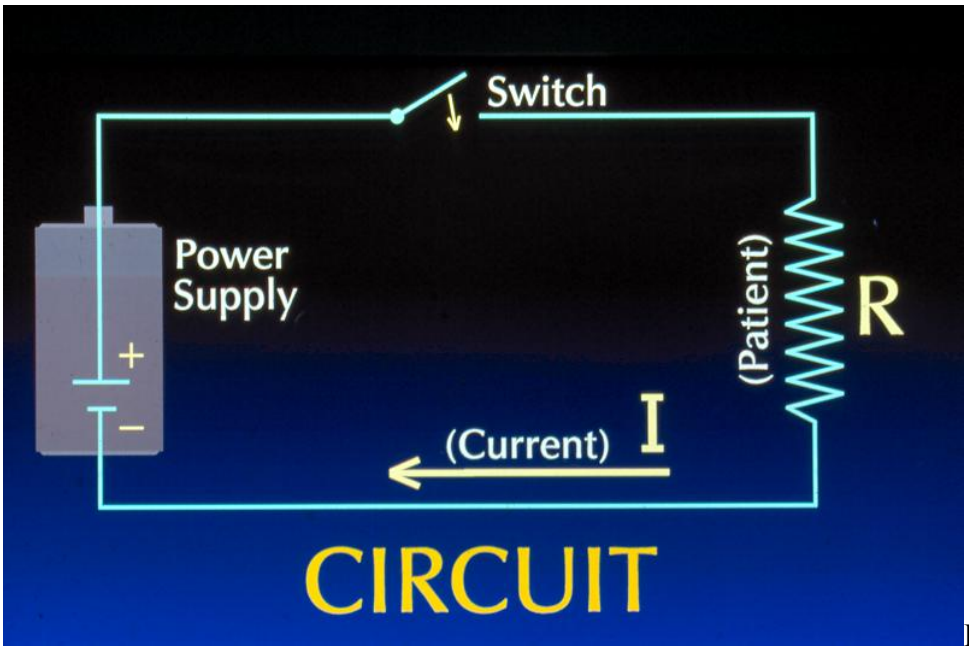
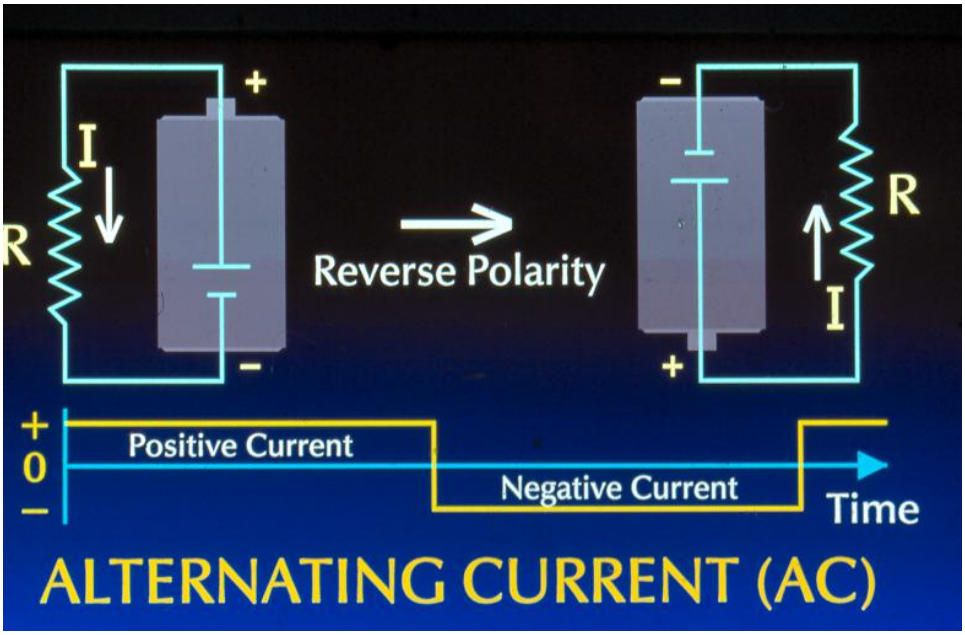
Basic Electrical Concepts & Skills:

