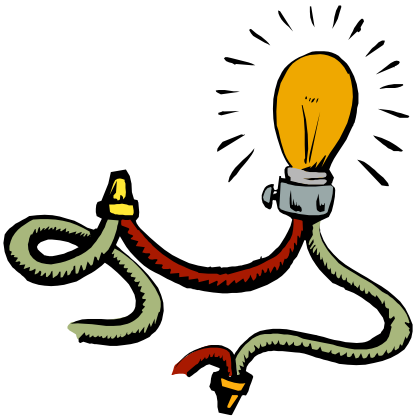
Series and Parallel Circuits

Foundations in Engineering – WV Curriculum



Current and Resistance

Electrons moving in a wire (current) are similar to water moving in a pipe. If there are clogs in the pipe, the water will run slower. The same thing happens in an electrical component, because of the material it is made of. Some components are made of materials that resist the flow of electrons better than others. This is called **resistance**. All materials have some level of resistance – the ones that resist electricity well are called **insulators**, and the ones that allow electricity to flow freely are called **conductors**. A light bulb is a resistor, and the wire inside the light bulb has so much resistance that it actually heats up and glows from the electrons passing through it!

Current and Voltage

Just like the water flow in the pipe needs a source of water (river, dam, ocean), the flow of electrons (current) needs a source of free electrons, which can be either a generator or a battery. A battery functions like a water storage tank. A chemical reaction within the battery releases electrons, which collect at the negative terminal of the battery. When a wire is connected to allow them to flow, the electrons flow toward the positive terminal to try to "balance out." This is called **potential difference**. Some of the electrons lose or change their form of energy in the circuit, (like the heat from the light bulb), but others flow through the battery again and are re-energized. The difference between the electrons at the two terminals is measured in **volts**, so potential difference is known as **voltage**.

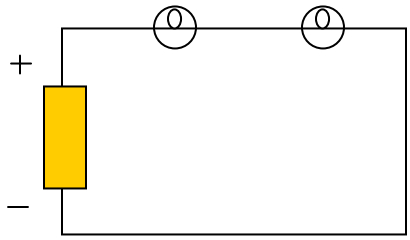
Electrical Symbols

Since we cannot see electricity, we must rely on diagrams of circuits and electrical devices. Pictorial drawing can be confusing, so symbols are used to show exactly what is in the circuit. Electrical drawings made with symbols are called **schematic drawings**. Refer to **Handout 10-1-1** for common schematic symbols, and **Transparency TM 10-1-1** to explain the meaning of the various parts of a schematic drawing.

Electrical Circuits

A **circuit** is a series of conductors and electrical components that electrical current moves through. The word **circuit** means a circle. Electricity flows in a circle. It both moves from and returns to its source. In this illustration, the battery terminals are connected by a conductor and two lamps. The conductor

and lamps allow electrons to flow through the circuit from the negative terminal to the positive terminal, in a complete circle.

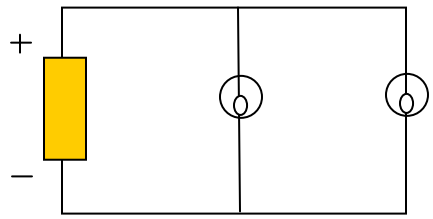


Types of Circuits

A **series circuit** provides only one path for current flow through a conductor and a variety of resistors (components). If the circuit is interrupted or broken, no electricity will flow. For example, if one of the light bulbs in the illustration above burns out, current will stop flowing.

An interruption of current flow is called an **open circuit**. An open circuit anywhere in a series circuit will cause the whole system to go dead. For example, a switch connected in series allows you to control the whole circuit. When you turn the switch on, current flows though the circuit. When you turn the switch off, current flow stops.

Parallel circuits have more than one path for current flow. With this type of circuit, current can flow equally along different paths. A parallel circuit can be open at one point yet continue to conduct electricity. In the illustration below, if one bulb burns out, the other bulb will keep burning. Current will flow as long as it has a complete path to follow.



