Chapter 4:
Series circuits

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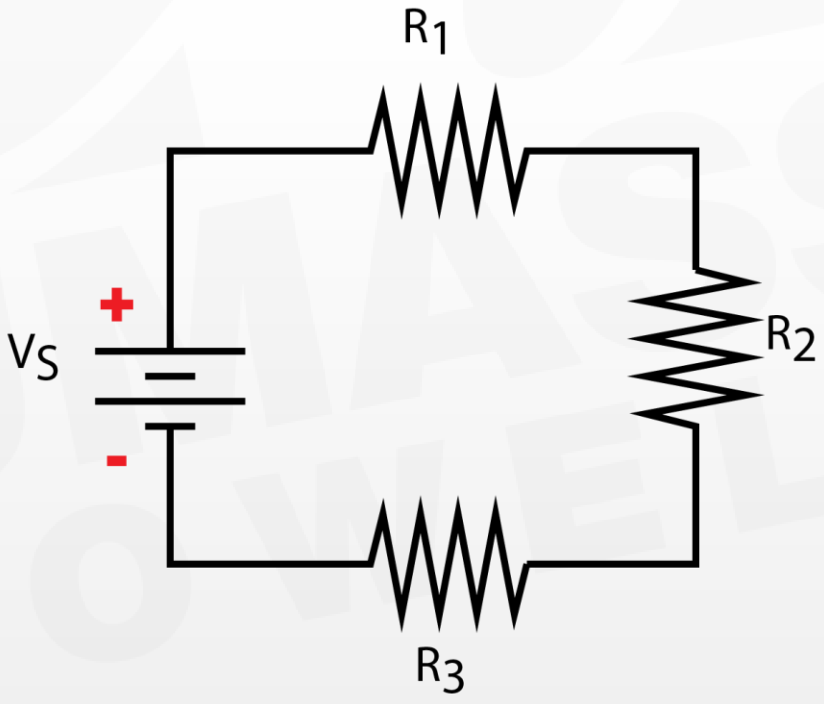
Resistors in series

Attributes

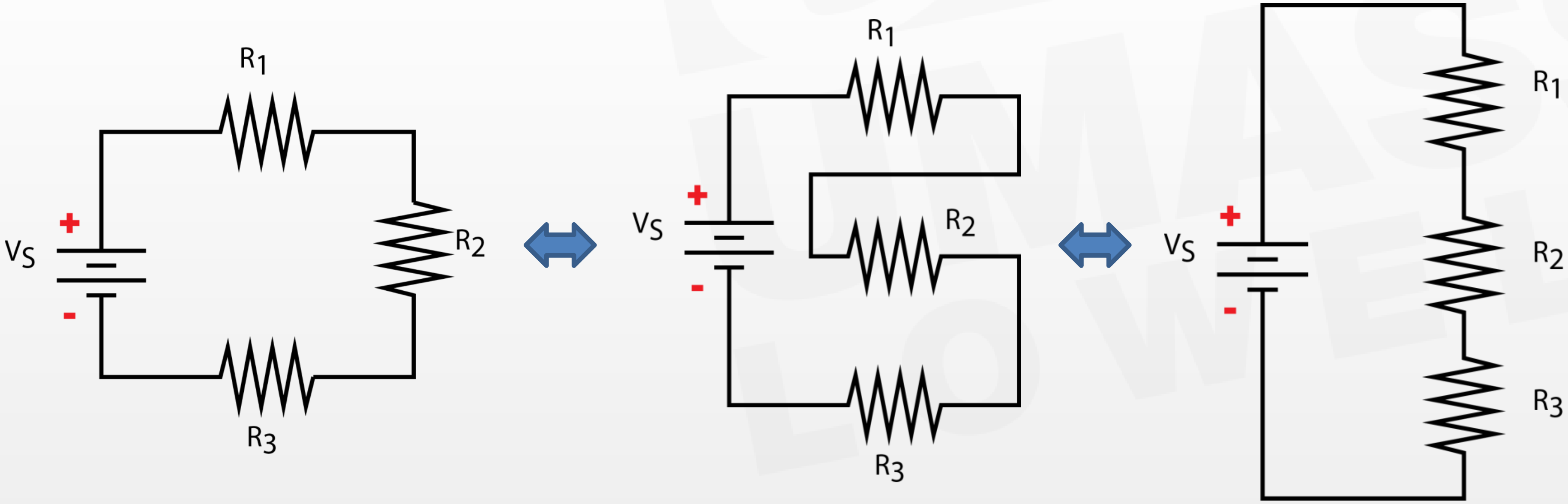
- Three common attributes
  1. A source of voltage
  2. A load
  3. A complete path