- AC vs. DC Electrical Circuits
- Frequency of AC Circuits
- Basic Ohms Law Relationships of Volts, Ohms and Amps (V=IR)
- Basic Electronic Components, functions & their symbols
- A basic electrical circuit
- How to read a schematic
- Use of a Digital Voltmeter (DVM), & induction Ammeter
    - Measure Voltage – AC or DC
    - Measure Impedance (Resistance)
- Cleaning of contacts on circuit boards and connectors
- Identifying Test Points on Circuit Boards and performing measurements outlined in service manuals.
- Electrical Safety
    - Retaining of electrical charge by capacitors and the need to discharge
- Online Resources & Links

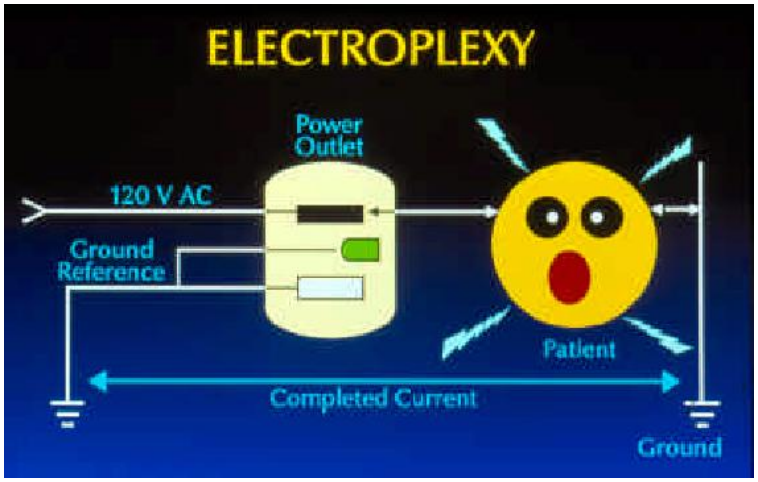
AC vs DC Circuits:
Alternating current versus Direct Current



Basic DC Circuit Using a Battery
Positive & Negative Poles.
Many circuit boards utilize low voltage DC transformers to energize various circuits and components on their boards. Use the DC Voltage setting on a DVM at the appropriate range to measure.



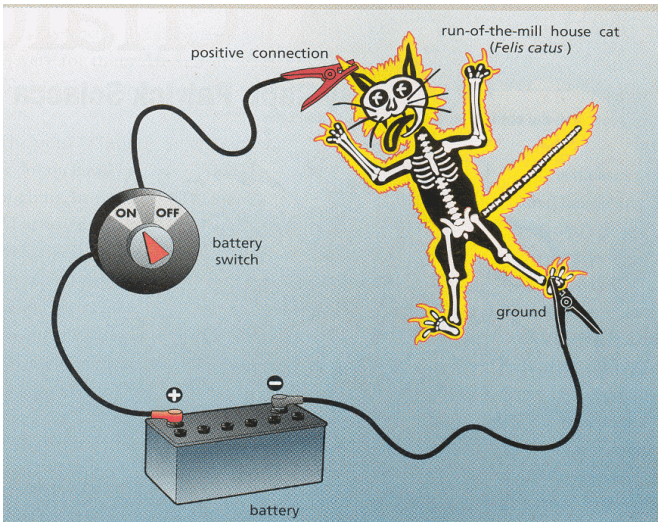
Creating an AC Circuit by repeatedly reversing polarity
Household current is AC current at 60 Hertz (HZ)
(Alternates polarity 60 times per second)
60Hz then is the frequency. European household current is at 50Hz



Basic Household Electrical Circuit, and possible shock hazards by completing circuit
"Hot" side of outlet
"Neutral" side of outlet (same as earth ground)
"Safety Ground" – earth ground redundant with neutral

