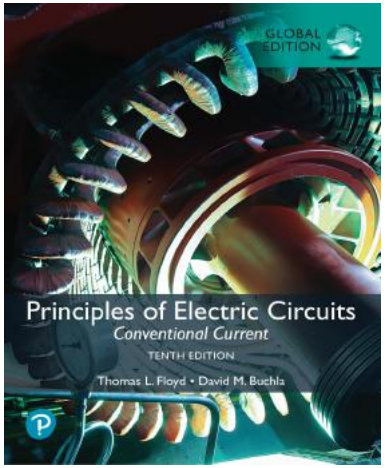
Principles of Electric Circuits: Conventional Current

Tenth Edition, Global Edition



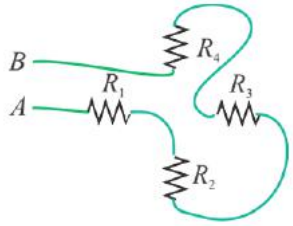
Chapter 5

Series Circuits

Summary: Resistors in series (1 of 3)

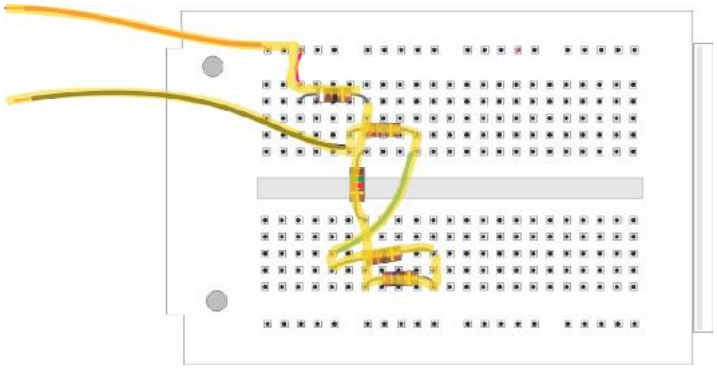
Resistors in series are connected “end to end” forming one path.

Connect the resistors in series between *A* to *B* in the order R_1, R_2, R_3, R_4.



Summary: Resistors in series (2 of 3)

Trace the single path to confirm the resistors are in series.



Summary: Resistors in series (3 of 3)

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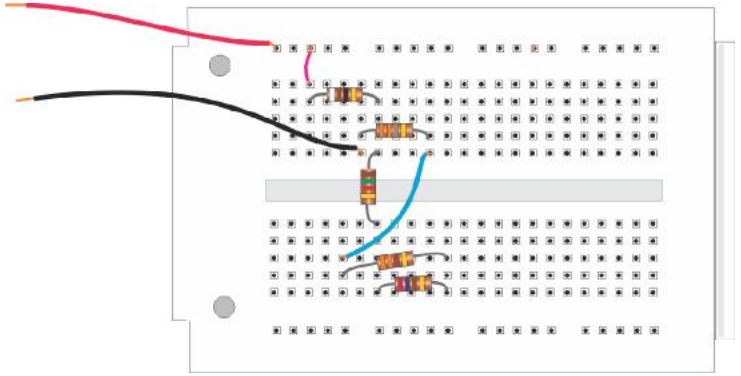


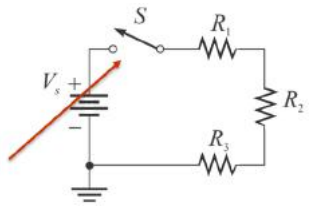
Summary: Series circuits

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

All circuits have three common attributes. These are:

1. A source of voltage.
2. A load.
3. A complete current path.

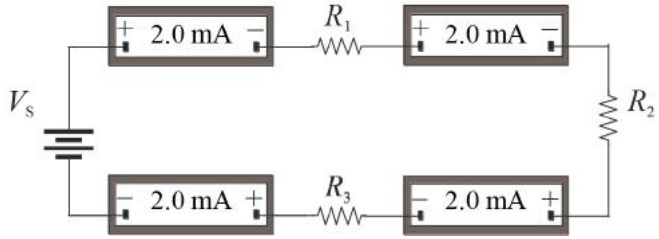
Most circuits also have a control element



Summary: Series circuit rule for current:

Because there is only one path, the current everywhere in a series circuit is: the same.

