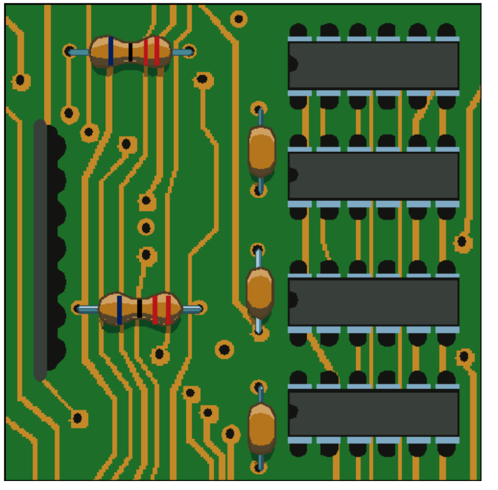
Basic Electronics

Well, basic to start…



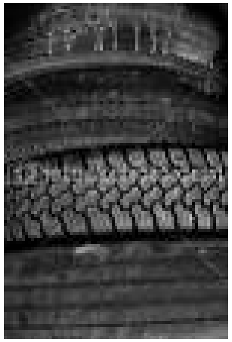
Charles Sekafetz

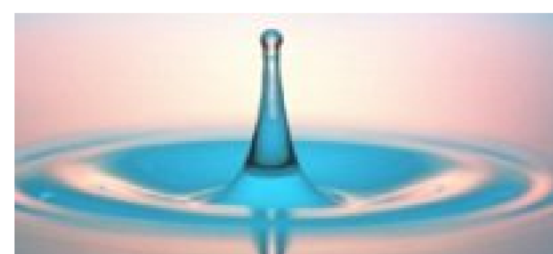
Chemeketa Community College

Areas of Focus

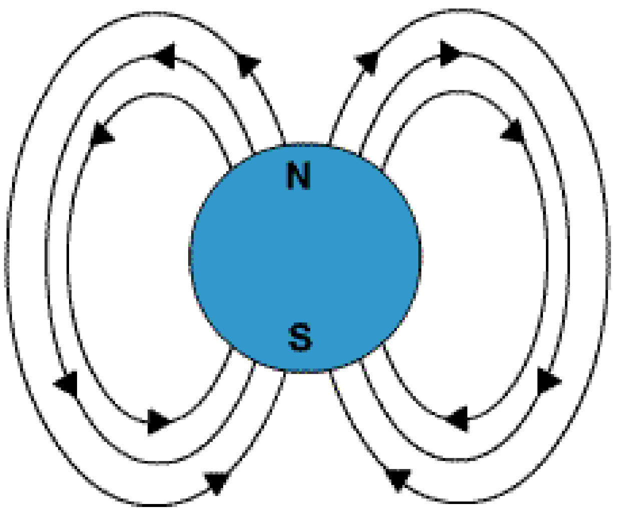
- Basic Fundamentals
- Soldering Safety