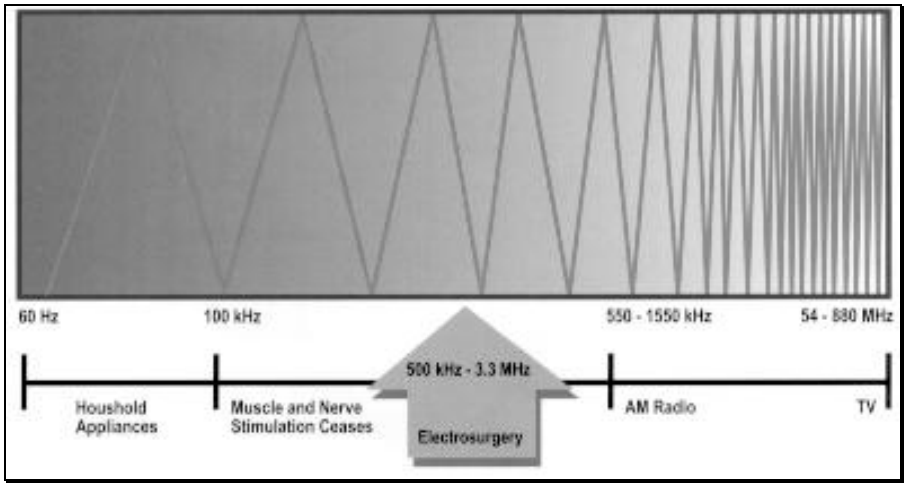
This is what safety polarity checkers look for. Hot and Ground on proper side with ground functioning.
(Demonstrate if have polarity checker, maybe discuss isolation transformer)

Completing the Circuit and getting shocked or electrocuted:



FREQUENCY of AC Circuits:

Household Current: 60Hz USA, 50Hz Europe – can cause equipment problems

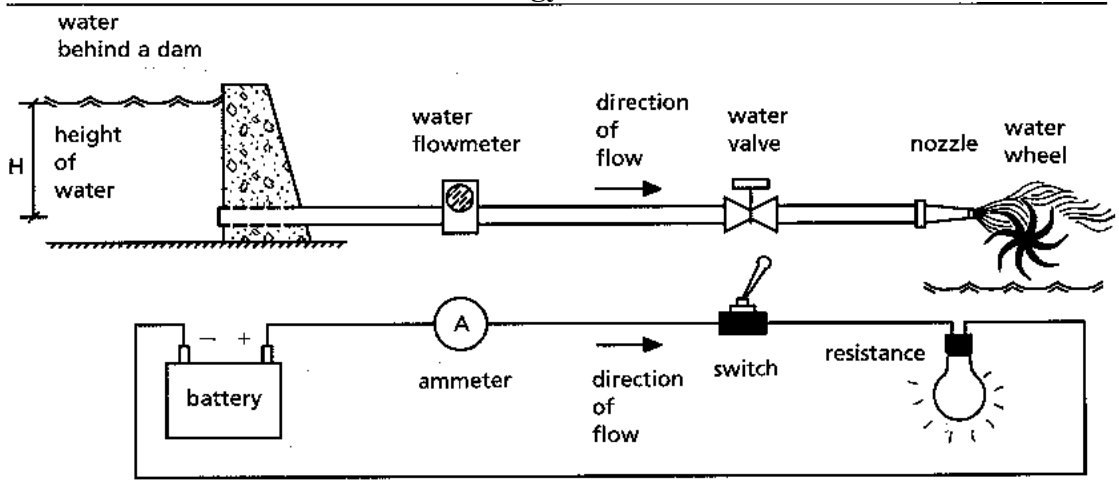


Frequencies below about 100kHz (100,000 Hz) cause neuromuscular stimulation which we associate with an electrical shock. Higher frequencies are "invisible" to our physiology.

RF (Radio Frequency) energy is just AC electricity in the high RF ranges.
For example the RF power supply on the Ultrapulse CO2 laser is at 81 MegaHertz (MHz).
AM Radio is in the 550-1600 KHz Range.
Electrosurgical Generators are in the 350KHz to 4MHz range.

Basic Ohm's Law Relationship of Voltage, Current and Resistance:

Analogy with water flow



VOLTAGE is the pressure head the water develops – based on height
RESISTANCE is an impediment to the flow of water – based on restrictions
CURRENT is the flow of water that finally results from the pressure and resistance combined.