Activity

1. Load 10 computers with Crocodile Clips 3 Elementary Edition (download from site http://www.crocodile-clips.com/education/m6_4.htm). Have 10 sets of basic electrical components available for students to experiment with. (FiE uses the Tronix kits).

2. Go over the basic principles of current, resistance and voltage, using the background information.

3. Explain how to read schematic drawings using **Transparency TM 10-1-1** and **Handout 10-1-1**.

4. Have groups of two students sit at a computer with Crocodile Clips loaded. They should also have an electricity kit with them.

5. Explain how to use the Crocodile Clips software to access lessons and to create circuits, and how to use electricity components to construct circuits (**Transparency TM 10-1-2** and **10-1-3**).

6. Pass out **Handouts 10-1-2** and **10-1-3** and assist students as they complete the questions and activities.

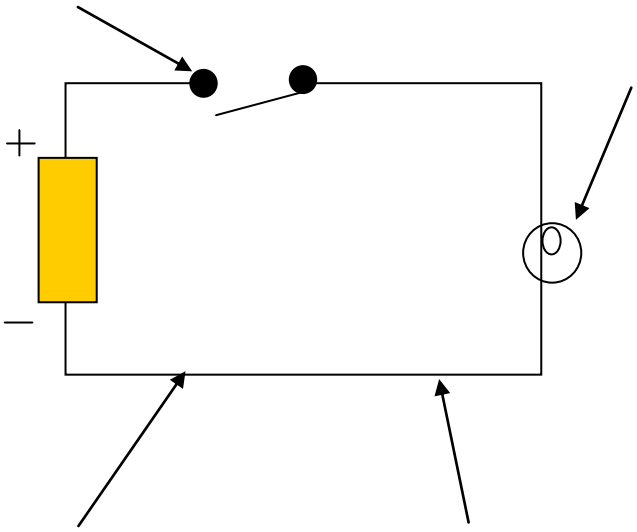
7. Review the answers and solutions to the open ended problems created in class.

Reading Schematic Diagrams

Transparency 10-1-1

Symbols are used to represent electrical and electronic components.

Symbols are positioned to make the drawing easy to read, and do not necessarily represent the physical position of the component in the actual circuit.



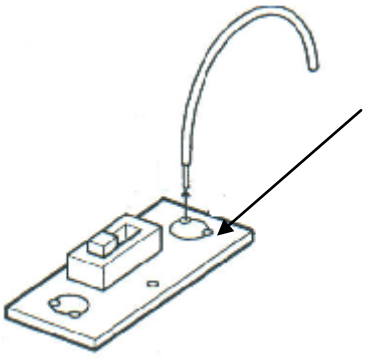
The length of the line does not represent the actual length of the wire needed to make the connection.

The lines between one component and another represent the connection between them, and are drawn as straight lines.

Using Tronix Components
Transparency 10-1-2

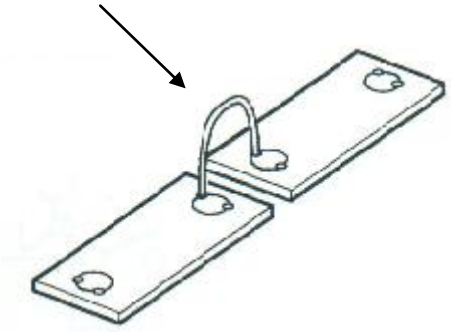
Making Connections

1mm solid copper wire is used for connections. Strip about 3mm of insulation from both ends of wire.

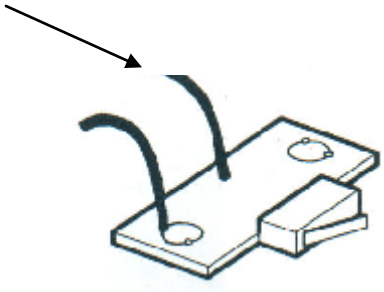


Push the wire into the socket on the component.

