

Exam concept sheet

What is necessary for current to flow?

What is a superconductor?

How does changing the temperature, length, thickness, or conductivity of a wire affect its resistance?

What is a series and a parallel circuit?

Which are wired in series, and which are wired in parallel – car headlights, Christmas lights, the appliances in your house?

What variable(s) is/are constant in series, and which in parallel?

Be able to analyze series, parallel, and combination circuits

Given a time value and a power value in Watts, be able to calculate the energy usage in kWh and amount of money spent

Know that voltmeters are wired in parallel and have high resistance, while ammeters are wired in series and have low resistance.

Fruit battery lab: know the general purpose of the metals and the acid in the fruit

Don't need to know how to jump a car battery, but the knowledge can't hurt you 😊

Know what each of the variables in these equations mean, and when to use these equations

$$I = \frac{\Delta Q}{\Delta t}$$

$$V = IR$$

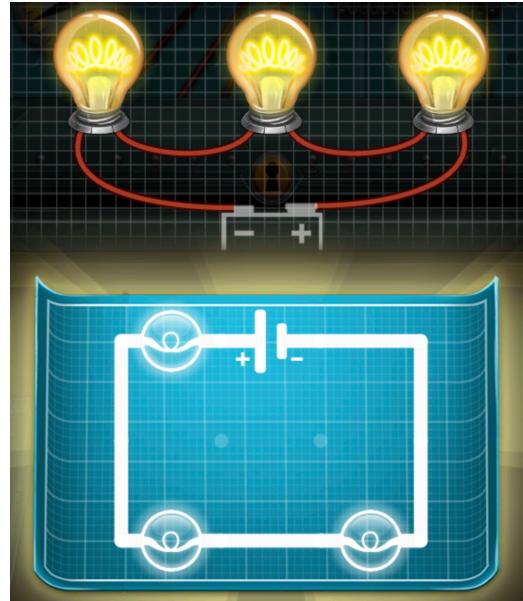
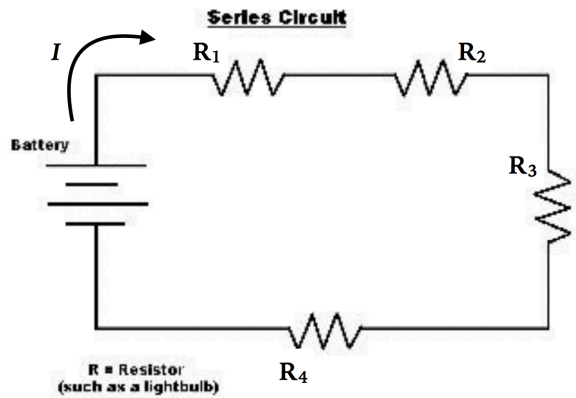
$$R = \frac{\rho L}{A}$$

$$P = \frac{E}{t}$$

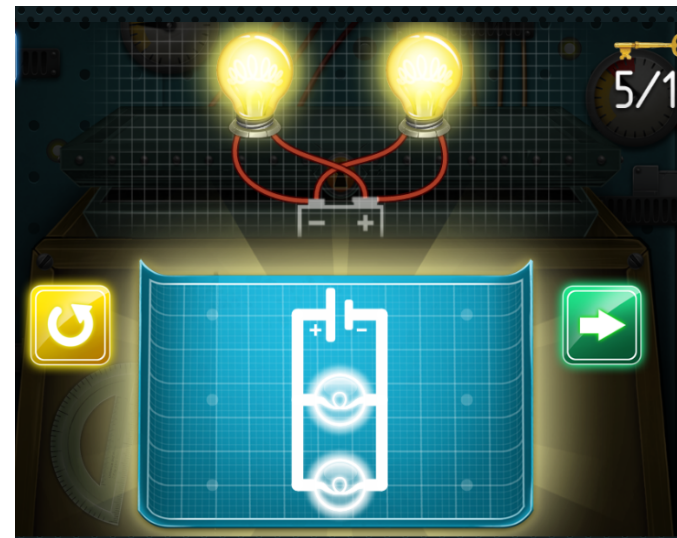
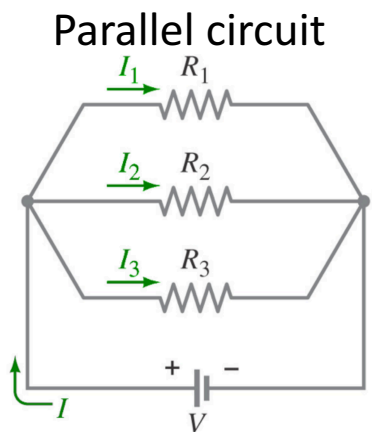
$$P = IV$$

$$R_{tot, in series} = R_1 + R_2 + R_3 \dots$$

$$\frac{1}{R_{tot, in parallel}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \dots$$



- When two or more resistors are connected end to end, they are said to be connected in series
- Any charge that passes through R 1 will also pass through R 2 and then R 3, etc.
 - Hence, the same current I will pass through each resistor
 - Each resistor eats up some of the energy supplied by the battery
 - i.e. the voltage will drop across each resistor
 - Drop by how much?
 - Ohm's Law tells us: $V_1 = IR_1$, $V_2 = IR_2$, $V_3 = IR_3$, etc.
 - $V = V_1 + V_2 + V_3 + V_4$



Parallel: voltage is the same across all paths.
(conservation of energy)

$$\frac{1}{R_{tot, in\ parallel}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \dots$$

Current splits at a junction (kirchhoff's junction rule: total current in = total current out)

Kirchhoff's Rules

- Loop Rule: the sum of the changes in potential around any closed path of a circuit must be zero ➤ (conservation of energy)
 - V supplied by battery – total V drop from resistor = 0
- Junction Rule: at any junction, the sum of currents in equals the sum of currents out

Finding V , I & R for a Series Circuit

1. Determine total \mathcal{E} (V from battery)
2. Find the total Resistance

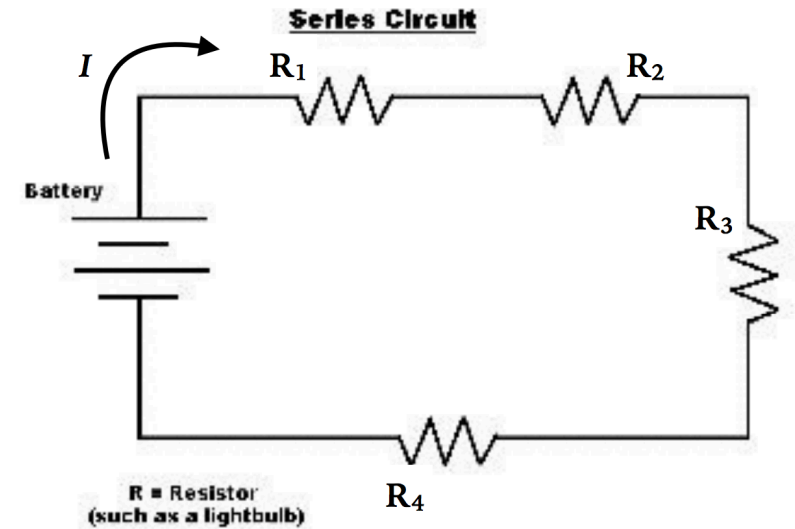
$$R_T = R_1 + R_2 + R_3 \dots$$

3. Determine I_T by

$$I = V_T / R_T$$

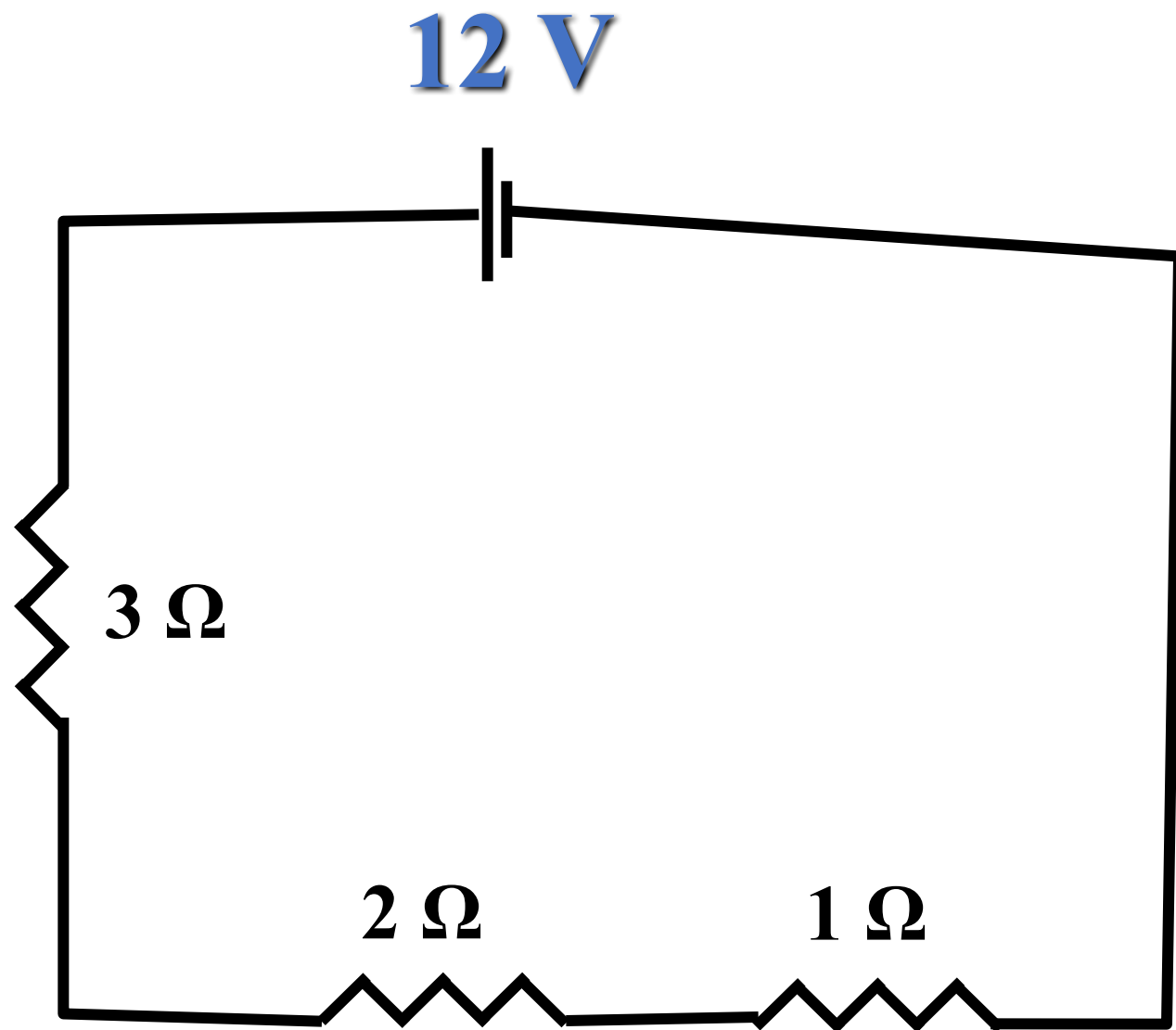
4. Because I is constant in a series circuit, find V (energy used) by each resistor using

$$V = I_T R$$



Finding V , I & R for a Series Circuit

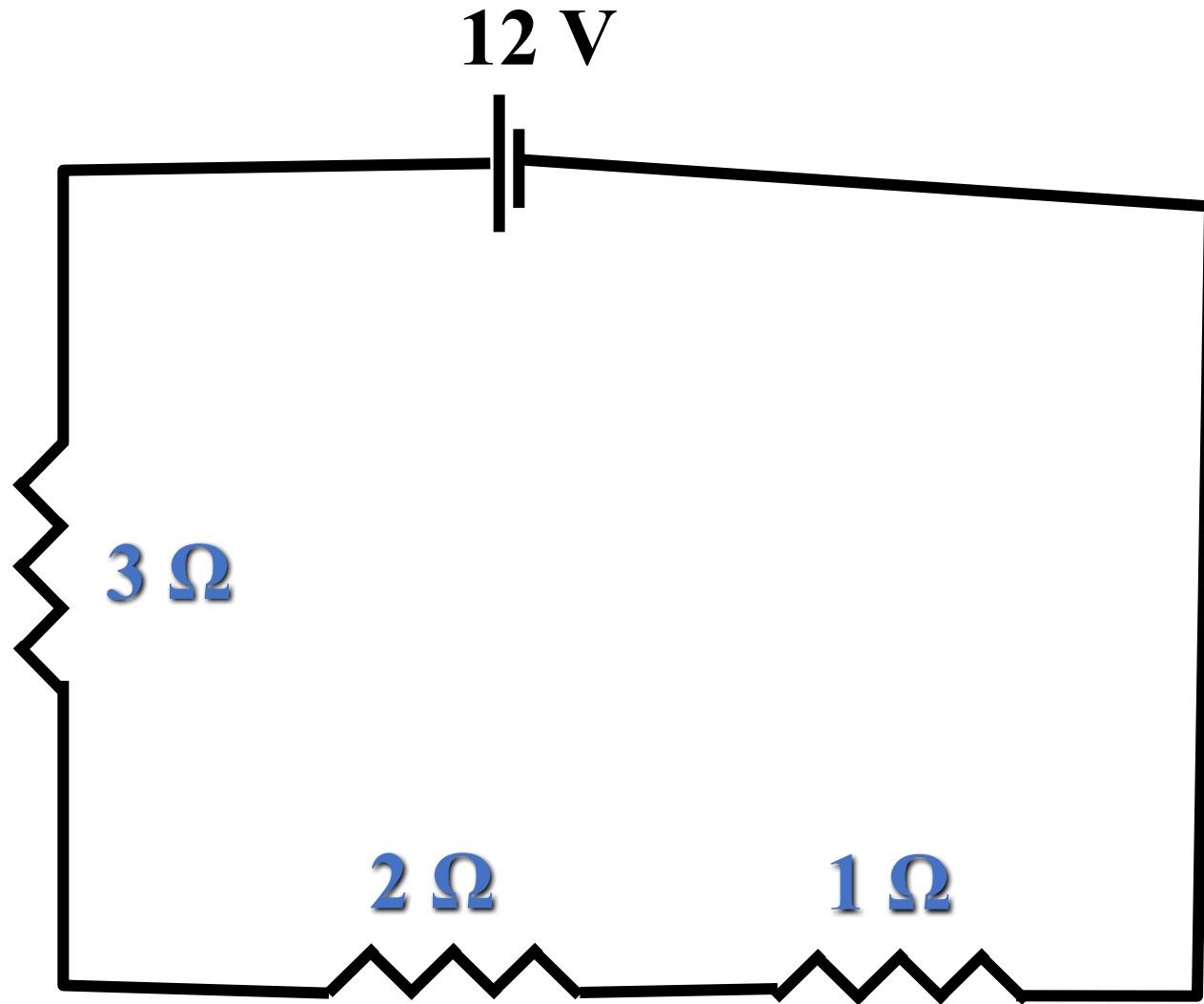
1. Determine \mathcal{E} (V from battery)



Finding V, I & R for a Series Circuit

1. Determine \mathcal{E} (V from battery) - **12V**
2. Find the total Resistance

$$R_T = R_1 + R_2 + R_3 \dots$$



$$6\ \Omega = 3\ \Omega + 2\ \Omega + 1\ \Omega$$

Finding V , I & R for a Series Circuit

1. Determine \mathcal{E} (V from battery) - **12V**
2. Find the total Resistance - **6 Ω**

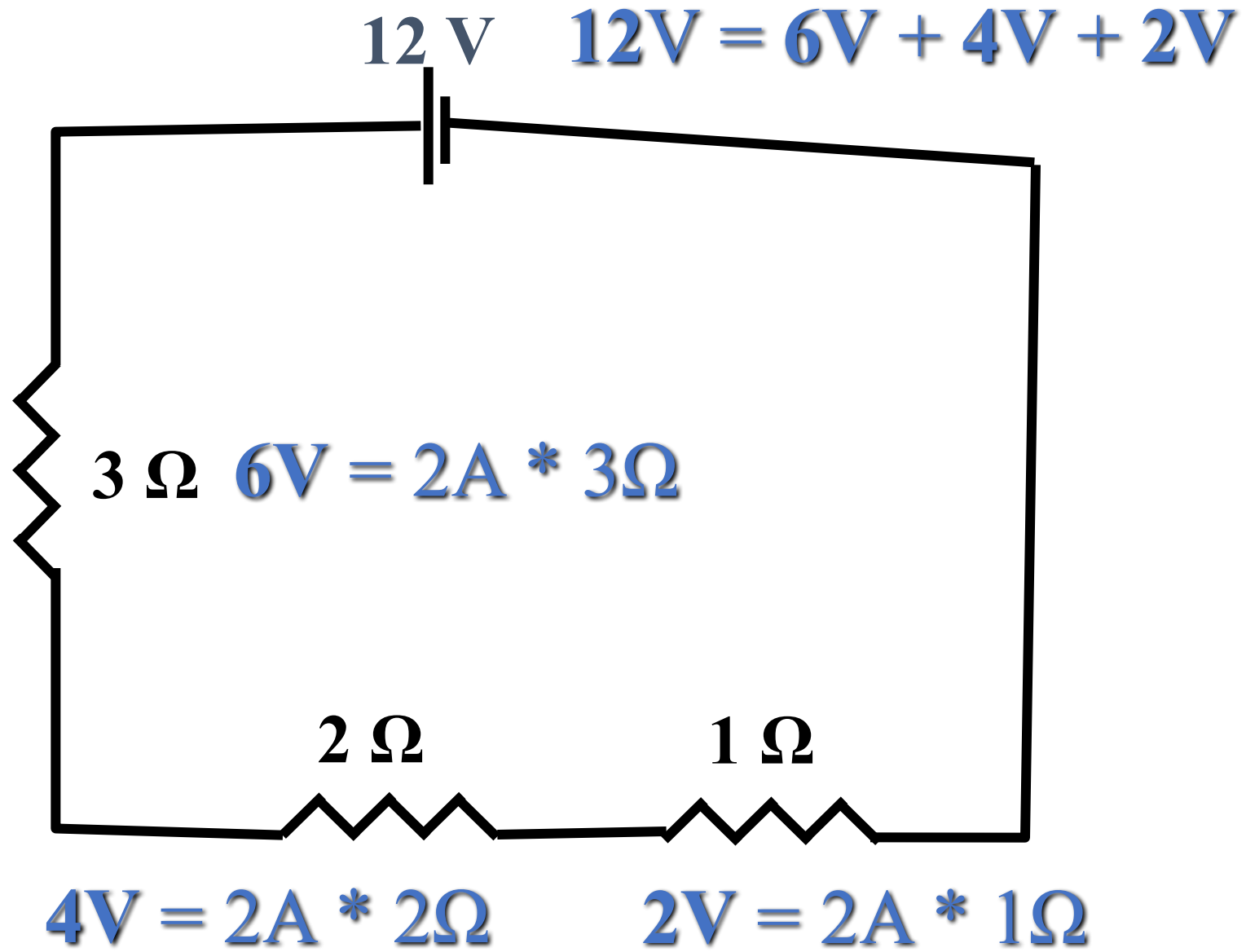
Finding V, I & R for a Series Circuit

1. Determine \mathcal{E} (V from battery) - **12V**
2. Find the total Resistance - **6 Ω**
3. Determine I_T by $I_T = V_T/R_T$

$$\mathbf{2\ A = 12\ V / 6\ \Omega}$$

Finding V , I & R for a Series Circuit

1. Determine \mathcal{E} (V from battery) - **12V**
2. Find the total Resistance - **6 Ω**
3. Determine that $I_T =$ **2 A**
4. Since I is constant in a series circuit, find V (energy used) for each resistor using $V = I_T R$



