615-4720 (10-160) Circuit Board Simulator

Additional Materials Needed:

- Water
- Food coloring
- 12V variable DC power source

Warranty, Replacement Parts:

We replace all defective or missing parts free of charge. Additional replacement parts may be ordered toll-free. We accept MasterCard, Visa, checks and School P.O.s. All products warranted to be free from defect for 90 days. Does not apply to accident, misuse or normal wear and tear. Intended for children 13 years of age and up. This item is not a toy. It may contain small parts that can be choking hazards. Adult supervision is required.

Introduction:

The relationship between voltage, current and resistance in a circuit is defined by Ohm's law, which may be simply stated as " 'when a voltage is applied to a resistive circuit, the current in Amperes will be proportional to the voltage and inversely proportional to the resistance in Ohms". This relationship is represented mathematically by the formula: $V = I R$, where V is Volts, I is Amps and R is Ohms.

This formula can be rearranged to look like: $I = V/R$ or $R = V/I$

If you find these difficult to remember, you may find the diagram below helpful:

Simply cover the value you are looking for with your finger and the formula you need remains exposed.
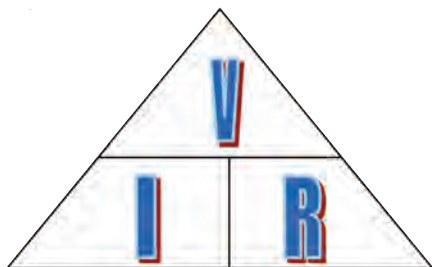
Series and Parallel Circuits:

In all circuits, combinations of components are used to achieve various effects. It is often essential to be able to work out the equivalent values of components connected together. To do this, one must be able to work out whether the components are connected in 'series', 'parallel', or a combination of both. In a series circuit, current flowing from the battery must pass through all the components. Because of this, the current is the same through all components. In a parallel circuit, the current can take a number of different paths - so currents may not be identical through various 'legs' of the circuit.
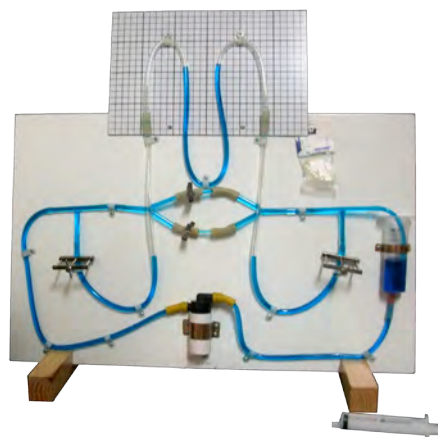
Resistors in series:

Resistors in a series circuit are simply added together to find the total resistance. In other words, a 10 ohm, 150 ohm and 1000 ohm resistor connected in series would be the equivalent of a single 1,160 ohm resistor. The formula is:
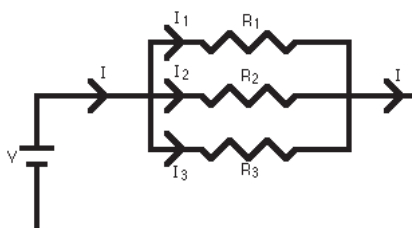
$$R_T = R_1 + R_2 + R_3 + \ldots$$
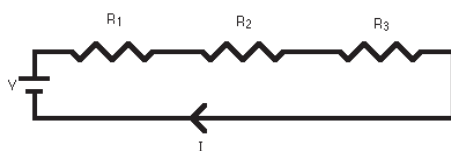
Resistors in parallel:

Resistors in a parallel circuit are a little more difficult. Here the reciprocals are added together to give the reciprocal of the total. The formula to use is:
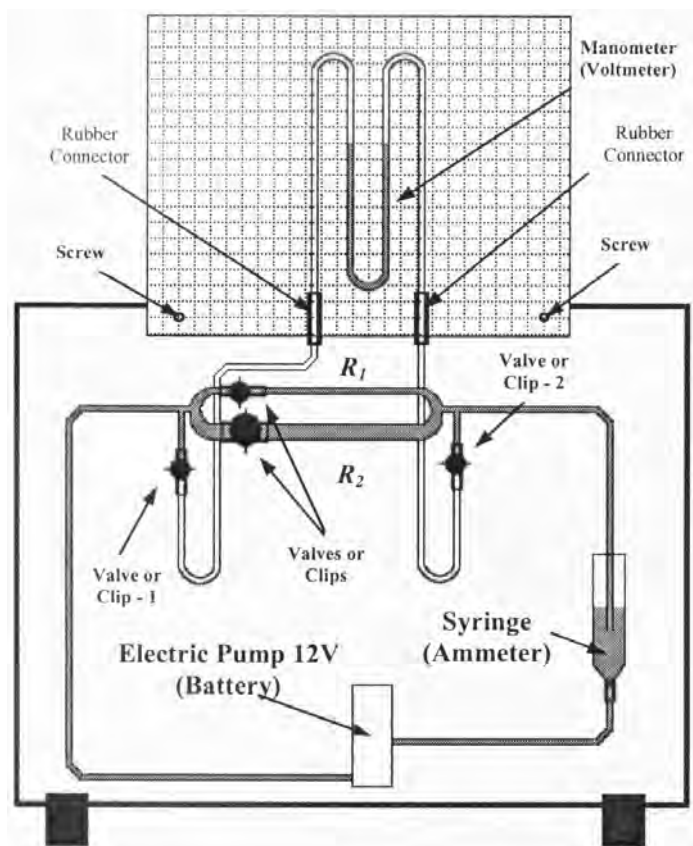
$$1/R_T = 1/R_1 + 1/R_2 + 1/R_3 + \ldots$$

