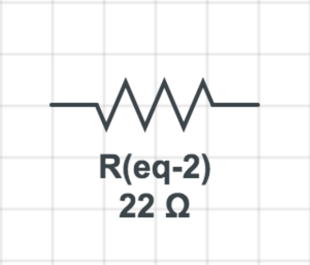


Series and Parallel

$$R_{eq_2} = 10\,\Omega + 12\,\Omega$$

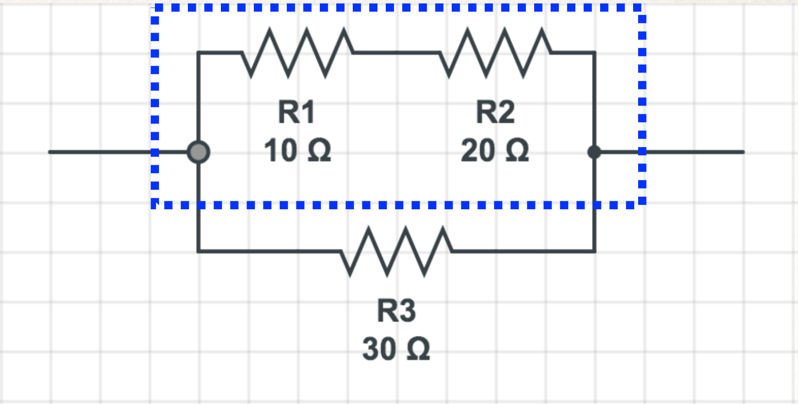


$$\boxed{R_{eq_2} = 22\,\Omega}$$

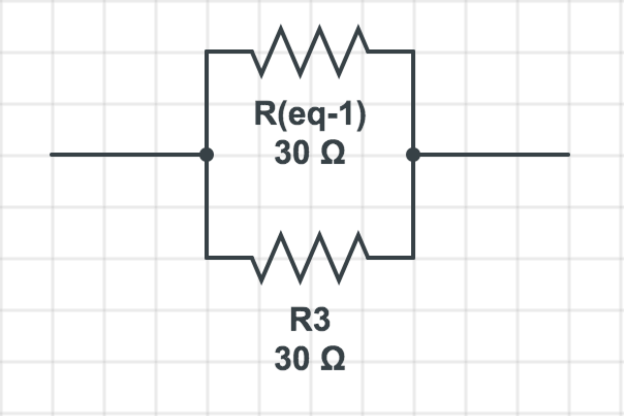


Series and Parallel

$$R_{eq_1} = 10\ \Omega + 20\ \Omega$$

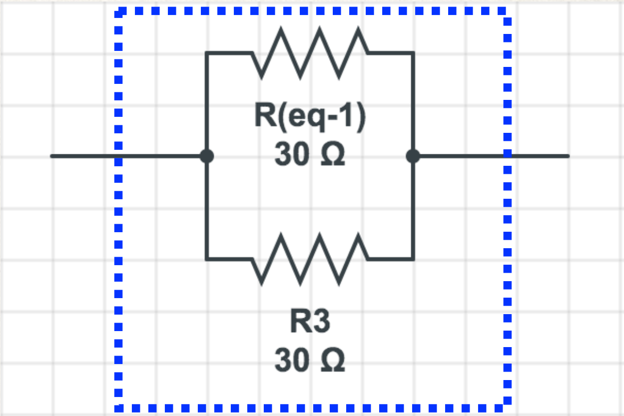


$$R_{eq_1} = 30\ \Omega$$



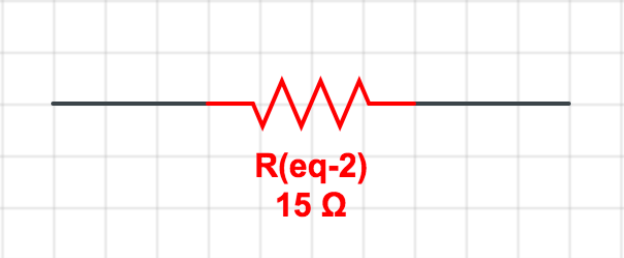
Series and Parallel

$$\frac{1}{R_{eq_2}} = \frac{1}{30\ \Omega} + \frac{1}{30\ \Omega}$$



$$\frac{1}{R_{eq_2}} = \frac{2}{30\ \Omega}$$

$$\boxed{R_{eq_2} = 15\ \Omega}$$



Series and Parallel

- Current
  - In Series: $I_{total} = I_1 = I_2 = I_3 = \ldots$
  - In Parallel: $I_{total} = I_1 + I_2 + I_3 + \ldots$