Looping the wire makes it easier to insert and remove connections.



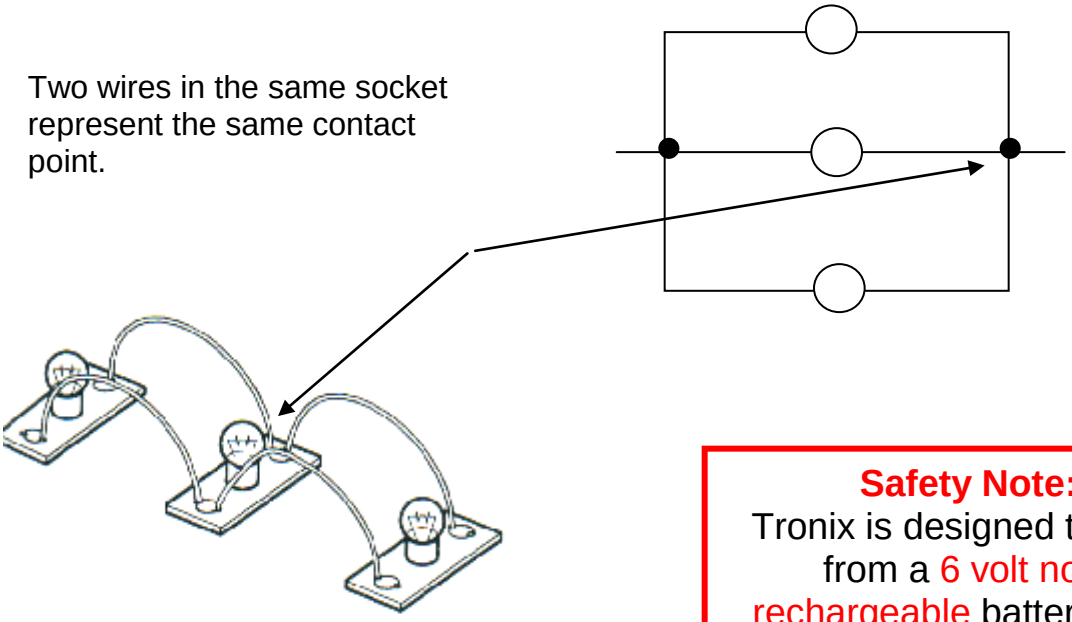
Some Tronix components also have sockets in other places.



Using Tronix Components
Transparency 10-1-3

Making Connections continued

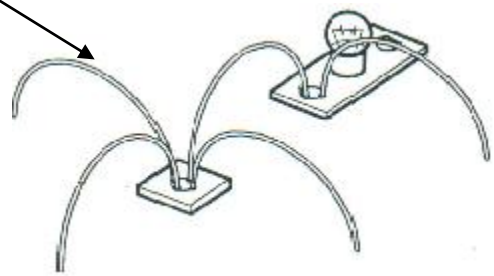
Two wires in the same socket represent the same contact point.



Safety Note:
Tronix is designed to work from a 6 volt non-rechargeable battery. It is safe to operate with non-rechargeable batteries up to 9 volts.

If using a rechargeable battery or a power supply unit, you **MUST** include a 200 mA fuse connected in series with the battery.

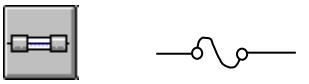
If more than 3 wires need to connect at one place, use a Tronix Extender.