V = I x R

(I = Induced Current, expressed in amperes)
(R = measured in Ohms. Called Impedance if measuring AC circuits, Resistance for DC)
(V = Volts, measured as AC or DC)

Holding Voltage constant but decreasing resistance will increase the current (amps)
And vice versa increasing resistance will decrease the current (amps)

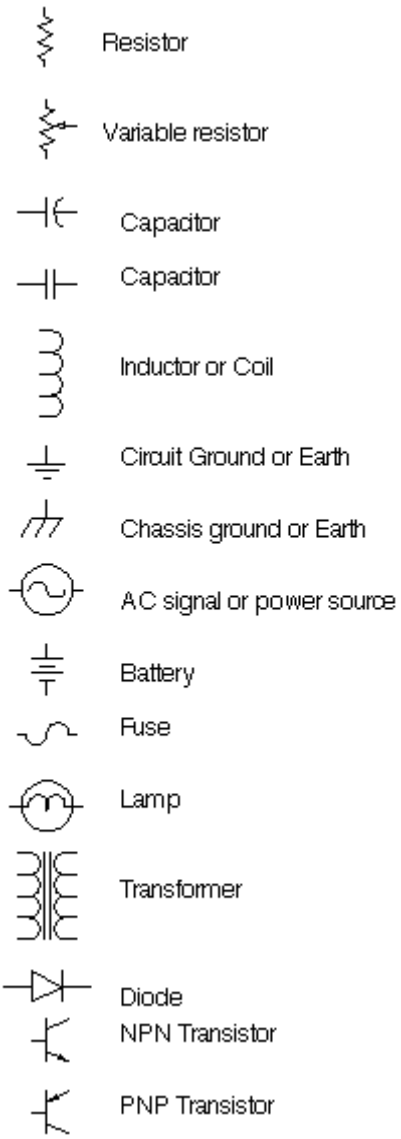
WATTS of power = AMPS x VOLTS

Using a hair dryer for Example:

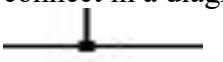
1200 Watt Hair Dryer, using 120v AC circuit. How many amps circuit will it take?
1200 = ? x 120
1200/120 = 10amps – you need at least a 10 amp circuit breaker.

Basic Electronic Components, Functions, and symbols:

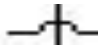
SYMBOLS:



A schematic in electronics is a drawing representing a circuit. It uses symbols to represent real-world objects. The most basic symbol is a simple conductor, shown simply as a line. If wires connect in a diagram, they are shown with a dot at the intersection:

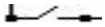


Conductors that do not connect are shown without a dot, or with a bridge formed by one wire over the other:



Among the connections are power and ground, the high and low system voltages respectfully. The 5 volt system power in the schematic is shown simply as 5V. There is also a +12V supply and a -12V supply. Ground, or 0 volts, has its own symbol:

A **switch** is a device that is capable of allowing the user to break the circuit as if the wire had been broken. Its symbol reflects this characteristic:



The three switches in the diagram are grouped in a Dual In-line Package (DIP).

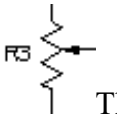
A **resistor** is a device that resists the flow of charge. Its symbol reflects this characteristic by making the line jagged:

Just in case you have seen "flow of current" elsewhere rather than "flow of charge", see "Science Myths" in K-6 Textbooks and Popular culture and the definition of current below.

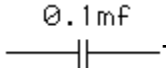
The unit of resistance is the **ohm**, pronounced om with a long o. The K in the schematics stands for kilohm or thousands of ohms. 10K means the same as 10,000. Meg and sometimes M mean megohm or million ohms. 4.7Meg or 4.7M is the same as 4,700,000.

You will see two variations on resistors in the schematic. One is the resistor array or network. It is a Single In-line Package (SIP) containing several resistors connected together. They can be found in many configurations. The one used here simply connects one end of the resistors to each other and brings them out to a common connection. The other end of each resistor is left free. Another variation is the variable resistor. It has a third contact that can move along the resistor element to permit the values at that point to be variable. The moveable part is called the wiper and is shown as an arrow.