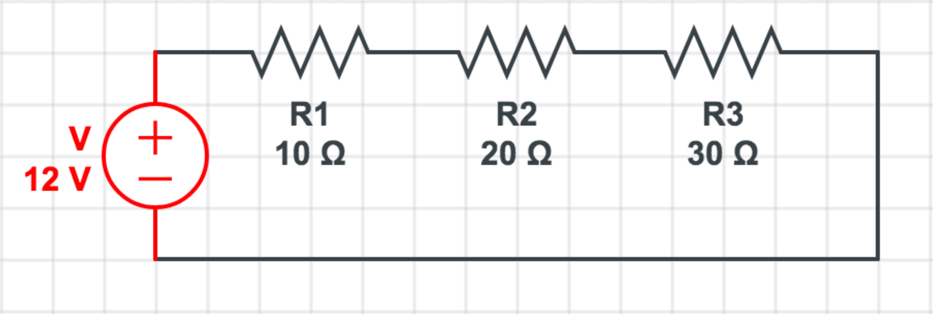
Series and Parallel

- Voltage
  - In Series: $V_{total} = V_1 + V_2 + V_3 + \ldots$
  - In Parallel: $V_{total} = V_1 = V_2 = V_3 = \ldots$

Series

- Find R_{eq}

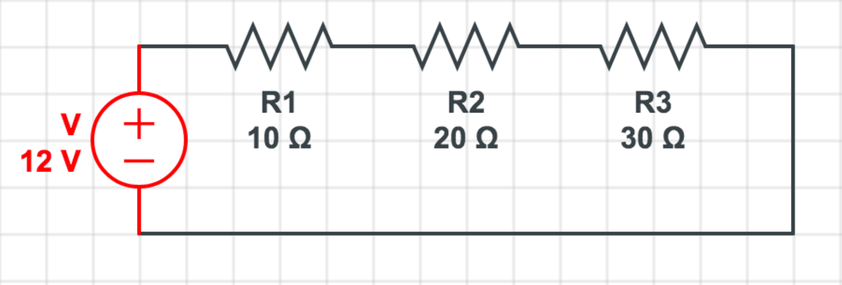
$$\boxed{R_{eq} = 60\ \Omega}$$



- Find I_{total}

$$I = \frac{V}{R} = \frac{12\text{ V}}{60\ \Omega} = \boxed{0.2\text{ A}}$$

Series



- Find V_1, V_2, V_3

$$V_1 = I_1 R_1 \quad V_1 = I_1 R_1 \quad V_1 = (0.2A)(10\Omega) \quad V_1 = 2\text{ V}$$

$$V_2 = I_2 R_2 \quad V_2 = I_2 R_2 \quad V_2 = (0.2A)(20\Omega) \quad V_2 = 4\text{ V}$$

$$V_3 = I_3 R_3 \quad V_3 = I_3 R_3 \quad V_3 = (0.2A)(30\Omega) \quad V_3 = 6\text{ V}$$

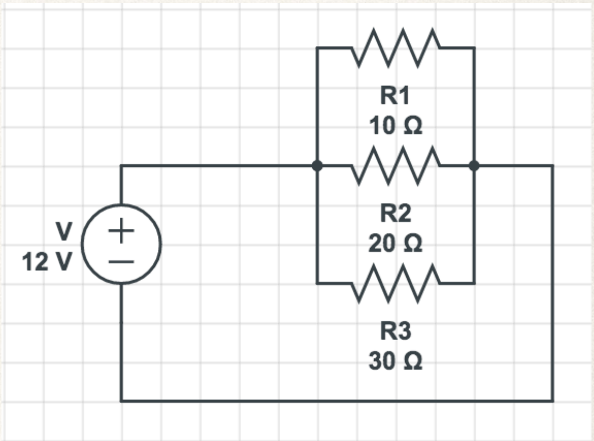
but… $I_{total} = I_1 = I_2 = I_3 = \ldots$

$$\boxed{V_{total} = 12\text{ V !}}$$

Parallel

- Find R_{eq}

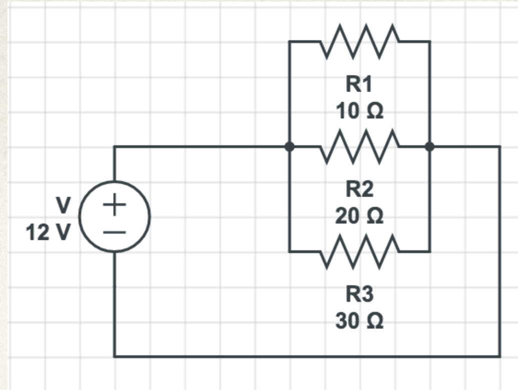
$$\boxed{R_{eq} = 5.45\ \Omega}$$



- Find I_{total}

$$I = \frac{V}{R} = \frac{12\ \text{V}}{5.45\ \Omega} = \boxed{2.20\ \text{A}}$$

Parallel



- Find V_1, V_2, V_3

$$V_{total} = V_1 = V_2 = V_3 = \ldots \qquad \text{so…} \qquad V_1 = V_2 = V_3 = \boxed{12\ \text{V}}$$