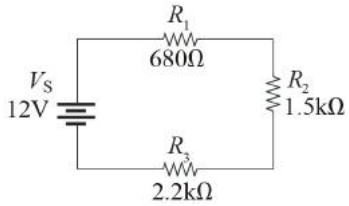
For example, the reading on the first ammeter is 2.0 mA, What do the other meters read?



Summary: Series circuits (1 of 2)

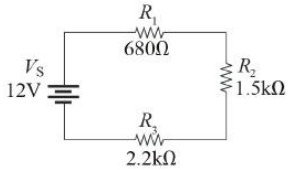
The total resistance of resistors in series is the sum of the individual resistors.

For example, the resistors in a series circuit are 680 Ω, 1.5 kΩ, and 2.2 kΩ. What is the total resistance?



4.38 kΩ

Summary: Series circuits (2 of 2)



Tabulating current, resistance, voltage and power is a useful way to summarize parameters in a series circuit.Continuing with the previous example, complete the parameters listed in the Table.

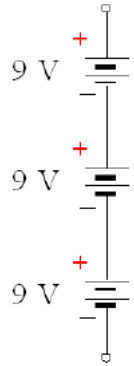
I_1= 2.74 mA	R_1= 0.68 kΩ	V_1= 1.86 V	P_1= 5.1 mW
I_2= 2.74 mA	R_2= 1.50 kΩ	V_2= 4.11 V	P_2= 11.3 mW
I_3= 2.74 mA	R_3= 2.20 kΩ	V_3= 6.03 V	P_3= 16.5 mW
I_T= 2.74 mA	R_T= 4.38 kΩ	V_S= 12 V	P_T= 32.9 mW

Summary: Voltage sources in series

Voltage sources in series add algebraically. For example, the total voltage of the sources shown is 27 V

Question:

What is the total voltage if one battery is accidentally reversed? 9 V

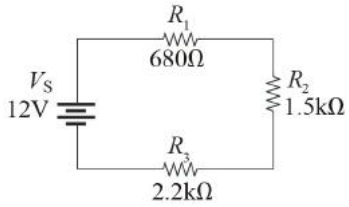


Summary: Kirchhoff's Voltage Law (KVL)

KVL is generally stated as:
The sum of all the 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.

Summary: Kirchhoff's Voltage Law



Notice in the series example given earlier that the sum of the resistor voltages is equal to the source voltage.

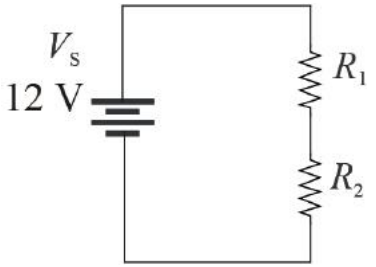
I_1= 2.74 mA	R_1= 0.68 kΩ	V_1= 1.86 V	P_1= 5.1 mW
I_2= 2.74 mA	R_2= 1.50 kΩ	V_2= 4.11 V	P_2= 11.3 mW
I_3= 2.74 mA	R_3= 2.20 kΩ	V_3= 6.03 V	P_3= 16.5 mW
I_T= 2.74 mA	R_T= 4.38 kΩ	V_S= 12 V	P_T= 32.9 mW

Summary: 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.

Question:

Assume R_1 is twice the size of R_2. What is the voltage across R_1? 8.0 V



Summary: Voltage dividers (1 of 3)

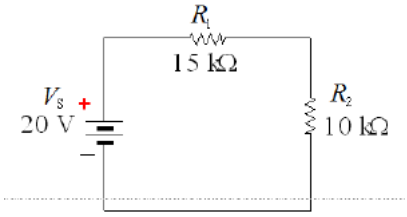
Example:

What is the voltage across R_2?