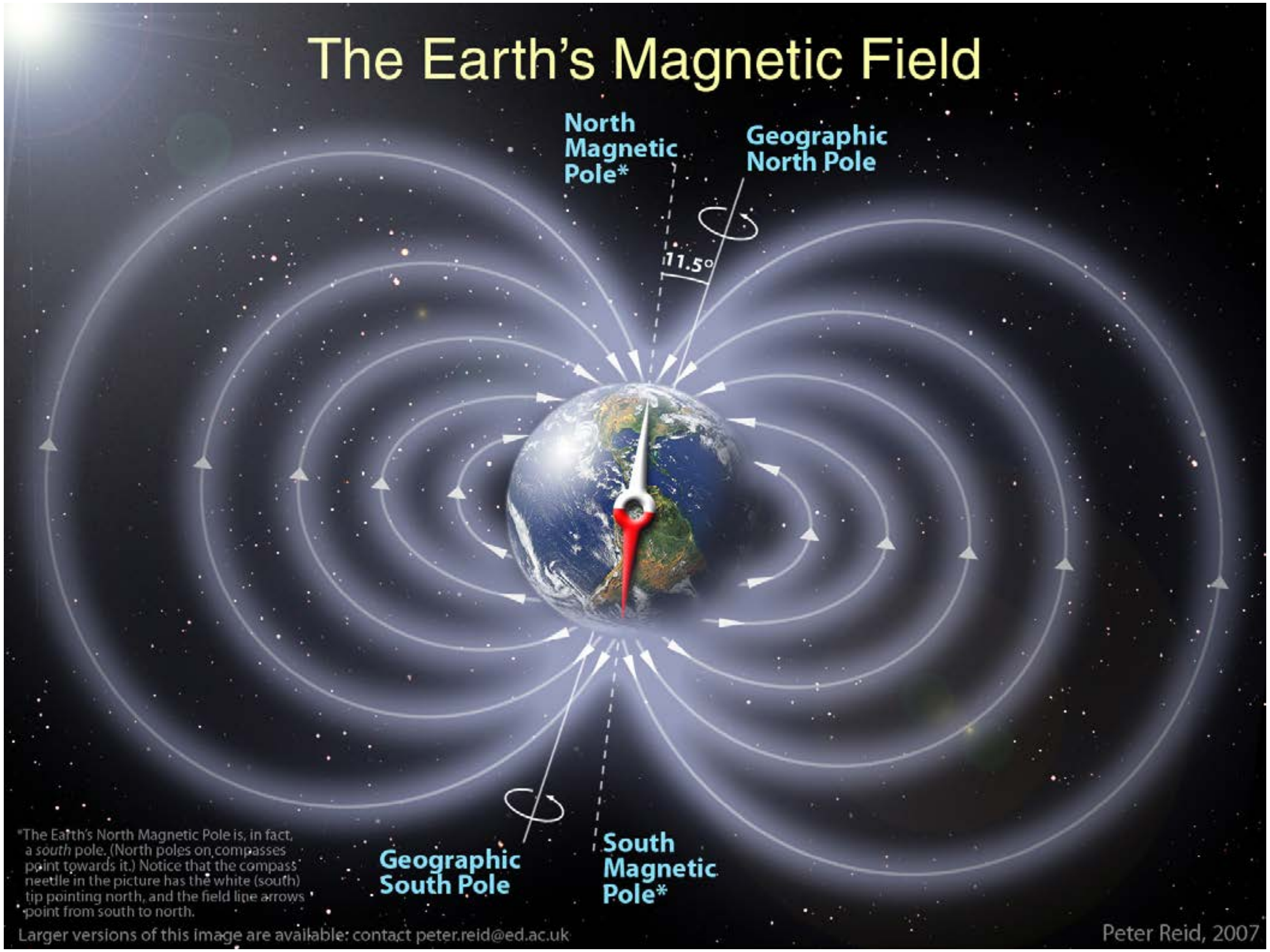
Conductors v Insulators

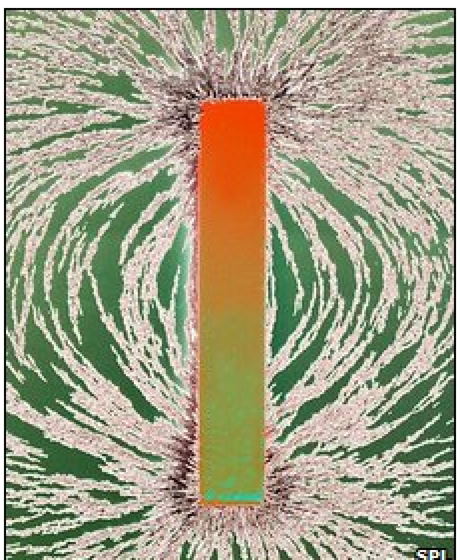


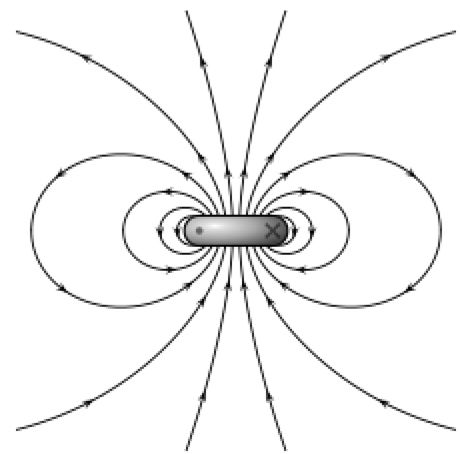


How this stuff works

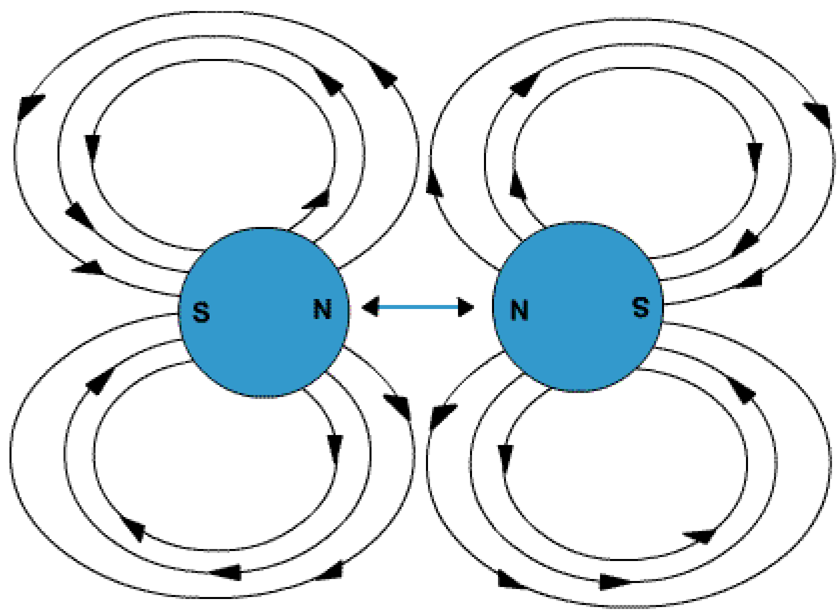



The Earth's Magnetic Field
North Magnetic Pole*
Geographic North Pole
11.5°
Geographic South Pole
South Magnetic Pole*
*The Earth's North Magnetic Pole is, in fact, a *south* pole. (North poles on compasses point towards it.) Notice that the compass needle in the picture has the white (south) tip pointing north, and the field line arrows point from south to north.
Larger versions of this image are available: contact peter.reid@ed.ac.uk
Peter Reid, 2007