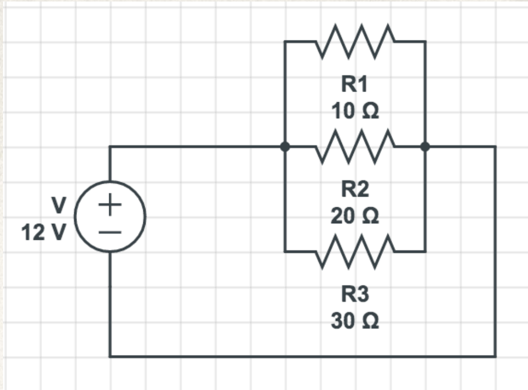
- Find I_1, I_2, I_3

$$I_1 = \frac{V_1}{R_1} \qquad I_2 = \frac{V_2}{R_2} \qquad I_3 = \frac{V_3}{R_3}$$

$$I_1 = \frac{12\ \text{V}}{10\ \Omega} \qquad I_2 = \frac{12\ \text{V}}{20\ \Omega} \qquad I_3 = \frac{12\ \text{V}}{30\ \Omega}$$

$$\boxed{I_1 = 1.2\ \text{A}} \qquad \boxed{I_2 = 0.6\ \text{A}} \qquad \boxed{I_3 = 0.4\ \text{A}}$$