Series Circuit

- Current is the same at all points

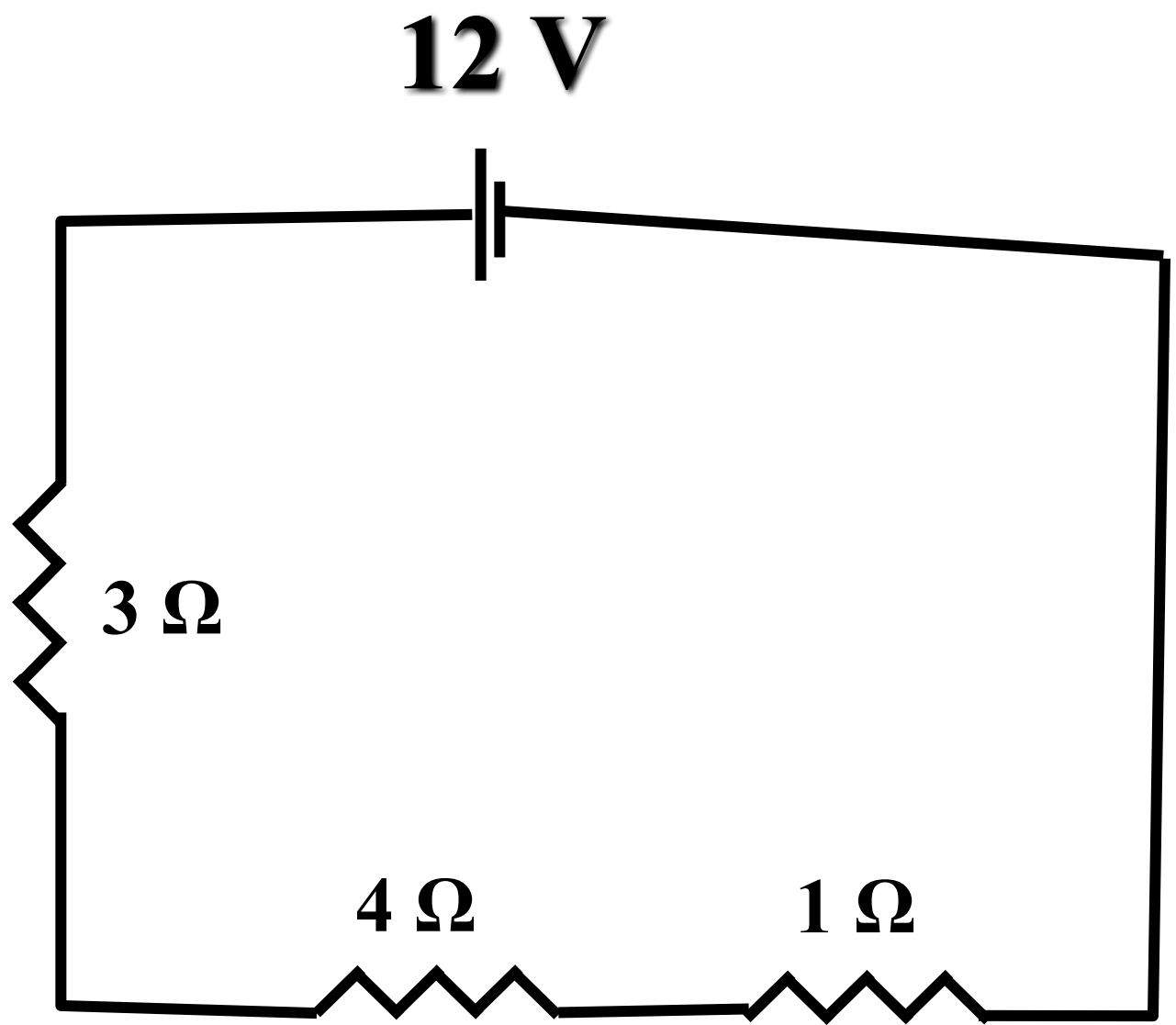
$$I = I_1 = I_2 = I_3 = I_4$$

- Volt is divided among all the resistor

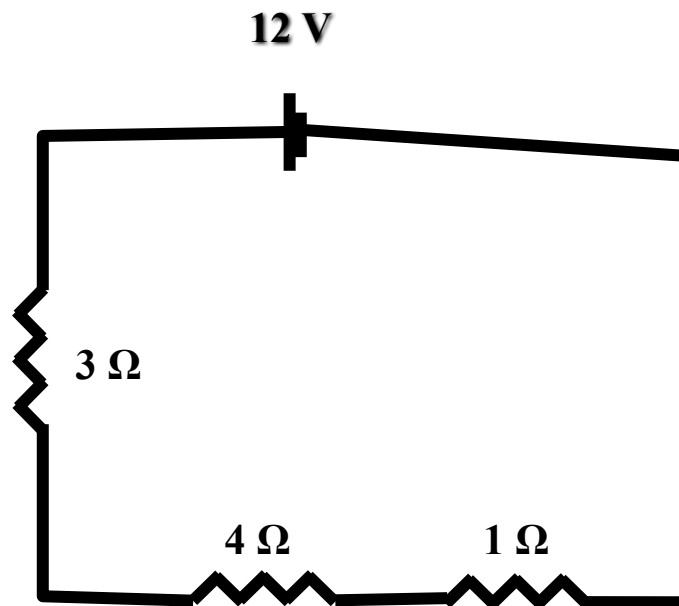
$$\mathcal{E} = V_1 + V_2 + V_3$$

- Resistance accumulates

$$R = R_1 + R_2 + R_3$$

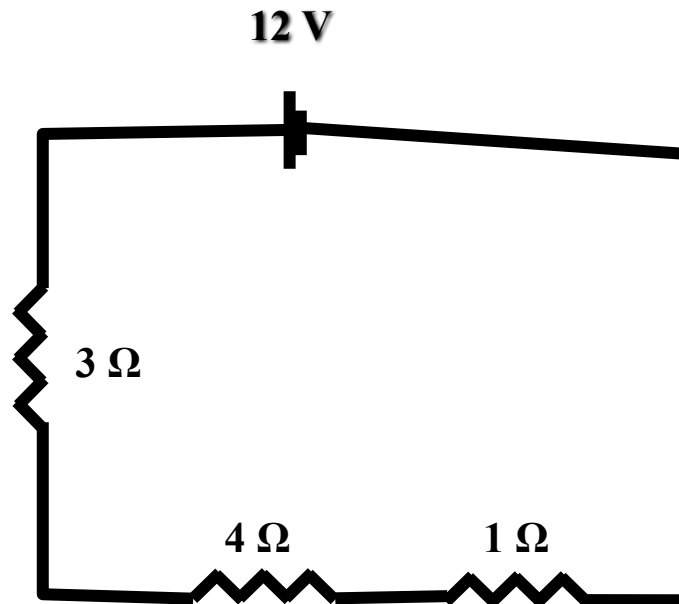


What is the total Resistance?



What is the total Resistance? 8Ω

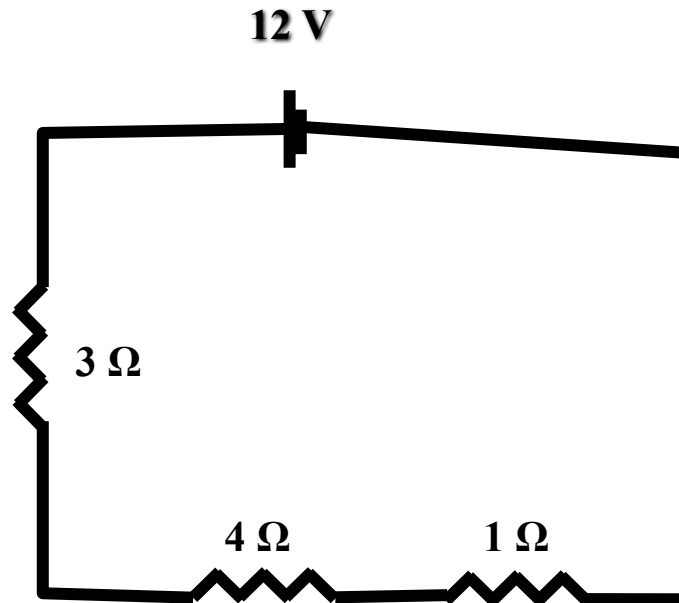
What is the current leaving the Battery?



What is the total Resistance? 8Ω

What is the current leaving the Battery? 1.5A

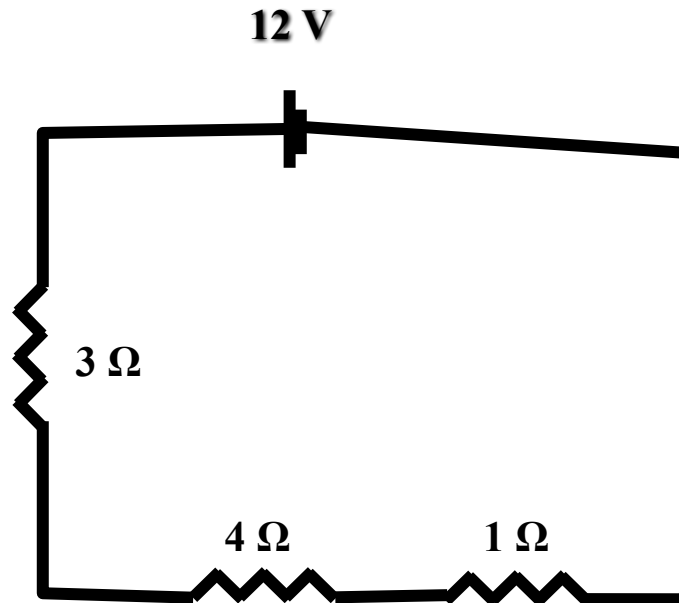
What is the voltage used by the $1\text{-}\Omega$ resistor?



What is the total Resistance? 8Ω

What is the current leaving the Battery? 1.5A

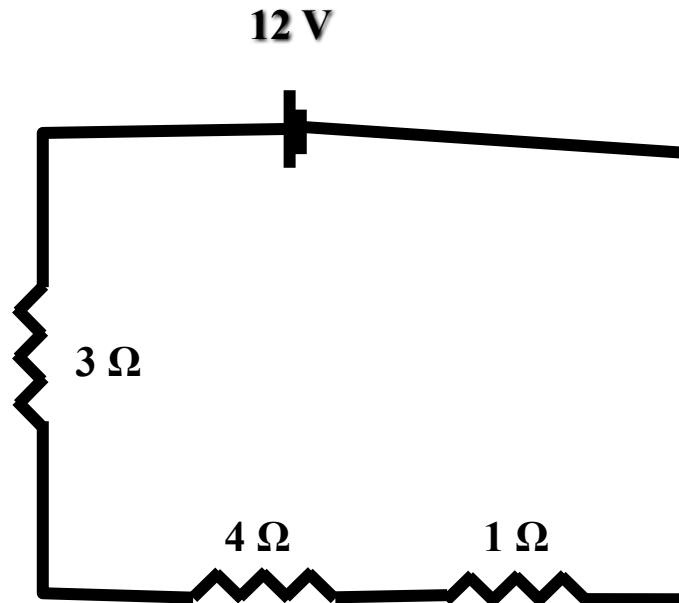
What is the voltage used by the $4\text{-}\Omega$ resistor?



What is the total Resistance? 8Ω

What is the current leaving the Battery? $1.5A$

What is the voltage used by the $3\text{-}\Omega$ resistor?



