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
Know how to use the Kirchhoff's Loop and Junction rules to analyze 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
Understand the logic of the Foutan board: be able to figure out how closing certain switches affects how bulbs are placed in series/parallel
Don't need to know how to jump a car battery, but the knowledge can't hurt you ☺

Equation sheet you'll be given

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

$$V = IR$$

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

$$P = \frac{E}{t} = IV = IV = I^2 R = \frac{V^2}{R}$$

$$Q = CV$$

$$PE_{capacitor} = \frac{1}{2} CV^2 = \frac{1}{2} QV = \frac{\frac{1}{2} Q^2}{C}$$

$$C = \frac{K \varepsilon_o A}{d}$$

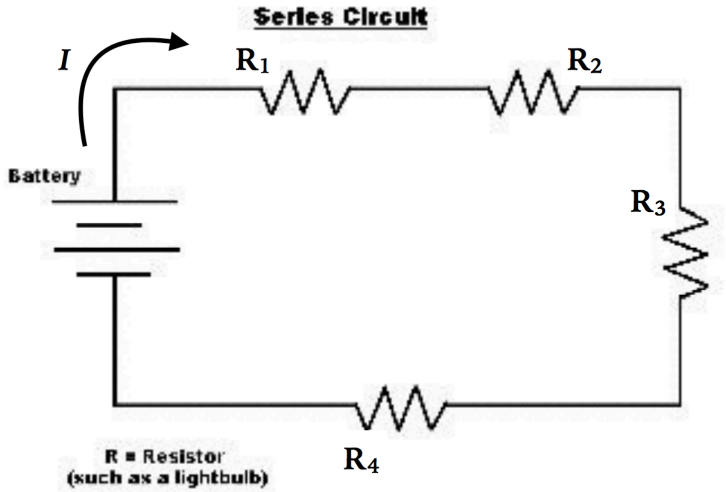
$$\Delta V = \frac{W}{q} = \frac{\Delta PE}{q}$$

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

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

$$C_{tot,in\ parallel} = C_1 + C_2 + C_3 \ldots$$

$$\frac{1}{C_{tot,in\ series}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} \ldots.$$



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

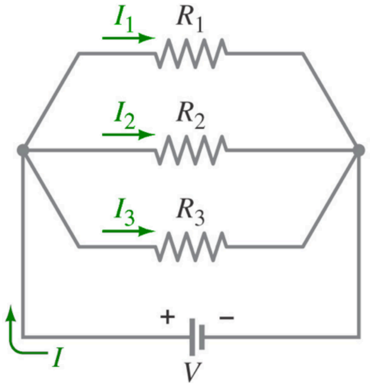
➢ i.e. the voltage will drop across each resistor

➢ Drop by how much?

➢ Ohm's Law tells us: V 1 = IR 1, V2 = IR 2, V3 = IR 3, etc.

➢ V = V 1 + V2 + V3 + V4

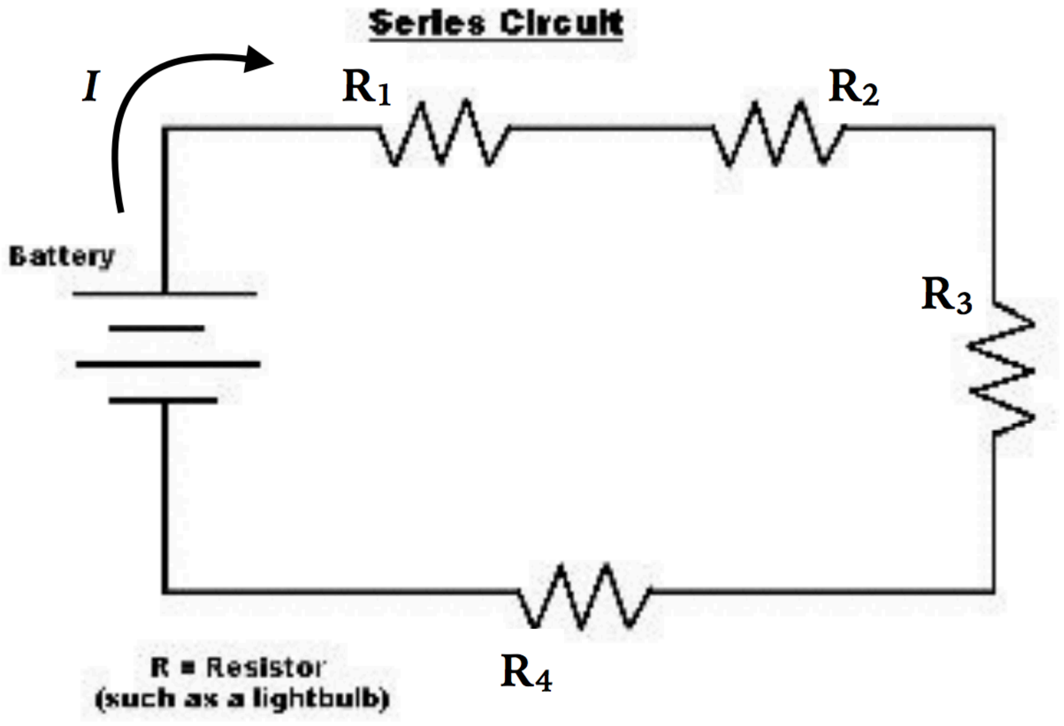
Parallel circuit

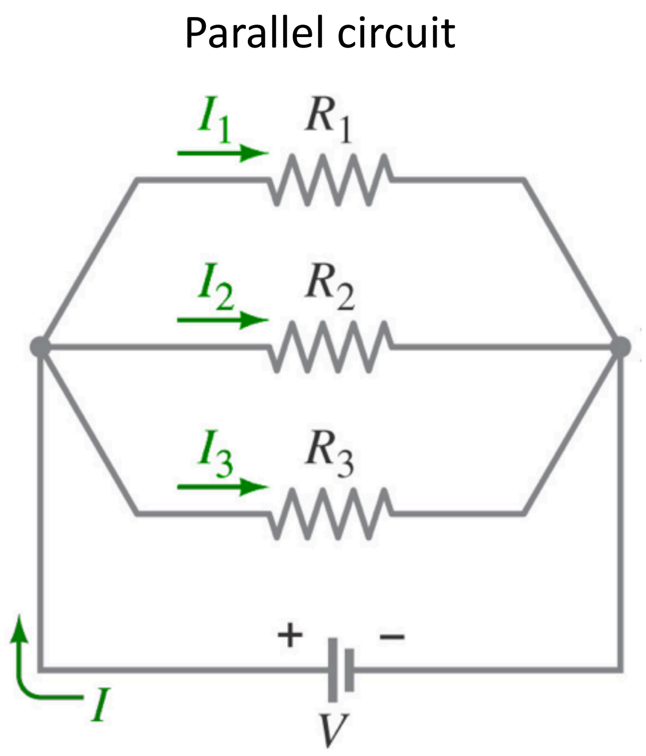


Parallel: voltage is the same across all paths.
(conservation of energy)

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

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


Series Circuit
I
R1
R2
Battery
R3
R4
R = Resistor
(such as a lightbulb)


Parallel circuit
I1
R1
I2
R2
I3
R3
+
−
I
V

Finding V, I & R for a Series Circuit

1. Determine total Ɛ (V from battery)
2. Find the total Resistance

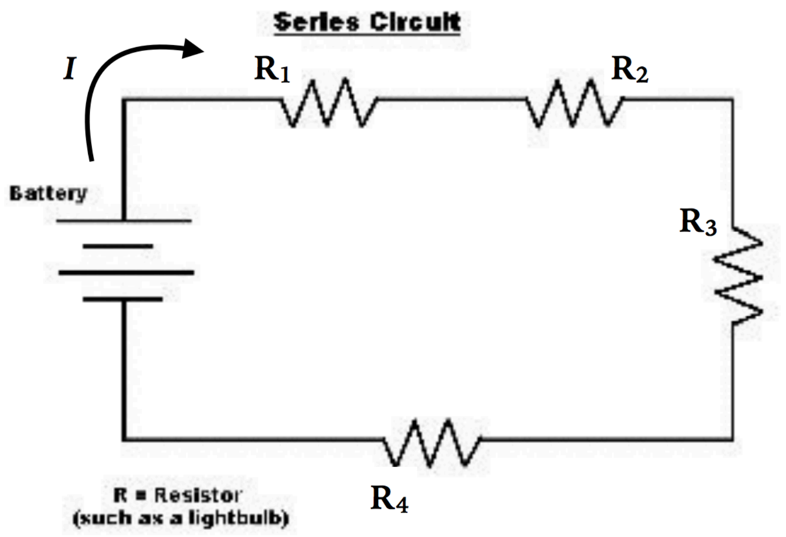
$$R_T = R_1 + R_2 + R_3 \ldots$$

3. Determine I_T by

$$I = V_T/R_T$$

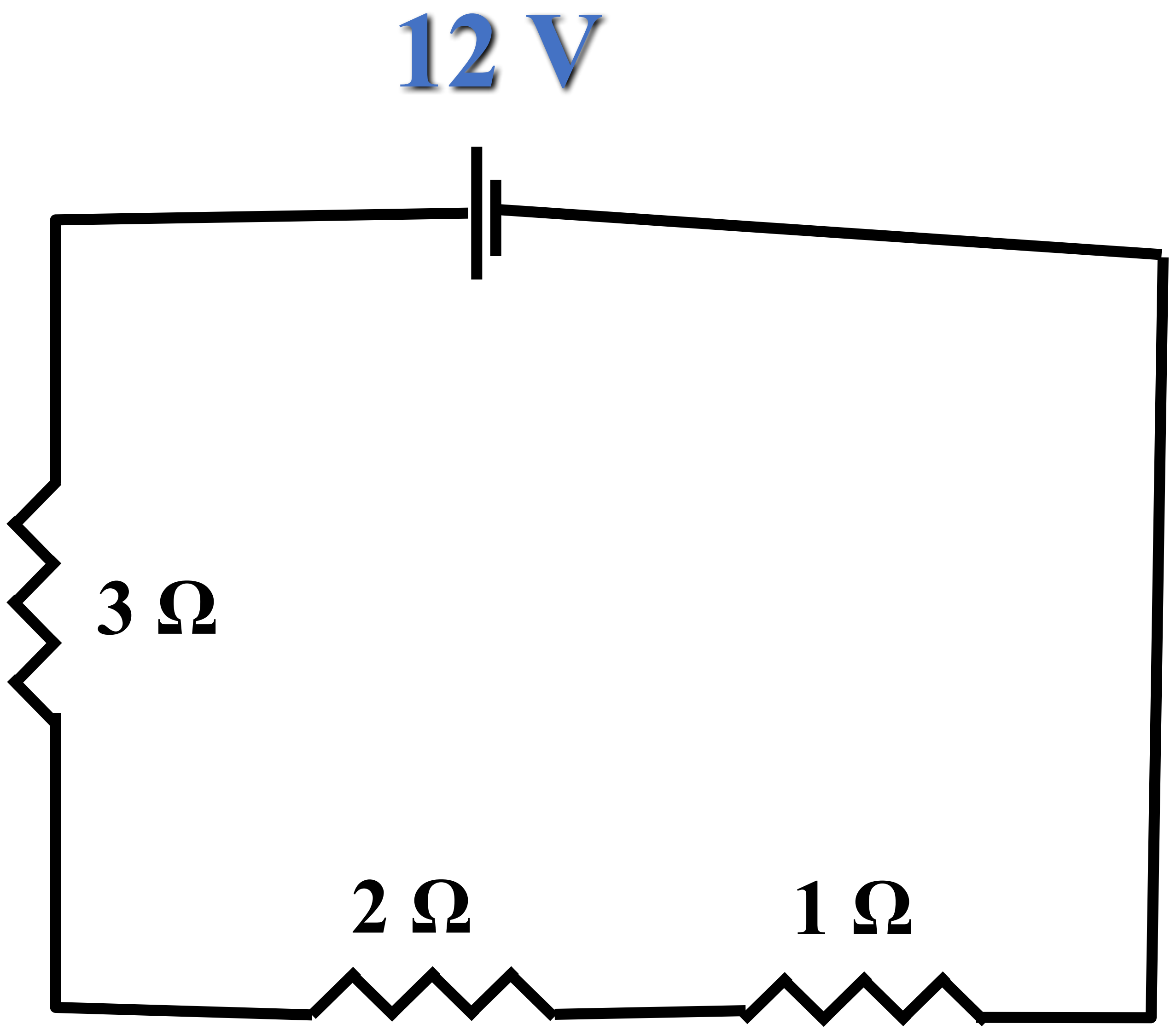
4. Because I is constant in a series circuit, find V (energy used) by each resistor using

$$V = I_T R$$



Finding V, I & R for a Series Circuit

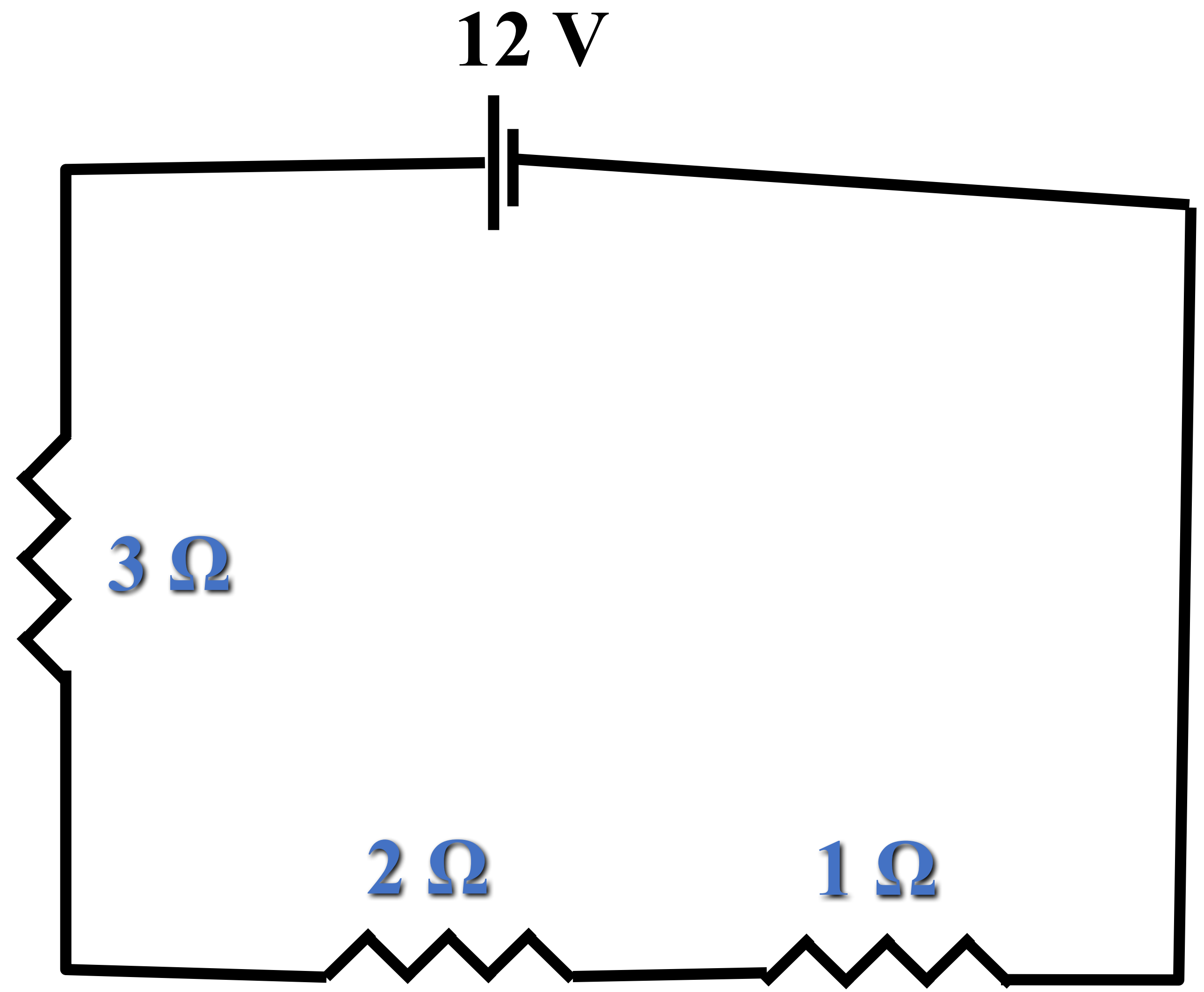
1. Determine Ɛ (V from battery)