Parallel



- Find I_{total}

$$I_{total} = I_1 + I_2 + I_3 + \ldots$$

and…

$$\boxed{I_1 = 1.2 \text{ A}}$$

$$\boxed{I_2 = 0.6 \text{ A}}$$

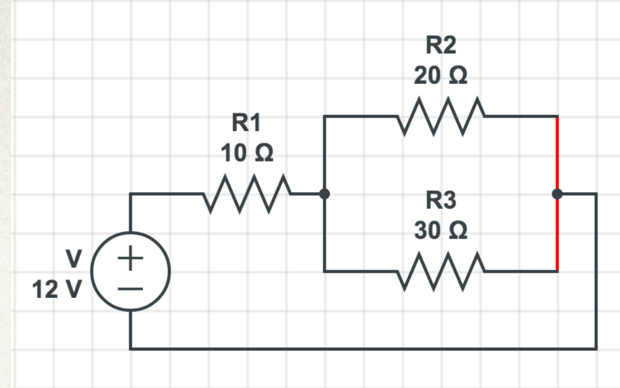
$$\boxed{I_3 = 0.4 \text{ A}}$$

and…

$$I_{total} = 1.2 \text{ A} + 0.6 \text{ A} + 0.4 \text{ A}$$

$$\boxed{I_{total} = 2.2 \text{ A !}}$$

Series & Parallel



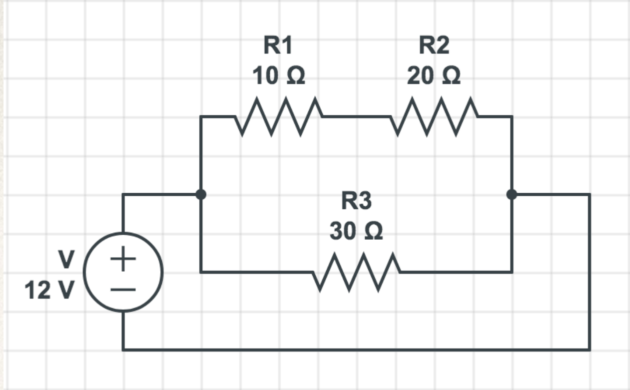
- Find R_{eq}

$$\boxed{R_{eq} = 22\ \Omega}$$

- Find I_{total}

$$I = \frac{V}{R} = \frac{12\ \text{V}}{22\ \Omega} = 0\boxed{.5455\ \text{A}}$$

Series & Parallel



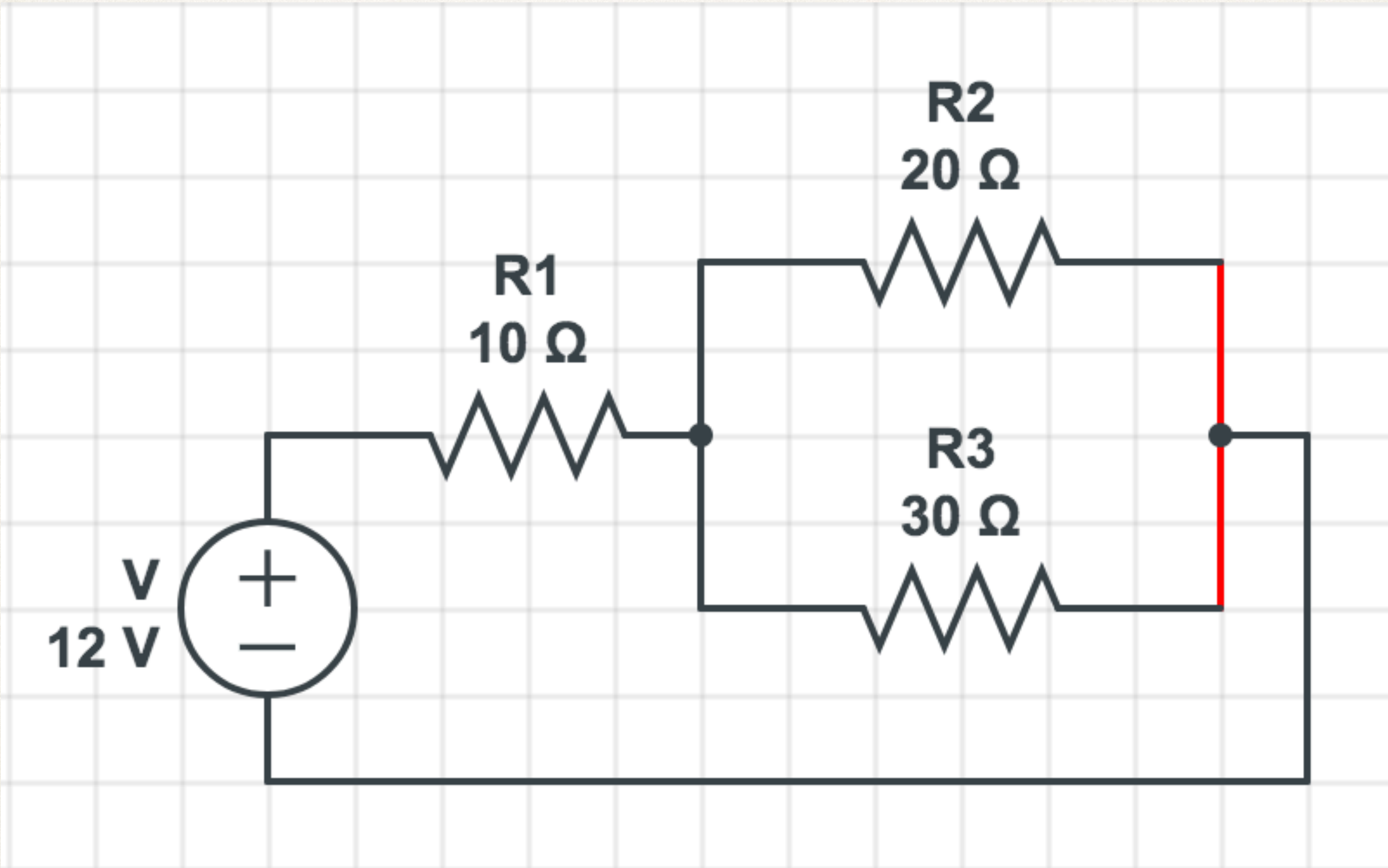
- Find R_{eq}

$$\boxed{R_{eq} = 15\ \Omega}$$

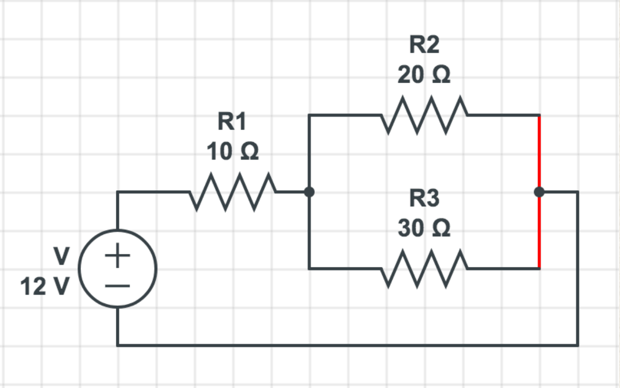
- Find I_{total}

$$I = \frac{V}{R} = \frac{12\ \text{V}}{15\ \Omega} = \boxed{0.80\ \text{A}}$$

Series & Parallel



Series & Parallel



- Find R_{eq}

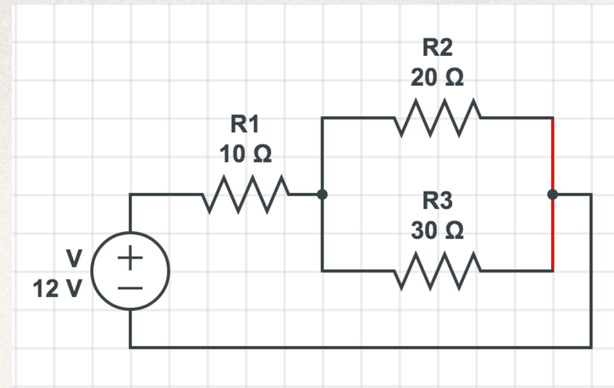
$$\boxed{R_{eq} = 22\ \Omega}$$

- Find $I_{battery}$

$$I = \frac{V}{R} = \frac{12\ \text{V}}{22\ \Omega} = 0.5454\ \text{A}$$

Keep more decimals than needed so you can minimize rounding errors!

