THE SOUTH CAROLINA DEPARTMENT *of* ADMINISTRATION

Multimeters indicate the presence of, and measure the quantity of, electrical properties such as *voltage*, *current*, and *resistance*. An **ammeter** measures current, a **voltmeter** measures the potential difference (voltage) between two points, and an **ohmmeter** measures resistance. A **multimeter** combines these functions and possibly some additional ones as well, into a single instrument. Even the simplest and cheapest types may include features which you are not likely to use. Some also have over-current protection, a nice feature for those who forget which scale they left the meter set. Multimeters often have more than two connections, and part of "telling" the multimeter what to measure (that is, whether to be a voltmeter or an ampere meter) is done by choosing the right two connections. This is explained in the operations manual for the multimeter, and often shown next to the connection points. Read these basic instructions before using your multimeter.

There are two kinds of voltmeters. The kind with a "pointer" needle takes energy from the thing being measured to move the needle along a scale to point to the number of volts (but you have to know which scale you're on to properly interpret readings). Be careful with this kind of voltmeter to make the correct positive and negative connections; if wrong connections are made, the voltmeter can be damaged. The second kind of voltmeter shows the numbers digitally. This kind of voltmeter is not damaged from "wrong" connections; instead, they just show a negative number.

If your meter is a manual-range type, the selector switch will change resistors inside the voltmeter so the one voltmeter can be used for a lot of different voltages, large and small (autoranging voltmeters can do this all by themselves). Set the selector switch to a high-range position; the indication will be small. Move the selector switch to the next lower DC voltage range setting and reconnect to the battery. The indication should be stronger now, as indicated by a greater deflection of the analog meter pointer (*needle*), or more active digits on the digital meter display. For the best results, move the selector switch to the lowest-range setting that does not "over-range" the meter. An over-ranged analog meter is said to be "pegged," as the needle will be forced all the way to the right-hand side of the scale, past the full-range scale value. An over-ranged digital meter sometimes displays the letters "OL", or a series of dashed lines. This indication is manufacturer-specific.

Some digital multimeters are *autoranging*. An autoranging meter has only a few selector switch (dial) positions. Manual-ranging meters have several different selector positions for each basic quantity: several for voltage, several for current, and several for resistance. Voltages can be either from a direct current or an alternating current. A voltmeter needs to be "prepared", or made for, one of them. If one tries to measure one kind of voltage with a voltmeter made for the other, the voltmeter will either show a wrong voltage, or be destroyed. Digital voltmeters take batteries. The reason for this is that the resistance scale requires the meter itself to put a little current into a wire to measure its resistance. Otherwise, the batteries aren't necessary to read voltage or milliamps. Always leave the meter set on a voltage scale to prevent draining the battery.

Analog vs. Digital

Autoranging multimeters may only have a single position for DC voltage, in which case you need to set the switch to that one position. Touch the red test probe to the positive (+) side of a battery, and the black test probe to the negative (-) side of the same battery. The meter should now provide you with some sort of indication. Reverse the test probe connections to the battery if the meter's indication is negative (on an analog meter, a negative value is indicated by the pointer deflecting left instead of right).

Used as a voltmeter, a digital meter versus an analog meter is usually better because its resistance is much higher. On the other hand, it is easier to follow a slowly changing voltage by watching the needle on an analog scale.

Step1 - Plug the probes into the meter. Red goes to the positive (+) and black to the negative (-).

Step2 - Turn the selector dial or switch to the type of measurement you want. To measure direct current – a battery, for example - use DCV. To measure alternating current, such as a wall outlet, use ACV.

Step3 - Choose the range setting. The dial may have options from 5 to 1000 on the DCV side and 10 to 1000 on the ACV side. The setting should be the top end of the voltage you are reading. Not all voltmeters have this setting.