12 V
3 Ω
2 Ω
1 Ω

Finding V, I & R for a Series Circuit

1. Determine Ɛ (V from battery) **- 12V**
2. Find the total Resistance

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



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

Finding V, I & R for a Series Circuit

1. Determine Ɛ (V from battery) **- 12V**
2. Find the total Resistance - **6 Ω**

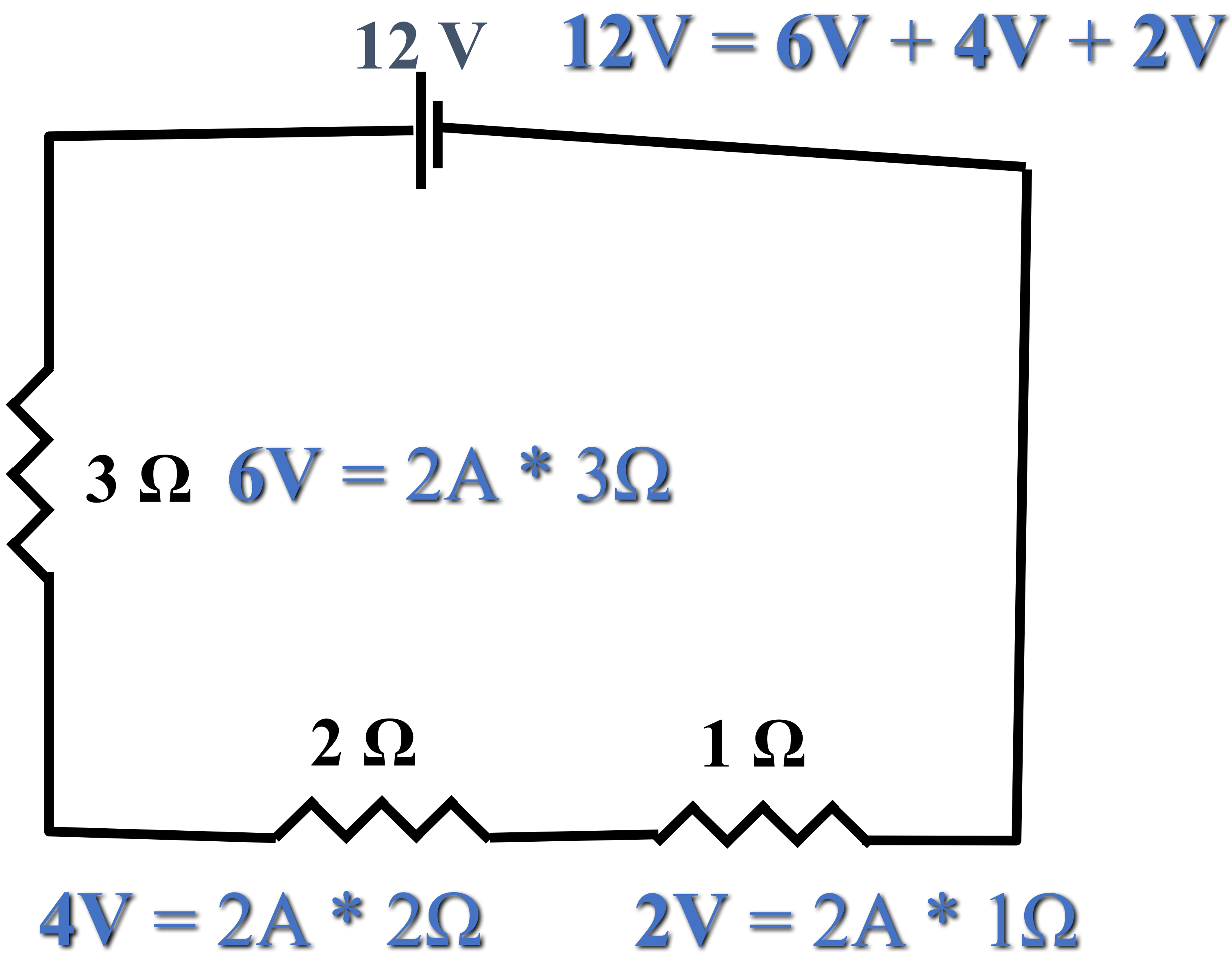
Finding V, I & R for a Series Circuit

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

2 A = 12 V/ 6 Ω

Finding V, I & R for a Series Circuit

1. Determine Ɛ (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 $V = I_T R$


12 V
12V = 6V + 4V + 2V
3 Ω
6V = 2A * 3Ω
2 Ω
1 Ω
4V = 2A * 2Ω
2V = 2A * 1Ω

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

$$R = R_1 + R_2 + R_3$$

Parallel Circuit

Finding V, I & R for a Parallel Circuit

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

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

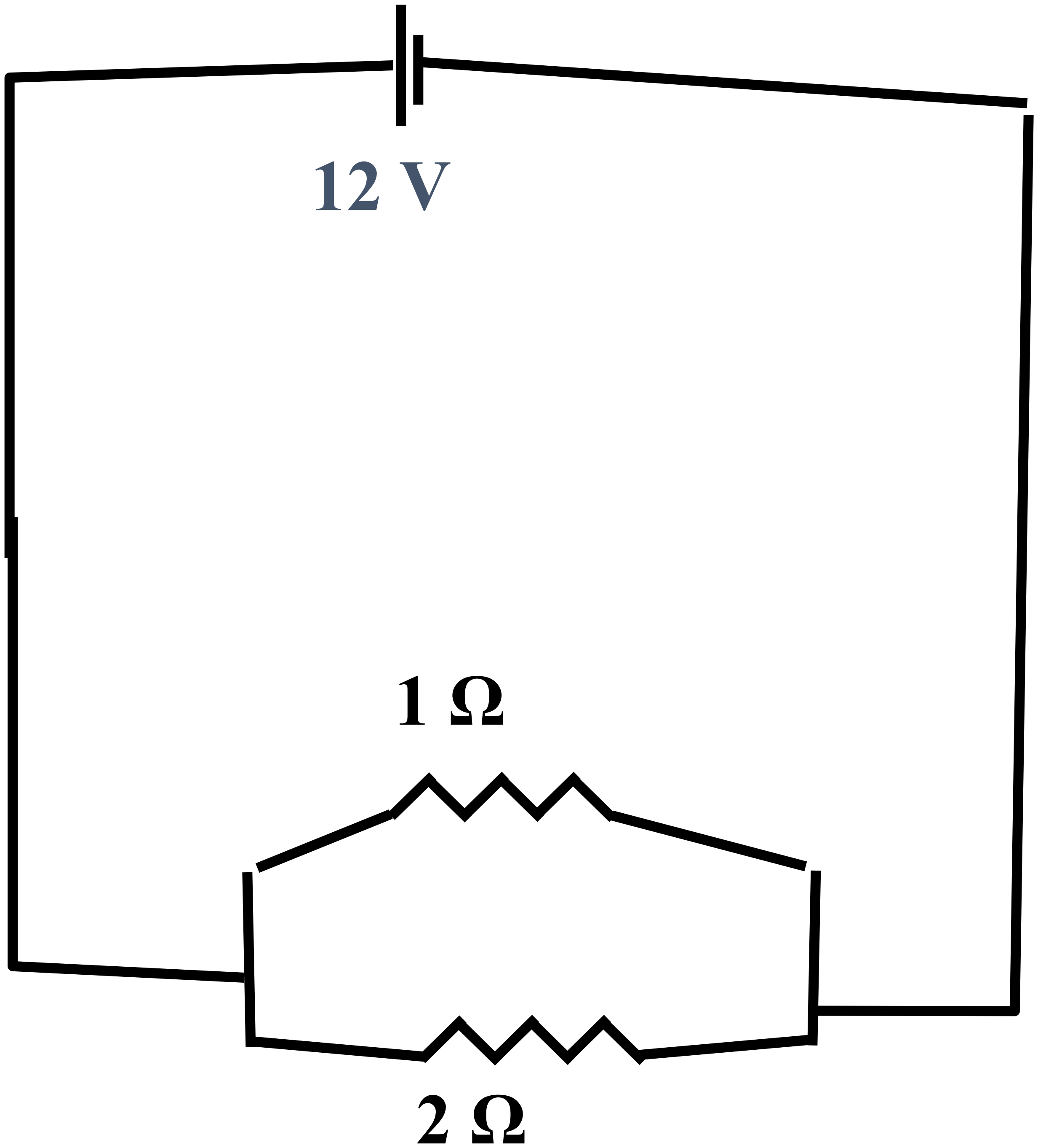
3. Determine I_T leaving battery by

$$I_T = V_T/R_T$$

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


12 V
1 Ω
2 Ω

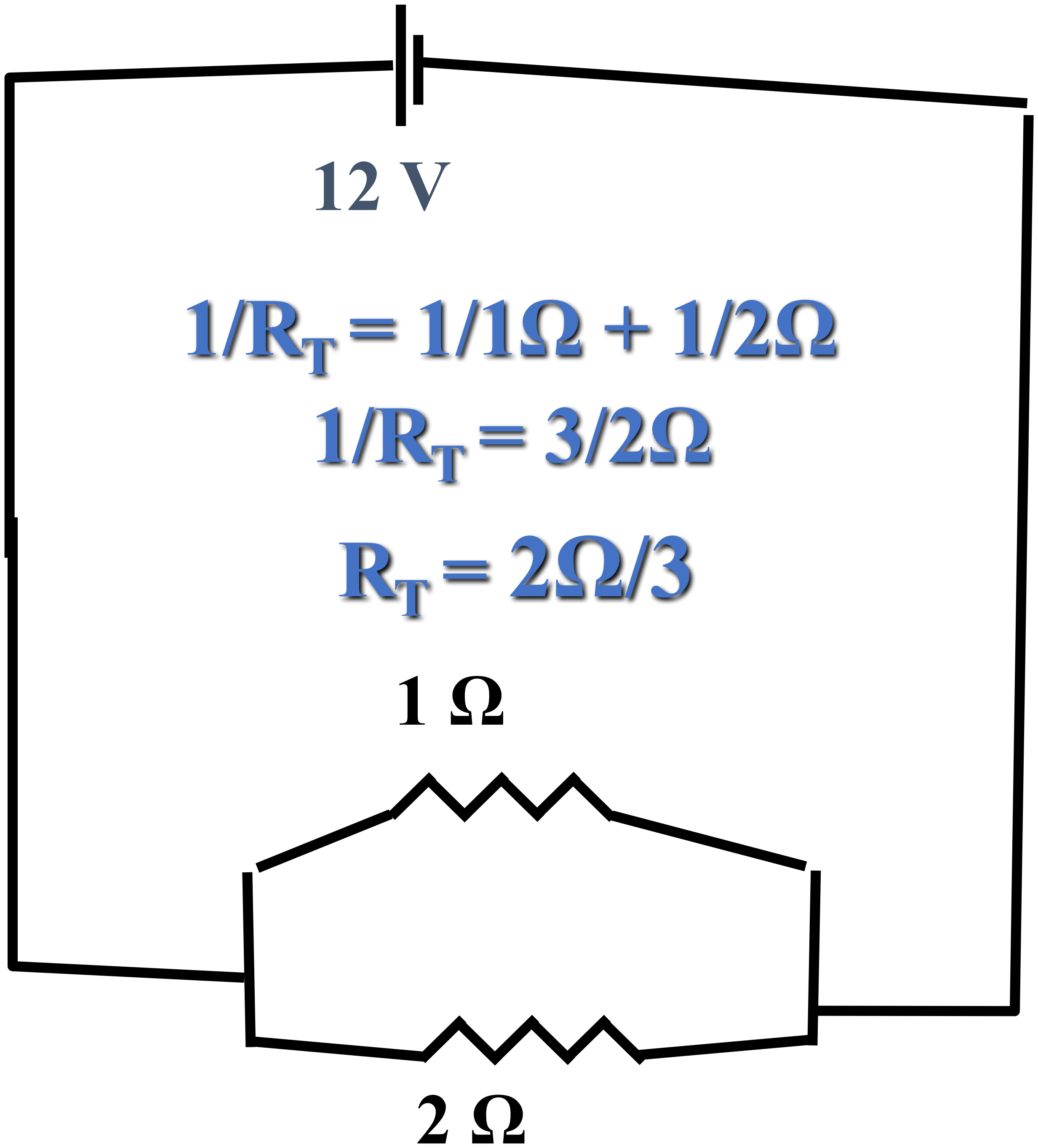
Finding V, I & R for a Parallel Circuit

1. Determine $\mathcal{E}$ **12 V**

Finding V, I & R for a Parallel Circuit

1. Determine E
2. Find the total Resistance

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



$$1/R_T = 1/1\Omega + 1/2\Omega$$

$$1/R_T = 3/2\Omega$$

$$R_T = 2\Omega/3$$

Finding V, I & R for a Parallel Circuit

1. Determine E
2. Find the total Resistance

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

$$\mathbf{R_T = 2\Omega/3}$$

Finding V, I & R for a Parallel Circuit

1. Determine E
2. Find the total Resistance

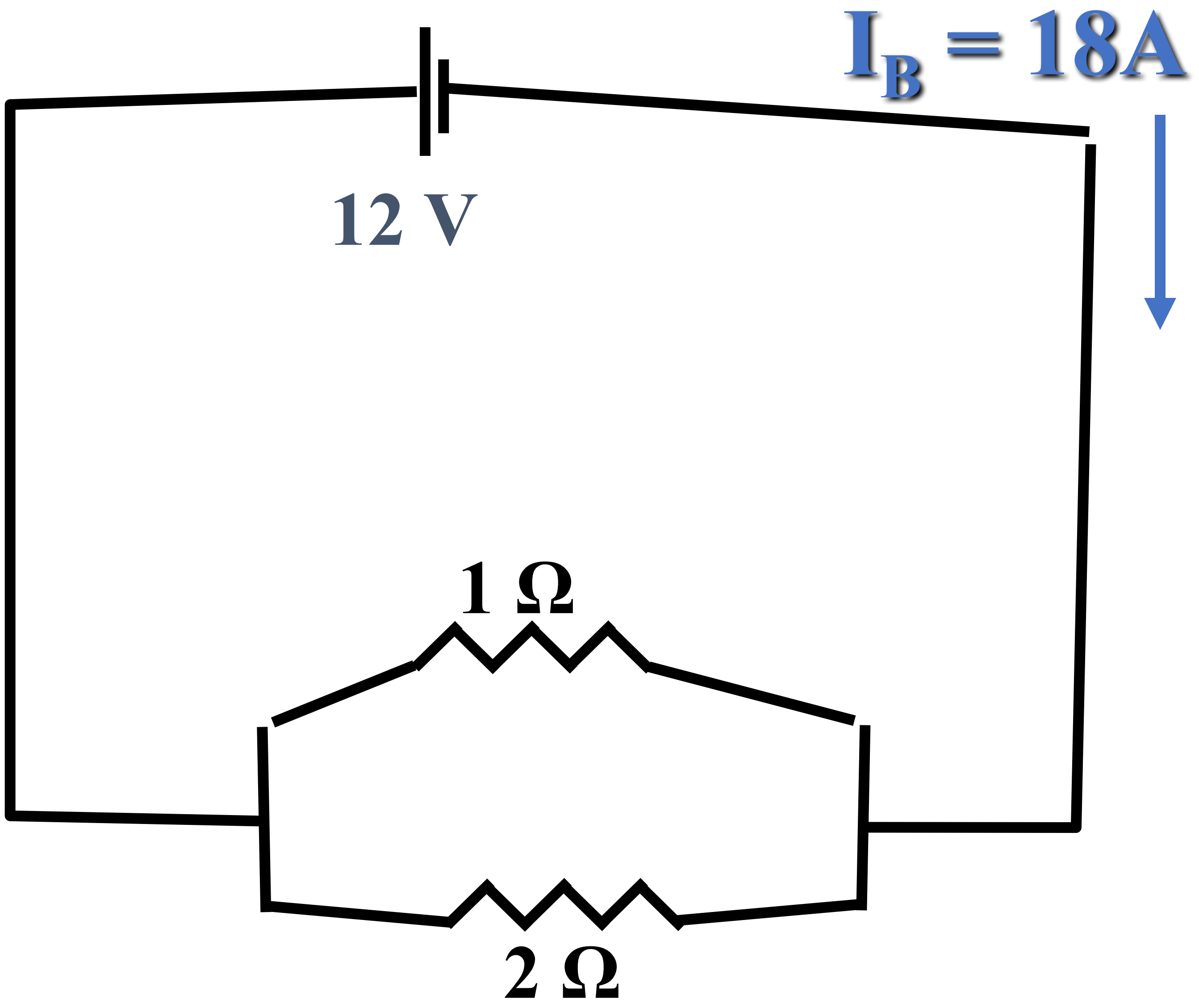
$$1/R_T = 1/R_1 + 1/R_2 + 1/R_3 \ldots$$

3. Determine I_B leaving battery by

$$I_B = V_B/R_T$$

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

$I_B = 18A$



$I_B = 18A$
12 V
1 Ω
2 Ω

Finding V, I & R for a Parallel Circuit

1. Determine E
2. Find the total Resistance

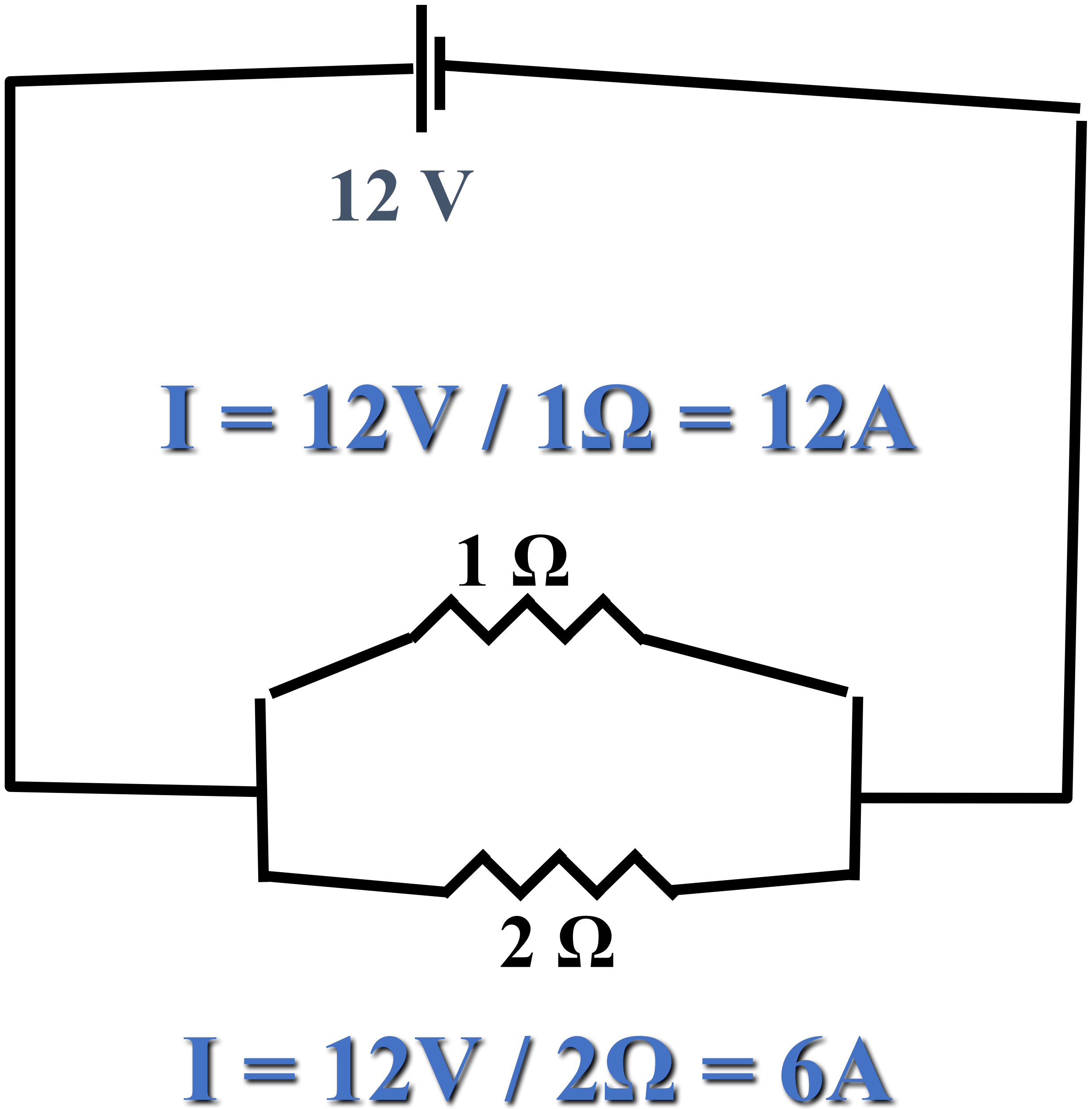
$$1/R_T = 1/R_1 + 1/R_2 + 1/R_3 \ldots$$

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 / 1Ω = 12A
1 Ω
2 Ω
I = 12V / 2Ω = 6A

