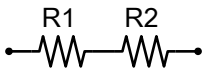
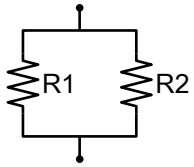
Worksheet: Parallel Resistance

1. The diagram to the right shows two resistors, R1 and R2, connected in ***series***. In the box next to the diagram, write the formula to calculate the combined resistance, R_T, that results from this configuration.



2. The diagram to the right shows two resistors, R1 and R2, connected in ***parallel***. Choose two resistors that have resistance values between 100Ω and 1000Ω. Measure and record their values in the table below. Then measure the combined resistance of the two resistors in a parallel configuration.

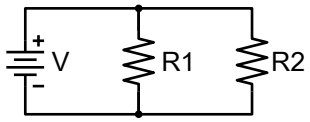


Parallel Resistors

R1	R2	R_T

Note: The total resistance in a parallel circuit is *always* smaller than the smaller of the two component resistors.

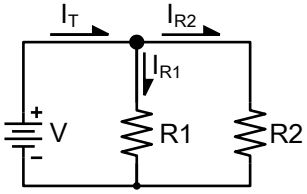
3. Parallel resistors connected to a power supply is shown in the diagram below. You can see that the voltage across each resistor will be the same as the voltage output by the power supply. Write the formula that expresses the current through each resistor given the voltage, V, and resistor values R1 and R2. Do not calculate any numerical value, simply write the formulas.



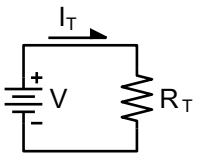
$I_{R1} =$	$I_{R2} =$

Kirchhoff's Current Law **: the sum of all currents into a node equals the sum of all currents out of the node.**

The diagram below and left shows the circuit from above, with labels for the current flowing into and out of the top node. The diagram below and right shows the same circuit, with R1 and R2 replaced with an equivalent resistor, R_T.



Two Parallel Resistors (R1, R2)



Equivalent Resistance (R_T)

Intuitively, it should be obvious that there can be no accumulation of electrons at any single point in a circuit. This includes the node where the circuit splits in to pathways: one that flows through R1 and another that flows through R2. This is *Kirchhoff's Current Law*. We can write this as an equation:

$$I_T = I_{R1} + I_{R2}$$

We can use *Ohm's law*, $I = \frac{V}{R}$, to replace each of the terms in the above equation with the equivalent values in relation to voltage. We can then factor out the voltage to get the relationship between R1 and R2, and the combined resistance, R_T.

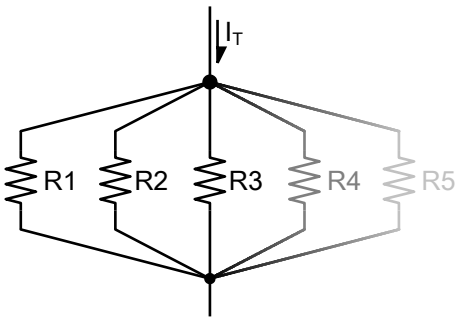
$$I_T = I_{R1} + I_{R2}; \quad \frac{V}{R_T} = \frac{V}{R1} + \frac{V}{R2}; \quad \frac{1}{R_T} = \frac{1}{R1} + \frac{1}{R2}$$

Worksheet: Parallel Resistance

This same process can be extended to any number of resistors, n, placed in parallel.

$$I_T = \sum_n I_{Rn} = I_{R1} + I_{R2} + I_{R3} + \ldots$$

$$\frac{V}{R_T} = \frac{V}{R1} + \frac{V}{R2} + \frac{V}{R3} + \ldots$$



Which simplifies to the formula you should memorize:

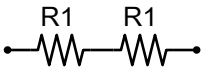
$$\frac{1}{R_T} = \frac{1}{R1} + \frac{1}{R2} + \frac{1}{R3} + \frac{1}{R4} + \ldots$$

Total Resistance for Parallel Resistors

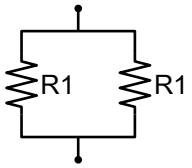
When there are only two resistors in series, the formula can be rearranged to make the calculation simpler:

$$\frac{1}{R_T} = \frac{1}{R1} + \frac{1}{R2} = \frac{R2}{R1 \cdot R2} + \frac{R1}{R1 \cdot R2} = \frac{R1 + R2}{R1 \cdot R2}; \qquad R_T = \frac{R1 \cdot R2}{R1 + R2}$$

4. Given two resistors that have the exact same value of resistance, $R1$, answer the questions, showing all the steps to simplify the equations.



Equal Resistors in Series



Equal Resistors in Series

a) Calculate the combined resistance when the resistors are in series.

$R_T =$

b) Calculate the combined resistance when the resistors are in parallel.

$R_T =$

5. Using the resistor values that you measure in question **2**, calculate the expected total resistance of those two resistors in parallel, and compare this to the total resistance you measured in the same question.

$R_T =$

6. Calculate the total resistance of the following three resistors in parallel: $2k\Omega$, $3k\Omega$, $6k\Omega$.