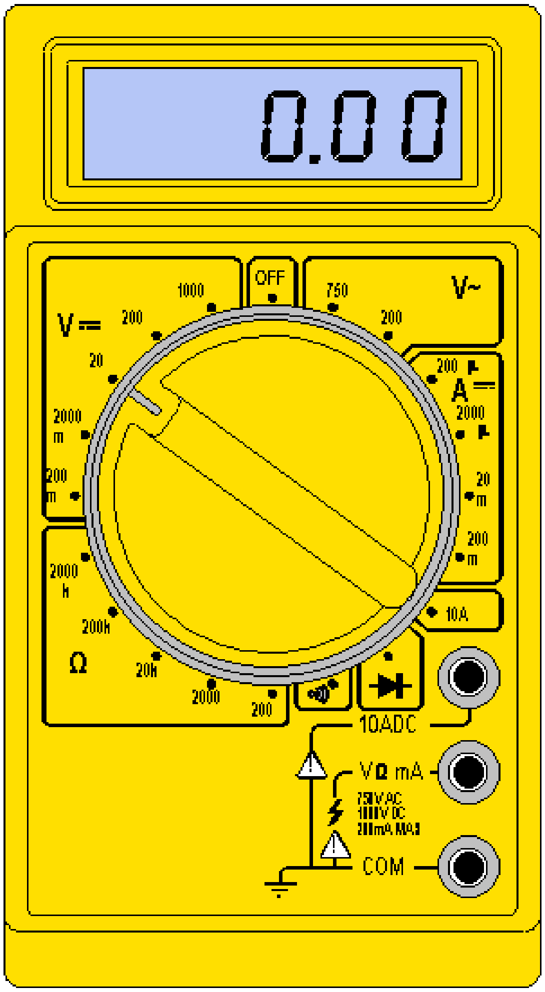
Step4 - Turn the meter on.

Step5 - Hold the probes by the insulated handles and touch the red probe to the positive side of a

DC circuit or either side of an AC circuit. Touch the other side with the black probe.

Step6 - Read the digital display or analog dial.

The diagram below shows a **switched range multimeter**:



The central knob has lots of positions and you must choose which one is appropriate for the measurement you want to make. If the meter is switched to 20 V DC, for example, then 20 V is the maximum voltage which can be measured. This is sometimes called 20 V fsd **(**full scale deflection)**.**

For circuits with power supplies of up to 20 V, which includes all the circuits you are likely to build, the 20 V DC voltage range is the most useful. DC ranges are indicated by V⎓ on the meter. Sometimes, you will want to measure smaller voltages, and in this case, the 2 V or 200 mV ranges are used.

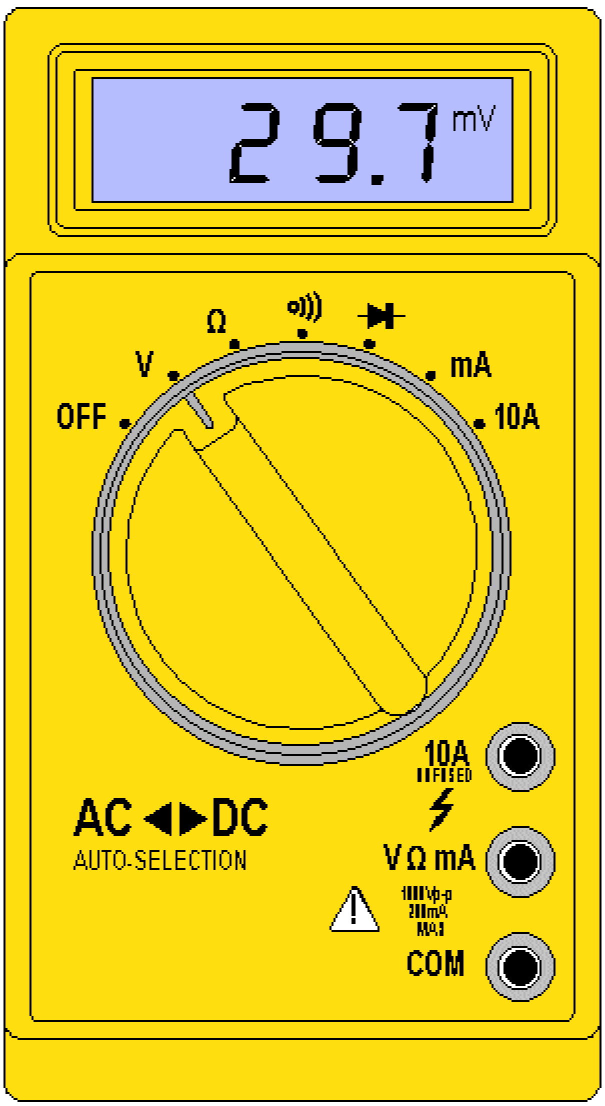
DC means **direct current**. In any circuit which operates from a steady voltage source, such as a battery, current flow is always in the same direction. AC means **alternating current**, i.e., the current flows first one way, then the other. That is, the current reverses, or alternates, in direction.