Parallel Circuit

Finding V, I & R for a Parallel Circuit

1. Determine \mathcal{E}
2. Find the total Resistance

$$1/R_T = 1/R_1 + 1/R_2 + 1/R_3 \dots$$

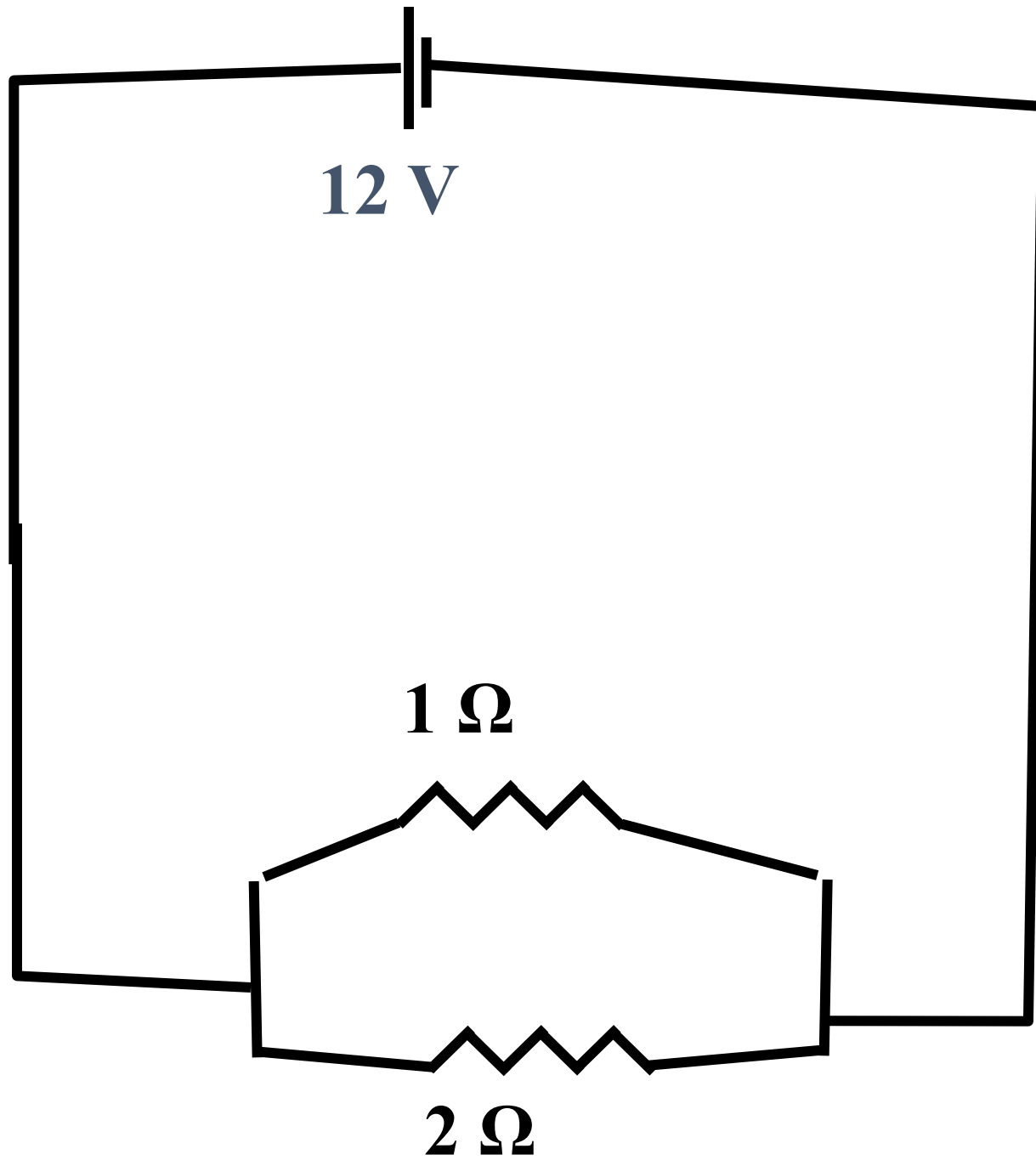
3. Determine I_T leaving battery by

$$I_T = V_T/R_T$$

4. V is constant for each part of a parallel circuit, find I through each resistor using

$$I = V/R$$

5. Check to verify that Kirchhoff's Law is true



Finding V , I & R for a Parallel Circuit

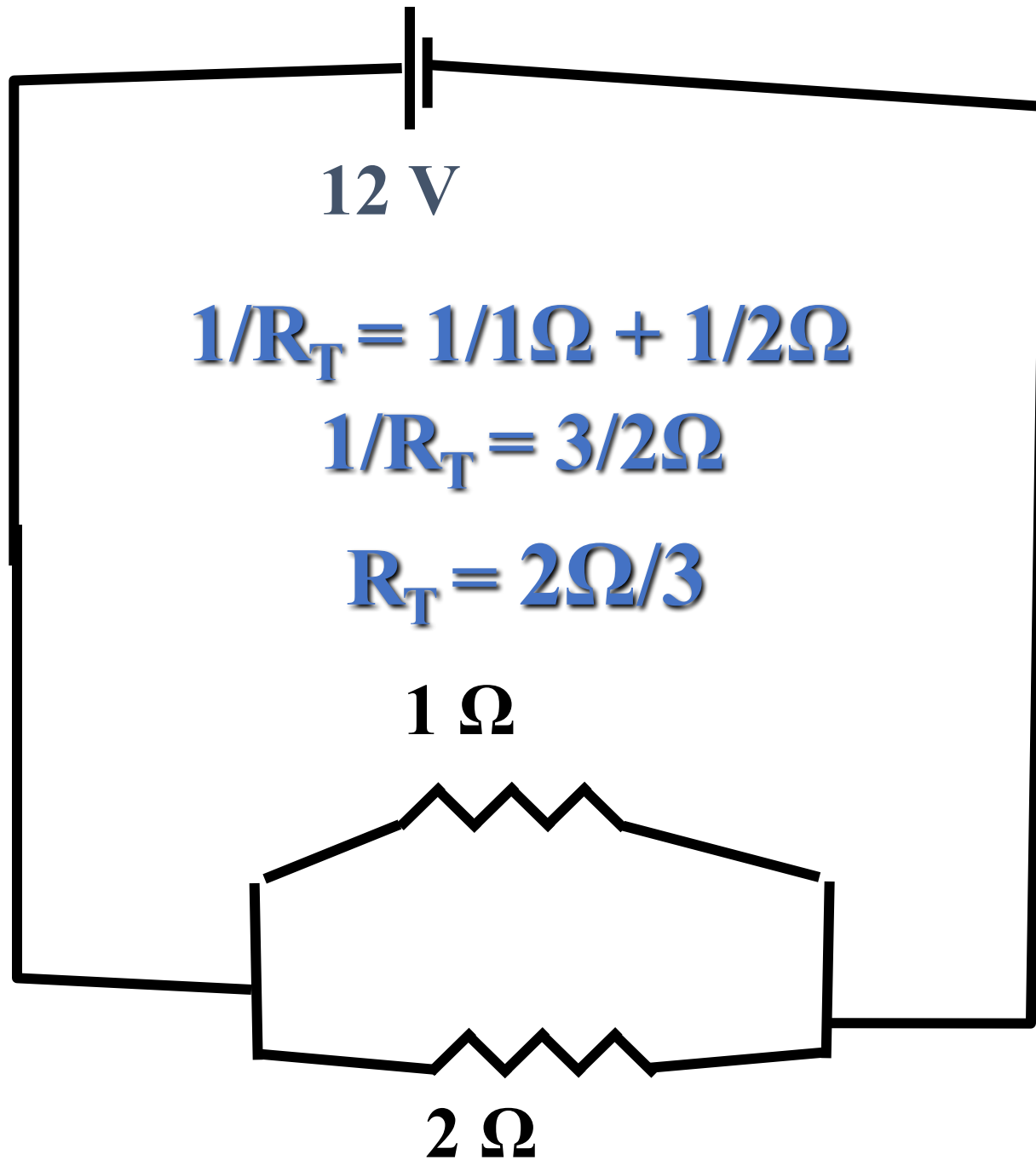
1. Determine \mathcal{E}

12 V

Finding V, I & R for a Parallel Circuit

1. Determine E
2. Find the total Resistance

$$1/R_T = 1/R_1 + 1/R_2 + 1/R_3 \dots$$



Finding V, I & R for a Parallel Circuit

1. Determine E
2. Find the total Resistance

$$1/R_T = 1/R_1 + 1/R_2 + 1/R_3 \dots$$

$$**R_T = 2\Omega/3**$$

Finding V, I & R for a Parallel Circuit

1. Determine E
2. Find the total Resistance

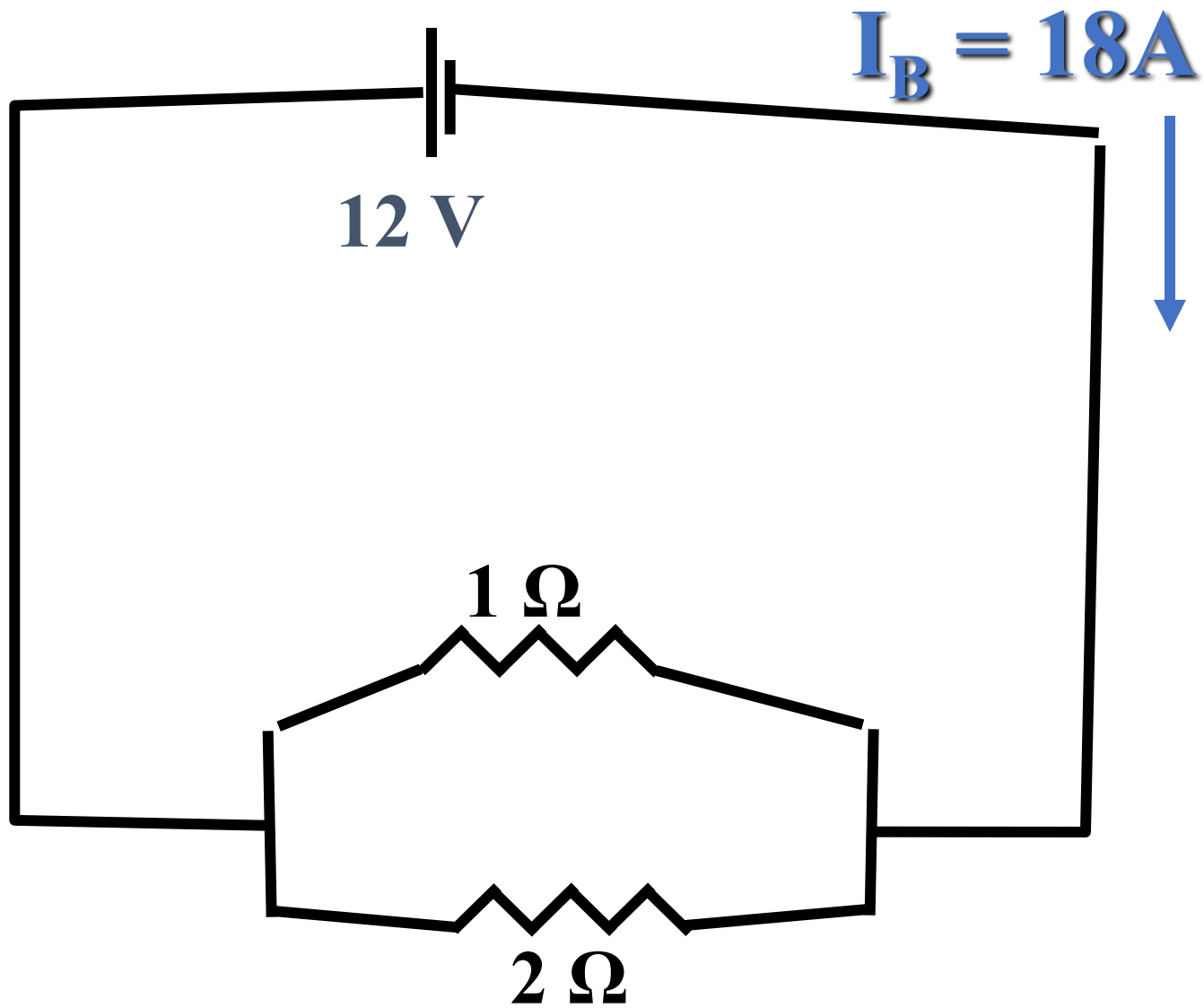
$$1/R_T = 1/R_1 + 1/R_2 + 1/R_3 \dots$$

3. Determine I_B leaving battery by

$$I_B = V_B / R_T$$

$$I_B = 12V / 2\Omega/3 \text{ or } 12V \times 3/2\Omega$$

$$I_B = 18A$$



Finding V, I & R for a Parallel Circuit

1. Determine E
2. Find the total Resistance

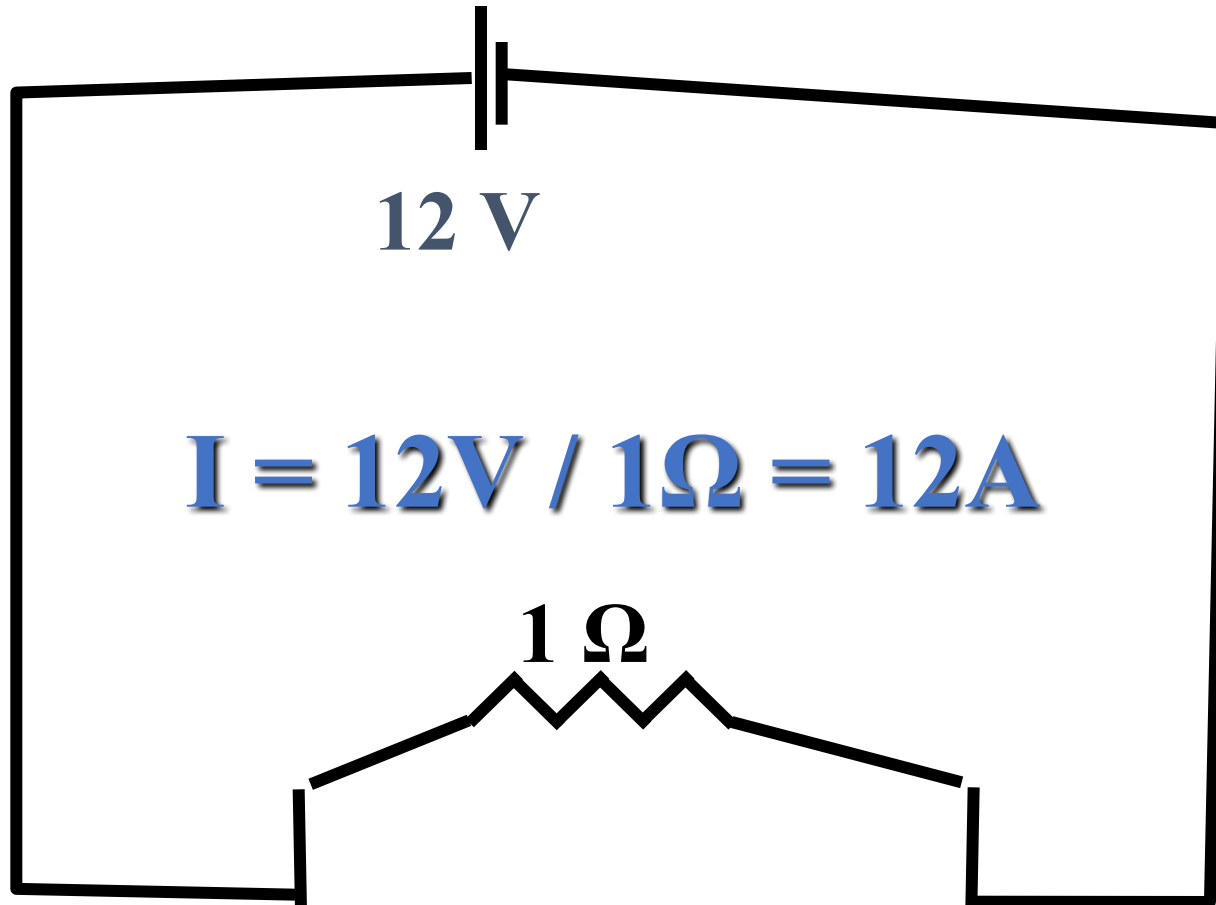
$$1/R_T = 1/R_1 + 1/R_2 + 1/R_3 \dots$$

3. Determine I_T leaving battery by

$$I_T = V_T/R_T$$

4. Since V is constant for each part of a parallel circuit, find I through each resistor using

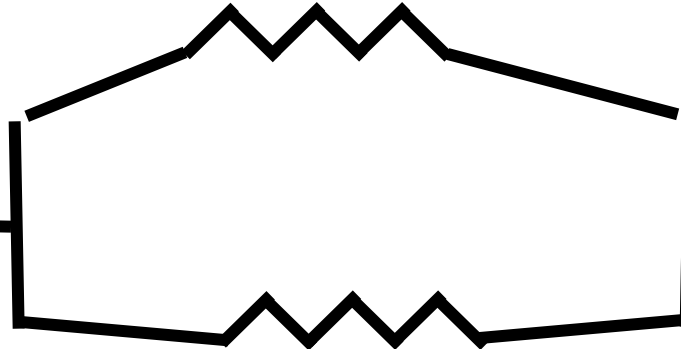
$$I = V/R$$



12 V

$$I = 12V / 1\Omega = 12A$$

1 Ω



2 Ω

$$I = 12V / 2\Omega = 6A$$

Finding V, I & R for a Parallel Circuit

1. Determine E

2. Find the total Resistance

$$1/R_T = 1/R_1 + 1/R_2 + 1/R_3 \dots$$

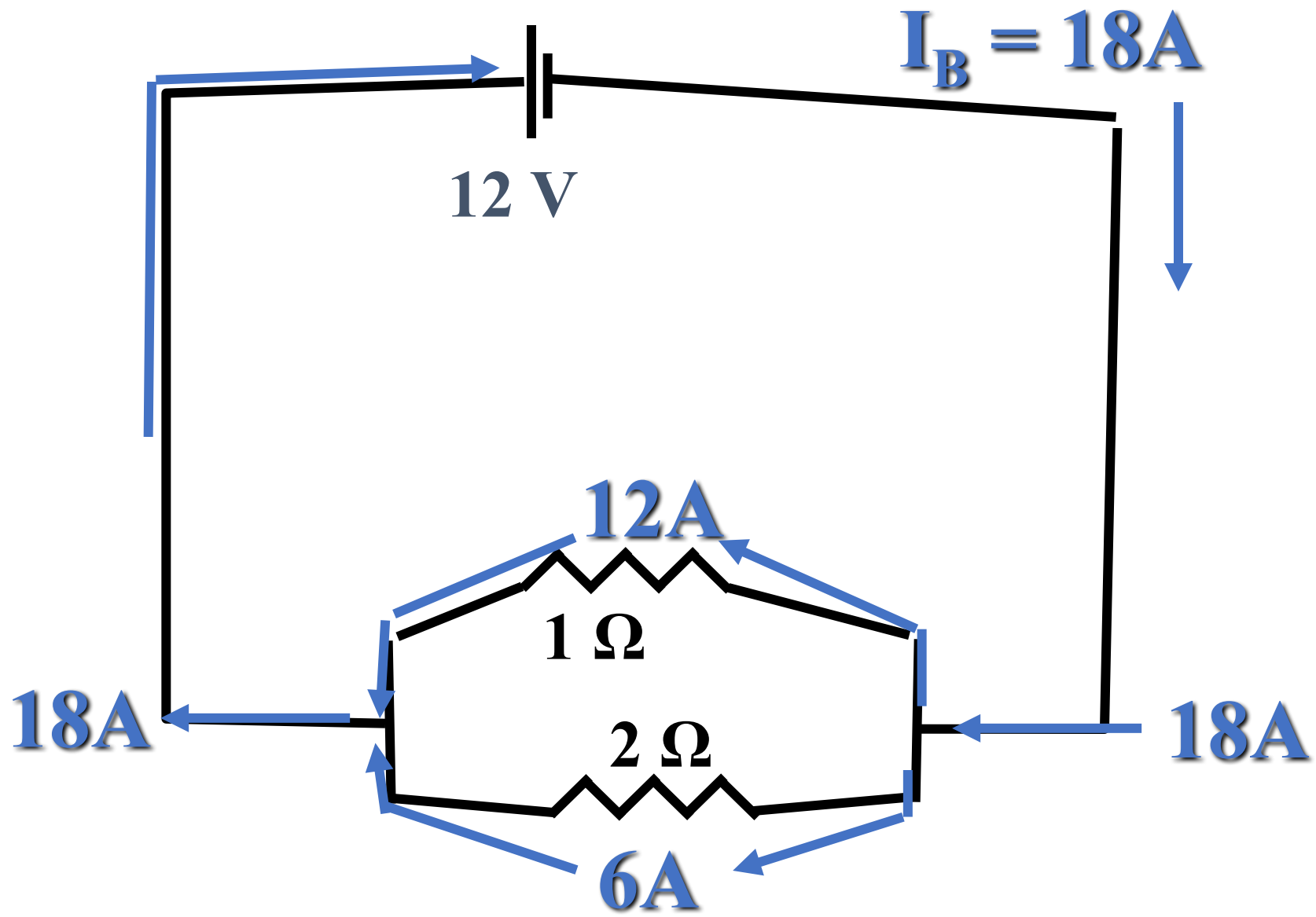
3. Determine I_T leaving battery by

$$I_T = V_T/R_T$$

4. Since V is constant for each part of a parallel circuit, find I through each resistor using

$$I = V/R$$

5. Check to verify that Kirchhoff's Rule is true



Parallel Circuit

Current accumulates

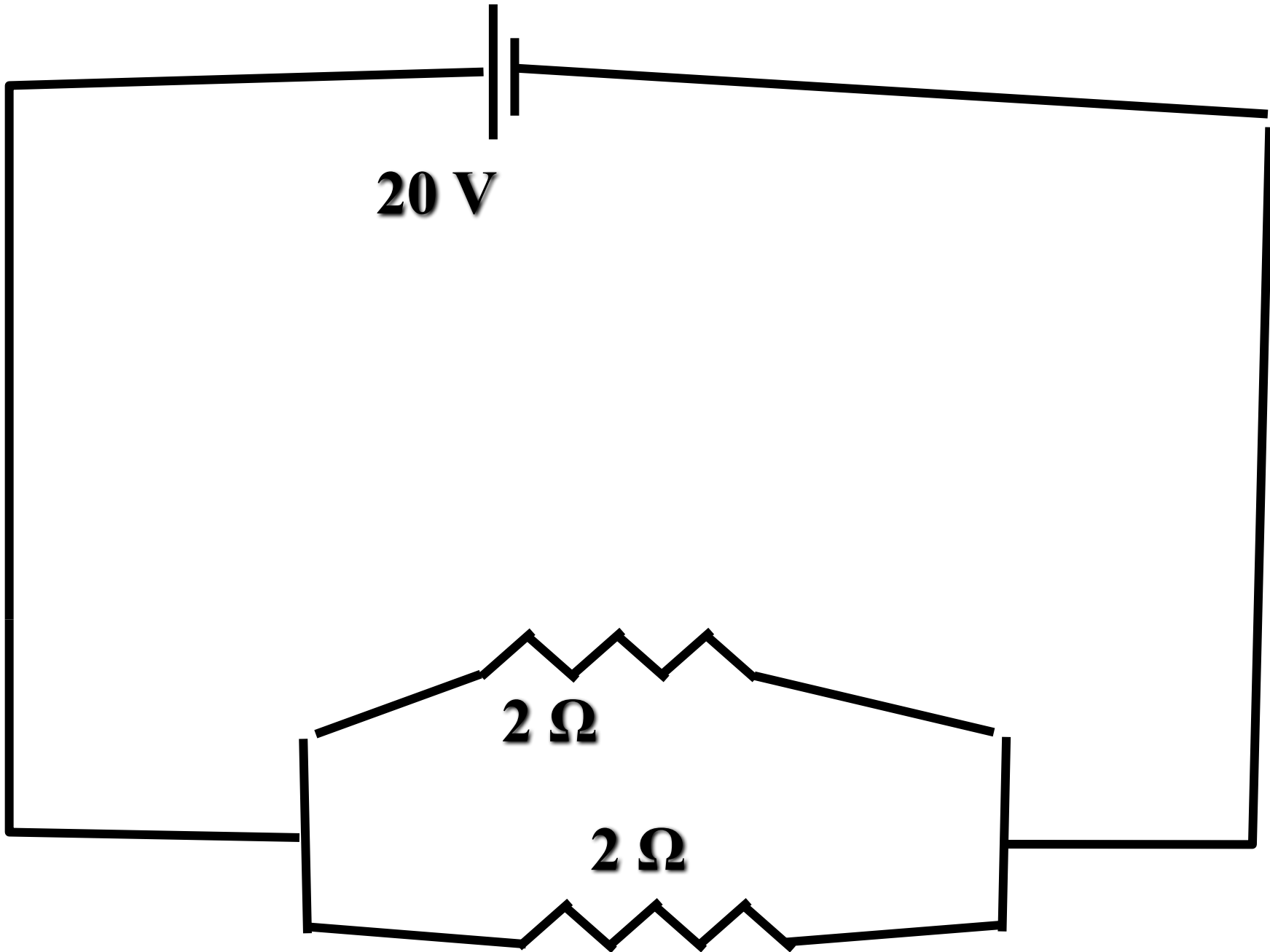
$$I = I_1 + I_2 + I_3$$

Volt is the same at all points

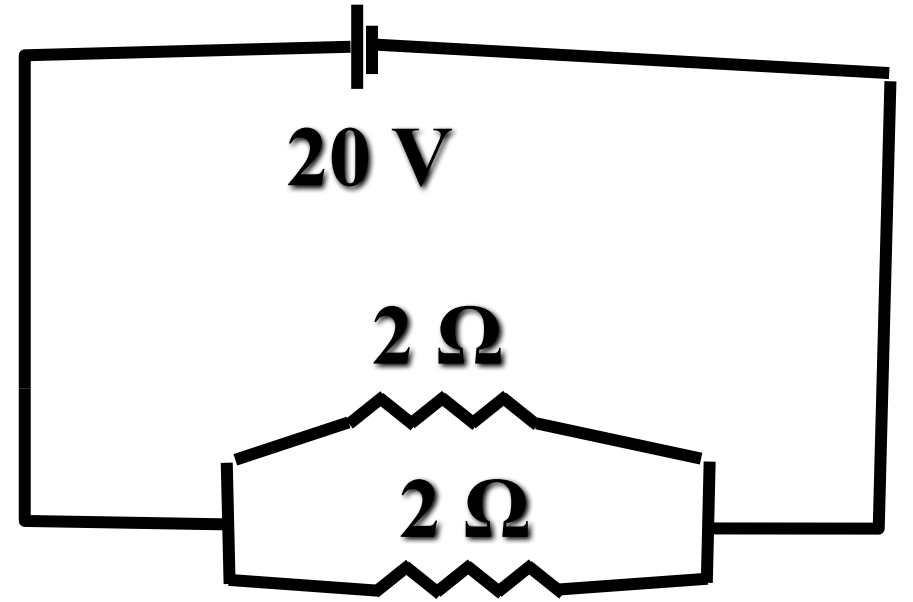
$$\mathcal{E} = V_1 = V_2 = V_3$$

Resistance

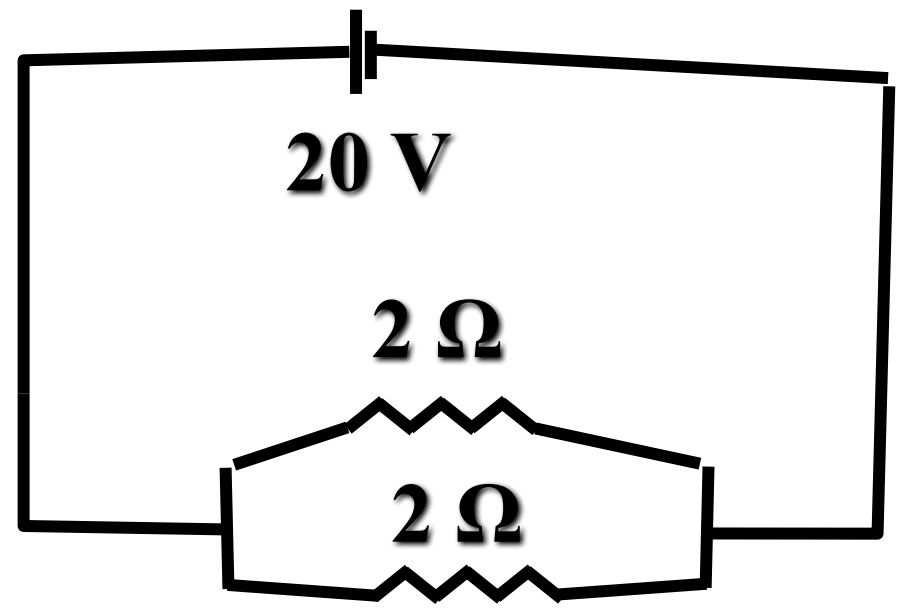
$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$



What is the voltage?



