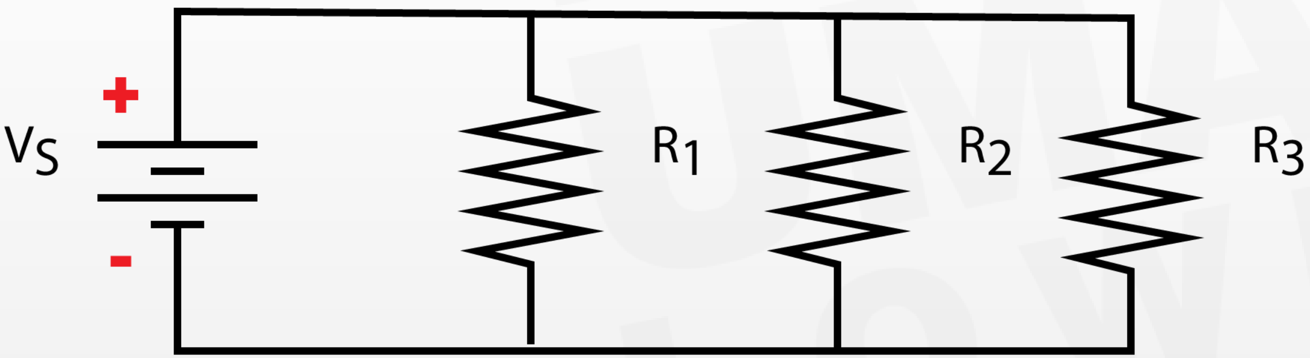
Chapter 5: Parallel circuits

Instructor: Jean-François MILLITHALER

http://faculty.uml.edu/JeanFrancois_Millithaler/FunElec/Spring2017

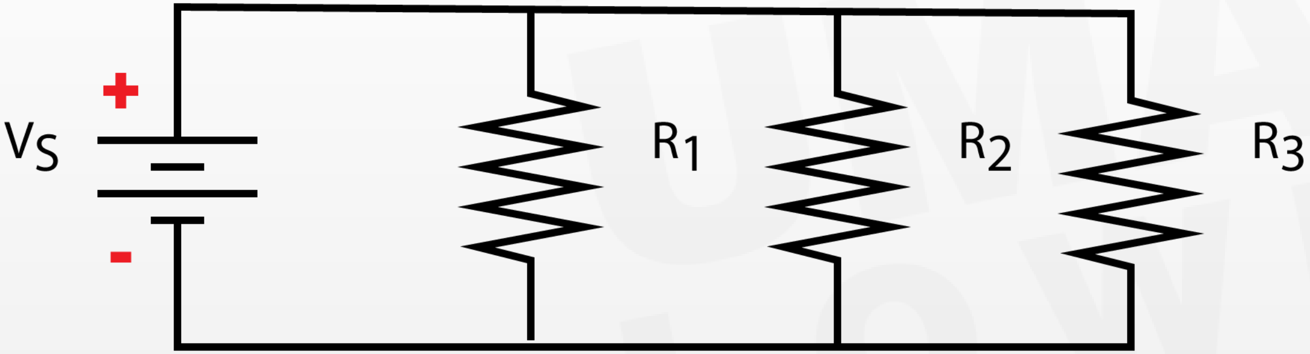
Resistors in parallel

- Resistors that are connected to the same two points are said to be in parallel.



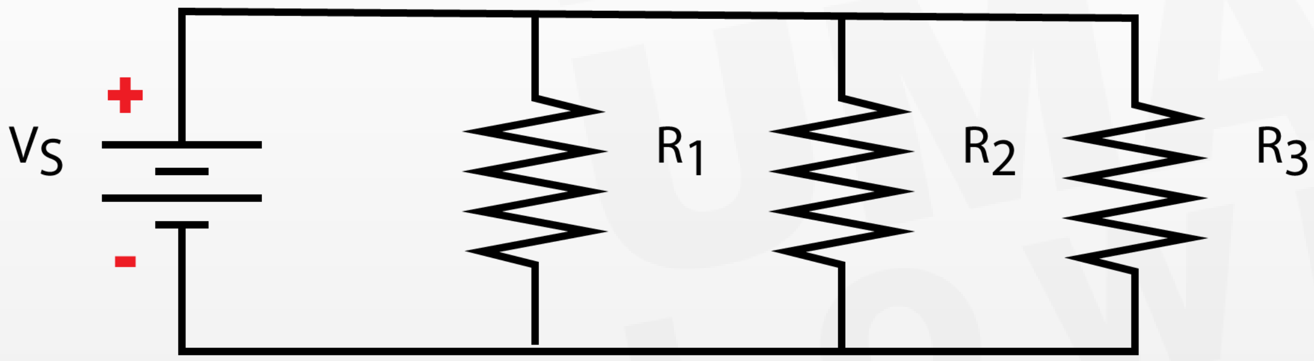
Resistors in parallel

- A ***parallel circuit*** is identified by the fact that it has more than one current path (branch) connected to a common voltage source.