Finding V, I & R for a Parallel Circuit

1. Determine E
2. Find the total Resistance

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

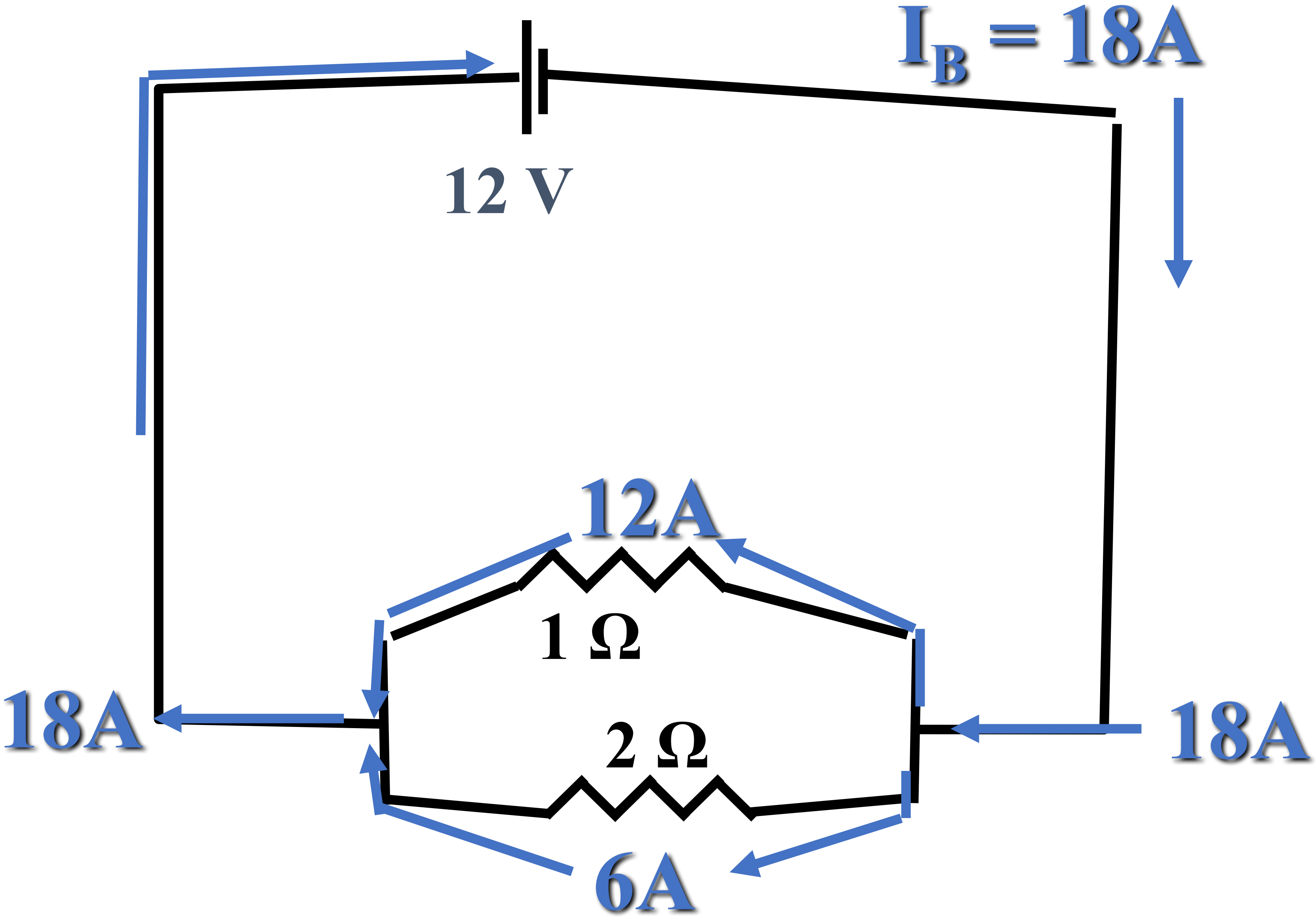
3. Determine I_T leaving battery by

$$I_T = V_T/R_T$$

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



$I_B = 18A$
12 V
12A
1 Ω
18A
2 Ω
18A
6A

Parallel Circuit

Current accumulates

$$I = I_1 + I_2 + I_3$$

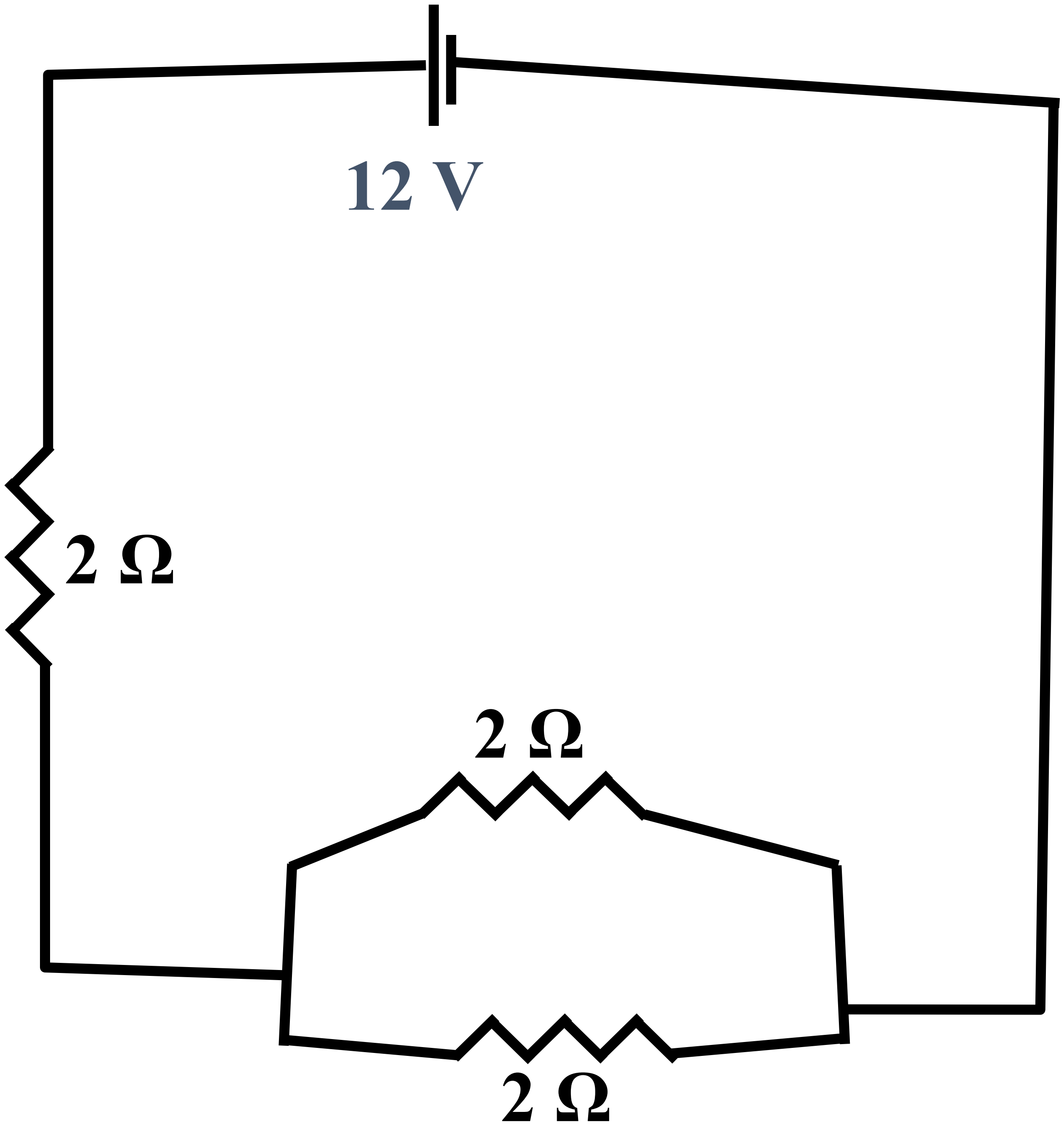
Volt is the same at all points

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

Resistance

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

Complex Circuits



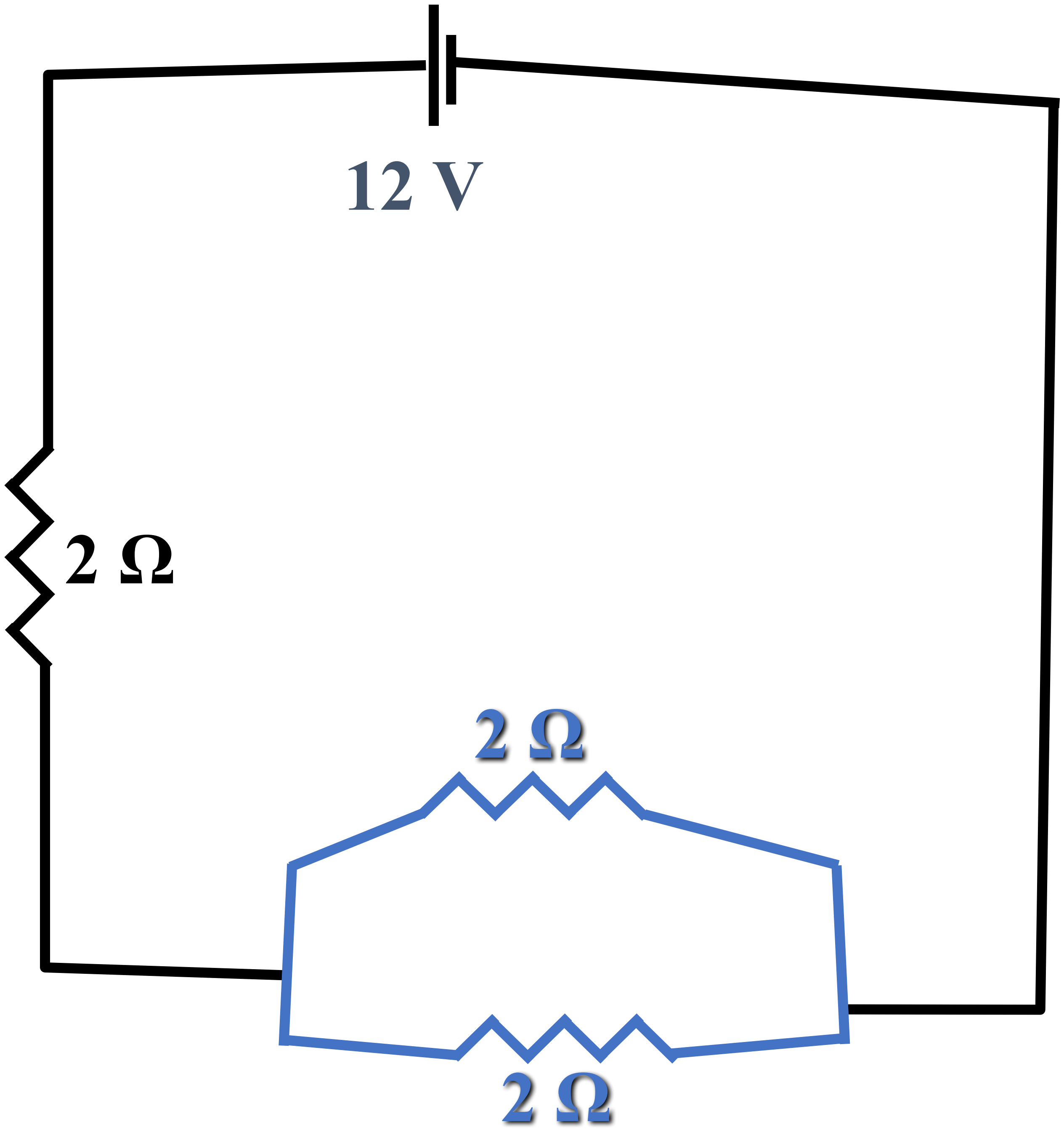
12 V
2 Ω
2 Ω
2 Ω

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 used on both sides will be identical, Find I
6. Make sure Kirchhoff's Rule is followed