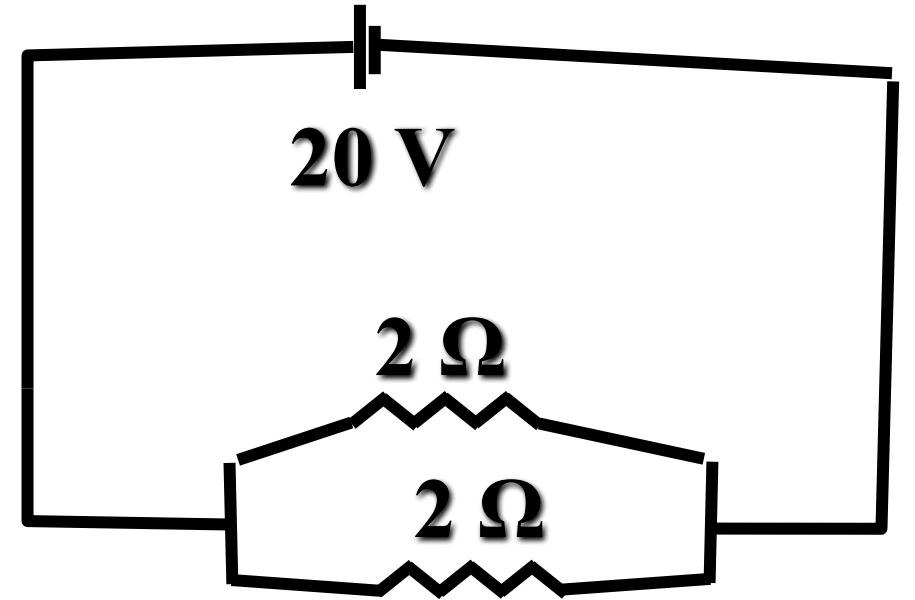
What is the voltage? 20V
What is the total
Resistance?



What is the voltage? 20V

What is the total Resistance? 1.0Ω

What is the total current?

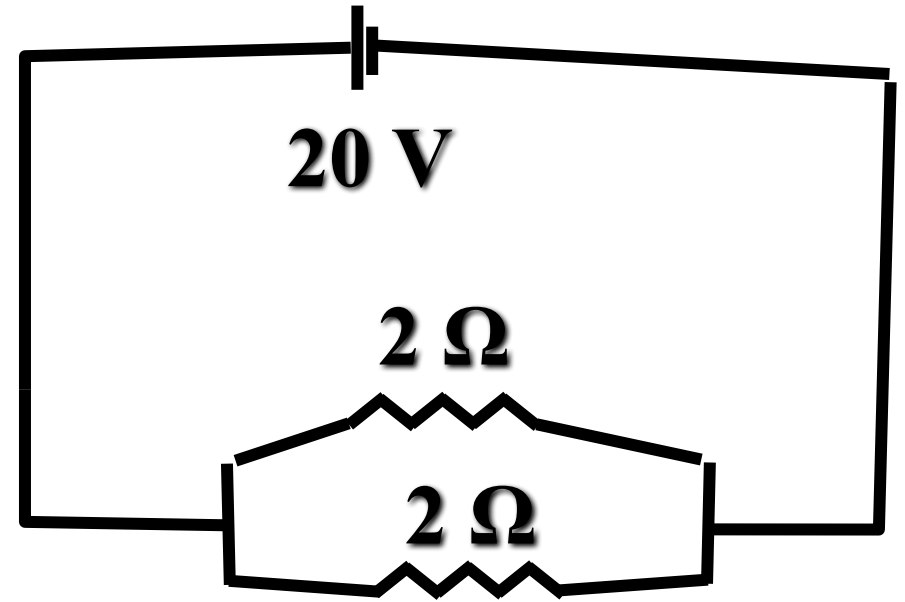


What is the voltage? 20V

What is the total Resistance? 1.0Ω

What is the total current? 20 A

What is the voltage through each resistor?



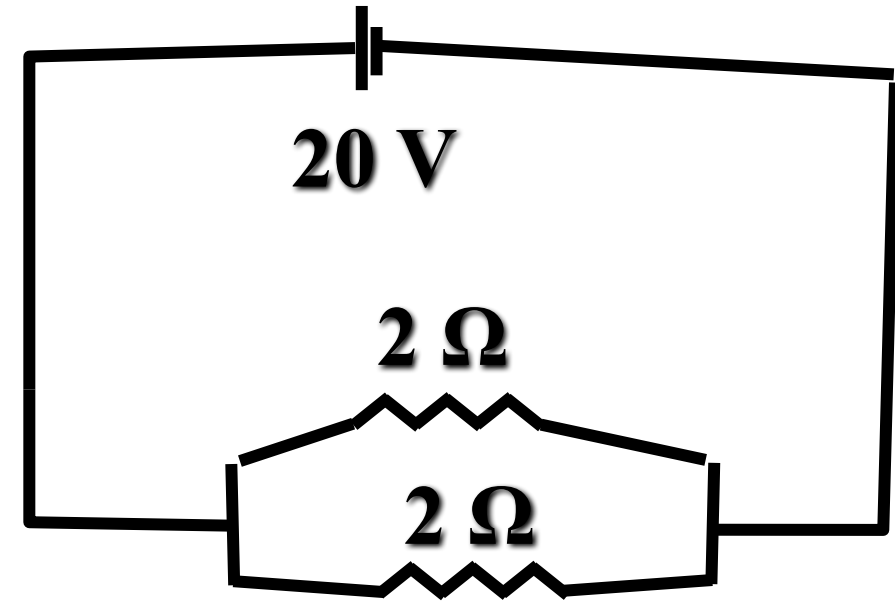
What is the voltage? 20V

What is the total Resistance? 1.0Ω

What is the total current? 20 A

What is the voltage through each resistor? 20V

What is the current through each resistor?



What is the voltage? 20V

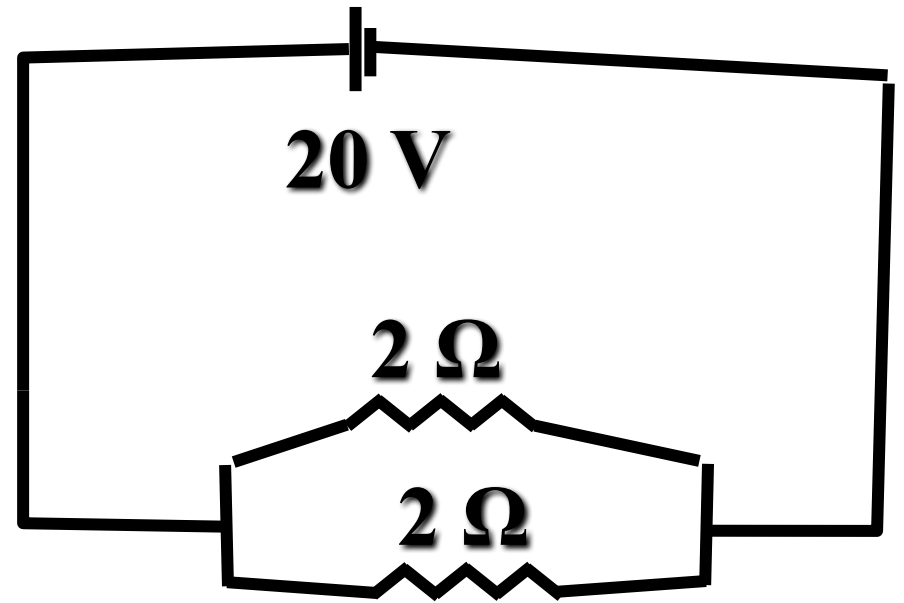
What is the total Resistance? 1.0Ω

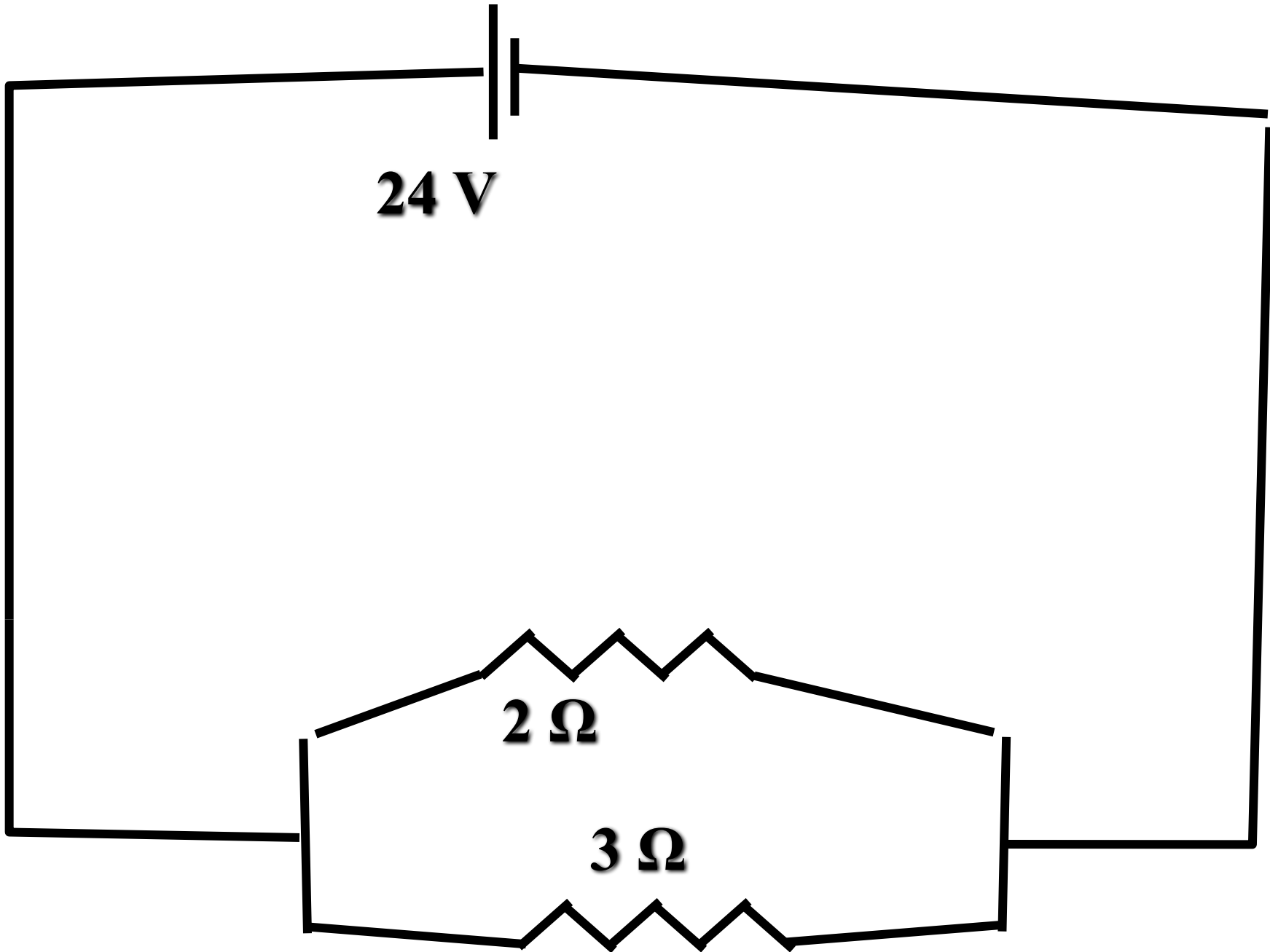
What is the total current? 20 A

What is the voltage through each resistor? 20V

What is the current through each resistor?

10A



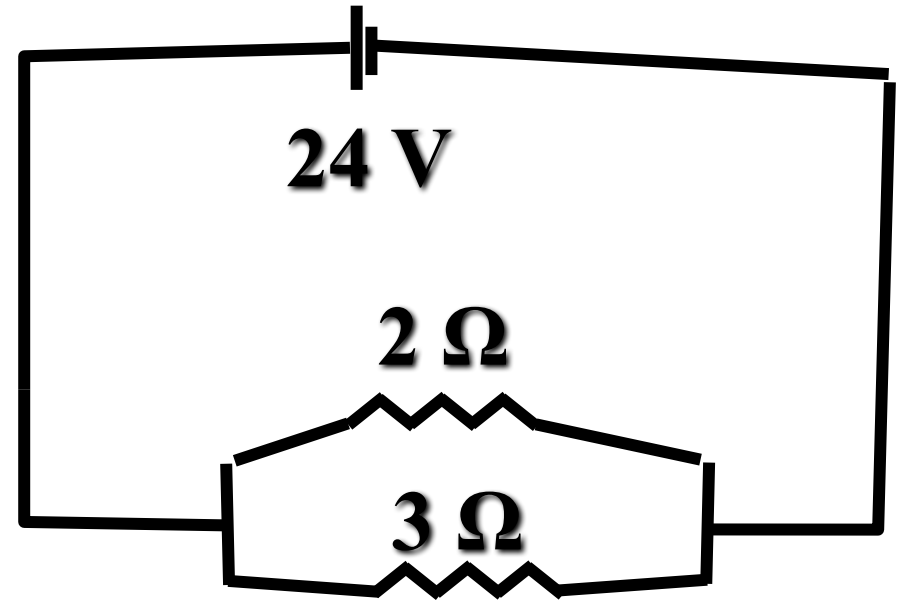


24 V

$2\ \Omega$

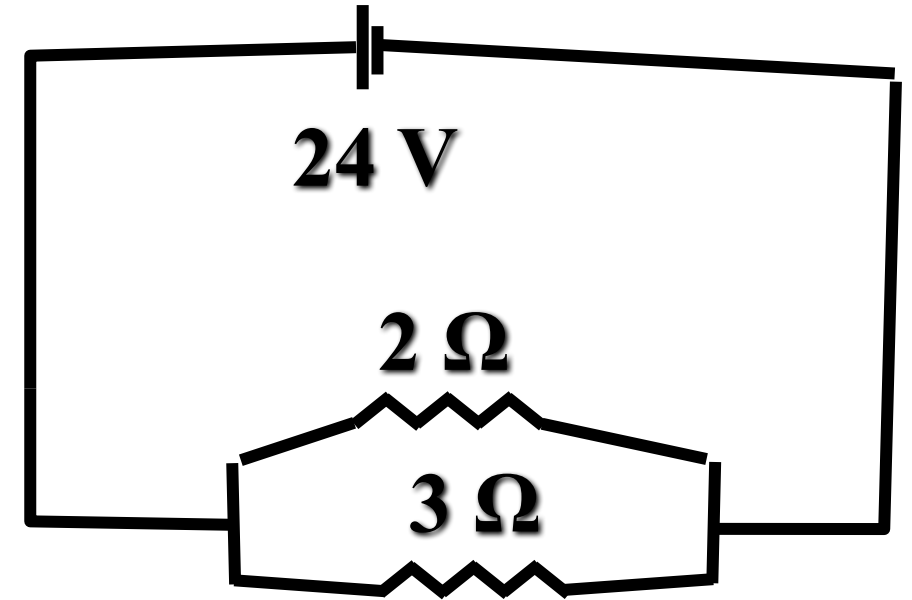
$3\ \Omega$

What is the voltage?



What is the voltage? 24V

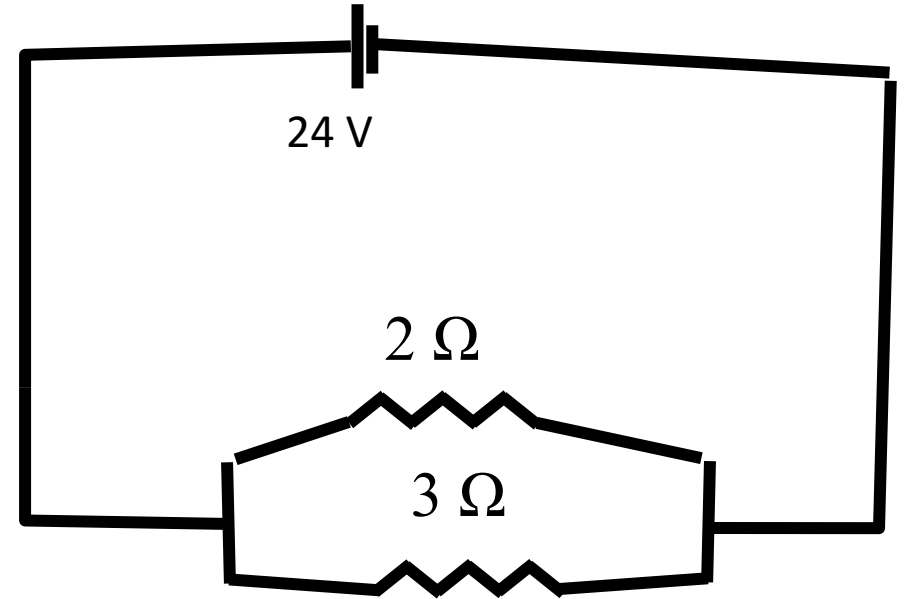
What is the total Resistance?



What is the voltage? 24V

What is the total Resistance? 1.2Ω

What is the total current?