Resistors in series

One path

- A ***series circuit*** is one that has **only one current path**



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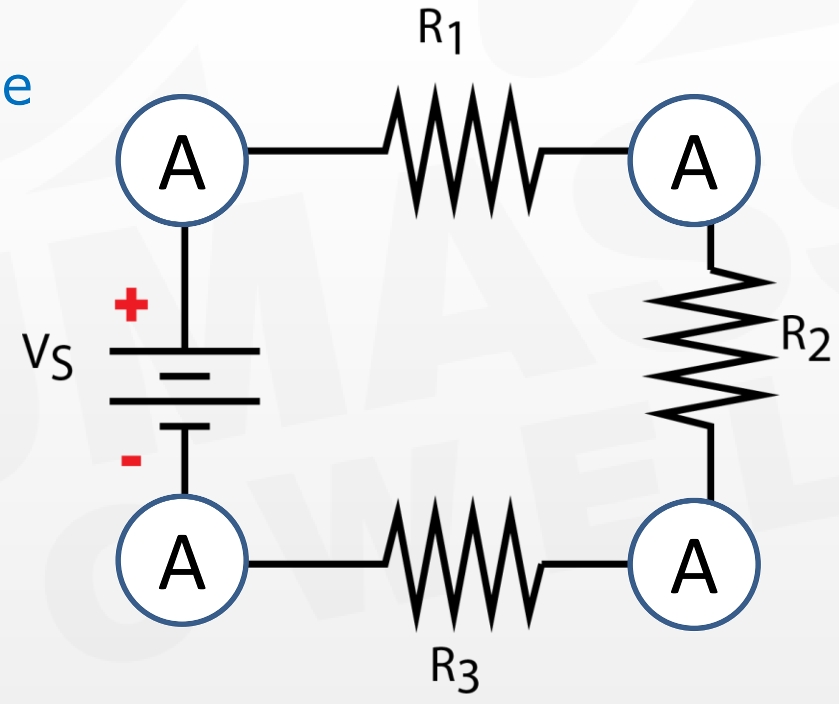
Resistors in series

Rule for current

Because there is only one path, the current everywhere is **the same**

An ammeter placed anywhere will give the **same value**

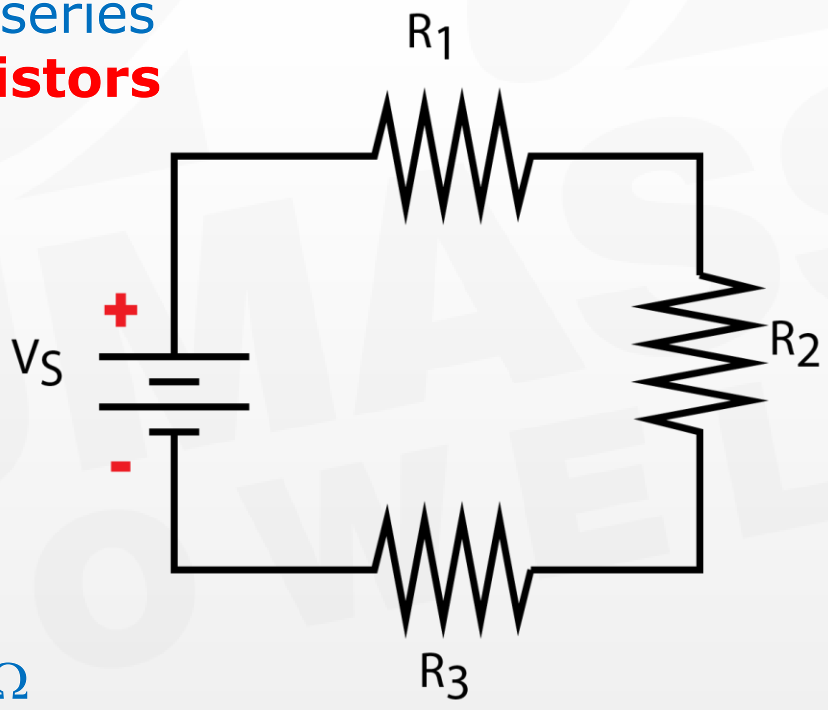


Resistors in series

Total resistance

The total resistance of resistors in series is **the sum of the individual resistors**