Series & Parallel



- Find I_1

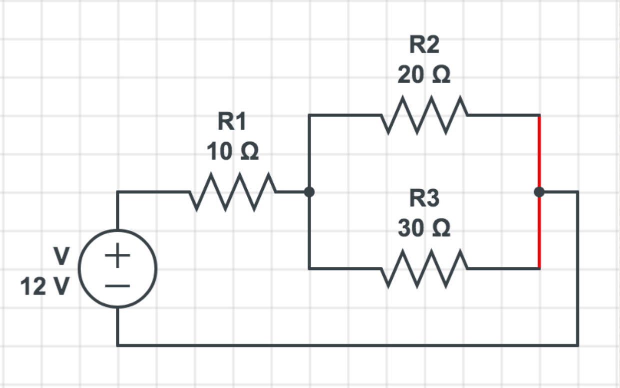
$$\boxed{I_1 = 0.5454\ \text{A}}$$

… because I_1 has the full current from the battery passing through it

- Find V_1

$$V = IR = (0.5454\ \text{A})(10\ \Omega) = 5.454\ \text{V}$$

Series & Parallel



- Find V_2

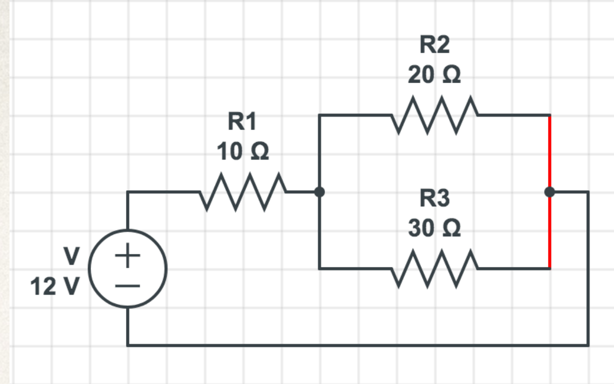
$$V_2 = V_{battery} - V_1 = 12\text{ V} - 5.454\text{ V} = 6.546\text{ V}$$

- Find V_3

$$V_3 = V_2 = 6.546\text{ V}$$

… because R_2 and R_3 are in parallel they have the same voltage drop.

Series & Parallel



- Find I_2

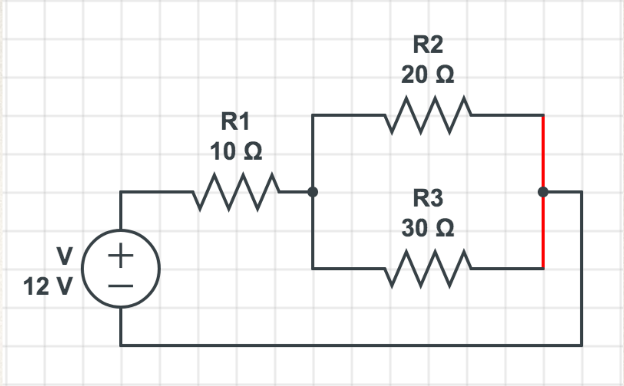
$$I_2 = \frac{V_2}{R_2} = \frac{6.546 \text{ V}}{20\ \Omega} = 0.3273 \text{ A}$$

- Find I_3

$$I_3 = \frac{V_3}{R_3} = \frac{6.546 \text{ V}}{30\ \Omega} = 0.2182 \text{ A}$$

… because R_2 and R_3 are in parallel they have the same voltage drop.

