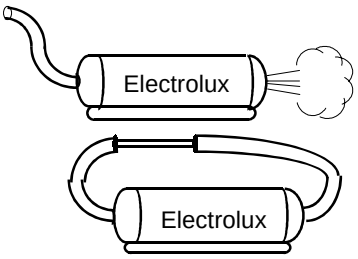
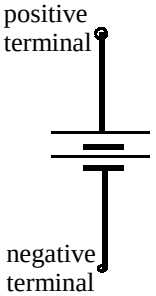
A. Fluid Currents and Electric Currents

1. When water flows downward from a faucet it sometimes forms a smooth, tapered stream.
   a. How does the number of pints per minute flowing through the wide part of the stream (at the top) compare with the number of pints per minute through the narrow part at the bottom? ____
   b. What causes the speed of the water to change as it falls? _____
   c. The speed of the water is greatest in the _____ part of the stream. (wide, narrow)
   d. Are 1a & 1c true for *all* continuous streams of fluid? _____

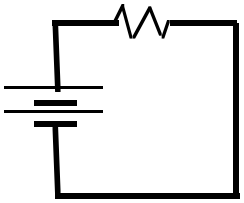


2. A vacuum cleaner is an air pump. It tries to pull air ***in*** through one end and to blow it ***out*** the other end. Imagine a vacuum cleaner with a hose connecting one end to the other, forming a complete path or "circuit" for the air to follow. Part of the path is a narrow segment of tubing:
   a. The vacuum cleaner causes air to flow _____ that tubing. (of, by, through, at, across, purple, cut) Draw arrows on the hoses in both diagrams to indicate the *direction* of that flow.
   b. As in #1, air will move faster in the _____ part of the tubing than in the _____ part. (wide, narrow)
   c. Do you expect the RATE of air flow (in molecules per second) to be greater in one section than another? ___ -Must that rate be *uniform* throughout the circuit? ___ -Does 1a agree? ___
   d. Does 2c agree with 1a & 1b? _____ (If not, please explain.)
   e. Is the "air flow rate" in 2c the same as the "speed" of the air? __ -Do they have similar units? ____
   f. Causing air to flow through the _____ tubing requires more effort than causing air to flow through _____ tubing. (wide, narrow) -Which kind of tubing "resists" the air flow more? _____

3. "Electrons" are negatively charged particles with the amazing ability to move through solid metal wires just as easily as air can move through a pipe or hose. But trying to make electrons emerge from the metal and move through the air is just as difficult as trying to make a vacuum cleaner blow air through solid concrete. The mobile electrons are *confined* to the wires.
   a. A "battery" is a chemically-driven electron pump. The two ends of a battery are called "terminals". The battery tries to push electrons out through its negative terminal and tries to pull them ___ through its ____tive terminal, just as a vacuum cleaner pulls air in through its "intake" port and pushes air ___ through its "exhaust" port. (Copy the ***italicized*** words from #2.)
   b. The illustration at the right shows the standard symbol for a battery. Please write the words "intake" and "exhaust" onto the appropriate ends of the battery and *also* the vacuum cleaners in the two diagrams above. *Make the arrows agree.*



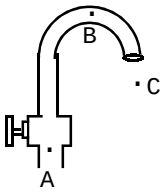
4. Here is a battery (electron pump) with a wire (electron passageway) connecting one end to the other to form a complete "circuit" (path) much like the one described in #2. Part of the path is a very thin segment of wire. It is called a "resistor" because it _____s the flow of electrons just as the _____ tubing in 2g resists the flow of air when you try to blow air through it.
   a. Draw arrows *on* the wires in the diagram to show the direction of electron flow.
   b. Do those arrows agree with #3? ____ (If not, please fix them.)