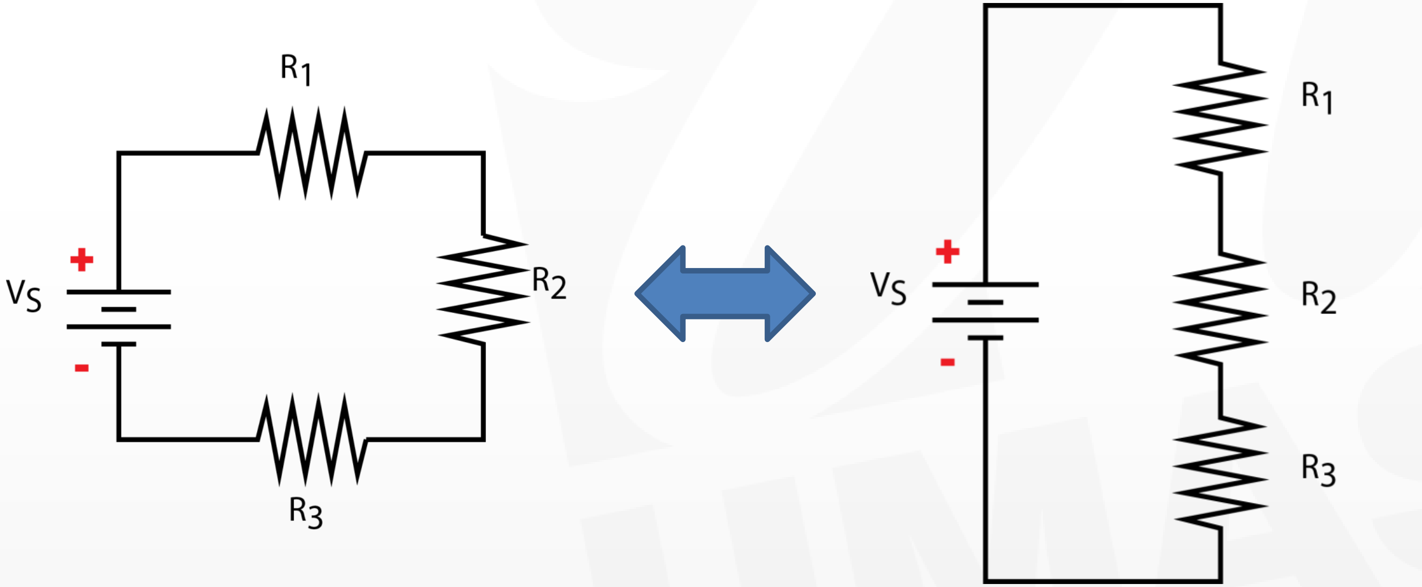
$$R_T = \sum_i R_i$$



Ex: R_1=550Ω, R_2=1.5kΩ, R_3=2.2kΩ

R_T = ?