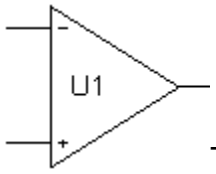
Each zig zag line represents a **resistor**. This is a simple device that has a desired resistance. These serve to control the proportion of current or signal that follows each branch of a circuit. It is designated as R1, and it's actual value would be shown in an attached table.



The resistor with an arrow in the middle is a **variable resistor or potentiometer**. This is the thing that most control knobs are attached to. If you conceive of the arrow as moving up and down across the resistance, you can visualize a varying proportion of the current being drawn off, or the voltage at the arrow changing.

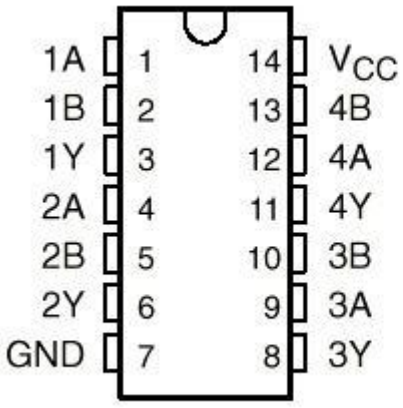


Two lines interrupting the circuit line represent a **capacitor**. Many times the feature of a capacitor is the ability to block low frequency signals. It stores an electrical charge and discharges it upon signaling. Large capacitors retain a large charge after a device is unplugged from its electrical source and can cause shock or even electrocution if touched, unless you wait 15-20 minutes for it to discharge, or intentionally discharge it by shorting it to ground. (Note: values for capacitors are given in microfarads. The proper symbol for this is the greek letter mu and an f. many programs don't properrly display this, turning the mu into an m. which strictly speaking would be "milifarads", however, microfarads is the usual intention.)



The triangle represents a rather complicated integrated circuit called an **operational amplifier (or Op-Amp)**. They are complicated to design and make, but pretty simple to use. The signal is connected to one of the two inputs, and appears at the output. A connection from the output back to the inverting input (with the minus sign) controls the amount of gain the op amp will give us. This kind of connection is called feedback. Simply connecting the output to the inverting input sets the gain at unity- no change in the signal level.

Integrated Circuits contain many individual components. They, in turn, usually form several functional blocks. For example, the following is a pinout for the 74LS08 Quad 2 Input AND gate, along with its truth table. VCC is the 5 volt supply, and GND is ground. Sometimes ground is shown as VSS. The gate inputs are the As and Bs, and the outputs are the Ys. Thus, the inputs to gate 1 are 1A and 1B, and the output is 1Y. You will see variations on these conventions, but they hold true in many cases.



FUNCTION TABLE
(each gate)

INPUTS		OUTPUT
A	B	Y
H	H	H
L	X	L
X	L	L

This is more in-depth electronics – don't worry about the functions, just recognize what an Integrated Circuit (IC) is, and recognize an IC chip.

Use of a Digital Voltmeter (DVM):

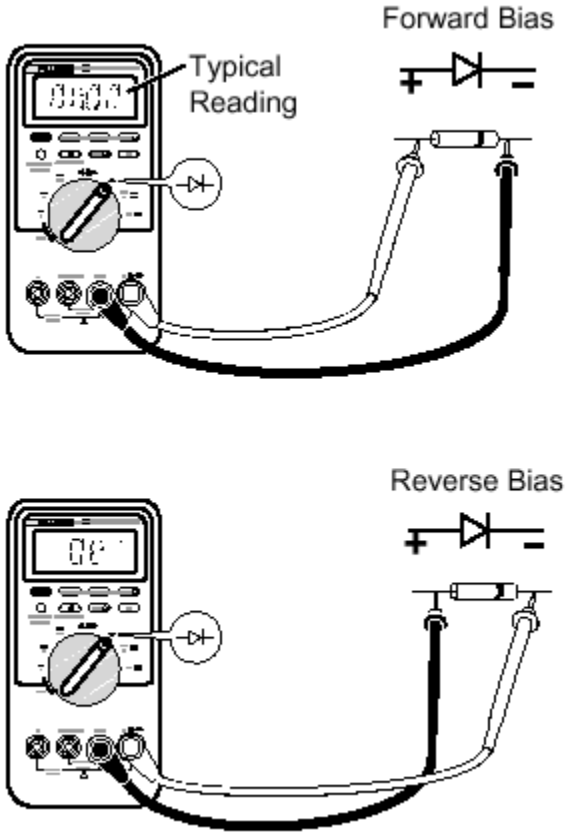
Demonstrate and Review: **VOLTAGE** – AC & DC, and scales