5. The "**electric current**" in a wire is the *electron flow rate* in the wire. In other words, electric current is the *number of electrons passing through during a time interval divided by the duration of that time interval.* A copy of this "BEGINNER'S DEFINITION" is being saved on RS ___.
   a. Now look at the electric "circuit" described in #4: How must the electron *flow rate* in the thick wire compare with the electron flow rate in the resistor? _____ (Read 2c & 2e.) -Does 1a agree? ____
   b. Does 5a agree with 1a?___ --With 2c? ___ -2e? ___ (If not, please explain.)
   c. Both flow rates in 5a can be measured in _____s per ____. Can that be used as a speed unit? ___

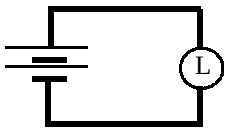
6. Try this at home: With the water turned off, press your thumb over the end of a faucet. Then gradually open the valve with your other hand. Stop when water begins to escape.
   a. You can feel the water pressure against your thumb ___creasing when you open the valve.
   b. Are you strong enough to prevent the flow of water from the faucet when the valve is open?____

The illustration at the right represents a water faucet like the kind in a science lab. Point A is inside the water pipe, B is a point inside the curved part of the faucet, and C is in the open air outside of the faucet.

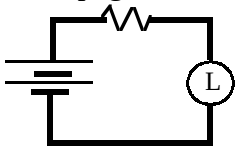


1. When the valve is opened water normally flows from A through B to C, because the water pressure at A is ____er than at B or C.
2. If the pressure at C were greater than at A then water would flow through B from ___ to ___. *Draw an arrow on the picture to illustrate your answer.*
3. Imagine that Superman is holding his thumb over the end of the faucet as you did on page 78.
   a. As you gradually open the valve the water pressure at B must gradually ___crease, but no water comes out because Superman is holding it back with his mighty thumb.
   b. The pressure at B can increase only until it is _____ ___ the pressure at A. (less than, equal to, greater than)
   c. Does 3b agree with #2? ___
4. When *you* tried the thumb stunt some water probably leaked out because you are not Superman. Ordinary people are not strong enough to hold the water back. Water flows out of the faucet past your thumb because the pressure at B is _____ than the pressure at ___.
   a. At the same time, water flows through the partly-opened valve from A to B because the water pressure at ___ is _____ than at B.
   b. When water is trickling past your thumb the pressure at B must be _____ than at A but _____ than at C. Do these answers contradict #1? ___ #2? ___ #4a? ___
5. What will happen if you suddenly increase your effort to block that flow?
   a. The ***resistance*** provided by your thumb will ___crease suddenly.
   b. The pressure at B will ___crease _____ly, causing the rate at which water flows past your thumb to ___crease _____ly.
6. The resistance provided by Superman's thumb in #3 was so _____ that it completely blocked the flow. (great, small, cold, pink) The pressure at B must then have been equal to the pressure at ____. No water flowed through the partly open valve because the difference between the pressures at ___ and ___ was _____. --Does this agree with 4b? ____
7. Just for practice, convert these numbers to scientific notation:
   a. 100 = _____ b. 0.00034 = _____
   c. 2500 = _____ d. 0.00102 = _____
8. Please invert these quantities. (In other words, calculate their *reciprocals*.) Express *all* of the results in scientific notation, with units. Remember to round off properly.
   a. 100 mi/hr: _____ _____ b. 0.005 cm/yr: _____ ____
   c. 4000 dollars per month: _____ _____ d. 6.24×10^7 cycle/sec: _____ _____
9. Double these quantities:
   a. 4.2×10^6 sec. _____ ____ b. 0.8×10^{-5} meter: _____ __
10. If my car gets 30 miles per gallon then how much gasoline does it use in:
    a. one mile? _____ ____ b. two miles? _____ _____
11. If there are 50 grapes in a one-kg bunch then the mass of one grape is roughly _____ ____.
12. If one "coulomb" is the amount of charge carried by 6.24×10^{18} electrons then each electron must have a negative charge of _____ coulombs. *Answer in scientific notation. Save on RS IX.*
13. A helium nucleus contains two protons and two neutrons. The helium in a balloon does not give you a shock if you touch it. Using #12, calculate the charge of a helium nucleus: _____ _____.