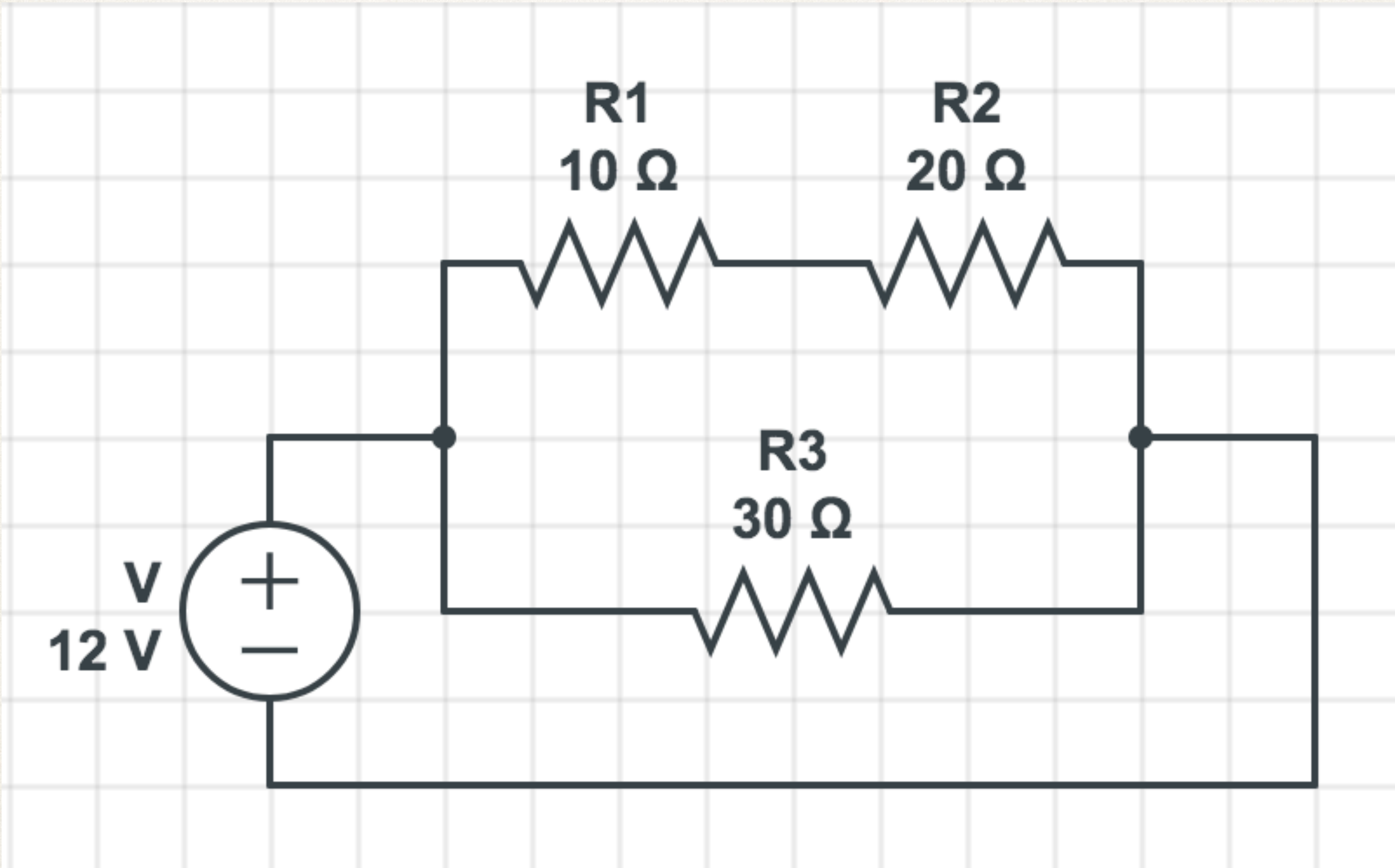
Series & Parallel



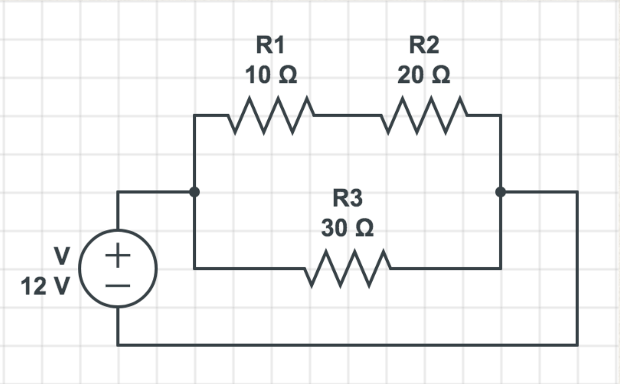
	Resistance	Voltage	Current
R_1	10 Ω	5.454 V	0.545 A
R_2	20 Ω	6.546 V	0.327 A
R_3	30 Ω	6.546 V	0.218 A

- Note:
  - V_1+V_2 or V_1+V_3 equals 12V
  - $I_1=I_2+I_3$

Series & Parallel



Series & Parallel



- Find R_{eq}

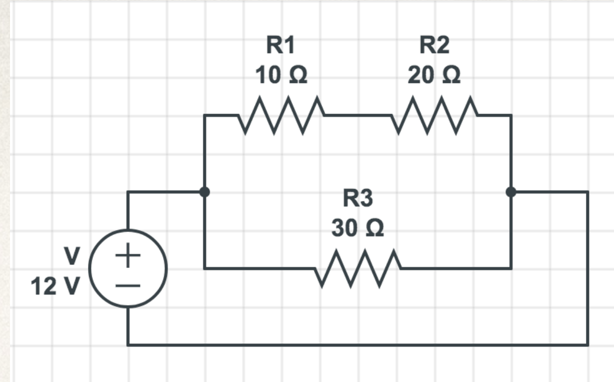
$$\boxed{R_{eq} = 15\ \Omega}$$

- Find $I_{battery}$

$$I = \frac{V}{R} = \frac{12\ \text{V}}{15\ \Omega} = 0.80\ \text{A}$$

Keep more decimals than needed so you can minimize rounding errors!