☠MAINS VOLTAGE☠

For safety reasons, you must NEVER connect a multimeter to the mains supply.

You are not at all likely to use the AC ranges, indicated by V~, on your multimeter.

An alternative style of multimeter is the **autoranging multimeter**:



The central knob has fewer positions and all you need to do is to switch it to the quantity you want to measure. Once switched to V, the meter automatically adjusts its range to give a meaningful reading, and the display includes the unit of measurement, V or mV. This type of meter is more expensive, but obviously much easier to use.

Where are the two meter probes connected? The **black** lead is always connected into the socket marked COM, short for COMMON. The **red** lead is connected into the socket labeled VΩmA. The 10A socket is very rarely used.

You need to know about Amps, Volts and Resistance, or Ohms, in order to troubleshoot electrical systems. The Amp is the basic unit of current in electricity. Current, or flow of electrons, is what's doing the work in a circuit. It's the current that heats up the filament in a light bulb, flows through the circuitry in a radio, creates electromagnetism in a solenoid (relay) and does everything we're accustomed to enjoy from electrical devices.

Voltage is the "pressure" of electricity. That is, current can't flow without a voltage potential forcing it to do so (think of it this way: if current is the stream of water flowing out a hose nozzle, voltage would be the water pressure in the pipes that is pushing it through the hose.)

Resistance (Ohms) is anything in a circuit that resists the flow of current. All circuits have resistance, because that's how electricity does work for us.

The Watt is the product of Amps times Volts (W = A x V). It is the unit of electrical power, and we use the formula to calculate the current. Adding Resistance to the mix, we come up with the formula: Volts = Amps x Resistance.

Electricity doesn't do any good without having a circuit. That is, electricity must flow from the power source through any switches and relays, through the device that's being operated and then to ground. That means the electrons have a closed circuit (path) in which to flow. If any item in the circuit is disconnected, corroded or otherwise "breaking" the circuit, no electricity will flow and the device won't work. Is there a way to check to see if electricity will flow at all? Is there a way to measure without turning on the power? Yes, it's called continuity, and we use the resistance scales in the meter to utilize it. The way this works is that the battery inside the meter provides a little voltage to the test leads. Connect the meter leads onto both the input and output sides of the device. Since the circuit is now complete, we have zero resistance or continuity.

Tracing a Circuit: Suppose you want to find out if a wire is the one that comes out at another location. Using the resistance setting you can connect one test lead to one end of the wire and the other lead (use a spare piece of wire to extend the reach, of course) to the other end. If the resistance is zero, or close to zero, you've found for certain that it's the same wire.

http://www.inspect-ny.com/electric/ElecSafetyDMMs.htm

Frequently check for damage to the meter itself, or for loose, cut, or worn test leads. If you can see the conductor in the leads, replace them. Check that there is low resistance between the leads themselves - a partial indication of good condition.

Use well insulated test leads that have finger guards.

Insulate yourself from possibly live electrical parts by careful selection of clothing, leather boots, and where appropriate, insulated gloves.