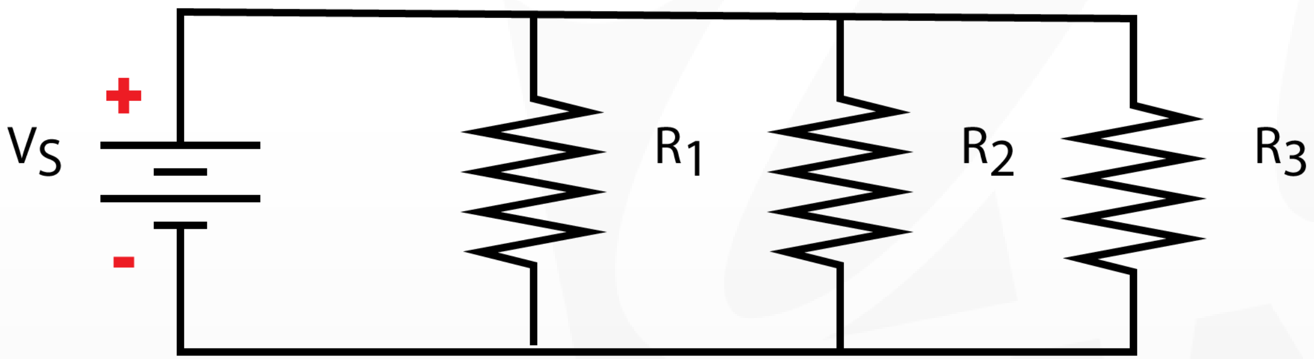


Resistors in parallel

- Because all components are connected across the same voltage source, the voltage across each is **the same**.



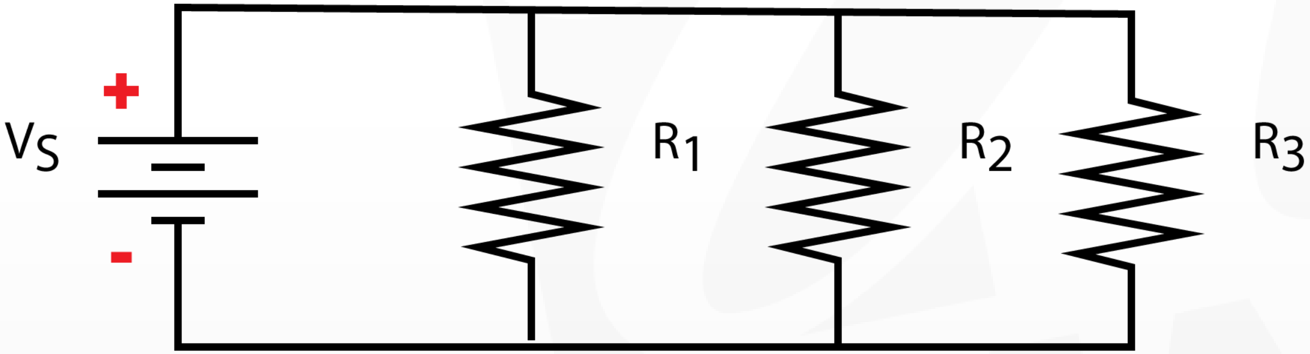
Parallel circuit



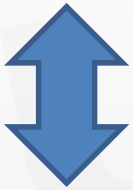
Voltage	Resistance	Current	Power
V_1=5.0 V	R_1=680 Ω	I_1=	P_1=
V_2=5.0 V	R_2=1.5 kΩ	I_2=	P_2=
V_3=5.0 V	R_3=2.2 kΩ	I_3=	P_3=
V_T=5.0 V	R_T=	I_T=	P_T=

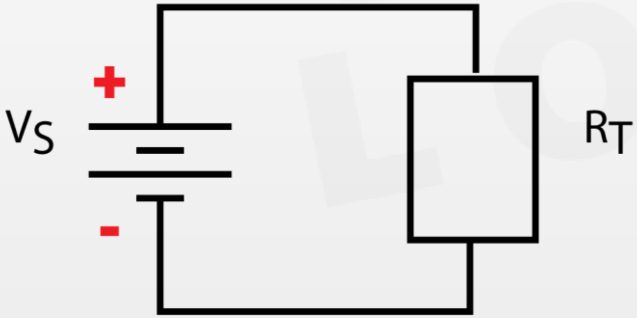
Is there a problem?