Series & Parallel



- Find I_3

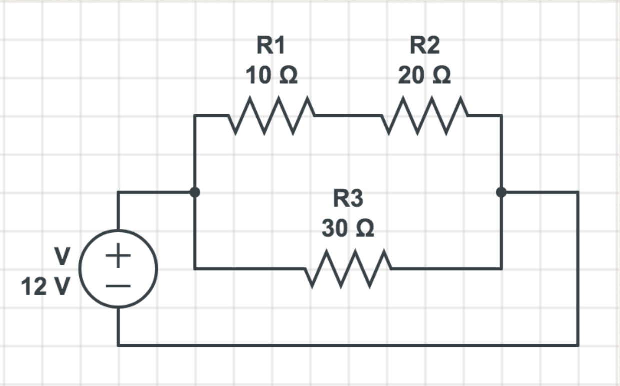
$$\boxed{I_1 = \frac{12\ \text{V}}{30\ \Omega} = 0.4\ \text{A}}$$

… because R_3 has the full voltage from the battery across it

- Find I_2 & I_3

$$I_2 = I_{battery} - I_3 = 0.8\ \text{A} - 0.4\ \text{A} = 0.4\ \text{A}$$

Series & Parallel



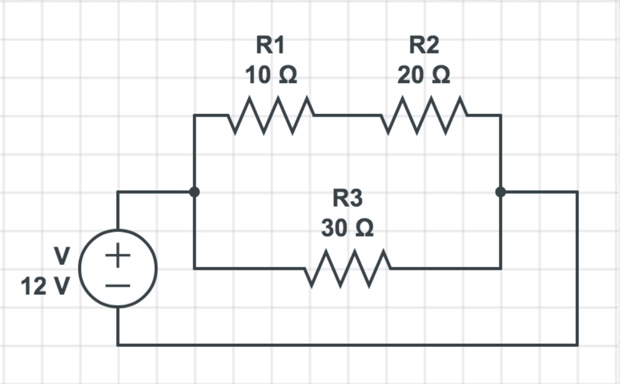
- Find V_1

$$V_1 = I * R = 0.4 \text{ A} * 10 \ \Omega = 4 \text{ V}$$

- Find V_2

$$V_1 = I * R = 0.4 \text{ A} * 20 \ \Omega = 8 \text{ V}$$

Series & Parallel



	Resistance	Voltage	Current
R_1	10 Ω	4 V	0.4 A
R_2	20 Ω	8 V	0.4 A
R_3	30 Ω	12 V	0.4 A

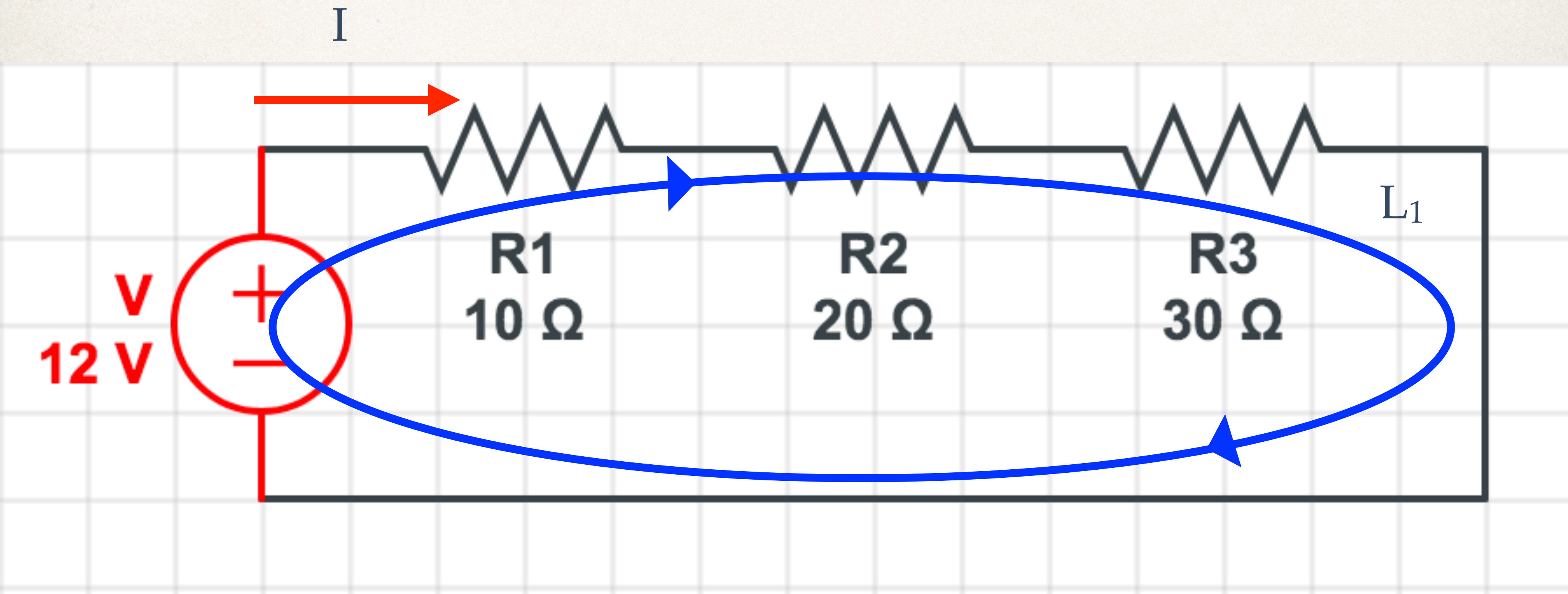
- Note:
  - $V_1+V_2 = V_3$ equals 12V
  - $I_1=I_2$ & $I_1 + I_3 = I_{battery}$