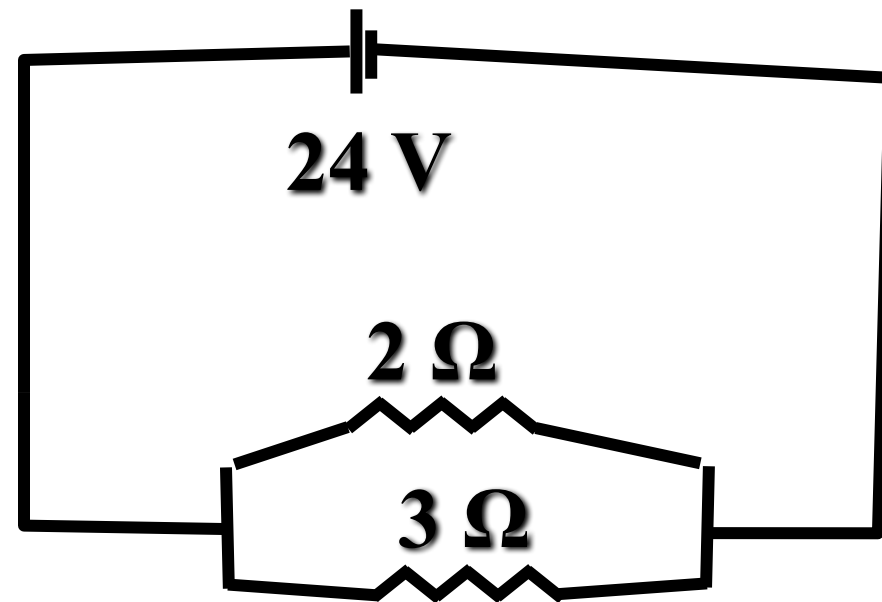


What is the voltage? 24V

What is the total Resistance? 1.2Ω

What is the total current? 20 A

What is the voltage through each resistor?



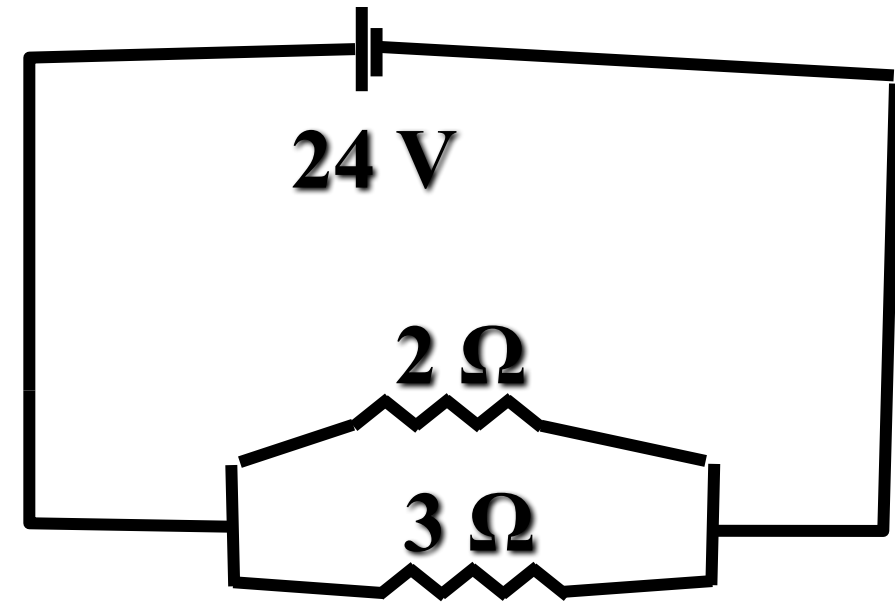
What is the voltage? 24V

What is the total Resistance? 1.0Ω

What is the total current? 20 A

What is the voltage through each resistor? 24V

What is the current through each resistor?



What is the voltage? 24V

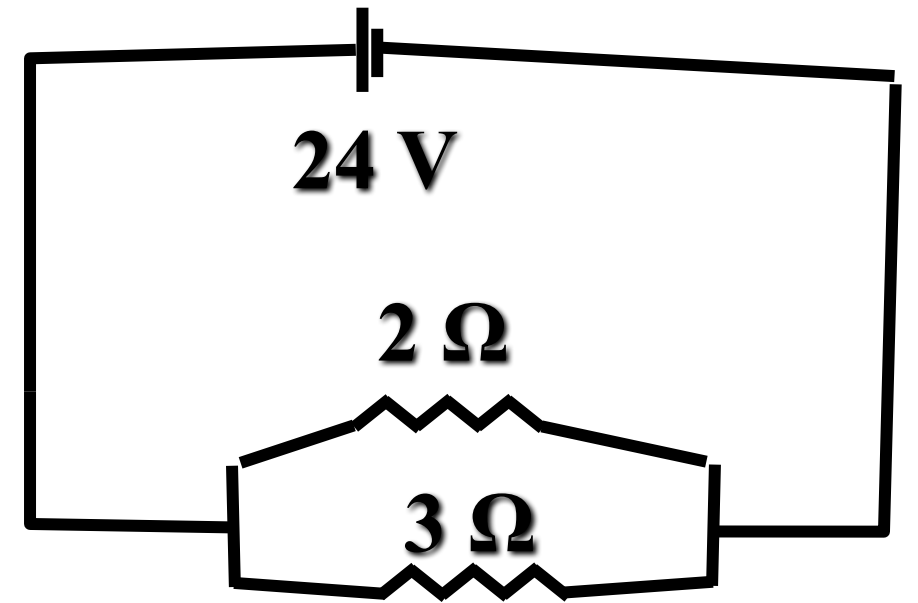
What is the total Resistance? 1.0Ω

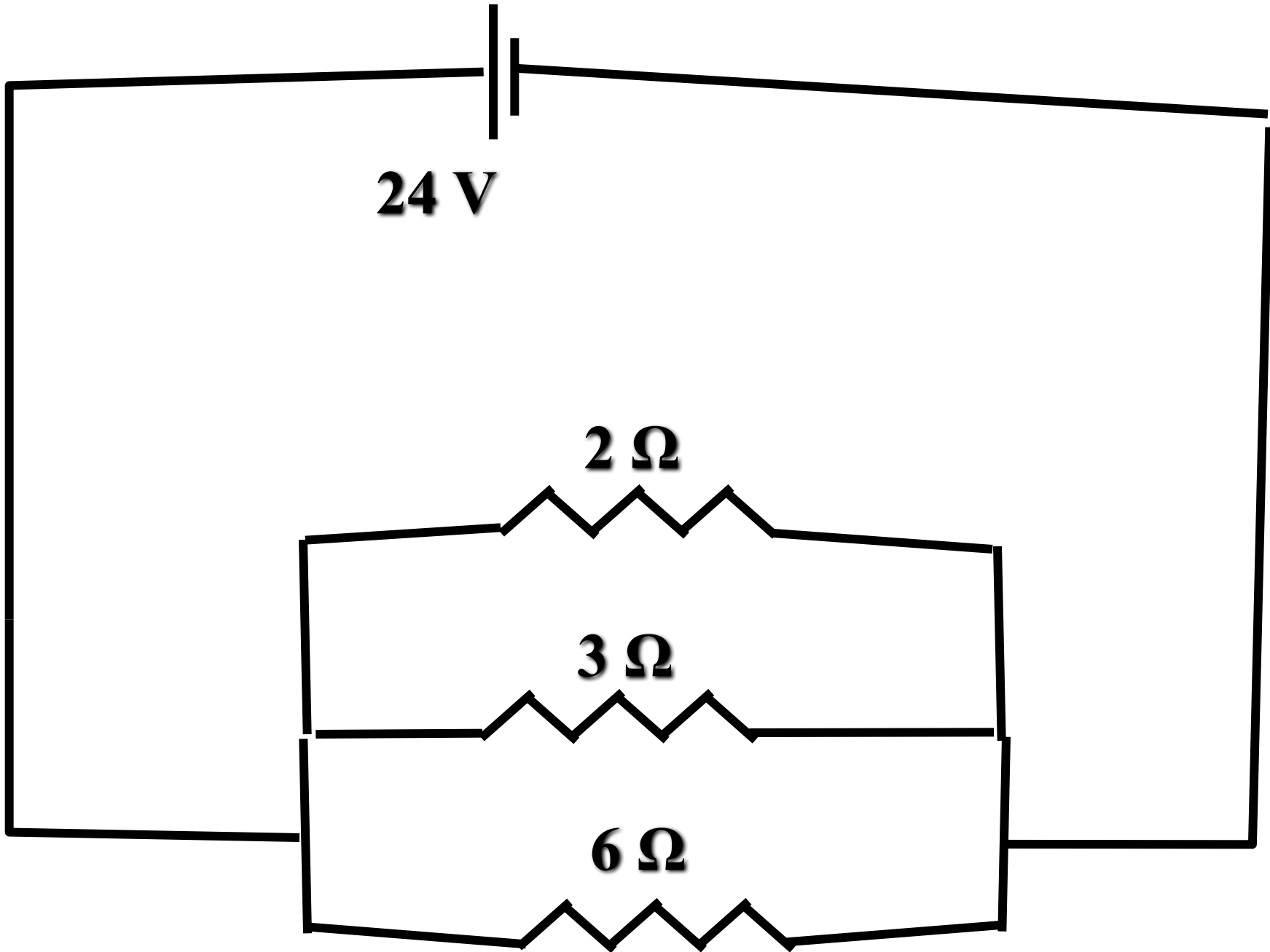
What is the total current? 20 A

What is the voltage through each resistor? 24V

What is the current through each resistor?

$$12A + 8A = 20A$$





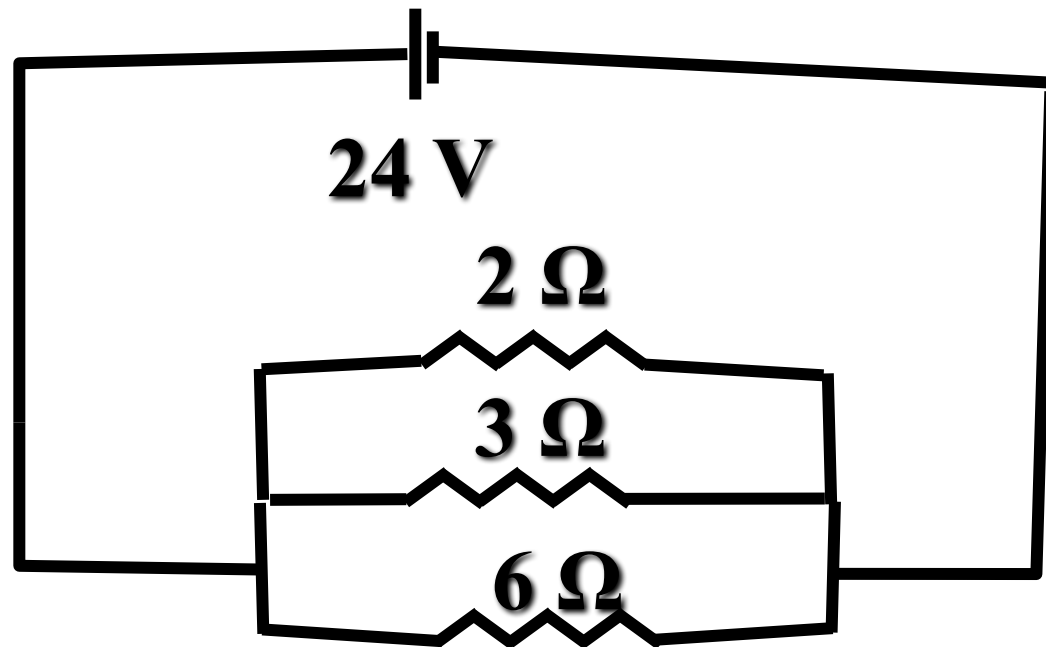
24 V

2 Ω

3 Ω

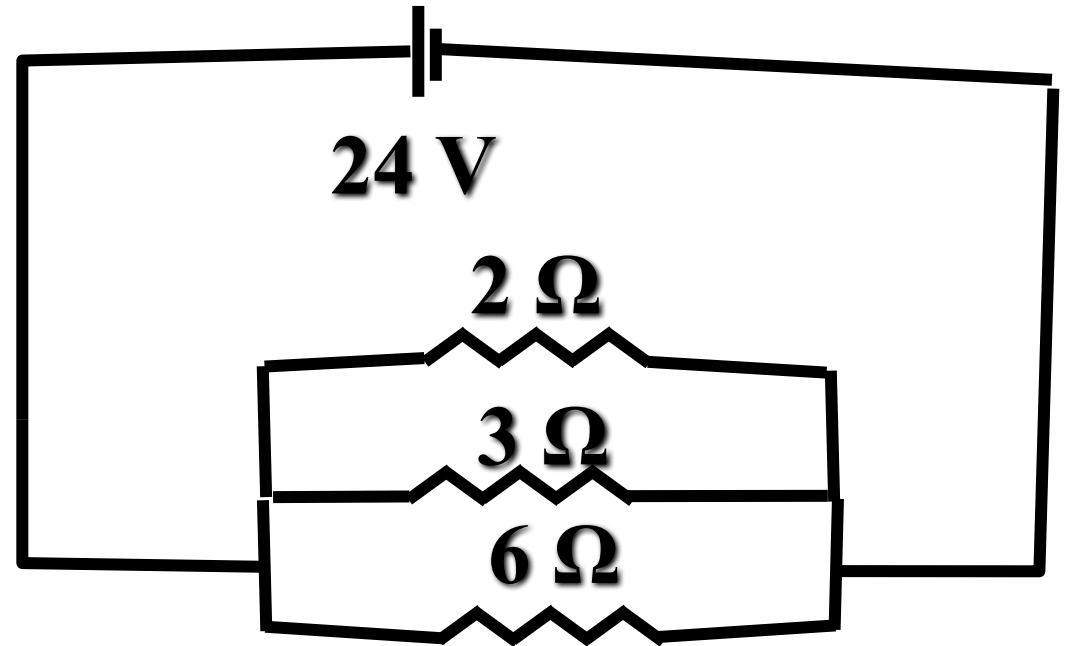
6 Ω

What is the voltage?



What is the voltage? 24V

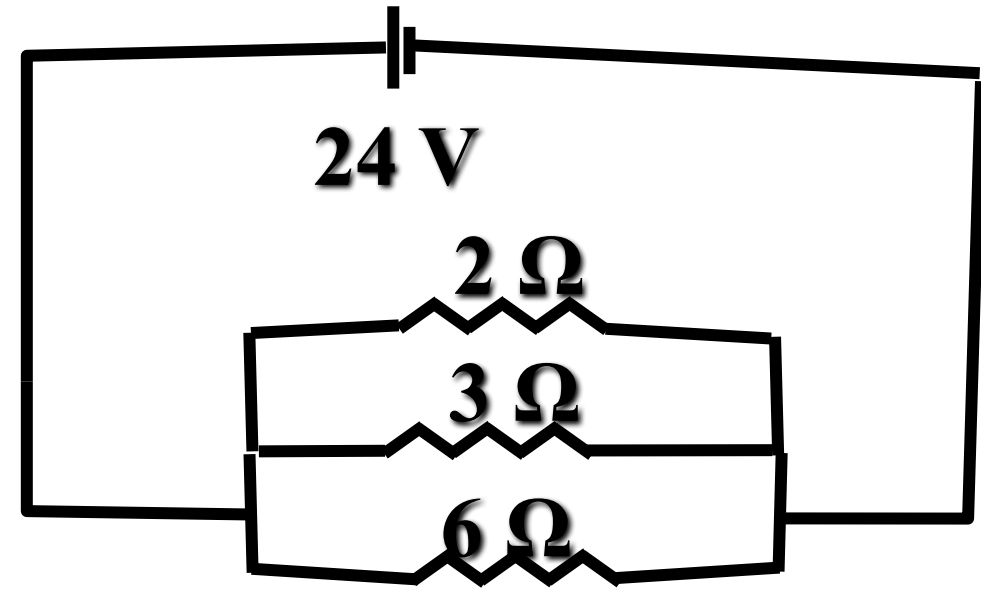
What is the total Resistance?



What is the voltage? 24V

What is the total Resistance? 1.0Ω

What is the total current?

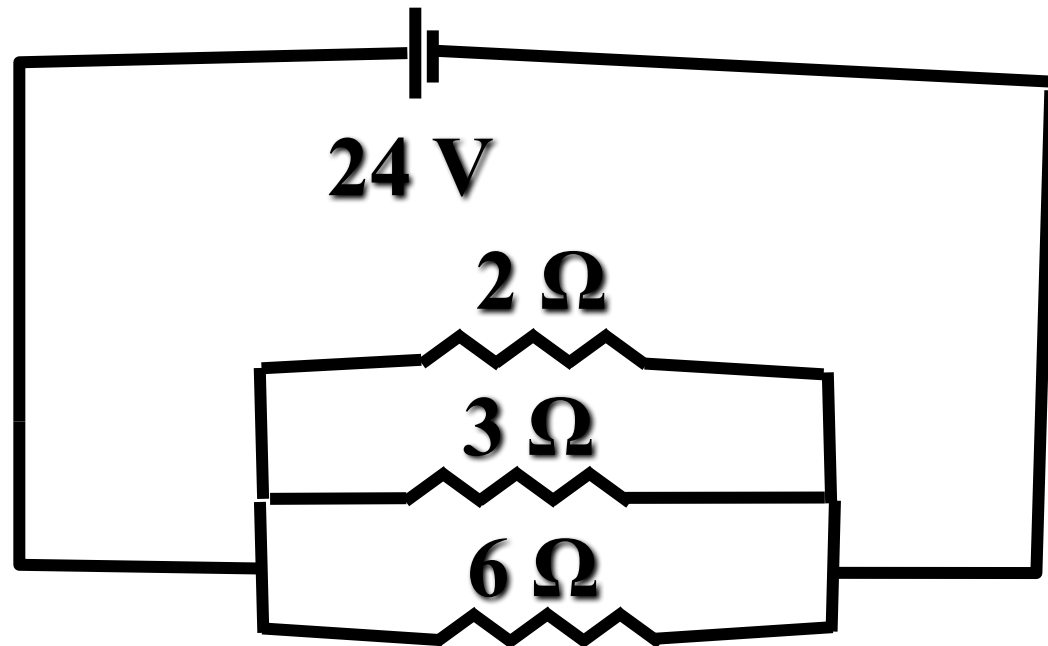


What is the voltage? 24V

What is the total Resistance? 1.0Ω

What is the total current? 24 A

What is the voltage through each resistor?



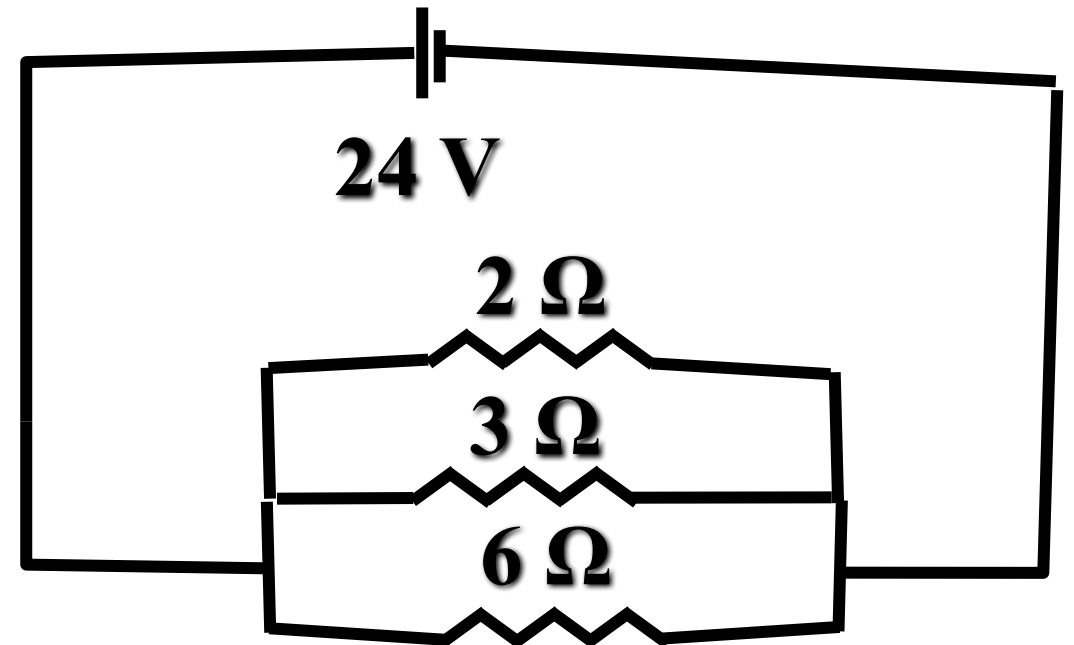
What is the voltage? 24V

What is the total Resistance? 1.0Ω

What is the total current? 24 A

What is the voltage through each resistor? 24V

What is the current through each resistor?