Common Schematic Symbols

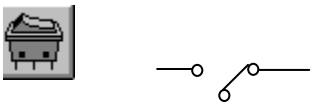
Handout 10-1-1

1.5 volt, 9 volt battery

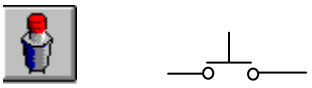


fuse

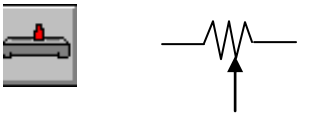
single pole single throw switch



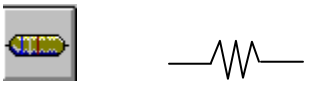
single pole double throw switch (3 way)



push button switch

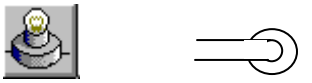


sliding switch (variable resistor/potentiometer)

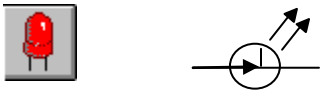


resistor

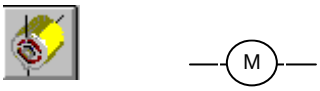
buzzer



lamp



light emitting diode (LED)



motor

Crocodile Clip (delete component key)

Series Circuits
Handout 10-1-2

1. Open Crocodile Clips software, and click on the “Series Lamps. ”

    a. Are lamps A, B and C brighter or dimmer than lamp D?

    _____

    b. Can you explain why?

    _____

    c. What would happen to lamps A and B if lamp C was broken?

    _____

2. Write a statement that summarizes what you have just discovered about the relationship between current and resistance in a series circuit.

    _____
    _____

3. Click on “Home,” then on “Create a Circuit.” Create a circuit with one lamp, a switch and a 1.5-volt battery. Can you find a way to make the lamp shine more brightly? (HINT: See “Batteries” section for more information).

    _____

4. Write a statement that summarizes what you have discovered about voltage.

    _____
    _____

5. You have been asked to design a plush animal for a toddler that has a nose that glows brightly when he is happy and glows dim when he is sad. Use Tronix components, including a single pole double throw switch.
   (HINT: See “Quiz” section for information on how a double throw switch works.)

Series Circuits

Handout 10-1-2 Answer Key

1. Open Crocodile Clips software, and click on the “Series Lamps. ”

   a. Are lamps A, B and C brighter or dimmer than lamp D?
   Dimmer

   b. Can you explain why?
   Lamps are providing resistance.

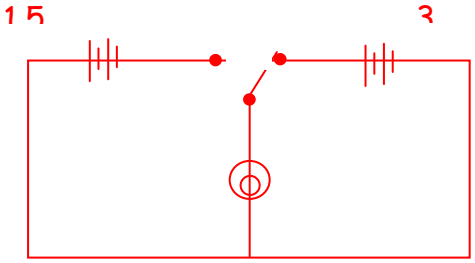
   c. What would happen to lamps A and B if lamp C was broken?
   They would get brighter.

2. Write a statement that summarizes what you have just discovered about the relationship between current and resistance in a series circuit.
   The higher the resistance, the lower the current. The lower the resistance the higher the current.

3. Click on “Home, ” then on “Create a Circuit. ” Create a circuit with one lamp, a switch and a 1.5-volt battery. Can you find a way to make the lamp shine more brightly? (HINT: See “Batteries” section for more information.)
   Add another battery (more voltage)

4. Write a statement that summarizes what you have discovered about voltage.
   Voltage can be increased by adding batteries in series. Increase the voltage, and the current is increased.

5. You have been asked to design a plush animal for a toddler that has a nose that glows brightly when he is happy and glows dim when he is sad. Use Tronix components, including a single pole double throw switch.
   (HINT: See “Quiz” section for information on how a double throw switch works.)



Parallel Circuits
Handout 10-1-3

1. Open Crocodile Clips software, and click on the "Parallel Lamps."

    a. Are lamps A, B and C brighter or dimmer than lamp D? _____

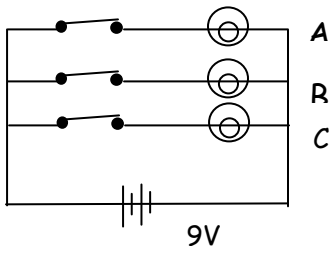
    b. Is the current through lamp D less than through lamp A? (To check this, hold the mouse over the lamp and read the amps.) _____

    c. What do you think would happen to lamps A and B if lamp C was broken?