Wear gloves: If you cannot operate your equipment while wearing gloves you have a safety problem.

Use the proper voltage range and other control settings on the meter.

If you attempt a voltage measurements with test leads in the amps or current jack (a big but common mistake) and if your probes or meter are not fused, the resulting short across the voltage source can cause an explosion in the meter.

Don't use a meter having cracked or loose parts. In selecting a meter, look for recessed input jacks to reduce shock risks at the connectors.

Amp measurements using voltage clamps avoid extra risks of having to handle live wires. [See sketch at left.]

When measuring amps without a current clamp, make sure power is off before connecting into the circuit.

When disconnecting the multimeter or voltmeter, always unplug the red (hot) lead first

Test for Presence of Electrical Voltage: **AC and DC non-contact voltage sensing tools** including pen-sized current sensors and even a simple neon-tester are available to test for electrical voltage without actually touching the equipment, a surface, or a wire, to sense the presence of live voltage. Recommend that you test the operation of the voltage detector on a known live circuit both before and after using it to test for the presence of electrical voltage at a wire or device.

Non-Contact Voltage Sensing Pen Tester

 A neon tester requires *touching* electrical contacts or grounded surfaces to check for the presence or absence of voltage.

 Electrical receptacle testers are used to check for proper wiring at electrical receptacles as well as to check the function of GFCI's.

The Top 10 Dumb Things Smart People Do When Testing Electricity (12/16/08)

http://www.flukedigitalmultimeter.com/news/3/15/The-Top-10-Dumb-Things-Smart-People-Do-When-Testing-Electricity.html

Anyone who makes their living by working with electricity quickly develops a healthy respect for anything with even a remote chance of being "live". Yet the pressures of the getting a job done on time or getting a mission-critical piece or equipment back on line can result in carelessness and uncharacteristic mistakes by even the most seasoned electricians. The list below was developed as quick reminder of what not to do when taking electrical measurements.

- **Replace the original fuse with a cheaper one.** If your digital multimeter meets today's safety standards, that fuse is a special safety sand fuse designed to pop before an overload hits your hand. When you change your Digital Multimeter's (DMM) fuse, be sure to replace it with an authorized fuse.
- **Use a bit of wire or metal to get around the fuse all together.** That may seem like a quick fix if you're caught without an extra fuse, but that fuse could be all that ends up between you and a spike headed your way.
- **Use the wrong test tool for the job.** It's important to match your Digital multimeters to the work ahead. make sure your test tool holds the correct CAT rating for each job you do, even if it means switching Digital multimeter's (DMMs) throughout the day.
- **Grab the cheapest DMM Digital multimeters on the rack.** You can upgrade later, right? Maybe not, if you end up a victim of a safety accident because that cheap test tool didn't actually contain the safety features it advertised. Look for independent laboratory testing.
- **Leave your safety glasses in your shirt pocket.** Take them out. Put them on. It's important. Ditto insulated gloves and flame-resistant clothing.
- **Work on a live circuit.** De energize the circuit whenever possible. If the situation requires you to work on a live circuit, use properly insulated gloves, remove watches or other jewelry, stand on an insulated mat and wear flame-resistant clothing, not regular work clothes.
- **Fail to use proper lock-out/tag-out procedures.**
- **Keep both hands on the test.** Don't! When working with live circuits, remember the old electrician's trick. Keep one hand in your pocket. That lessens the chance of a closed circuit across your chest and through your heart. Hang or rest the meter if possible. Try to avoid holding it with your hands to minimize personal exposure to the effects of transients.
- **Neglect your leads.** Test leads are an important component of DMM Digital multimeters safety. Make sure your leads match the CAT level of your job as well. Look for the test leads with double insulation, shrounded input connectors, finger guards and a non-slip surface.
- **Hang onto your old test tool forever.** Today's test tools contain safety features unheard of even a few years ago, features that are worth the cost of an equipment upgrade and a lot less expensive than an emergency room visit.