What is the voltage? 24V

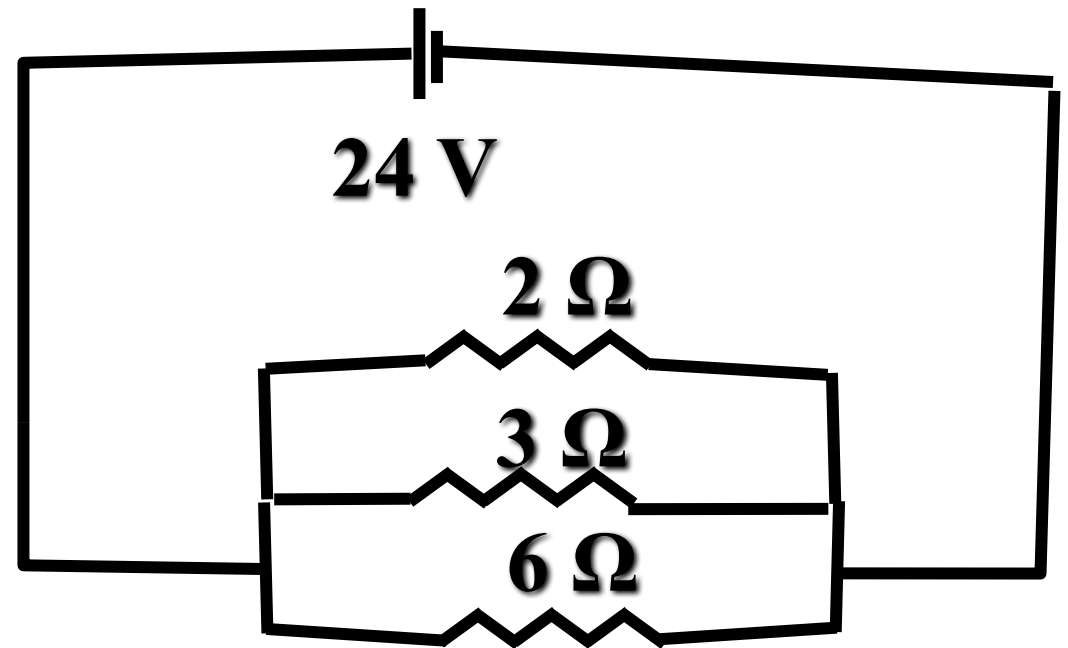
What is the total Resistance? 1.0Ω

What is the total current? 24 A

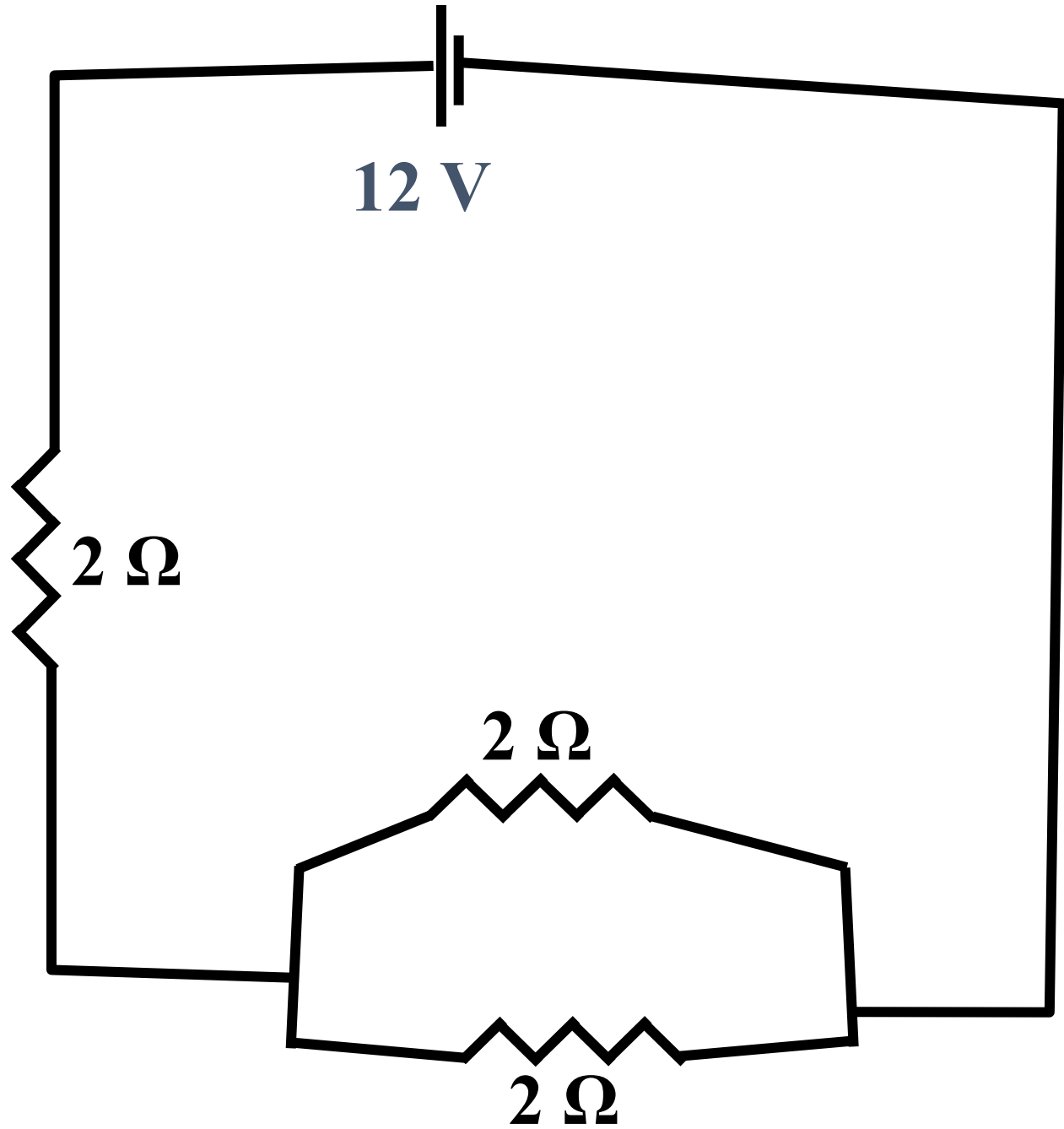
What is the voltage through each resistor? 24V

What is the current through each resistor?

$$4A + 8A + 12A = 24A$$



Complex Circuits

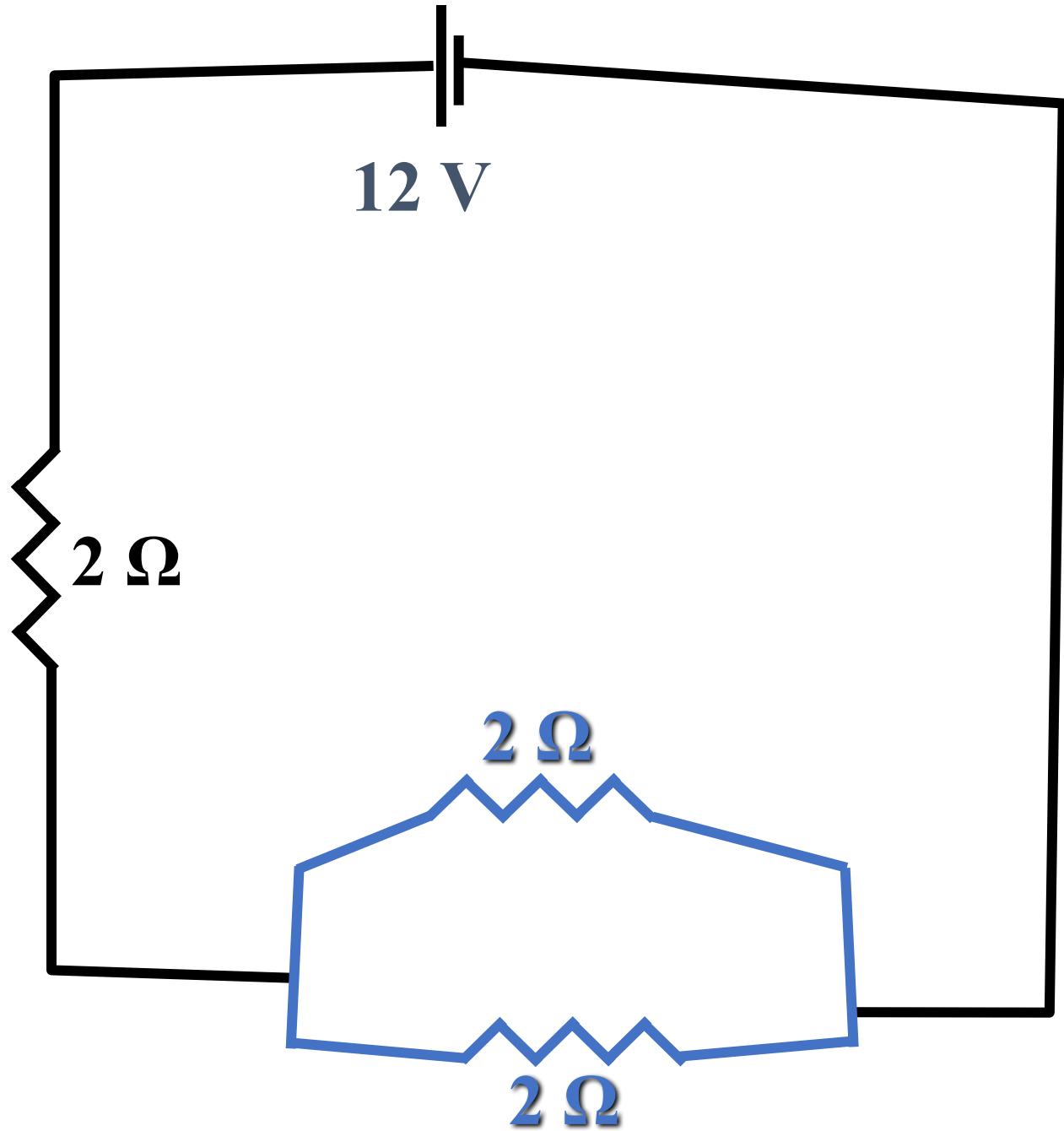


Finding V, I & R for a Complex Circuit

1. Find the most complex portion of the Circuit – usually part of the Parallel
2. Find the Total Resistance for that portion
3. Continue until the Total Resistance for the Circuit is known
4. Starting with the least complex resistor, find the voltage it uses
5. Continue until the parallel portion where the remaining voltage will be used on both sides will be identical, Find I
6. Make sure Kirchhoff's Rule is followed

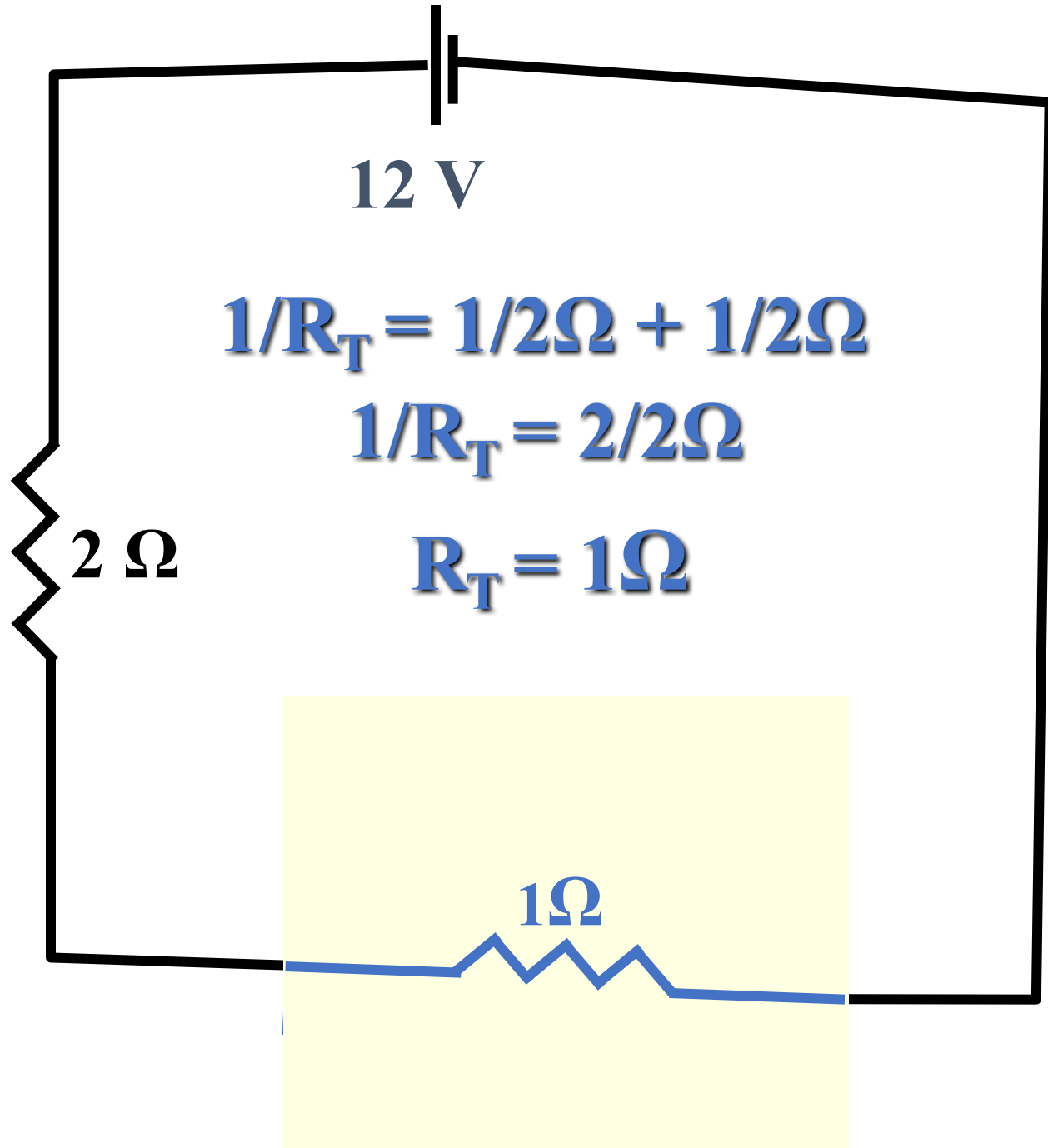
Finding V, I & R for a Complex Circuit

1. Find the most complex portion of the Circuit – usually part of the Parallel



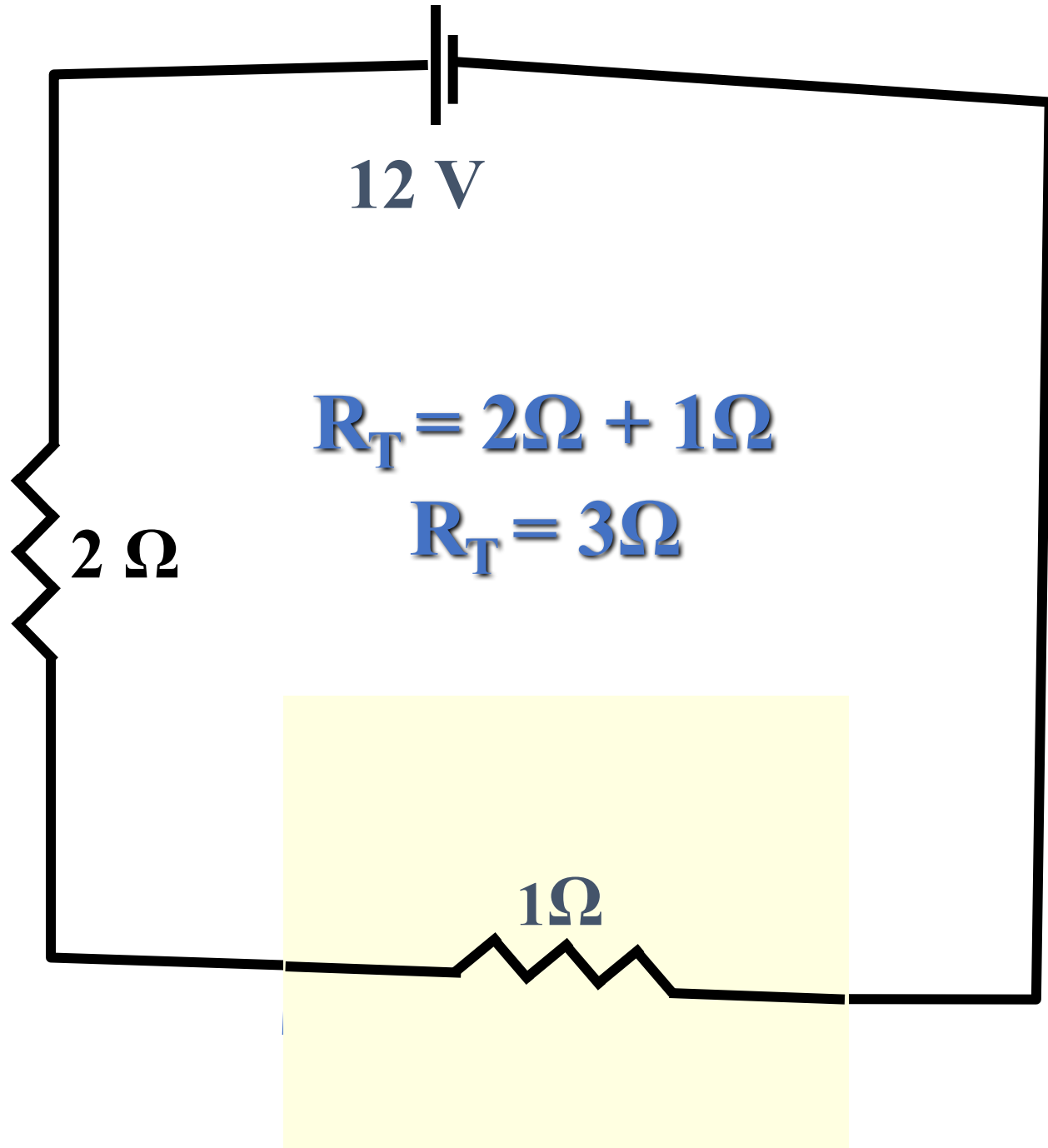
Finding V, I & R for a Complex Circuit

1. Find the most complex portion of the Circuit – usually part of the Parallel
2. Find the Total Resistance for that portion