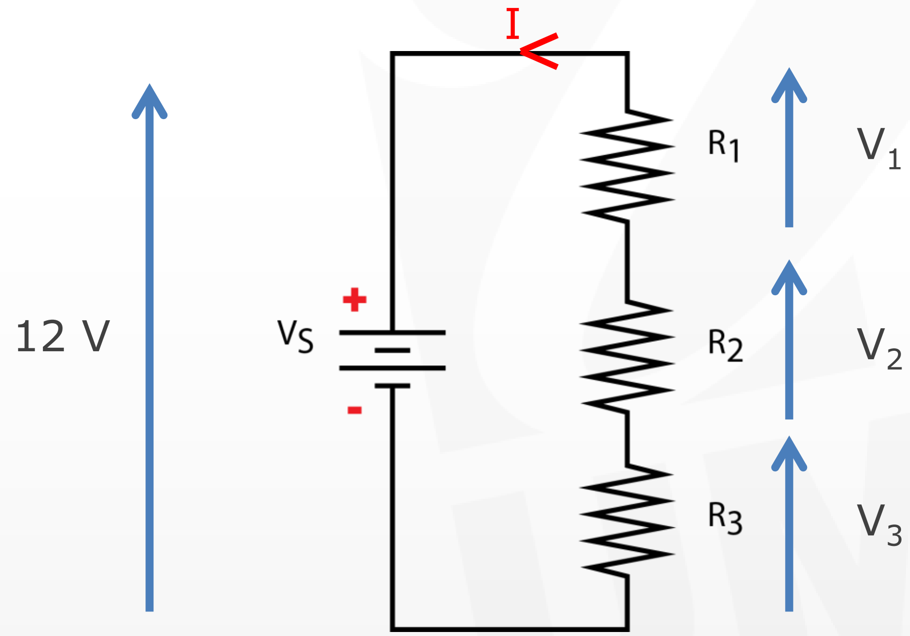
Resistors in series



These two circuits are exactly the same

The 2nd can be easier for visualization and to make calculations

Resistors in series



R_1=500Ω, R_2=1.3kΩ, R_3=2.2kΩ

R_T=

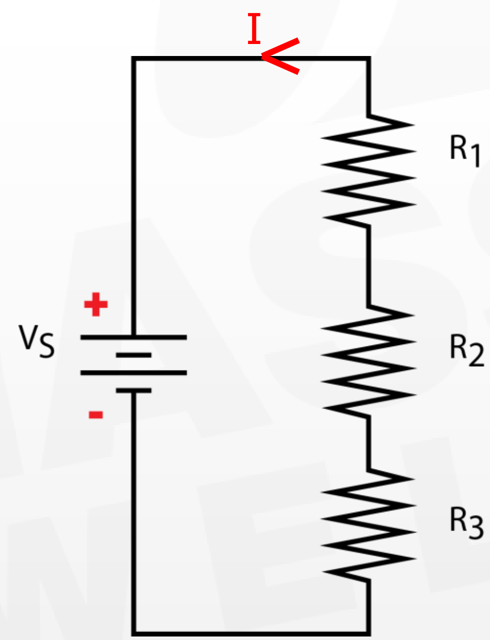
Using Ohm's law, the current is:

I =

What are V_1, V_2 and V_3?

Resistors in series

Current	Resistance	Voltage	Power
I=	R_1=500 Ω	V_1=	P_1=
I=	R_2=1.3 kΩ	V_2=	P_1=
I=	R_3=2.2 kΩ	V_3=	P_1=
I= 3 mA	R_T=	V_T=12 V	P_T=



Kirchhoff's voltage law

Kirchhoff's voltage law (KVL):

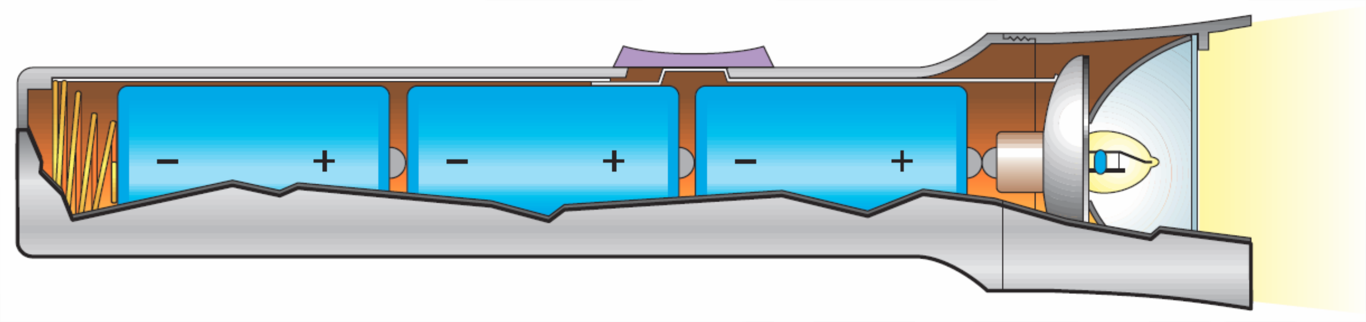
The sum of all voltage drops around a single closed path in a circuit is equal to the total source voltage in that closed path.