Rule for resistances



- Equivalent system

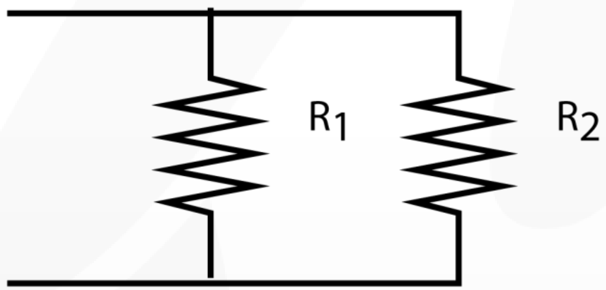




Rule for resistances

- 2 resistance in parallel

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}$$



$$R_T = \frac{R_1 R_2}{R_1 + R_2}$$

General equation

$$\frac{1}{R_T} = \sum_I \frac{1}{R_I}$$

- What is the total resistance if R_1=27kΩ and R_2=56 kΩ?

Learning with Purpose

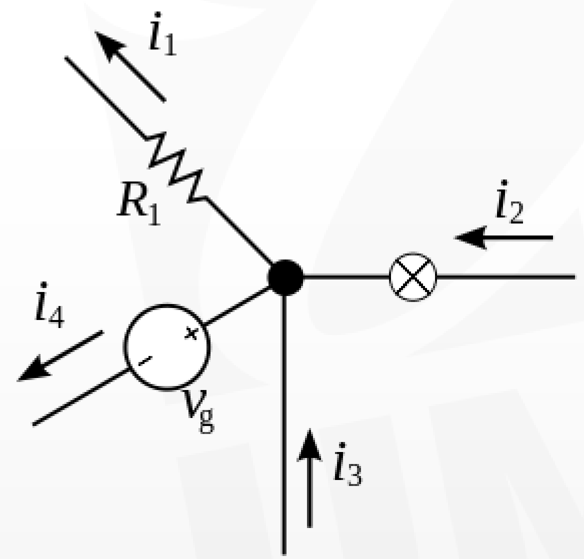
Kirchhoff's current law

Gustav Robert Kirchhoff, German physicist, 1824-1887

- Kirchhoff's current law (KCL) is generally stated as:
- The sum of the currents entering a node is equal to the sum of the currents leaving the node.

Voltage	Resistance	Current	Power
V_1= 5.0 V	R_1= 680 Ω	I_1= 7.4 mA	P_1= 36.8 mW
V_2= 5.0 V	R_2= 1.5 kΩ	I_2= 3.3 mA	P_2= 16.7 mW
V_3= 5.0 V	R_3= 2.2 kΩ	I_3= 2.3 mA	P_3=11.4 mW
V_T= 5.0 V	R_T= 386 Ω	I_T= 13.0 mA	P_T= 64.8 mW

Kirchhoff's current law



- The current entering any junction is equal to the current leaving that junction. $i_2 + i_3 = i_1 + i_4$

$$\sum_{k=1}^{n} I_k = 0$$

Current divider

- When current enters a node (junction) it divides into currents with values that are inversely proportional to the resistance values.

- The most widely used formula for the current divider is the two-resistor equation. For resistors R_1 and R_2,

$$I_1 = \left(\frac{R_2}{R_1+R_2}\right) I_T \qquad I_2 = \left(\frac{R_1}{R_1+R_2}\right) I_T$$

- Notice the subscripts. The resistor in the numerator is not the same as the one for which current is found.

Current divider

- Assume that R_1 is a 2.2 kΩ resistor that is in parallel with R_2, which is 4.7 kΩ. If the total current into the resistors is 8.0 mA, what is the current in each resistor?

$$I_1 = \left(\frac{R_2}{R_1+R_2}\right) I_T =$$

$$I_2 = \left(\frac{R_1}{R_1+R_2}\right) I_T =$$

- Notice that the larger resistor has the smaller current.

Power in parallel circuits

- Power in each resistor can be calculated with any of the standard power formulas. Most of the time, the voltage is known, so the equation $P = \frac{V^2}{R}$ is most convenient.

- As in the series case, the total power is the sum of the powers dissipated in each resistor.

- What is the total power if 10 V is applied to the parallel combination of R_1 = 270 Ω and R_2 = 150 Ω?

Exercise

- Assume there are 8 resistive wires that form a rear window defroster for an automobile.
- If the defroster dissipates 90 W when connected to a 12.6 V source, what power is dissipated by each resistive wire?
- What is the total resistance of the defroster?