Solution:

The total resistance is 25 kΩ. Applying the voltage divider formula:

$$V_2 = V_S\left(\frac{R_2}{R_T}\right) = 20\text{ V}\left(\frac{10\text{ k}\Omega}{25\text{ k}\Omega}\right) = 8.0\text{ V}$$



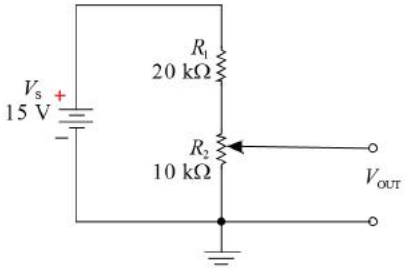
Notice that 40% of the source voltage is across R_2, which represents 40% of the total resistance.

Summary: Voltage dividers (2 of 3)

Voltage dividers can be set up for a variable output using a potentiometer. In the circuit shown, the output voltage is variable.

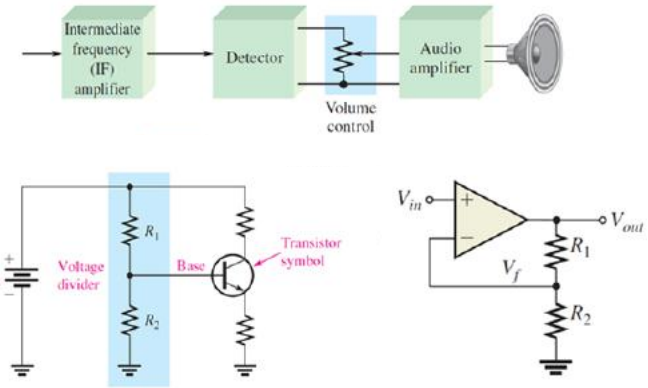
Question:

What is the largest output voltage available? 5.0 V



Summary: Voltage dividers (3 of 3)

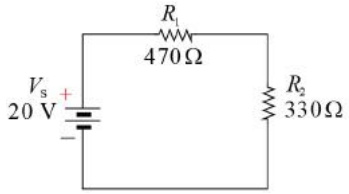
Voltage dividers are widely used in circuits. Some examples are:



Summary: Power in series circuits

Example:

Use the voltage divider rule to find V_1 and V_2. Then find the power in R_1 and R_2 and P_T.



Solution:

Applying the voltage divider rule:

$$V_1 = 20\text{ V}\left(\frac{470\ \Omega}{800\ \Omega}\right) = 11.75\text{ V}$$

$$V_2 = 20\text{ V}\left(\frac{330\ \Omega}{800\ \Omega}\right) = 8.25\text{ V}$$

The power dissipated by each resistor is:

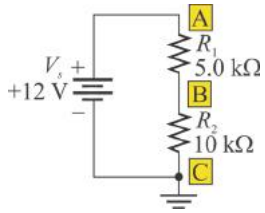
$$P_1 = \frac{(11.75\text{ V})^2}{470\ \Omega} = 0.29\text{ W}$$

$$P_2 = \frac{(8.25\text{ V})^2}{330\ \Omega} = 0.21\text{ W}$$

$$P_T = 0.5\text{W}$$

Summary: Circuit ground (1 of 2)

The term *ground* has more than one meaning. Typically it means a common or reference point in the circuit. This is called **reference ground.**



Voltages that are given with respect to ground are shown with a single subscript. For example, V_A means the voltage at point A with respect to ground. V_B means the voltage at point B with respect to ground. V_{AB} means the difference voltage between points A and B.

Question:

What are V_A, V_B, and V_{AB} for the circuit shown?

$V_A = 12$ V $\quad V_B = 8.0$ V $\quad V_{AB} = 4.0$ V

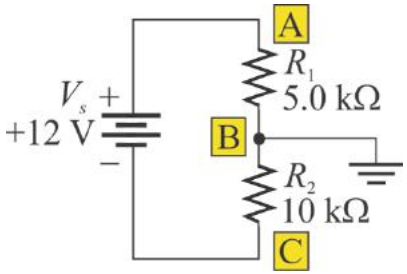
Summary: Circuit ground (2 of 2)

Reference ground changed, so that B is now the reference ground. This is the only change.