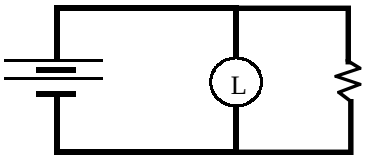
1. Copy these diagrams and definitions into your notebook. Put positive and negative signs near the battery terminals, as explained on page 78. Also draw arrows *on each wire in each circuit* to show the direction of electron flow, as explained on page 78.



Simple circuit with light bulb and battery



Light and resistor "connected in **series**" to a battery



Bulb and resistor connected "in **parallel**" to a battery

2. In the "_____" circuit above every electron must pass through both the resistor and the light bulb. In the "_____" circuit an electron will pass through the resistor OR the light bulb, but not both. *Please use the words printed in* **boldface type** *in #1. Spell them correctly.* The words "series" and "parallel" are needed *only* for circuits containing more than __ devices. (The battery is *one* device.)

* 3. Obtain a light bulb and two wires. Use a wire to connect one terminal of the light bulb to one terminal of the lab power supply. Use the second wire to connect the other terminal of the light bulb to the second terminal of the power supply, as in the first diagram in #1. Observe what happens and *when* it happens. Describe your observations in this *and all future exercises* with statements that are so clear that even a physics teacher can understand them. Illustrate with diagrams similar to #1.

4. Draw a diagram of a circuit with two light bulbs connected in parallel. (Use #1 as a model.)
   a. After showing the diagram to your teacher for approval, obtain a second light bulb and some more wire and hook up the circuit. If the bulbs don't light up then try different bulbs.
   * b. Describe exactly what happens to *each* of the two bulbs when one of them is removed from its socket, and what happens when it is replaced. *This question asks for observations, not opinions.*

5. Draw a new diagram with a third bulb (called "C") connected in series with the first pair (called "A" and "B"), so so that each electron must pass through the new bulb before entering either of the old ones. (Bulbs A and B are still connected in _____, as in #4.) Use the given letters to *label* the bulbs. After your plan has been approved, hook up the circuit. Be sure to use identical bulbs.
   * a. Describe how these three bulbs compare in brightness.
   * b. What happens to the brightness of the bulbs when you reverse the direction of electron flow?
   * c. Describe what happens when bulb A is removed from its socket. *Don't contradict 5b or 5a.*
   * d. What kind of connection do the remaining two bulbs have when bulb A is removed? (Use #2.)

6. The **"Terminals"** of a light bulb are the places where you connect wires to it.
   a. Electrons can enter or leave a bulb only through its _____s.
   b. Copy the diagram from #5 and make dots on the two terminals of bulb C in the new diagram.
   c. Draw an additional wire connecting the two terminals of bulb C. Such a wire is called a ***"jumper"*** and is said to be ***"connected across bulb C"***. Please use those italicized words when you label the wire in your diagram *and* when you describe what happens, in 6f & 7.
   d. Show the diagram to your teacher for approval.
   e. Without unplugging anything, connect the jumper wire. *Do ONLY what the diagram says.*
   * f. We use *verbs* to describe changes (as in 5c) because a change is an *action*, not a condition. With that in mind, describe what happened to *each* of the three bulbs when you connected the jumper.

* 7. Repeat #6 for bulb A or B. Start with a diagram. Use only *one* jumper, and get your plan approved. Describe what happens, using *past-tense verbs* with a phrase ***like the one italicized in 6c***.

* 8. Connect several identical bulbs in series. (First draw a diagram.) If you find that some are brighter than others then describe what happens when you exchange the brightest and the dimmest bulbs.
   a. What happens when you remove one bulb from its socket? -when you increase the number of bulbs?
   b. Describe what happens when you reverse the electron flow through the series of bulbs.
   c. Some people believe that a light bulb consumes electrons, converting them into light. If that is true, then many electrons must enter the first bulb in the series and the number going on to the next bulb must be _____er. Please explain how this experiment *does* or *does not* support that theory.

9. Invent a way to connect four bulbs so that removing any *one* from its socket causes *two* bulbs to stop glowing, leaving the other two lit. Get your plan approved before testing your idea.