The Electric Circuit Simulator:

is a working model which uses water to simulate an electric circuit and to assist in the understanding of the invisible nature of electricity. Water is pumped around a simple circuit to demonstrate movement of charge, resistors, an ammeter and a voltmeter.

Assembly Directions:

- Rest the board in its supplied feet.
- Fix the voltmeter board to the top of the main board using the screws (supplied) as shown in the diagram.
- Close valves 1 and 2 on either side of the manometer.
- Disconnect the two rubber connections on both sides of the Manometer.
- Fill the center of the manometer tube half way with water and a drop of food coloring to make it visible.
- Re-connect the manometer.
- Open valves 1 and 2.
- Connect a variable DC power supply (maximum of 12 volts) to the input terminals of the Electric Circuit Simulator water pump.
- Fill the syringe with water and a

Manometer (Voltmeter)

Rubber Connector

Rubber Connector

Screw

Screw

R_1

Valve or Clip - 2

R_2

Valve or Clip - 1

Valves or Clips

Syringe (Ammeter)

Electric Pump 12V (Battery)

drop of food coloring.
- Apply a small amount of power to the pump and begin pumping water through the circuit. The water level of the right side tube of the voltmeter (manometer) should rise higher than the left side. Do not let the level of water in the voltmeter rise completely to the top or else it will become flooded and you will have to remove the water and re-start the system.
- *It may be necessary to prime the pump the first time the unit is used. Use the included syringe plunger to force a small amount of water from the syringe through the pump. The pump will than function normally.*
- Remove any air locks in the resistors by opening and closing each valve separately.
- Do not simultaneously close both resistor valves or else the voltmeter will be flooded.
- Remove all air pockets in the circuit except for the voltmeter. Pockets of air trapped in the circuit can be moved by gently tapping the tubing.

- The system is ready to use and will stay operable as long as the syringe is 3/4 full and the outlet tube is submerged in the water.
- **The pump should not be used without water flowing through it, and it should not be overheated by running for extended periods.**

1. Demonstrate a Voltmeter:

Before the power is switched on, the water levels in the Manometer (Voltmeter) are observed to be at the same level. As the pump voltage is increased, the 'Voltmeter' registers this by an increased water level in the right hand tube, which means higher pressure on the left side. With the power switched off, there is no movement in the 'ammeter'.

The "electricity" is present at all components in the circuit the instant the power is switched on; i.e. there is no delay between switching the power on and the charge arriving at the various components in the circuit. This can be demonstrated by the fact that the

level of the water in the 'voltmeter' is rising immediately.

The unit demonstrates the need for connecting voltmeters in parallel and ammeters in series by showing that the 'ammeter' (which is in series) must actually be part of the circuit for it to work. The water has to flow through it just like the current flows through a real ammeter. If the 'ammeter' is broken or incorrectly connected, the circuit will not work just like it would not work in a real situation. It also shows that a voltmeter (connected in parallel is not actually part of the circuit and has little effect on the circuit. This can be clearly seen as no water flows through the 'voltmeter'.

2. Demonstrate resistance:

The Electric Circuit Simulator contains two 'resistors' in parallel. At one point, the tube divides. The two sections represent different resistances: one tube has a much thinner bore than the other. Clips enable one or the other or both sections to be opened or the flow through them adjusted: thus the effect on the current of different 'resistances' can be seen. If the resistance of either of them is increased, the 'voltmeter' clearly demonstrates that the 'voltage drop' across them also increases, just like it would in a real electrical circuit.

Circuit Board Simulator Curriculum
Content: *interactions of energy and matter. Content standards C and D.*
Grades 5-8: *Transfer of energy*
Grades 9-12: *Conservation of energy, interactions of energy and matter.*