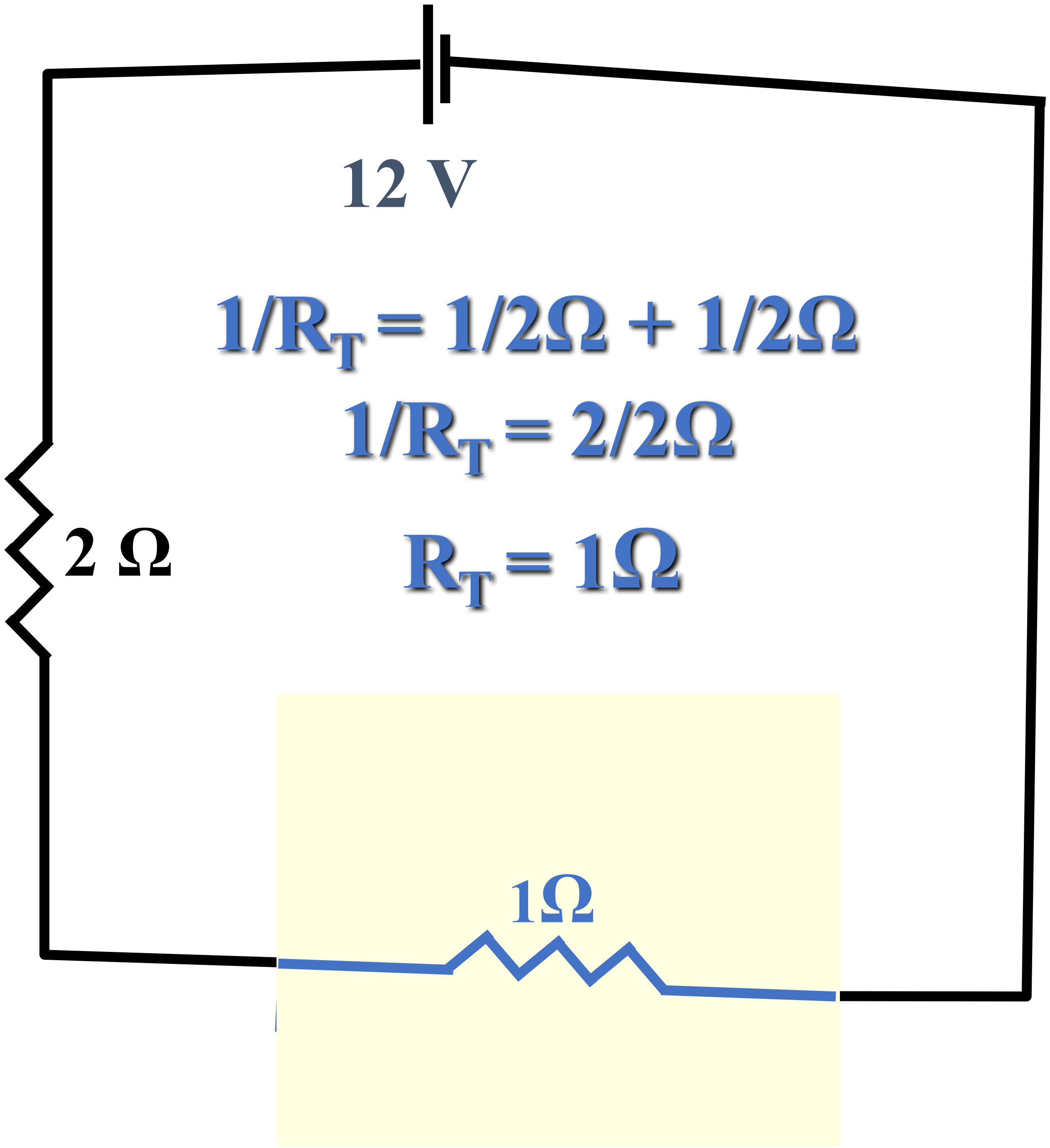
Finding V, I & R for a Complex Circuit

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


12 V
2 Ω
2 Ω
2 Ω

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



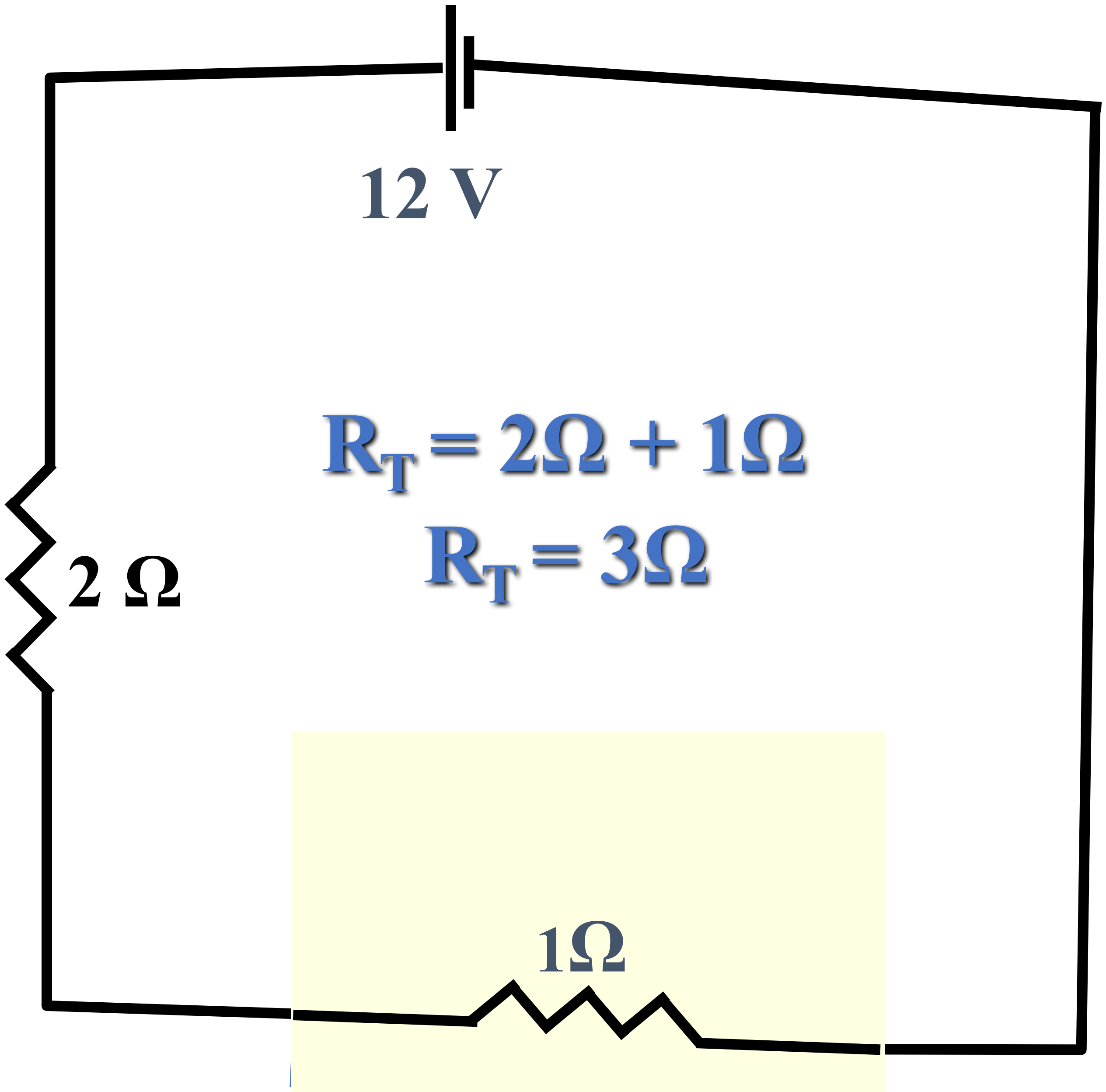
$$1/R_T = 1/2\Omega + 1/2\Omega$$

$$1/R_T = 2/2\Omega$$

$$R_T = 1\Omega$$

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

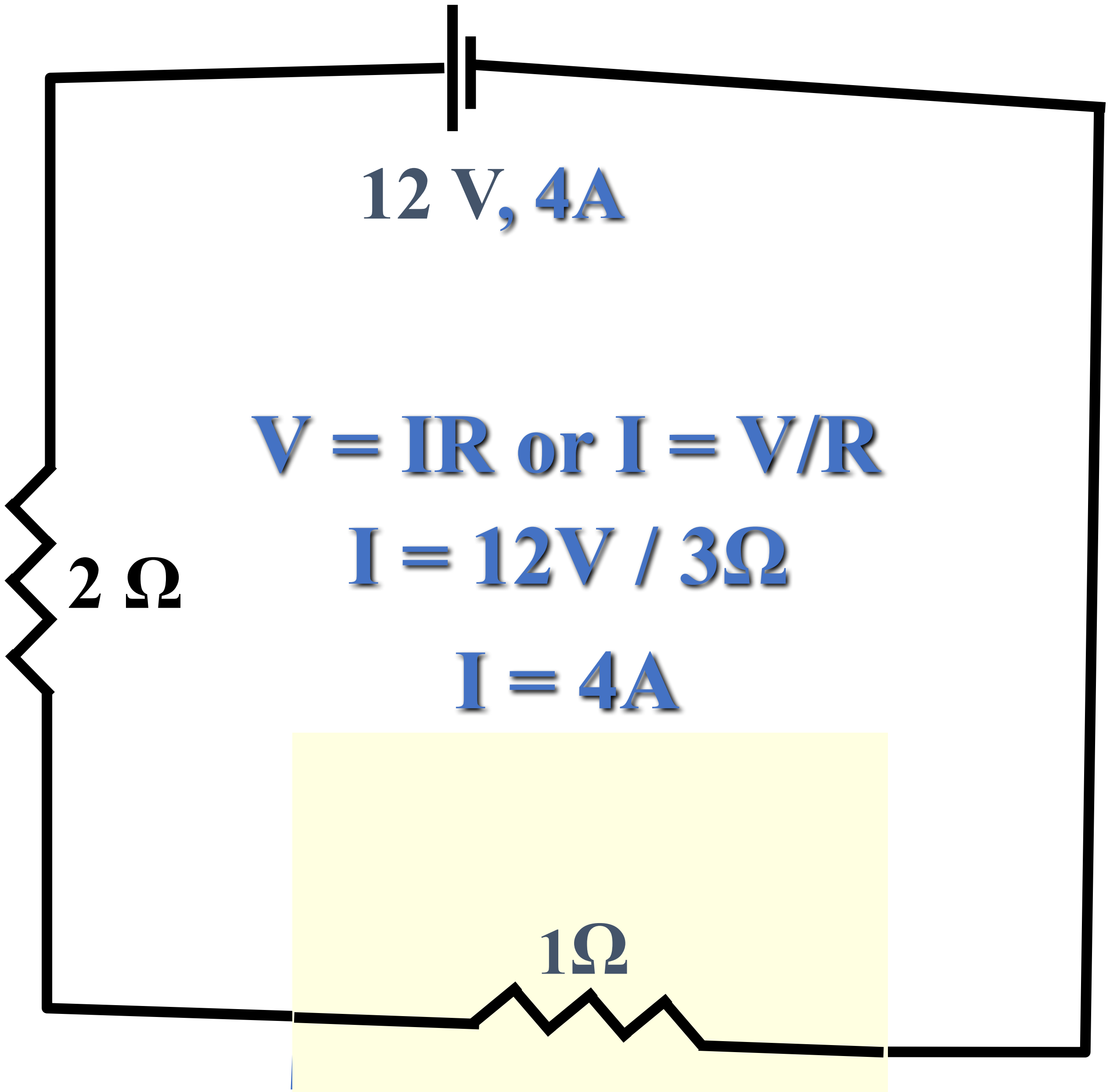


$$R_T = 2\Omega + 1\Omega$$

$$R_T = 3\Omega$$

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



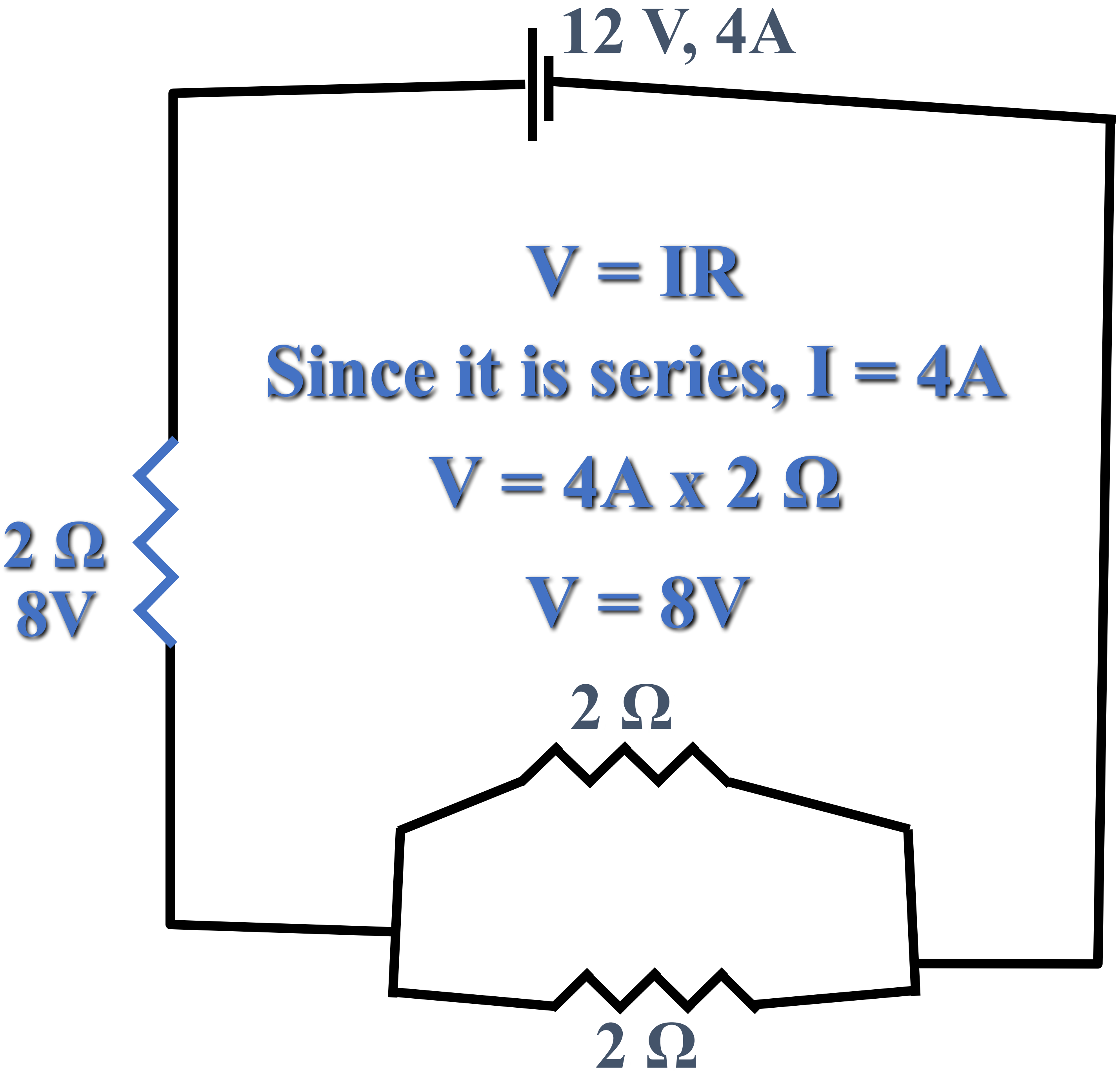
$V = IR$ or $I = V/R$

$I = 12V / 3\Omega$