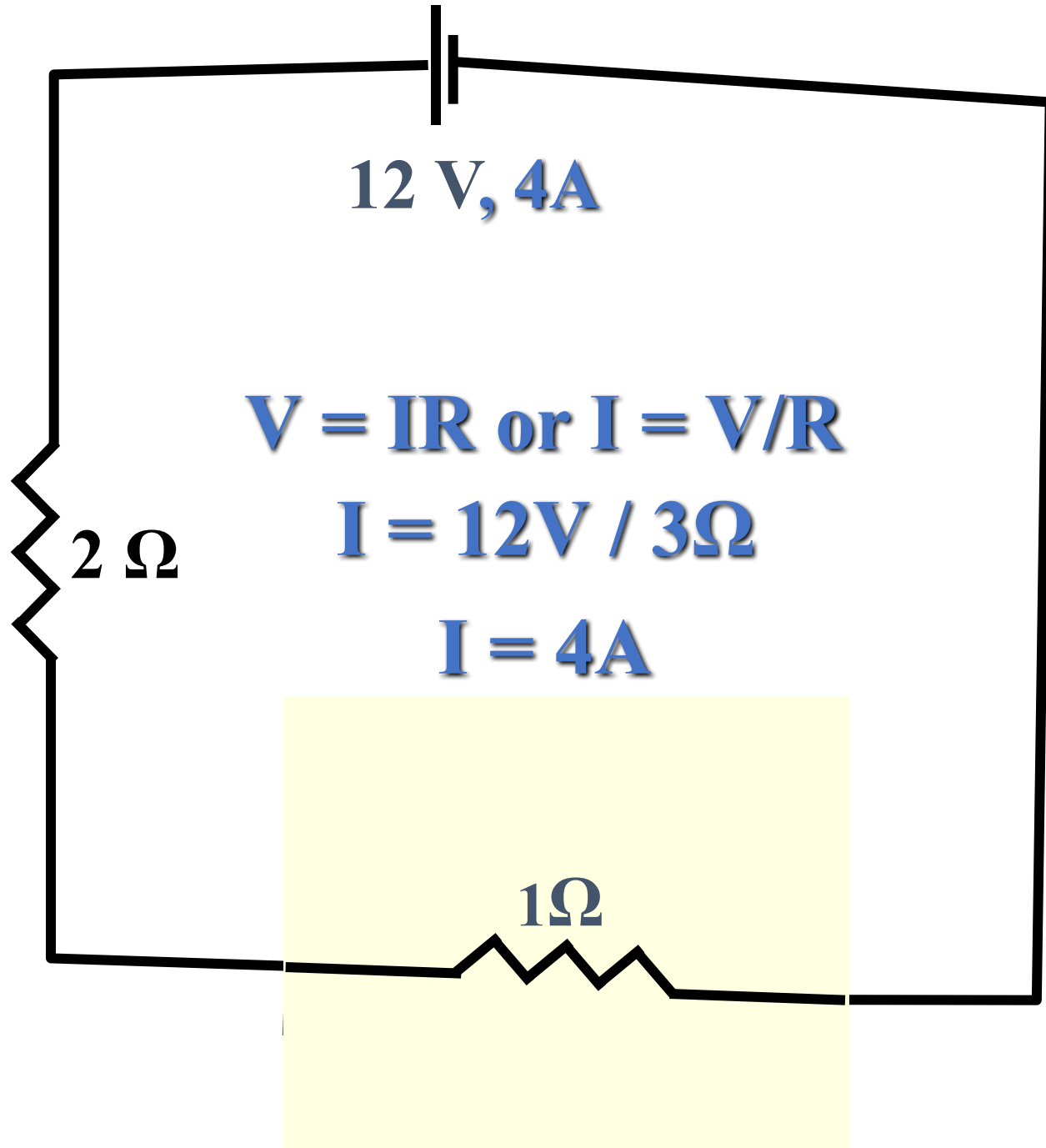
Finding V, I & R for a Complex Circuit

1. Find the most complex portion of the Circuit – usually part of the Parallel
2. Find the Total Resistance for that portion
3. Continue until the Total Resistance for the Circuit is known



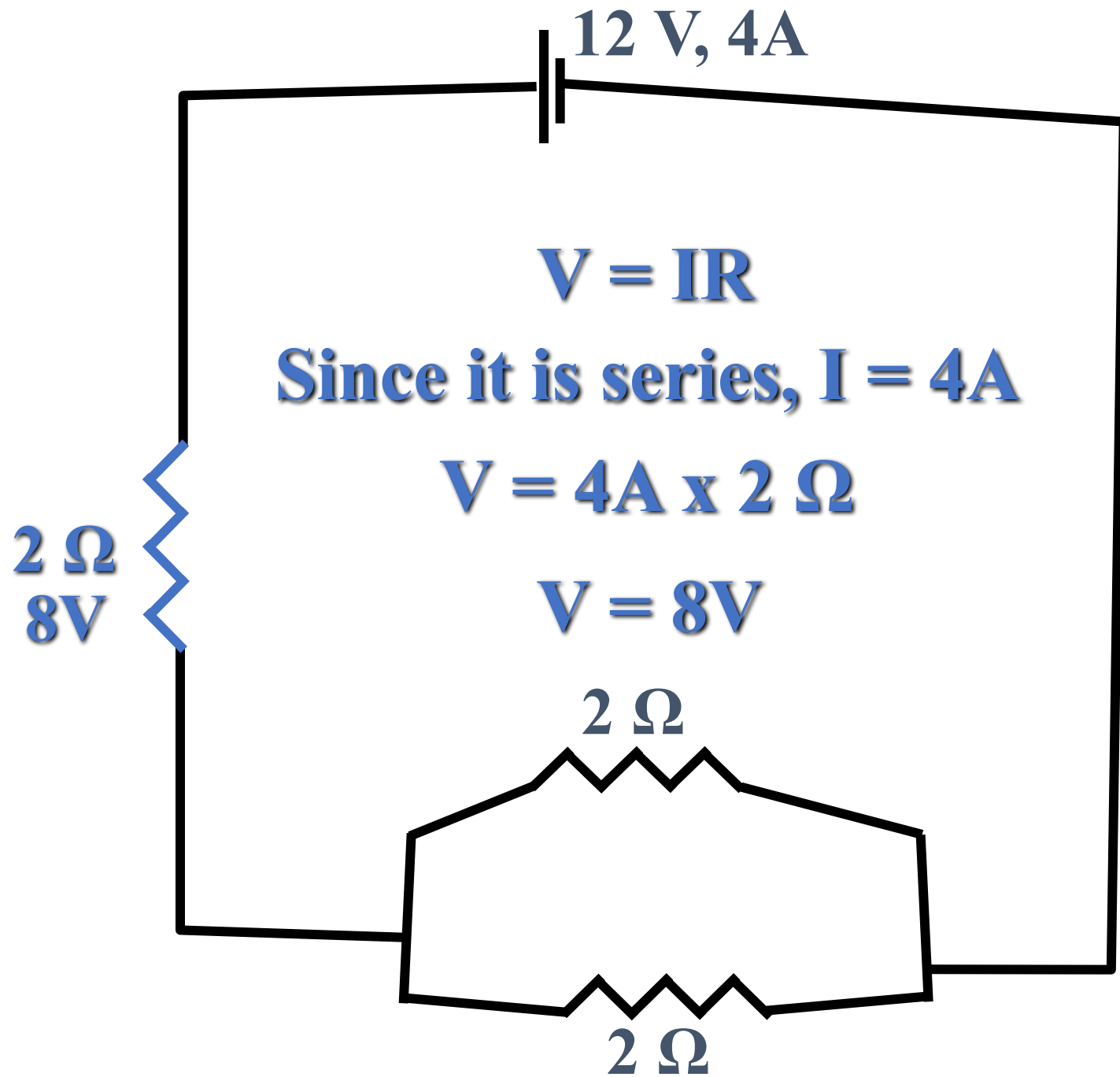
Finding V , I & R for a Complex Circuit

1. Find the most complex portion of the Circuit – usually part of the Parallel
2. Find the Total Resistance for that portion
3. Continue until the Total Resistance for the Circuit is known
4. Find the Current that leaves the battery



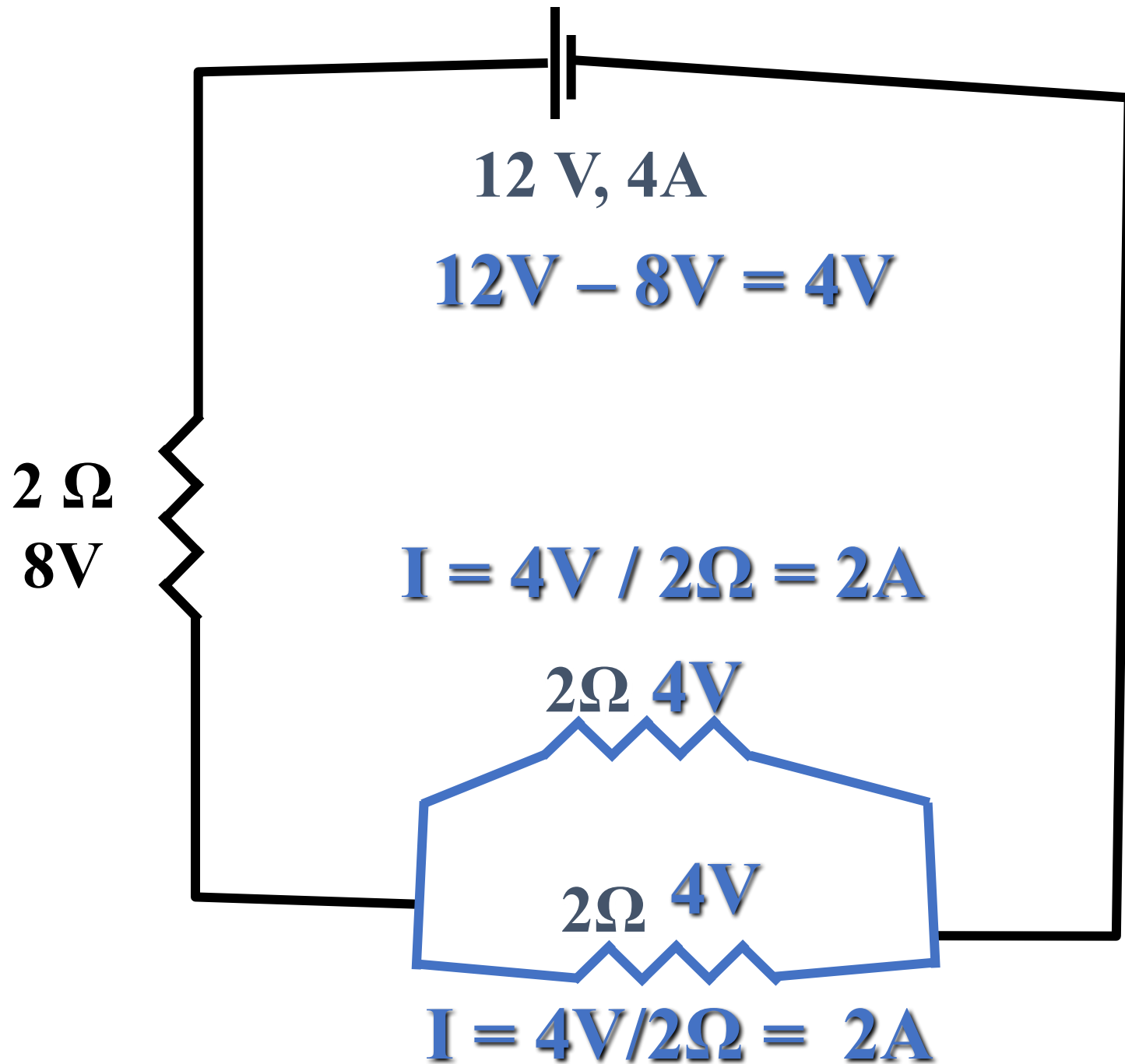
Finding V, I & R for a Complex Circuit

1. Find the most complex portion of the Circuit – usually part of the Parallel
2. Find the Total Resistance for that portion
3. Continue until the Total Resistance for the Circuit is known
4. Starting with the least complex resistor, find the voltage it uses



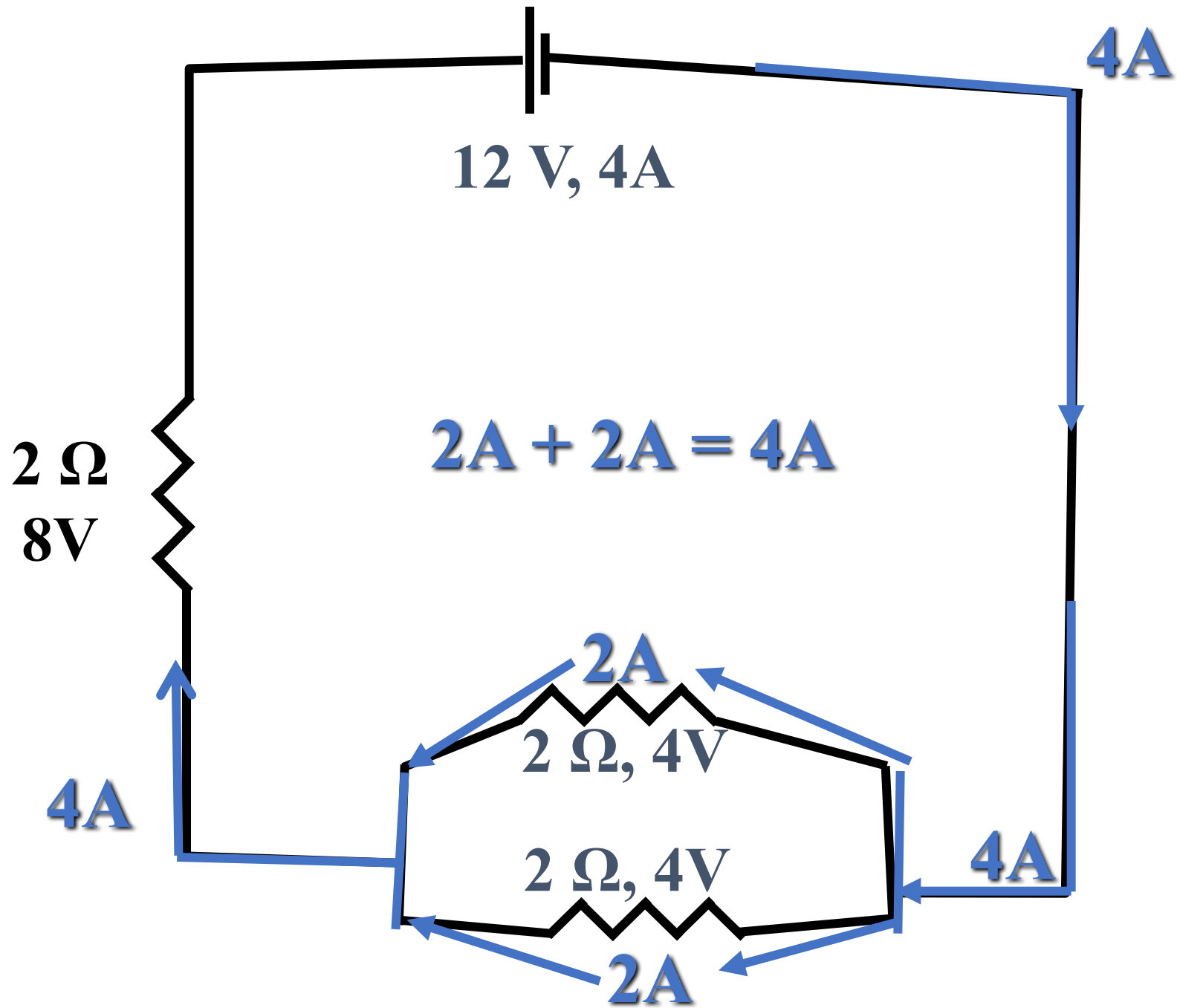
Finding V, I & R for a Complex Circuit

1. Find the most complex portion of the Circuit – usually part of the Parallel
2. Find the Total Resistance for that portion
3. Continue until the Total Resistance for the Circuit is known
4. Starting with the least complex resistor, find the voltage it uses
5. Continue until the parallel portion where the remaining voltage used on both sides will be identical, Find I

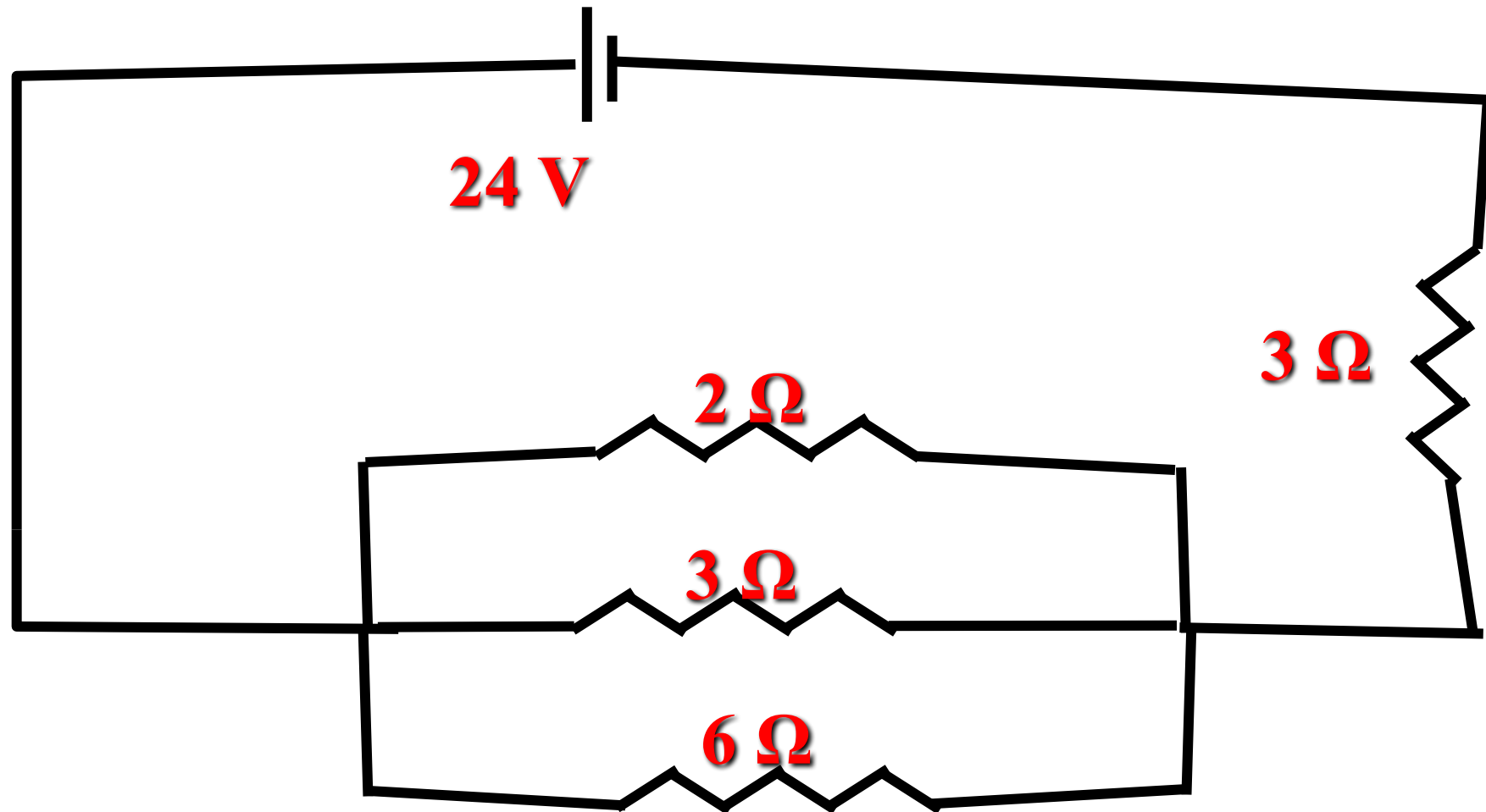


Finding V , I & R for a Complex Circuit

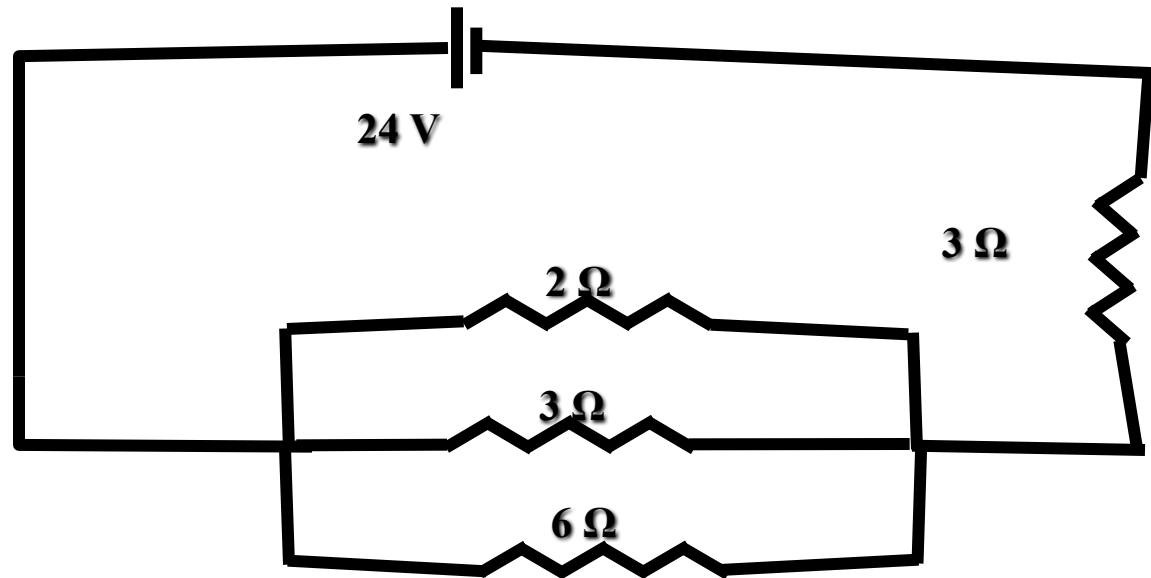
1. Find the most complex portion of the Circuit – usually part of the Parallel
2. Find the Total Resistance for that portion
3. Continue until the Total Resistance for the Circuit is known
4. Starting with the least complex resistor, find the voltage it uses
5. Continue until the parallel portion where the remaining voltage will be used on both sides will be identical, Find I
6. Make sure Kirchhoff's Rule is followed



Try this!