    _____

2. A hospital has a room with four beds in it. If one of the patients needs attention they can flip a switch that turns on a light in the nurse's office. Design a system for doing this. Remember, more than one patient could need help at the same time. Use Tronix components.

3. Click on "Home," then on "Create a Circuit." Create the circuit below with three lamps, three switches and a 9-volt battery.



    a. Turn on switch A. What happens?

    _____

    b. Turn on switch B. What happens?

    _____

4. Compare the brightness of lamps A and B. Can you explain why?

    _____

5. Compare the brightness of lamp A before and after you turn on switch B.

_____

6. Turn off switch B, and measure the current from the battery (by holding the mouse pointer over it) when only lamp A in on.

_____

7. Now turn on switch B and measure the current drawn from the battery.

_____

8. Finally, measure the current when all three lamps are on.

_____

9. Write a statement that summarizes what you have discovered about current in parallel circuits.

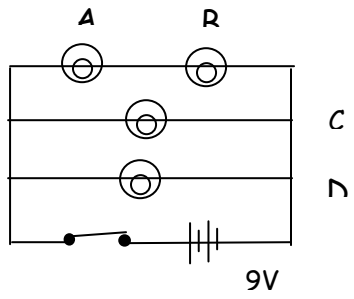
_____

_____

10. Using what you have just learned, describe the brightness of each bulb in the circuit shown below.

_____

_____



Parallel Circuits

Handout 10-1-3 Answer Key

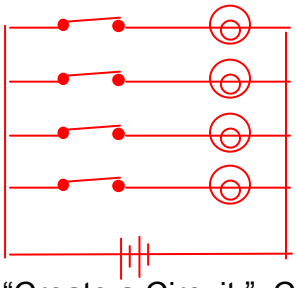
1. Open Crocodile Clips software, and click on the "Parallel Lamps."

   a. Are lamps A, B and C brighter or dimmer than lamp D? No

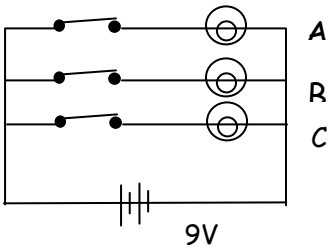
   b. Is the current through lamp D less than through lamp A? (To check this, hold the mouse over the lamp and read the amps.) No

   c. What do you think would happen to lamps A and B if lamp C was broken?
   They would stay the same

2. A hospital has a room with four beds in it. If one of the patients needs attention they can flip a switch that turns on a light in the nurse's office. Design a system for doing this. Remember, more than one patient could need help at the same time. Use Tronix components.



3. Click on "Home," then on "Create a Circuit." Create the circuit below with three lamps, three switches and a 9-volt battery.



   a. Turn on switch A. What happens?
   Lamp A lights up

   b. Turn on switch B. What happens?
   Lamp B lights up. Lamp A stays on.

4. Compare the brightness of lamps A and B. Can you explain why?
   Same brightness, because the voltage across them is the same.

5. Compare the brightness of lamp A before and after switch B is turned on.
   Same brightness, because the voltage across them is the same.

6. Turn off switch B, and measure the current from the battery (by holding the mouse pointer over it) when only lamp A in on.
   481 ma

7. Now turn on switch B and measure the current drawn from the battery.

8. Finally, measure the current when all three lamps are on.
   1.44 A or 1440 ma

9. Write a statement that summarizes what you have discovered about current in parallel circuits.
   The overall current drawn from the battery increases as more lamps are added into a parallel circuit.

10. Using what you have just learned, describe the brightness of each bulb in the circuit shown below.
    Lamps A and B will be the same brightness; lamps C and D will be the same brightness; but A and B will be half as bright as C and D.