$I = 4A$

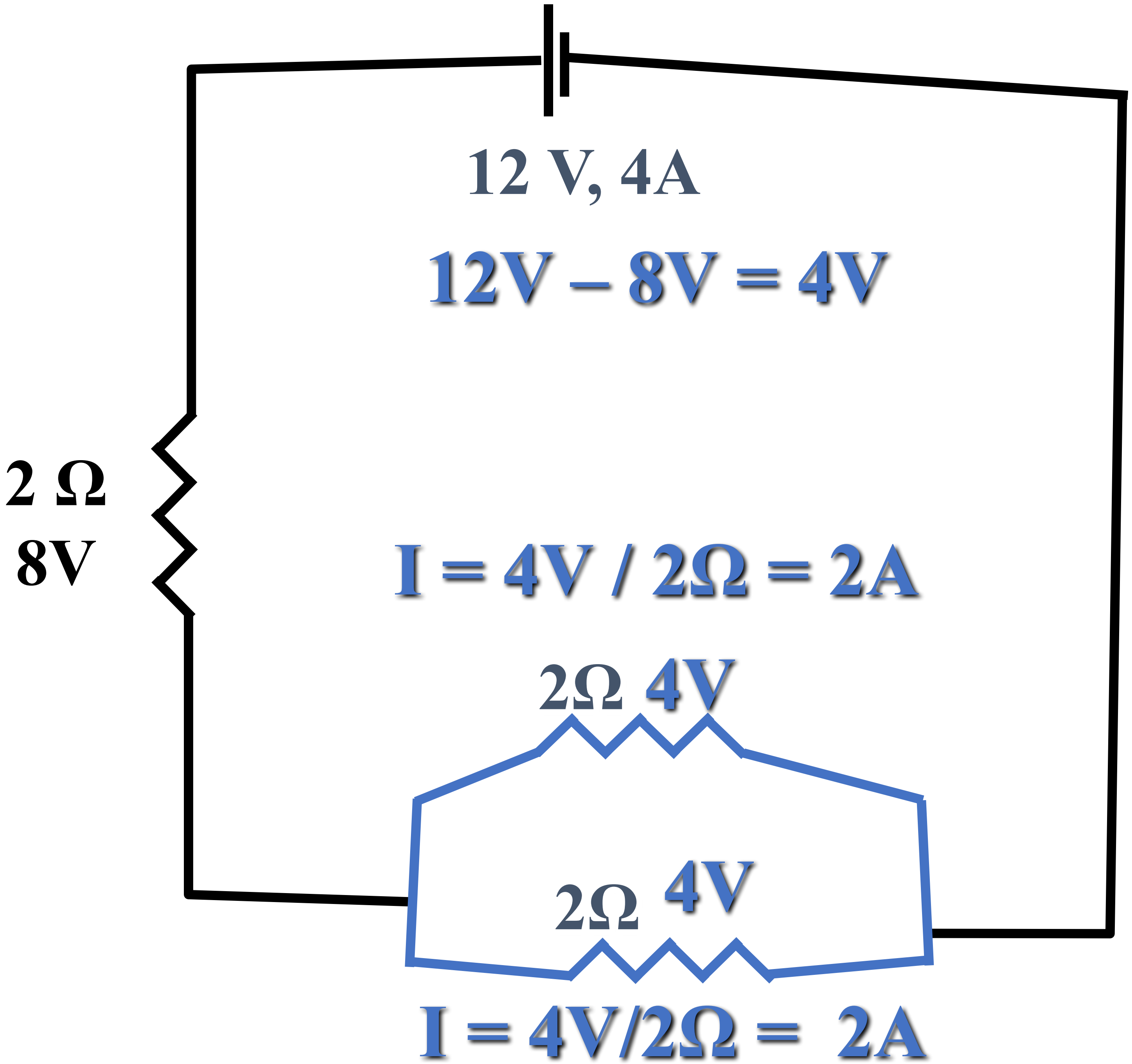
Finding V, I & R for a Complex Circuit

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


12 V, 4A
V = IR
Since it is series, I = 4A
V = 4A x 2 Ω
V = 8V
2 Ω
8V
2 Ω
2 Ω

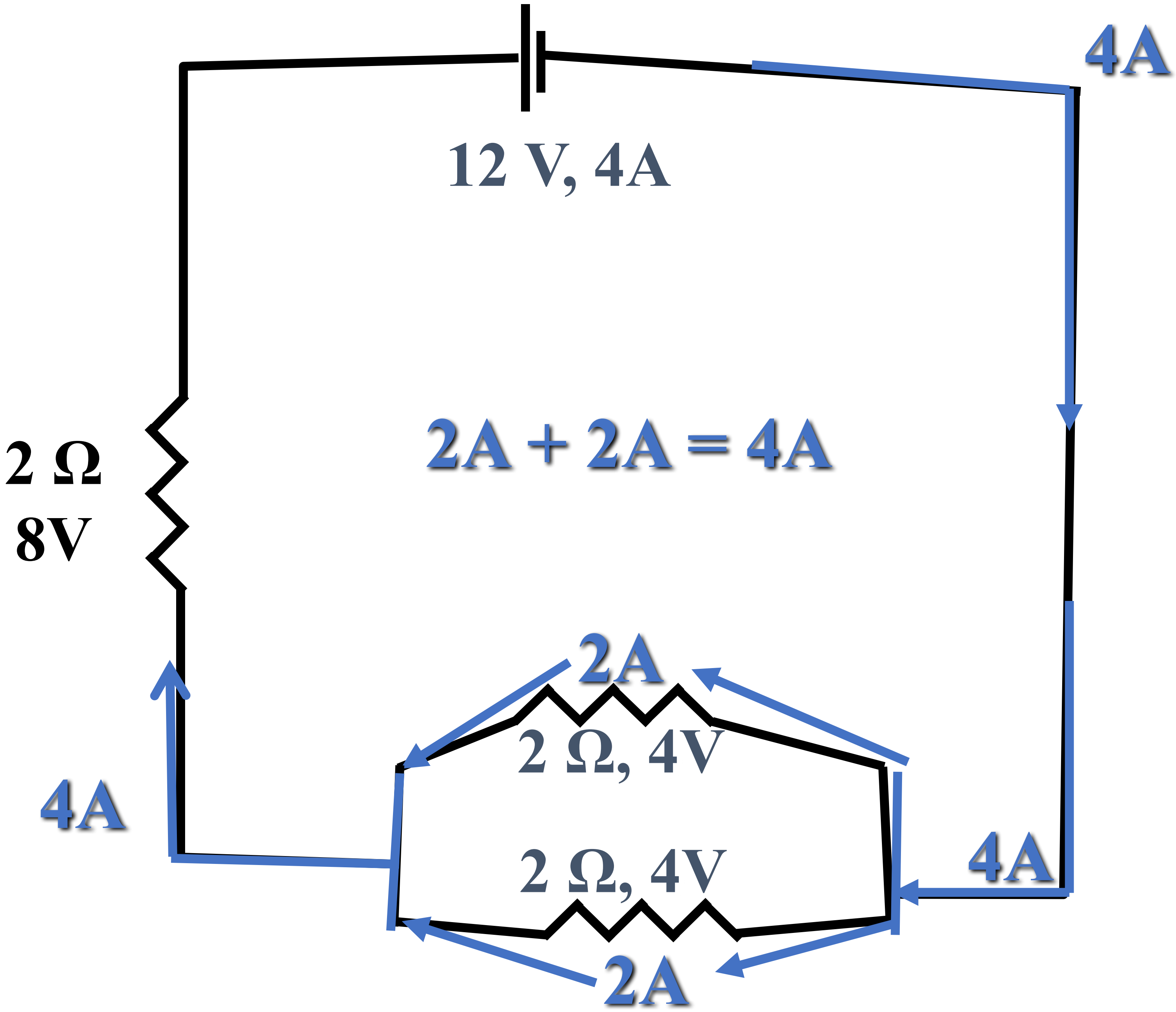
Finding V, I & R for a Complex Circuit

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


12 V, 4A
12V – 8V = 4V
2 Ω
8V
I = 4V / 2Ω = 2A
2Ω 4V
2Ω 4V
I = 4V/2Ω = 2A

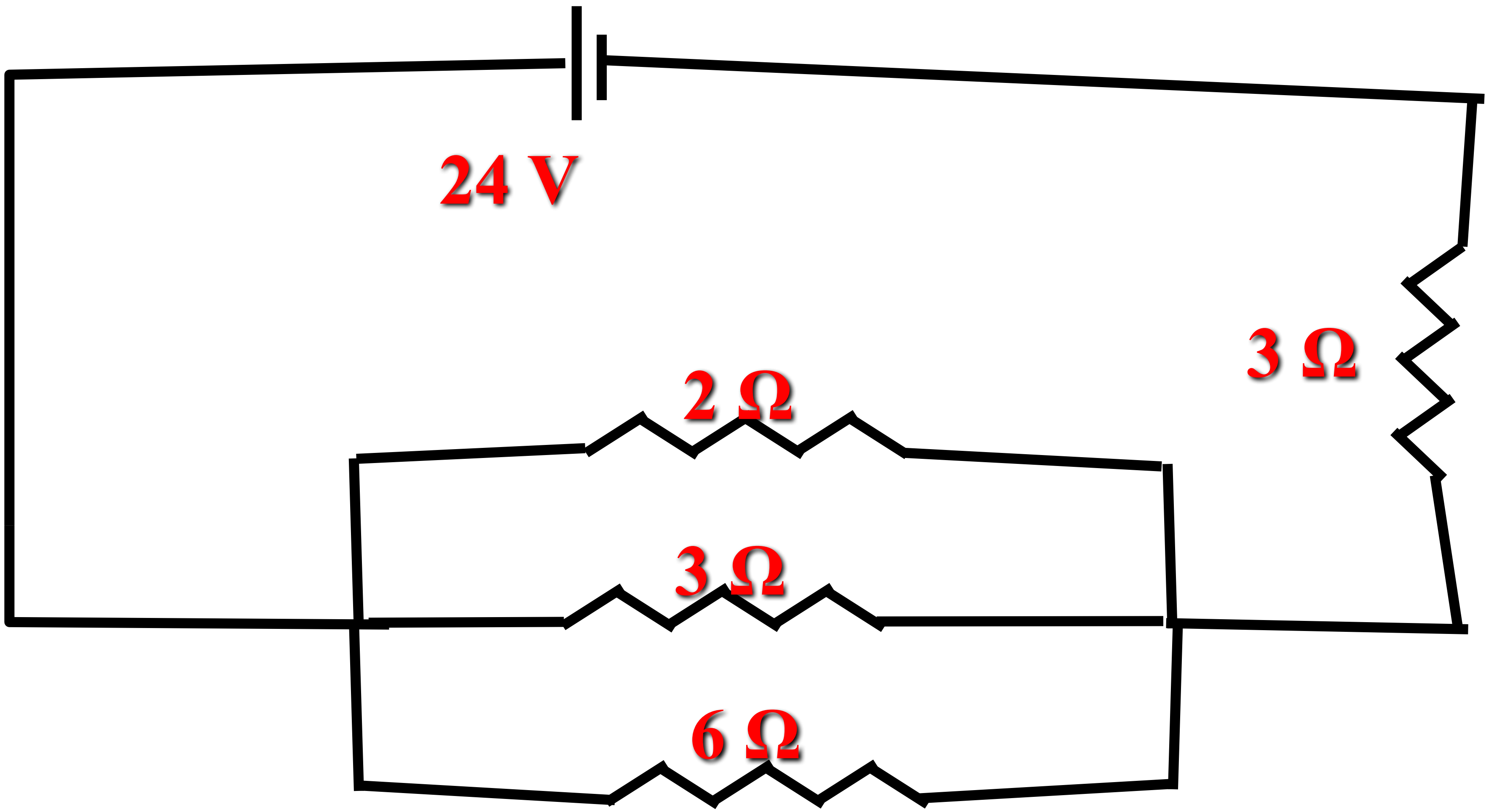
Finding V, I & R for a Complex Circuit

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 used on both sides will be identical, Find I