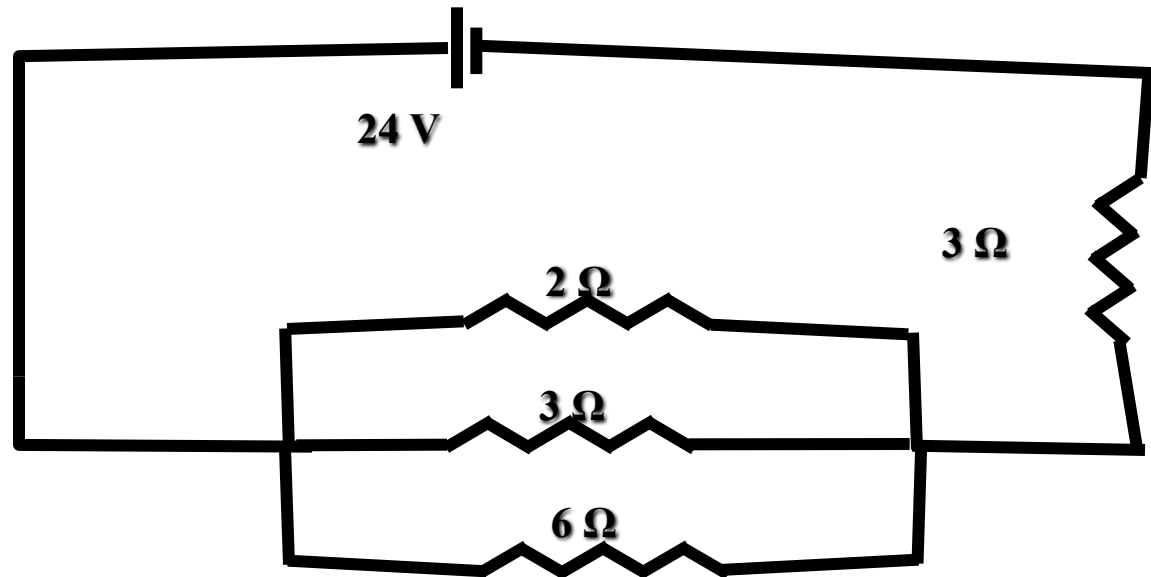


What is the voltage?



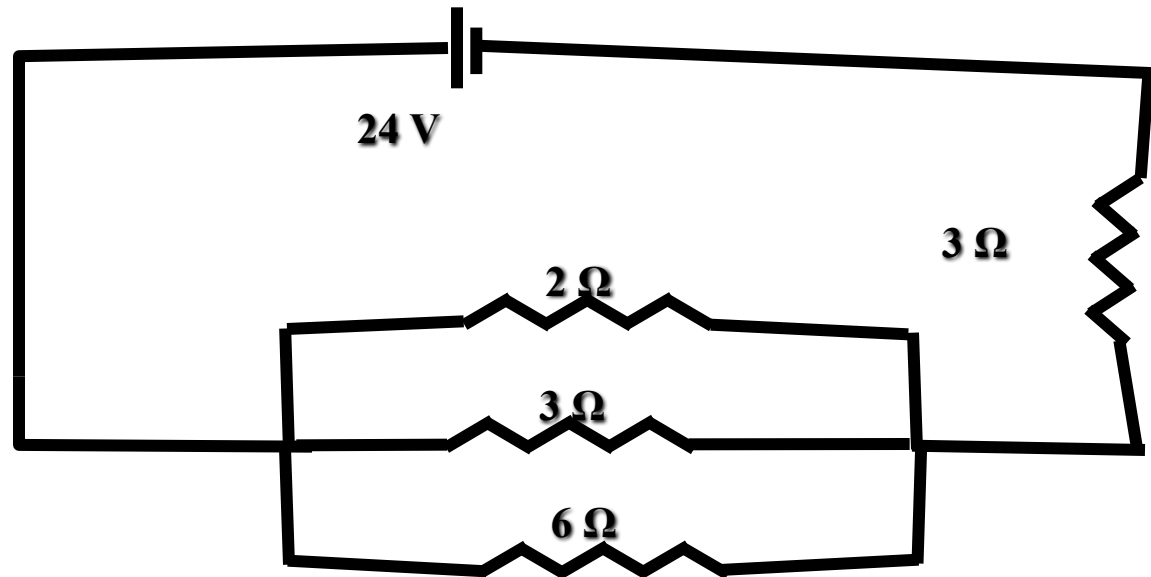
What is the voltage? 24V

What is the total Resistance?



What is the voltage? 24V

What is the total Resistance? 4.0Ω What is the total current?

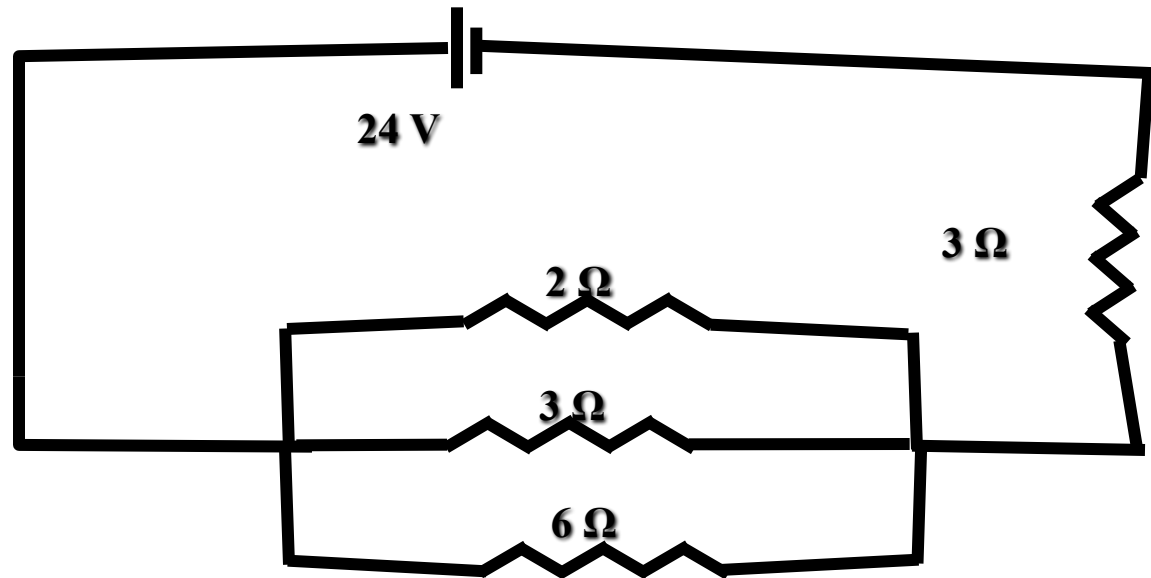


What is the voltage? 24V

What is the total Resistance? 4.0Ω

What is the total current? 6.0 A

What is the voltage through each resistor?



What is the voltage? 24V

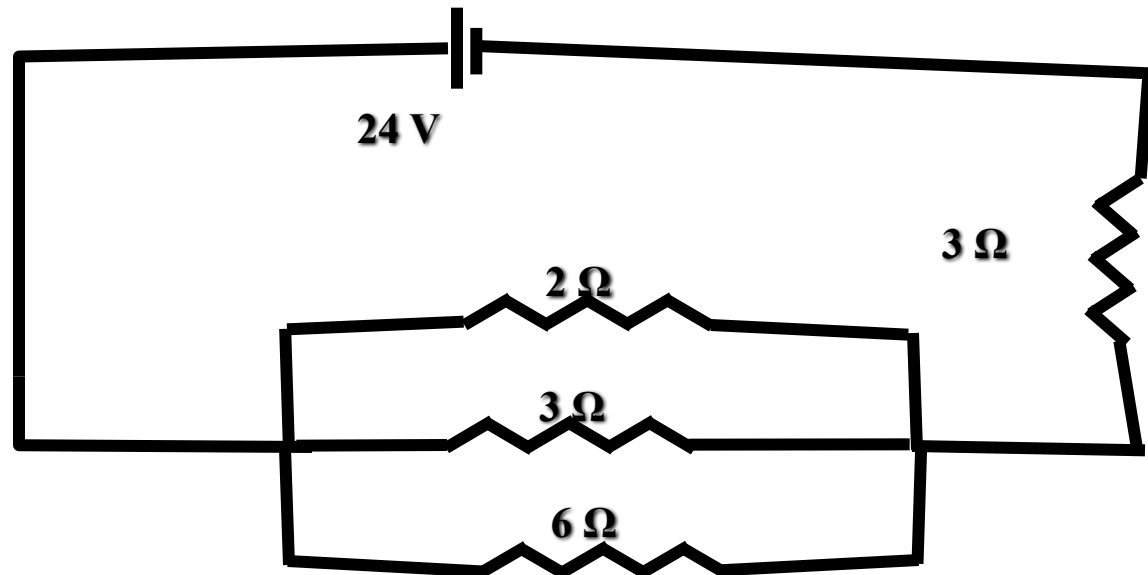
What is the total Resistance? 4.0Ω

What is the total current? 6 A

What is the voltage through each resistor?

3Ω : 18V and 6V

What is the current through each resistor?



What is the voltage? 24V

What is the total Resistance? 4.0Ω

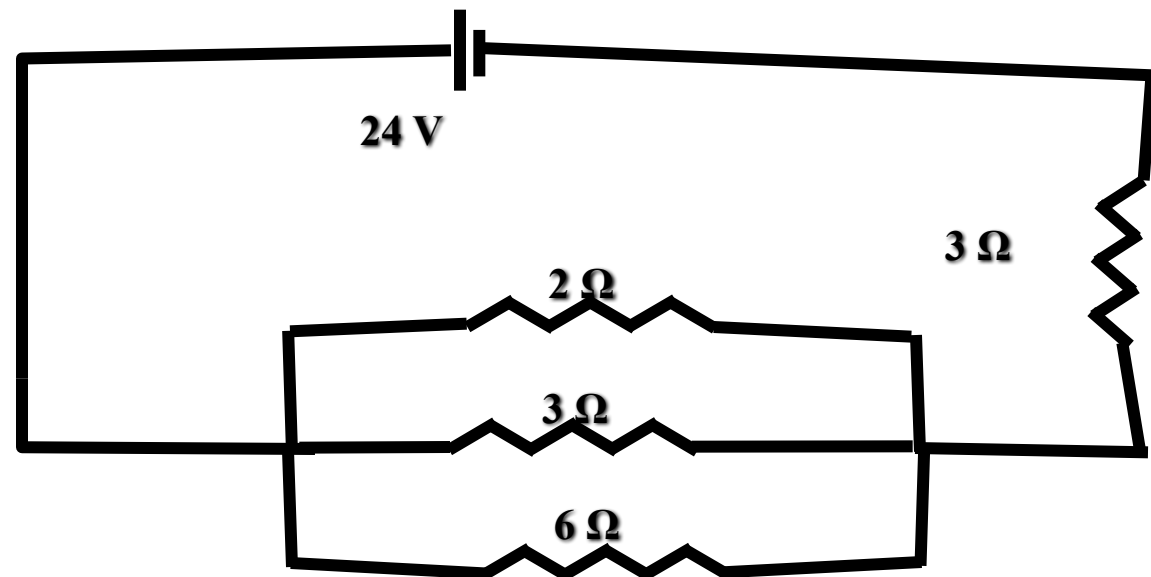
What is the total current? 6 A

What is the voltage through each resistor?

3Ω : 18V and 6V

What is the current through each resistor?

3Ω : 6A 2Ω : 3A 3Ω : 2A 6Ω : 1A



Concept Test

For resistors in series, what is the same for every resistor? R , V or I ?

Answer: I

For resistors in parallel, what is the same for every resistor? R , V or I ?

Answer: V

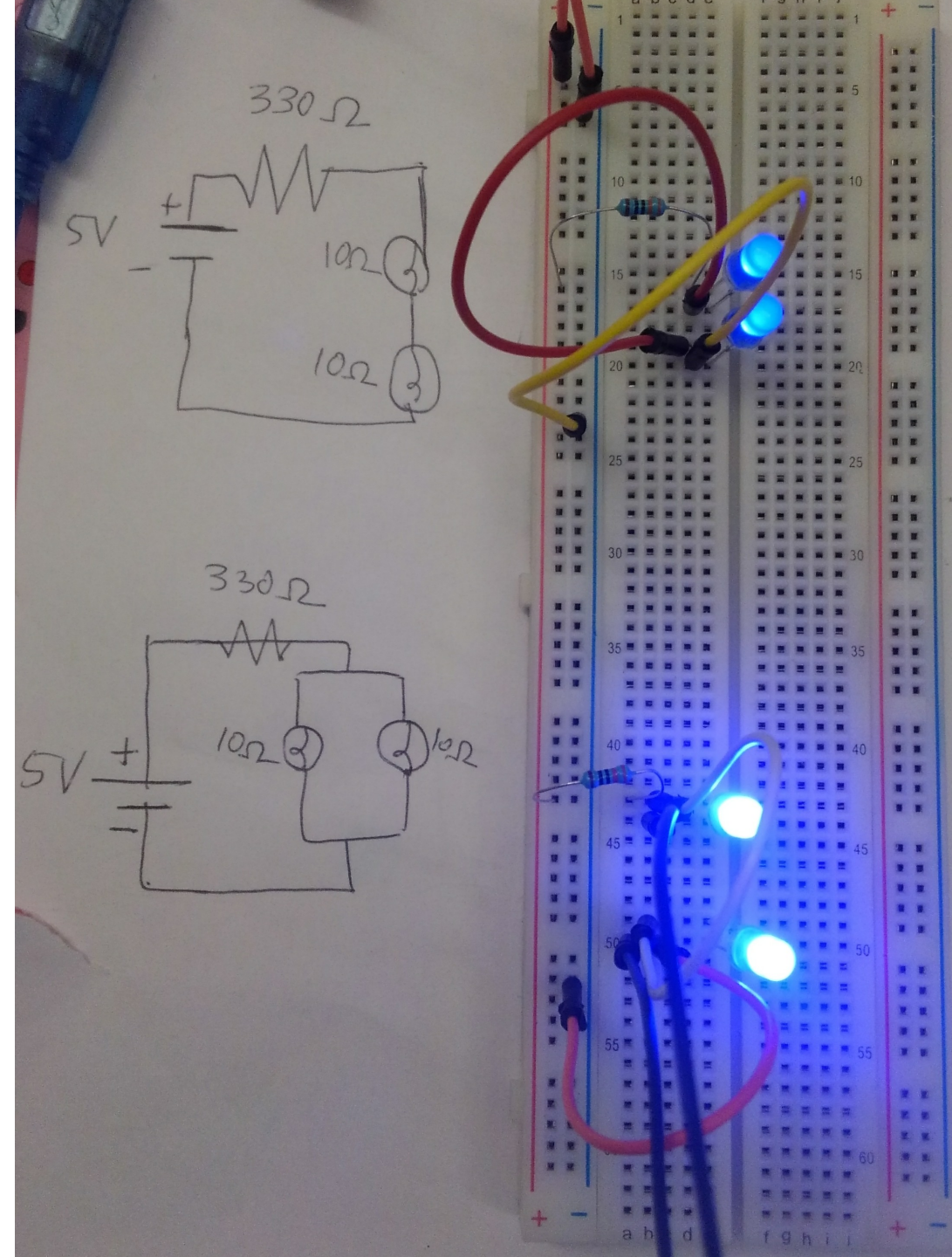
Compare the current flowing out of the battery in the series vs. combination circuit.

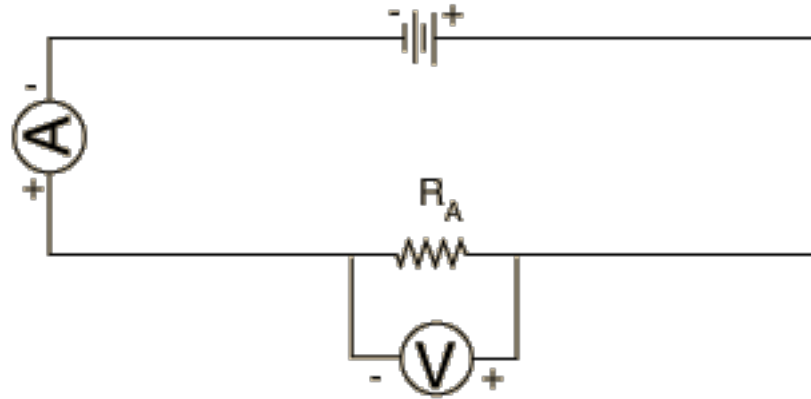
$$I_{\text{series}} = 0.014 \text{ Amps}$$

$$I_{\text{combo}} = 0.015 \text{ Amps}$$

Why is the parallel brighter?

If you remove one light, why does the other turn off in series, but remains lit in parallel?





Voltmeters (V) must be connected in parallel and have a very large resistance so they minimize how much current they take from the resistor

Ammeters (A) must be connected in series and have minimal resistance so they don't impede the flow of current through a circuit