Kirchoff's Laws

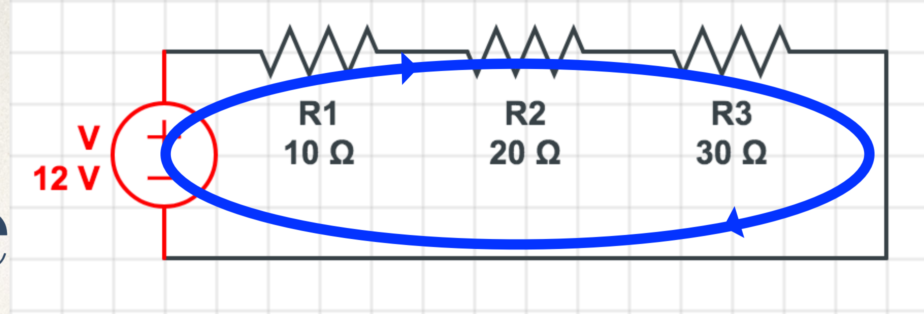
- Loop Rule:
  - Any closed loop in a circuit will have a net potential change of zero.
- Junction Rule:
  - For any Junction, the total current into the junction must equal the current out of the junction

Conservation of Matter & Charge !

Kirchoff's Examples



Kirchoff's Example



- Loop #1

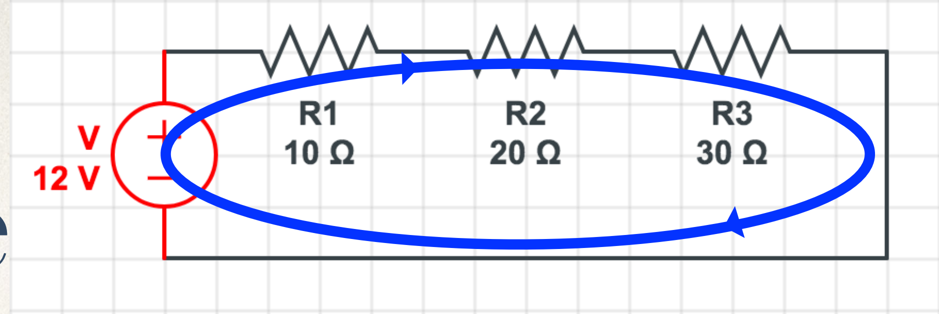
$$V_{battery} - I_1 R_1 - I_2 R_2 - I_3 R_3 = 0$$ … but

$$I_1 = I_2 = I_3$$ … then

$$V_{battery} - I\left(R_1 + R_2 + R_3\right) = 0$$

- Junction #1 - There are no junctions

Kirchoff's Example



- Solve

$$V_{battery} - I\left(R_1 + R_2 + R_3\right) = 0$$

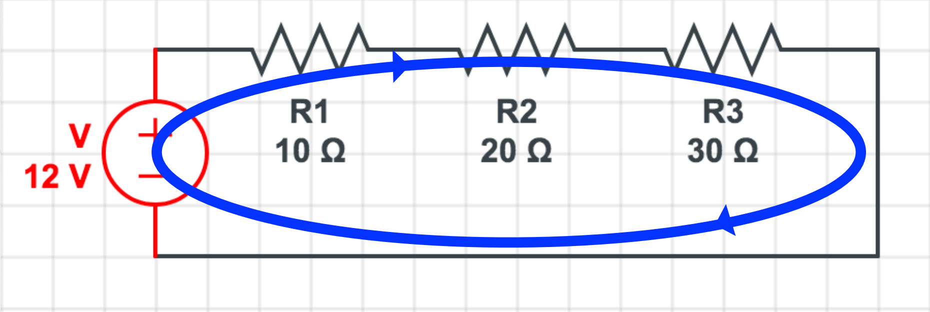
$$12\text{ V} - I\left(10\ \Omega + 20\ \Omega + 30\ \Omega\right) = 0$$

$$I\left(60\ \Omega\right) = 12\text{ V}$$

$$I = \frac{12\text{ V}}{60\ \Omega}$$

$$\boxed{I = 0.200\text{ A}}$$

Kirchoff's Example



- Solve

$$V_{R_1} = IR_1 \qquad V_{R_2} = IR_2 \qquad V_{R_3} = IR_3$$

$$V_{R_1} = (0.2\text{ A})10\ \Omega \qquad V_{R_2} = (0.2\text{ A})20\ \Omega \qquad V_{R_3} = (0.2\text{ A})30\ \Omega$$

$$\boxed{V_{R_1} = 2\text{ V}} \qquad \boxed{V_{R_2} = 4\text{ V}} \qquad \boxed{V_{R_3} = 6\text{ V}}$$

$$V_{total} = V_1 + V_2 + V_3 = 2\text{ V} + 4\text{ V} + 6\text{ V} \qquad \boxed{V_{total} = 12\text{ V !}}$$

Kirchoff's Examples