6. Make sure Kirchhoff's Rule is followed

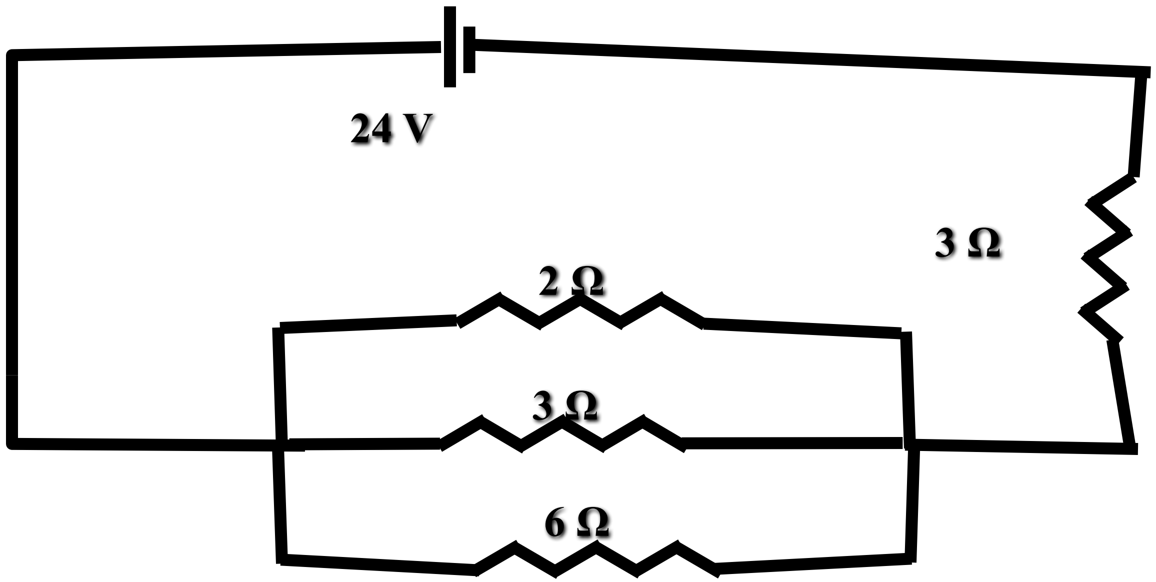


4A
12 V, 4A
2 Ω
8V
2A + 2A = 4A
2A
2 Ω, 4V
4A
2 Ω, 4V
4A
2A

Try this!

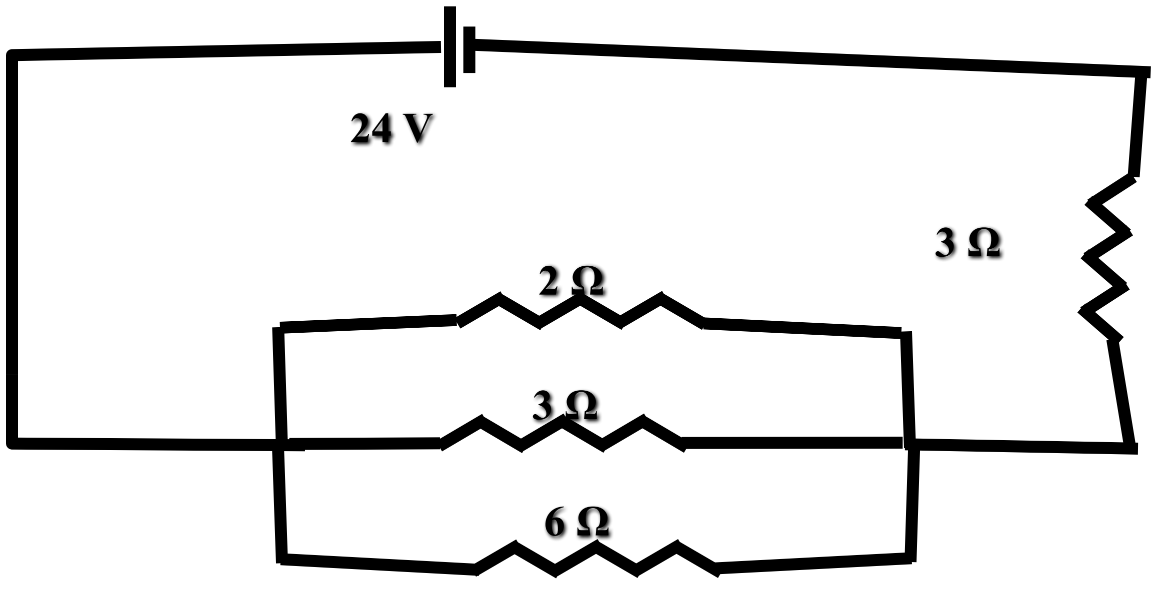


What is the voltage?



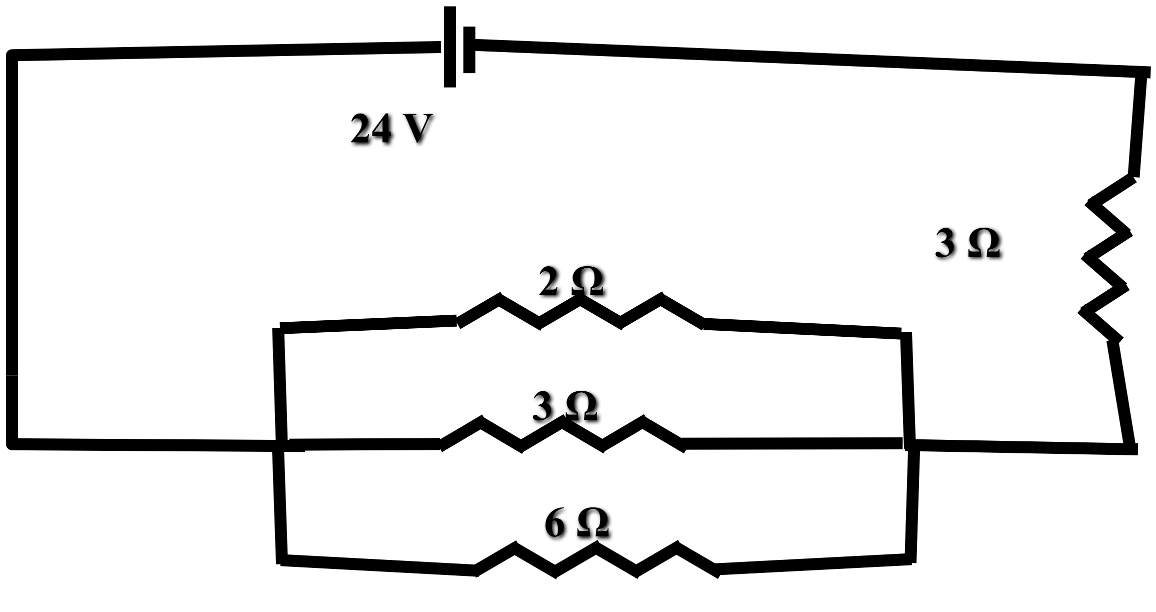
What is the voltage? 24V

What is the total Resistance?



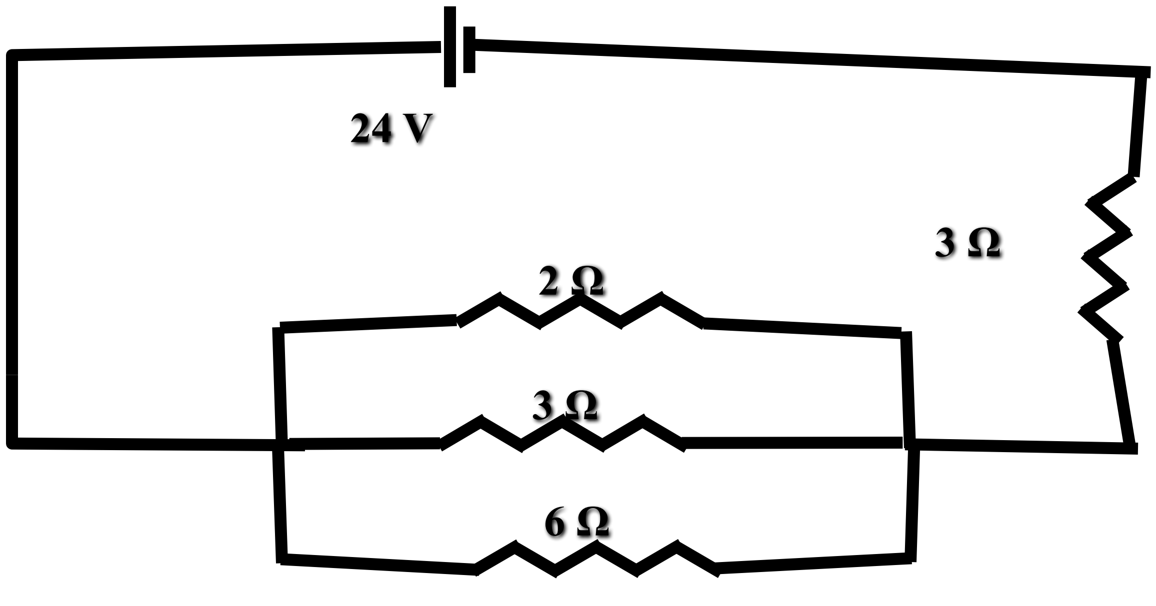
What is the voltage? 24V

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



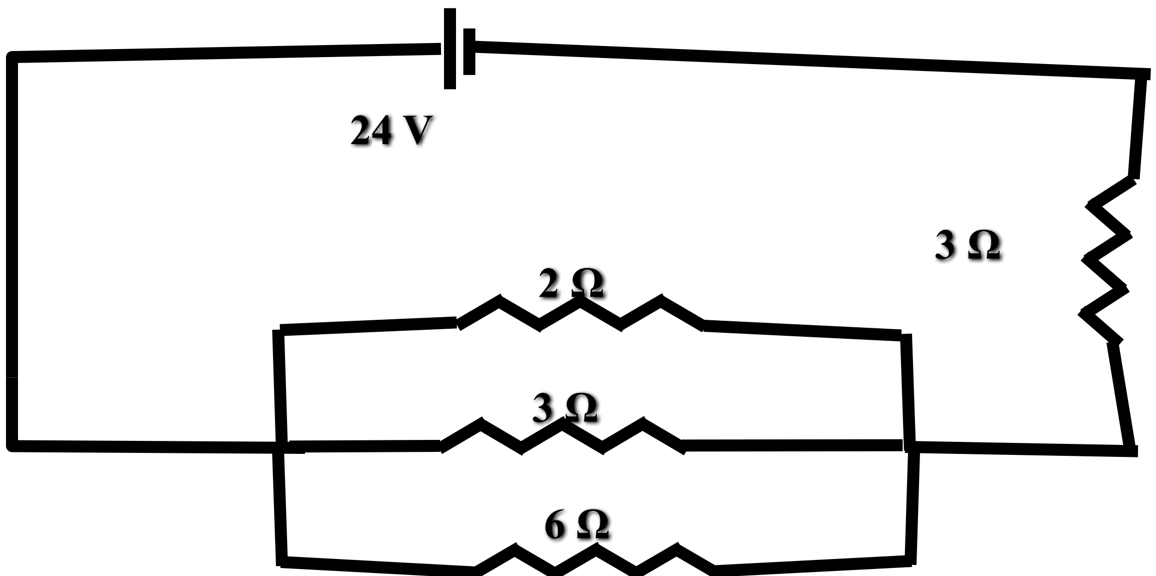
What is the voltage? 24V
What is the total Resistance? 4.0 Ω
What is the total current? 6.0 A

What is the voltage through each resistor?