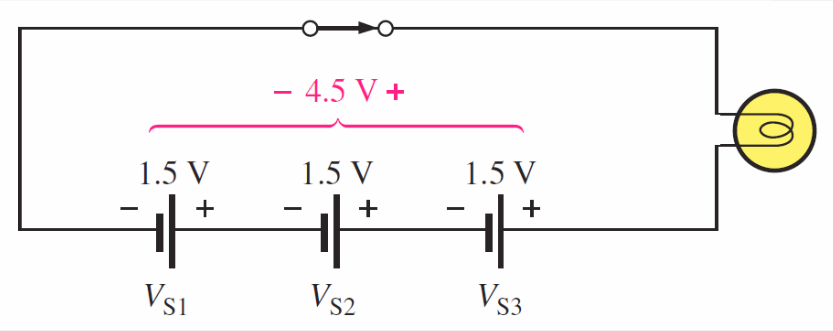
KVL applies to all circuits, but you must apply it to only one closed path. In a series circuit, this is (of course) the entire circuit

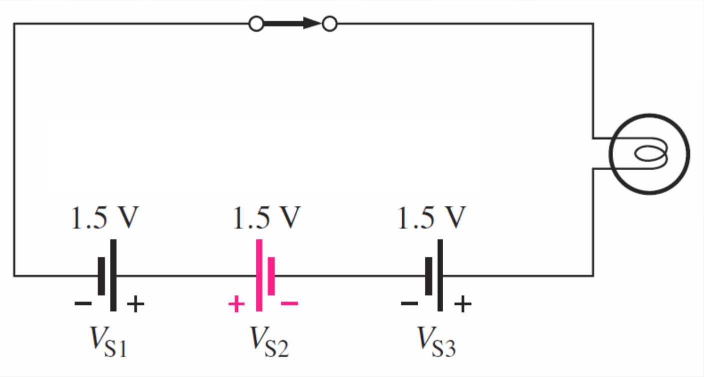
A mathematical shorthand way of writing KVL is

$$\sum_{i=1}^{n} V_i = 0$$

Voltage sources in series

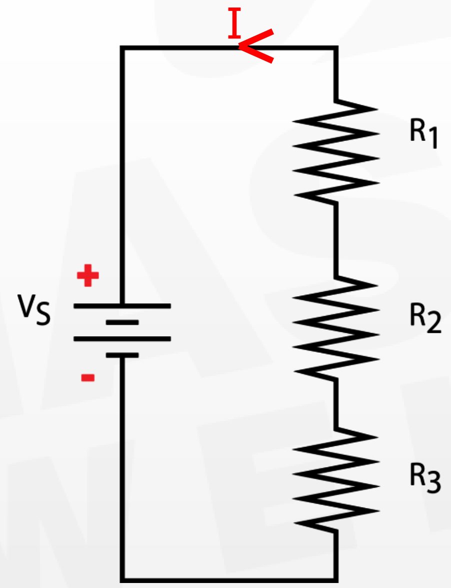






Kirchhoff's voltage law

Current	Resistance	Voltage	Power
I= 3 mA	R_1=500 Ω	V_1=1.5 V	P_1=4.5 mW
I= 3 mA	R_2=1.3 kΩ	V_2=3.9 V	P_1=11.7 mW
I= 3 mA	R_3=2.2 kΩ	V_3=6.6 V	P_1=19.8 mW
I= 3 mA	R_T= 4 kΩ	V_T=12 V	P_T=36 mW



The sum of all resistor voltages is equal to the source voltage

$$\sum_{i=1}^{n} V_i = V_1 + V_2 + V_3 - V_T = 0$$

Voltage divider rule

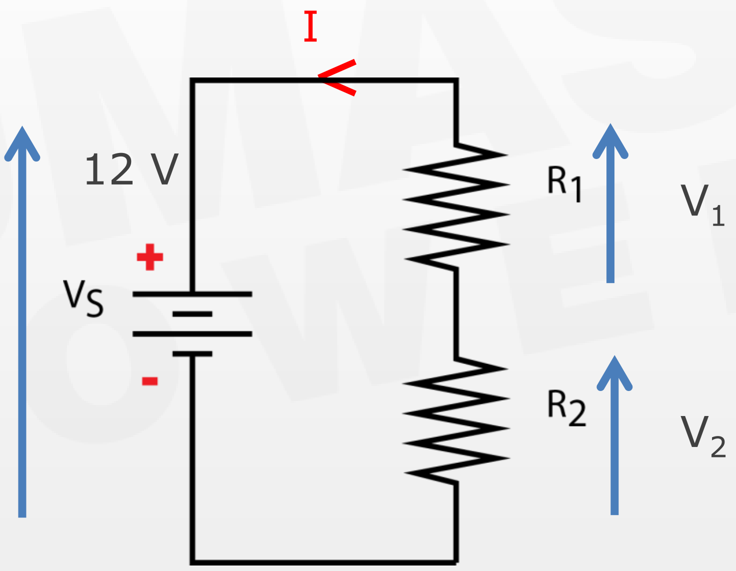
The voltage drop across any given resistor in a series circuit is equal to the ratio of that resistor to the total resistance, multiplied by source voltage

$$V_i = \frac{R_i}{R_T} V_S$$

Q 1: If R_1 is twice R_2,
What is the voltage across R_2 ?