RESISTANCE (IMPEDANCE), and continuity checks

INDUCTION AMMETER USE (separate from the DVM)

More Advanced Optional – DIODE checking.
A diode is like a one way check valve, flowing current just one way

DIODE TESTING USING FLUKE DVM: (Advanced)



Avoid damage to equipment or meter by disconnecting circuit power and discharging all high voltage capacitors before testing.

This can be used to check diodes, transistors (i.e. in the passbank of ion lasers), silicon controlled rectifiers (SCRs), and other semiconductors. It tests a semiconductor junction by sending a current through it and measuring the voltage drop. A good silicon junction drops between 0.5v and 0.8v.

To test a diode OUT OF A CIRCUIT, set up the meter as shown. For forward-bias readings on any semiconductor component, place the red test lead on the components positive (P) terminal and place the black lead on the component's negative (N) terminal.

WITHIN A CIRCUIT, a good diode should still produce a forward-bias reading of 0.5v to 0.8v; however, the reverse-bias reading will vary depending on the resistance of other pathways between the probe tips

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CLEANING contacts in Circuit Boards and Connectors:

This can be a MAJOR reason for electronic malfunctions, especially on older equipment or ones that have sat idle for some period. When troubleshooting electrical / electronic problems it can be very useful just to pre-emptively unseat and reseat circuit boards and connectors in their mounts just to make good connections. The conductive strips on the bottom of circuit boards can be effectively cleaned by using a good clean pencil eraser on them and reseating them. Another very useful item for ensuring good connections is "Corrosion Block" sold in spray cans in boat stores.

This can even be used directly on electronic components if needed and will not short out components. Spraying and letting soak from several minutes to 24 hours is sometimes required to clean up corroded contacts on components. Do not get this onto optical components.

IDENTIFYING TEST POINTS on Circuit Boards and following measurements in manual:

Many circuits have small posts that are intended as measuring points or "Test Points (TP)". They may be denoted on a schematic for example as TP1 or something. Service procedures should spell out what reading you should get under what circumstances. Learn to use the small grasping clips that attach to DVM probes so that you can more easily use test points in a hands-free manner.

ELECTRICAL SAFETY PLUS CAPACITORS:

Review basic rules, use of right hand, don't grab chassis with other hand, eliminate jewelry, don't chase dropped tools, SITUATIONAL AWARENESS of where you are and what you're working around.

HV CAPACITORS RETAIN THEIR CHARGES for some time after disconnection from the power source. Severe shock or even electrocution can result if you touch these shortly after unplugging equipment. Generally wait 15-20 minutes (the longer the better), or intentionally ground out Caps to chassis ground or similar by something like a HV probe if you're going to be working in and around the power supply or the circuit the capacitors are associated with. (The Leyden jar used by Benjamin Franklin for social parlor games was a capacitor).

LINKS & RESOURCES, and source of parts of this material:

How to Read a Schematic:
http://arts.ucsc.edu/ems/music/tech_background/schematics/ReadSchem.html

http://www.learn-c.com/schemat.htm

Free Course in Electronics:
http://www.electronicstheory.com/ - recommend that you do this easy online course if you have no background at all in electronics.

How To Use A Multimeter For Beginners – Part 1 Voltage – YouTube Video
https://www.youtube.com/watch?v=ZBbgiBU96mM
Part 2a Current - https://www.youtube.com/watch?v=EVFkKBFJsZg
Part 3 Continuity & Resistance - https://www.youtube.com/watch?v=InJhgwmj2So