What is the voltage? 24V
What is the total Resistance? 4.0 Ω
What is the total current? 6 A
What is the voltage through each resistor?
3 Ω: 18V and 6V

What is the current through each resistor?



What is the voltage? 24V

What is the total Resistance? 4.0 Ω

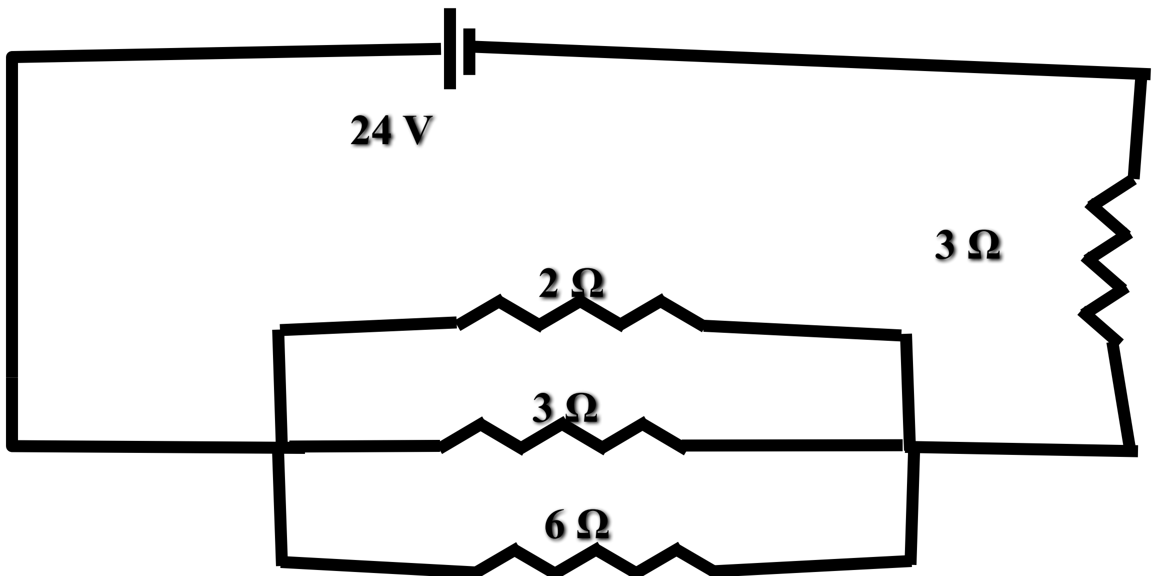
What is the total current? 6 A

What is the voltage through each resistor?

3 Ω: 18V and 6V

What is the current through each resistor?

3 Ω: 6A 2 Ω: 3A 3 Ω: 2A 6 Ω: 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?

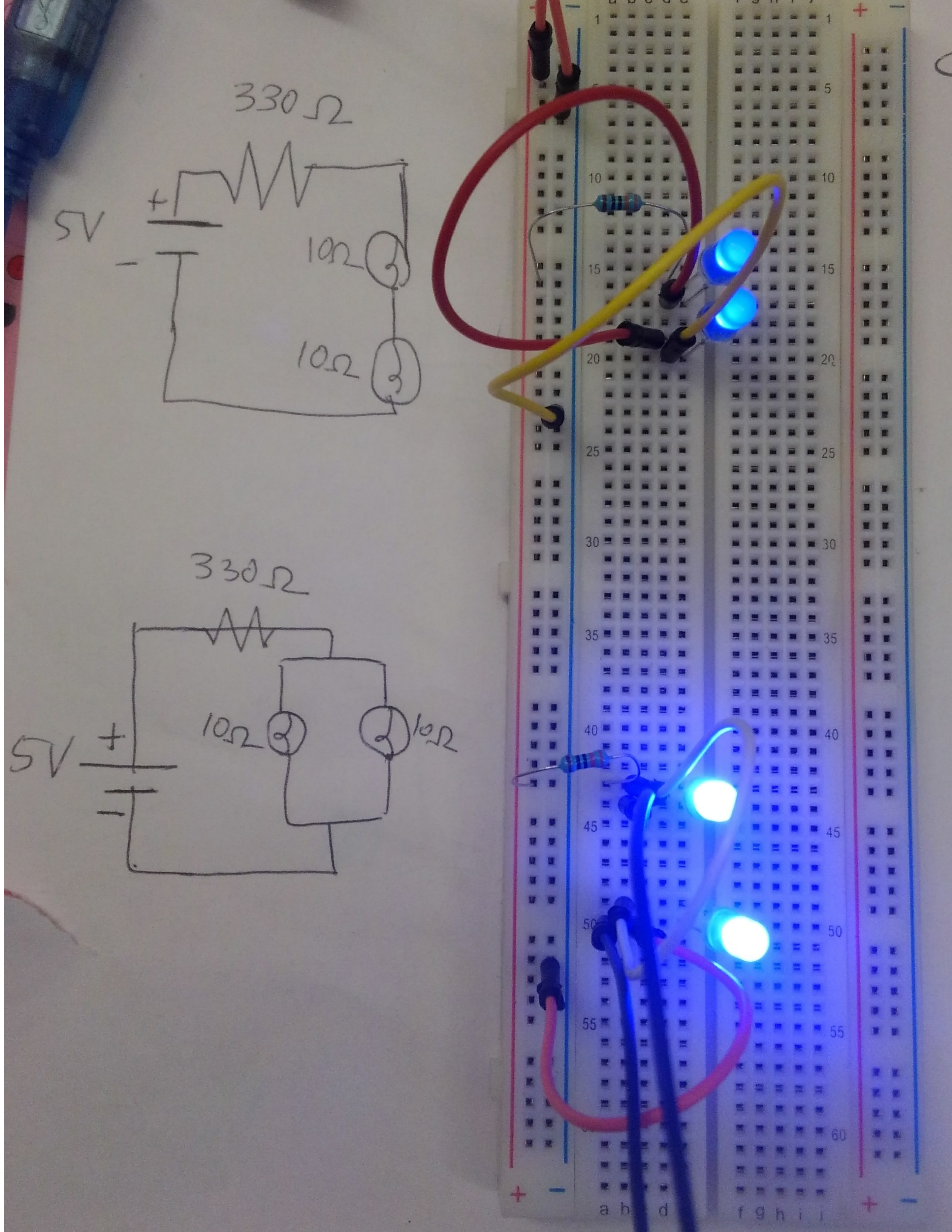
Answer: V

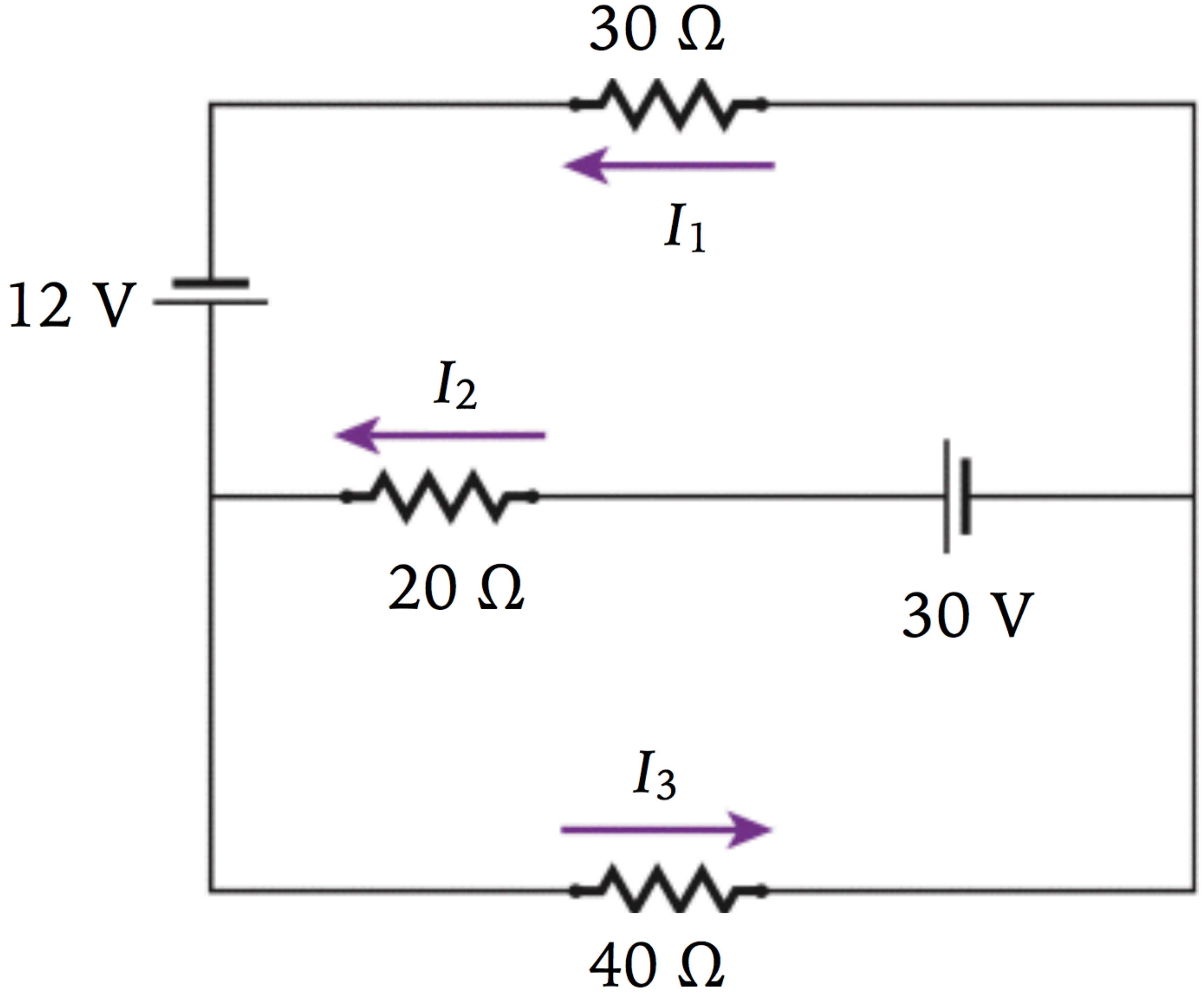
Compare the total resistance of the series vs. combination circuits:
350 Ohms in series, 335 Ohms in combo

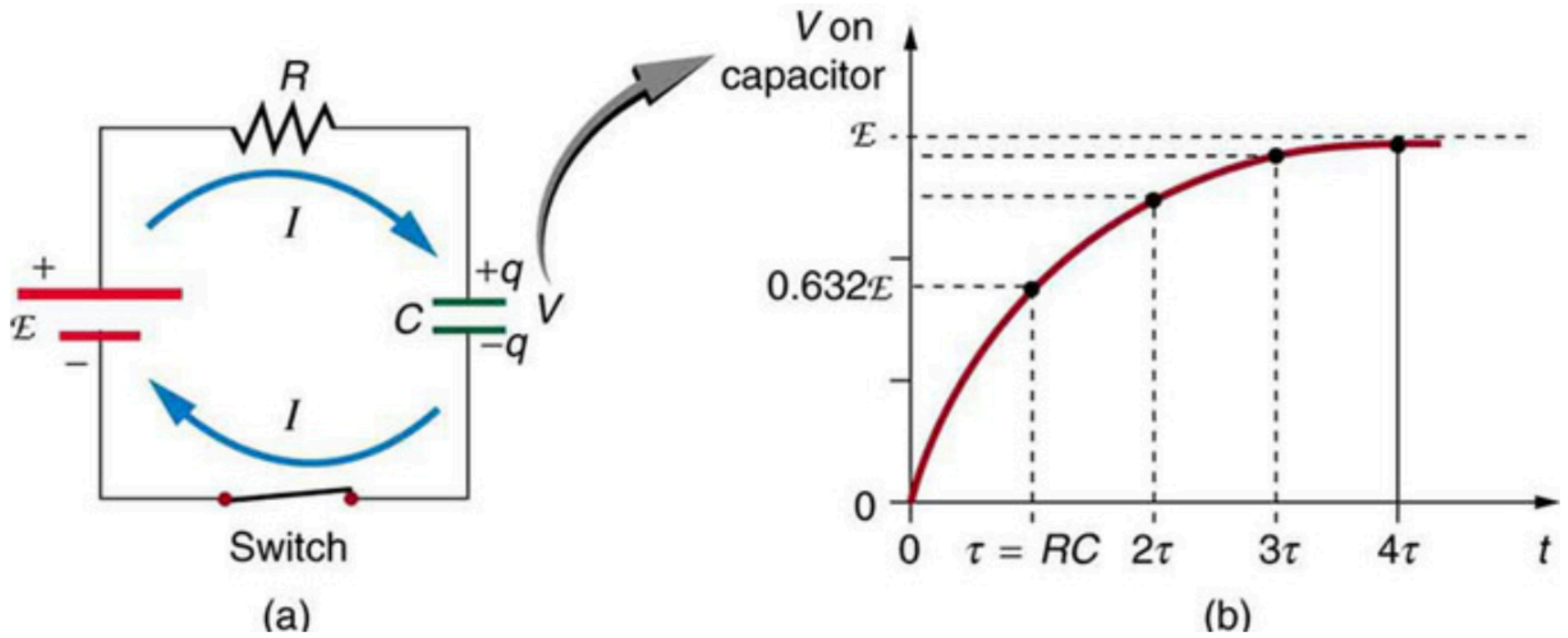
When you remove a light in series, the other goes out, but if you remove a light in parallel the other stays on. Why?

