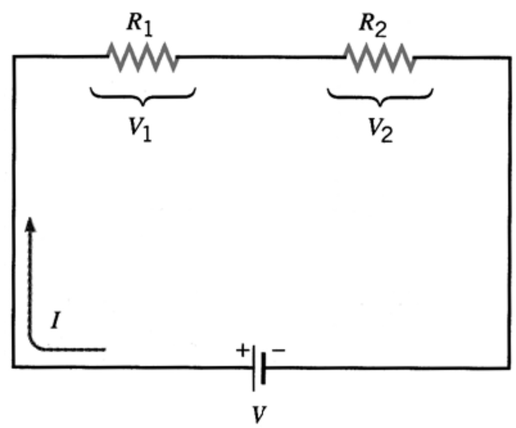
Series Circuits

Thus far, we have dealt with circuits that include only a single device, such as a light bulb. There are, however, many circuits in which more than one device is connected to a voltage source. This lesson introduces the first of two methods by which such connections may be made, namely, **series** and **parallel** wiring.

Series Wiring

Series wiring means that the devices are connected in such a way that there is the **same electric current through each device**. The diagram below shows a circuit in which two different devices, represented by resistors R_1 and R_2, are connected in series with a battery.



Note the following characteristics of devices connected in series:

- they are connected along the same current pathway
- if the current in one device is interrupted, the current in the other is also interrupted

Because of the series wiring, the voltage V supplied by the battery is divided between the two resistors. The diagram indicates that the portion of the voltage across R_1 is V_1, while the portion across R_2 is V_2, therefore,

$$V = V_1 + V_2$$

Applying Ohm's law to each resistor shows that

$$\begin{aligned} V &= V_1 + V_2 \\ &= IR_1 + IR_2 \\ IR_s &= I(R_1 + R_2) \end{aligned}$$

where R_s is called the **equivalent resistance** of the series circuit.

Thus, two resistors in series are equivalent to a single resistor whose resistance is

$$R_s = R_1 + R_2$$

This line of reasoning can be extended to any number of resistors in series, such that:

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

Example 1

A $6.00\ \Omega$ resistor and a $3.00\ \Omega$ resistor are connected in series with a $12.0\ V$ battery. Find

a) the equivalent resistance.

b) the current.

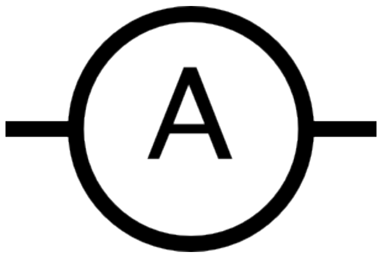
c) the power dissipated in each resistor.

d) the total power supplied by the battery.

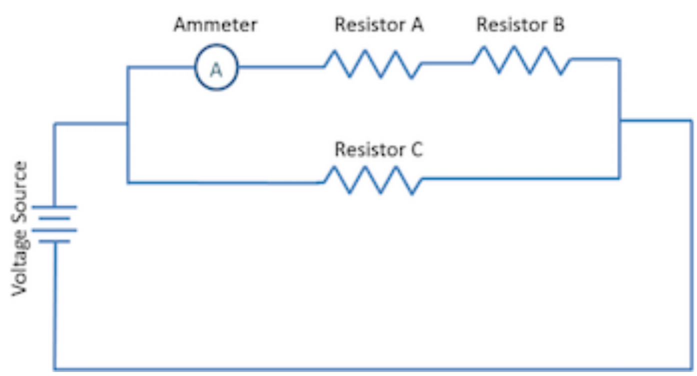
Measuring Current

An **ammeter** is a device used to measure the current in a circuit. Electric currents are measured in Amperes (A). Instruments used to measure smaller currents, in the milliampere or microampere range, are called milliammeters or micorammeters. The image on the right shows a typical ammeter.

The symbol used to represent an ammeter on a schematic diagram is shown below.



In order to measure the current that flows through a device the **ammeter must be connected in series** with the device. For example, in the circuit shown below, the ammeter is measuring the current through Resistor A and Resistor B (all 3 are in series), but not through Resistor C (not in series).



If you wanted to measure the current through resistor C, you would place the ammeter on the same branch of the circuit as resistor C. If you wanted to measure the total current in the circuit, you would place the ammeter in series with the voltage source.

Circuits Worksheet #5

1. The current in a $47\ \Omega$ resistor is $0.12\ A$. This resistor is in series with a $28\ \Omega$ resistor, and the series combination is connected across a battery. What is the battery voltage? ($9\ V$)

2. Three resistors, 25, 45, and $75\ \Omega$, are connected in series, and a $0.51\ A$ current passes through them. What is (a) the equivalent resistance and (b) the potential difference across the three resistors? ($145\ \Omega$, $74\ V$)

3. A $36\ \Omega$ resistor and an $18\ \Omega$ resistor are connected in series across a $15\ V$ battery. What is the voltage across (a) the $36\ \Omega$ resistor and (b) the $18\ \Omega$ resistor? ($10\ V$, $5\ V$)

4. A battery dissipates $2.50\ W$ of power in each of two $47\ \Omega$ resistors connected in series. What is the voltage of the battery? ($21.7\ V$)

5. Three resistors, 9.0, 5.0, and $1.0\ \Omega$, are connected in series across a $24\ V$ battery. Find (a) the current in, (b) the voltage across, and (c) the power dissipated in each resistor. ((a) $1.6\ A$ (b) $14.4\ V$, $8\ V$, $1.6\ V$ (c) $23.04\ W$, $12.8\ W$, $2.56\ W$)

6. The current in a series circuit is $15\ A$. When an additional $8\ \Omega$ resistor is inserted in series, the current drops to $12\ A$. What is the resistance in the original circuit? ($32\ \Omega$)