Q2: If $R_1 = R_2$,
What is the voltage across R_2 ?

What is the power dissipated ?



Voltage measurements

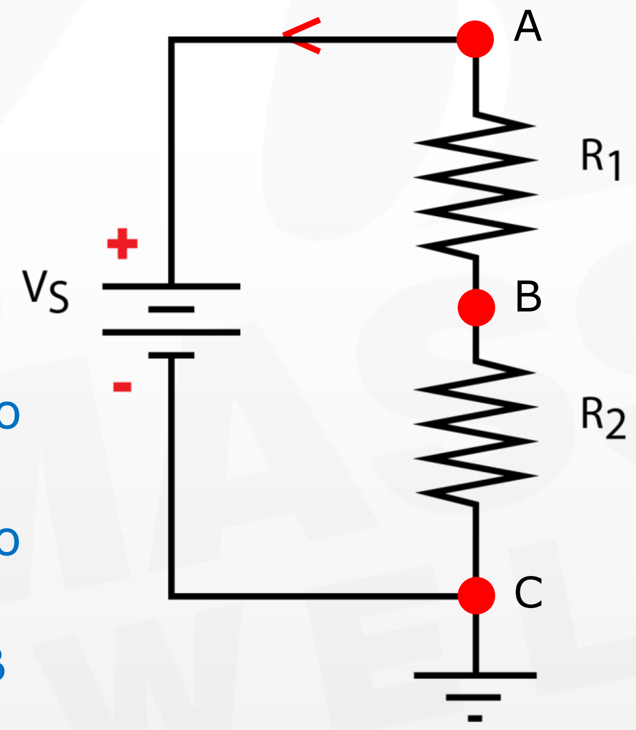
Voltage is relative and is measured with respect to another point in the circuit.

Voltages that are given with respect to ground are shown with a single subscript.

$\boldsymbol{V_A}$ means the voltage at point A with respect to ground (reference ground)

$\boldsymbol{V_B}$ means the voltage at point B with respect to ground

$\boldsymbol{V_{AB}}$ means the voltage between points A and B



With V_S=12V, R_1=5kΩ and R_2=10kΩ

V_A =

V_B =

V_{AB} =

Voltage measurements

Ground reference is not always at the lowest point in a circuit. Assume the ground is moved to B as shown.

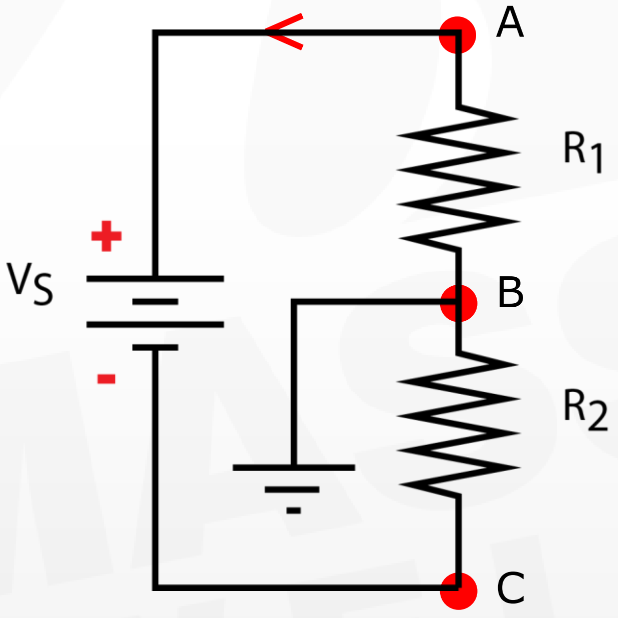
With V_S=12V, R_1=5kΩ and R_2=10kΩ

V_A =

V_B =

V_C =

Did V_{AB} changed from previous circuit ?



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