Parallel still has conductive path

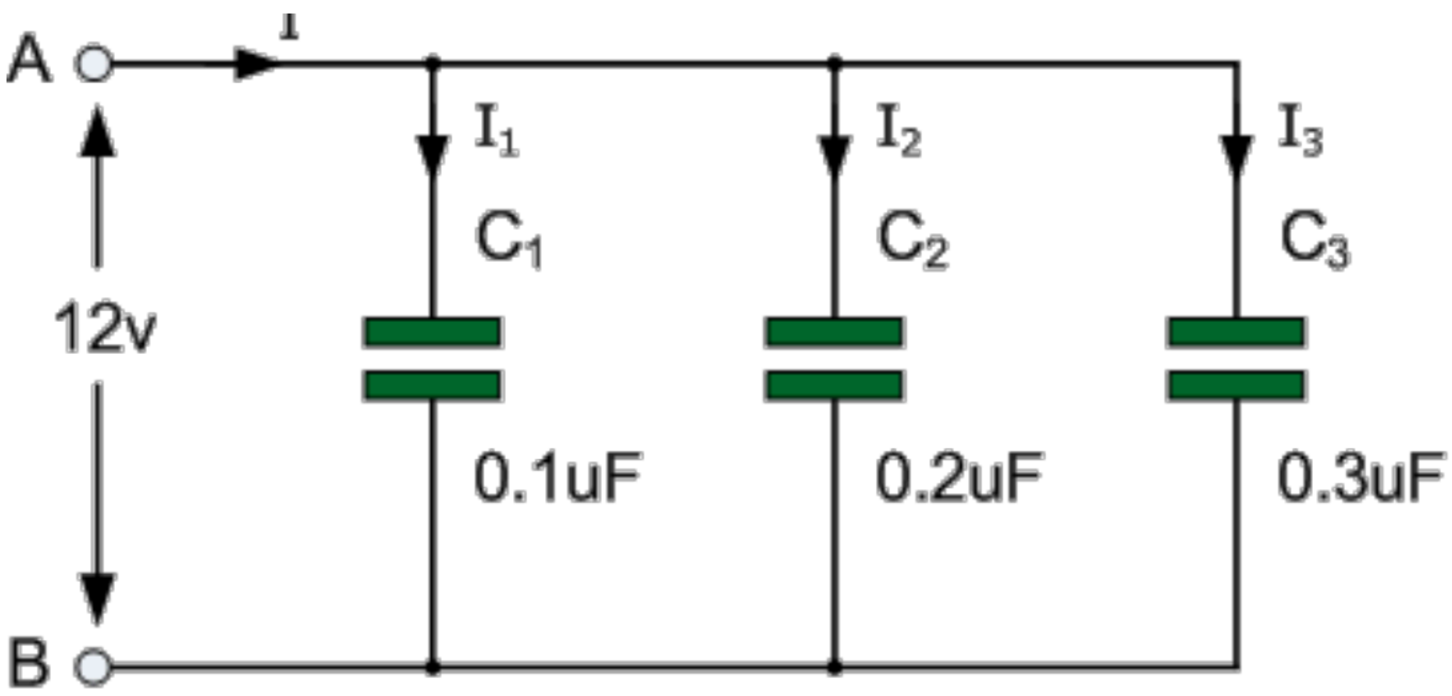
Christmas lights wired in series, while car headlights and home appliances wired in parallel.




30 Ω
I_1
12 V
I_2
20 Ω
30 V
I_3
40 Ω

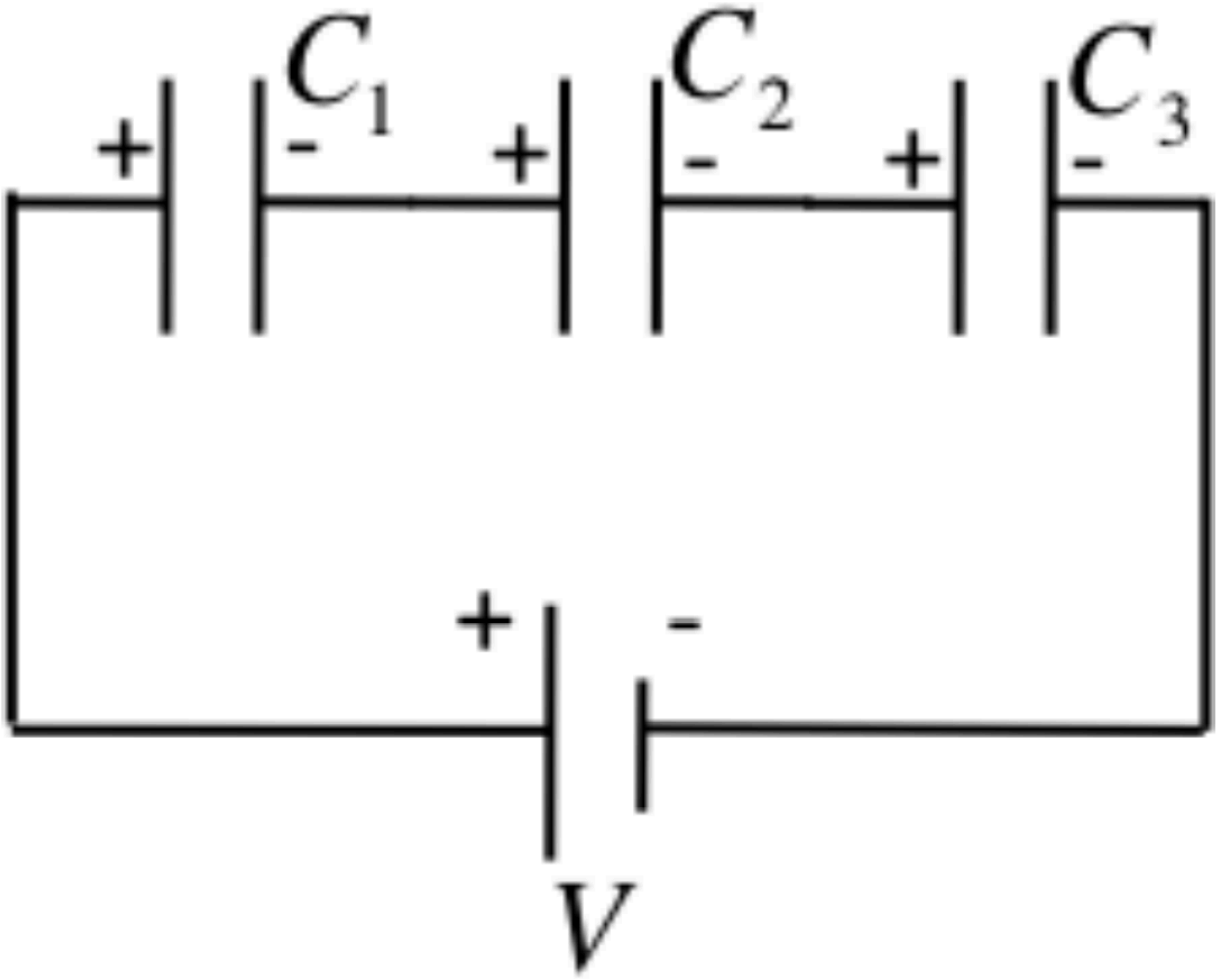


Capacitors in circuits: current flows until the potential difference in the capacitor = the emf (voltage) provided by the battery. Graph shows the voltage increasing over time



By the junction rule, I in = I out
So by extension, Q in = Q out.
Voltage is constant in parallel
Q = CV

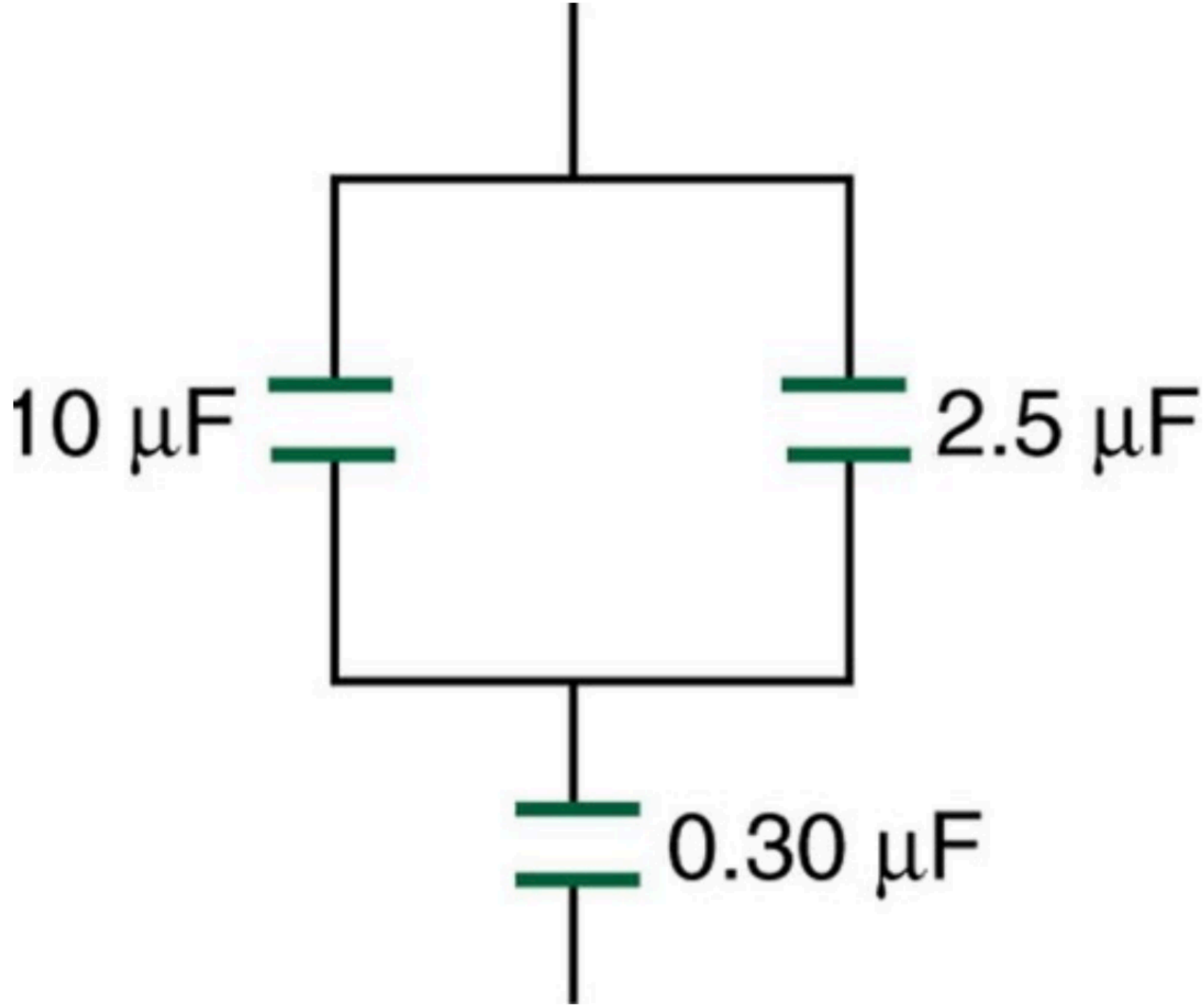
Parallel capacitors: Ceq = C1 + C2 + C3…



By the loop rule, sum of voltage drops across components of a circuit = voltage provided by battery.

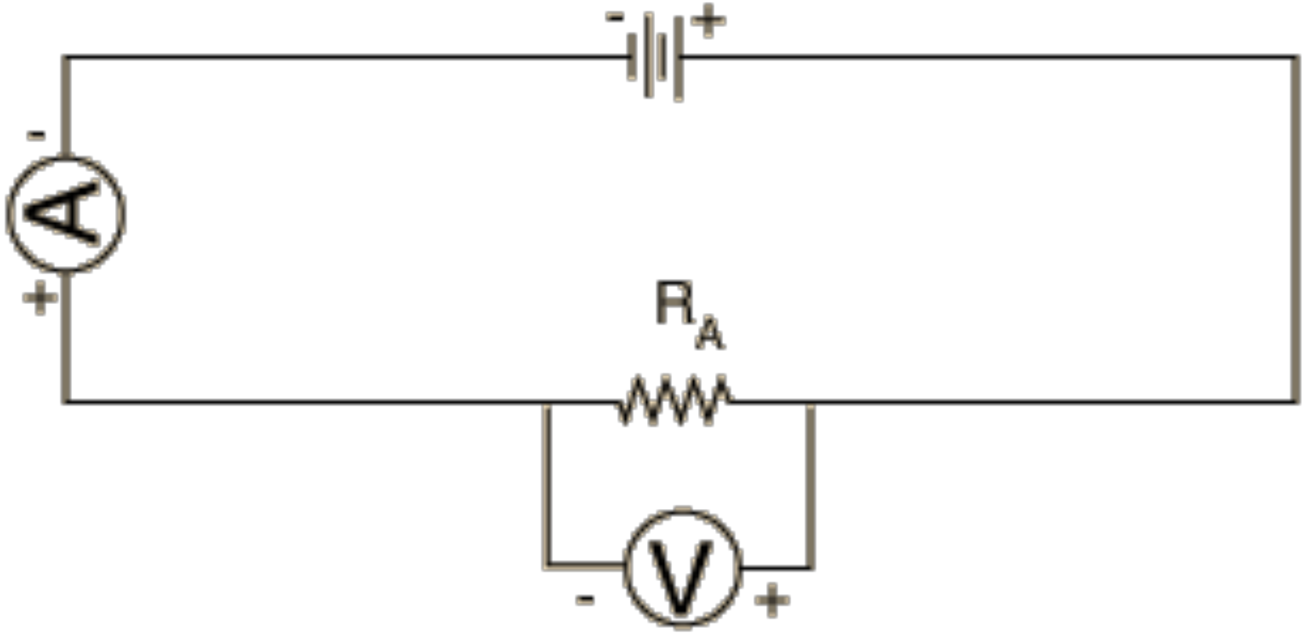
I is constant in series, so by extension, Q is constant in series

Q = CV
Series capacitors: 1/Ceq = 1/C1 + 1/C2 + 1/C3…



Determine the total capacitance of this section of a circuit

Ceq = 0.29 μF



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