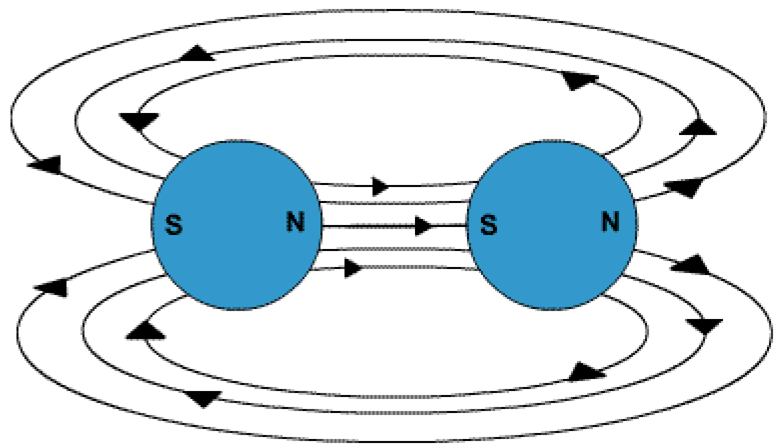

SPL



Charges – Like Charges Repel

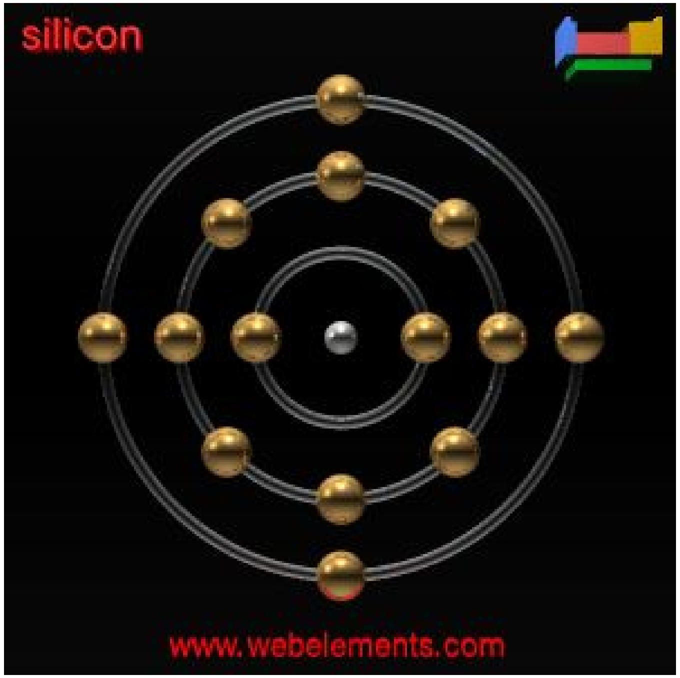


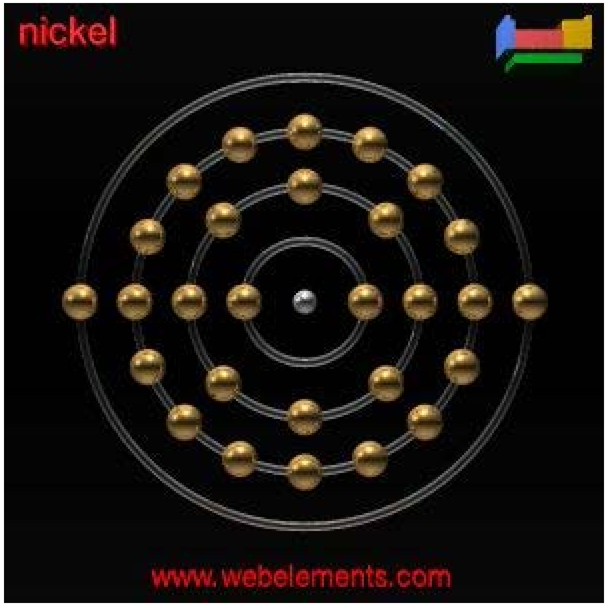
Charges – Dissimilar Charges Attract



What creates this attaction?