Question:

What are V_A, V_B, and V_{AB} for the circuit now?

$V_A = 4.0$ V $\quad V_B = 0$ V $\quad V_{AB} = 4.0$ V



Key Terms (1 of 2)

Circuit ground	A method of grounding whereby the metal chassis that houses the assembly or a large conductive area on a printed circuit board is used as a common or reference point; also called chassis ground.
Kirchhoff's voltage law	A law stating that (1) the sum of the voltage drops around a closed loop equals the source voltage in that loop or (2) the algebraic sum of all of the voltages (drops and source) is zero.
Open	A circuit condition in which the current path is broken.

Key Terms (2 of 2)

Series	In an electric circuit, a relationship of components in which the components are connected such that they provide a single path between two points.
Short	A circuit condition in which there is zero or an abnormally low resistance between two points; usually an inadvertent condition.
Voltage divider	A circuit consisting of series resistors across which one or more output voltages are taken.

Quiz (1 of 11)

1. In a series circuit with more than one resistor, the current is
   a. larger in larger resistors
   b. smaller in larger resistors
   c. always the same in all resistors
   d. there is not enough information to say

Quiz (2 of 11)

2. In a series circuit with more than one resistor, the voltage is
   a. larger across larger resistors
   b. smaller across larger resistors
   c. always the same across all resistors
   d. there is not enough information to say

Quiz (3 of 11)

3. If three equal resistors are in series, the total resistance is
   a. one third the value of one resistor
   b. the same as one resistor
   c. three times the value of one resistor
   d. there is not enough information to say

Quiz (4 of 11)

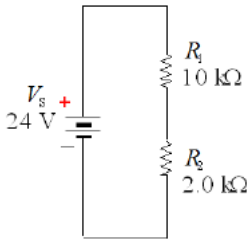
4. A series circuit cannot have
   a. more than two resistors
   b. more than one voltage source
   c. more than one path
   d. all of the above

Quiz (5 of 11)

5. In a closed loop, the algebraic sum of all voltages (both sources and drops)
   a. is 0
   b. is equal to the smallest voltage in the loop
   c. is equal to the largest voltage in the loop
   d. depends on the source voltage

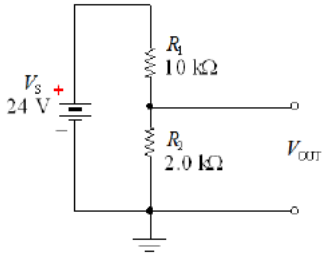
Quiz (6 of 11)

6. The current in the 10 kΩ resistor is
   a. 0.5 mA
   b. 2.0 mA
   c. 2.4 mA
   d. 10 mA



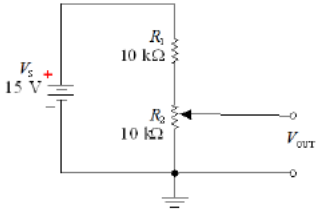
Quiz (7 of 11)

7. The output voltage from the voltage divider is
   a. 2.0 V
   b. 4.0 V
   c. 12 V
   d. 20 V



Quiz (8 of 11)

8. The smallest output voltage available from the voltage divider is
   a. 0 V
   b. 1.5 V
   c. 5.0 V
   d. 7.5 V



Quiz (9 of 11)

9. The total power dissipated in a series circuit is equal to the
   a. power in the largest resistor
   b. power in the smallest resistor
   c. average of the power in all resistors
   d. sum of the power in all resistors

Quiz (10 of 11)

10. The meaning of the voltage V_{AB} is the voltage at
    a. Point A with respect to ground
    b. Point B with respect to ground
    c. The average voltage between points A and B.
    d. The voltage difference between points A and B.

Quiz (11 of 11)

Answers:

1. c
2. a
3. c
4. c
5. a
6. b
7. b
8. a
9. d
10. d

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