- Atomic Structure
  - Protons
  - Electrons



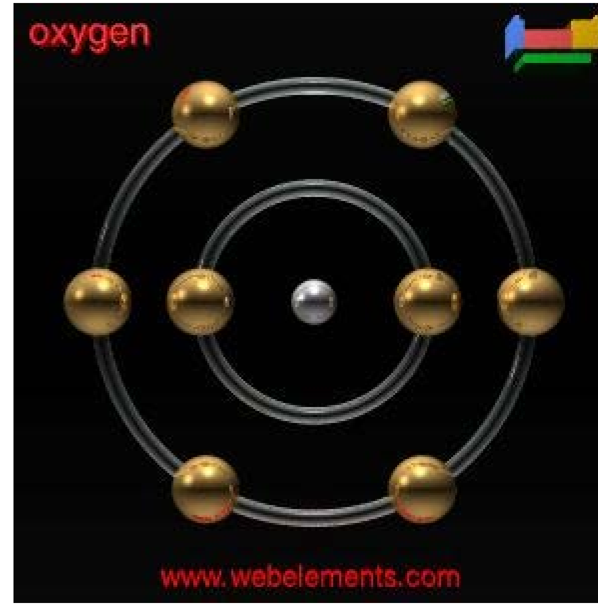

nickel
www.webelements.com


lead
www.webelements.com


silver
www.webelements.com

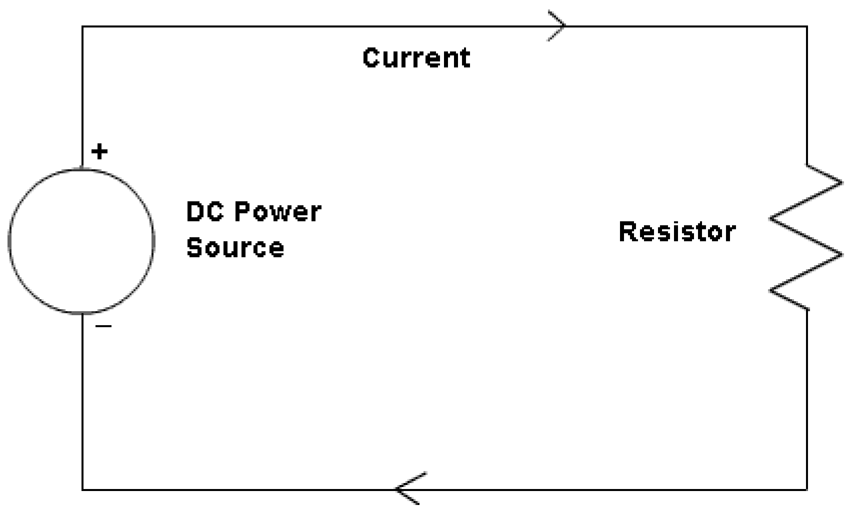

copper
www.webelements.com


gold
www.webelements.com


oxygen
www.webelements.com


argon
www.webelements.com

DC Theory



Voltage

- Electromotive Force (EMF)
- It is the force that “pushes” electrons through a wire
- Electrical Pressure or Potential
- Ohms Law Symbol fo Voltage is E or V
- The unit of voltage is V.

Current

- The rate of charge flow measured in amperes (Amps).
- Milliamps or microamps are common within electronics

Resistance

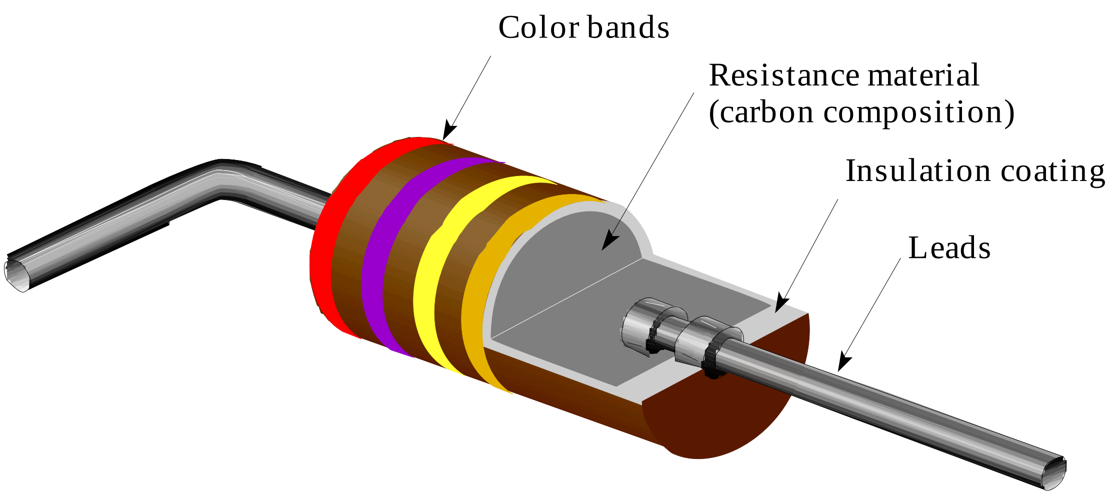
- The opposition to current flow measured in Ohms. (Ω)

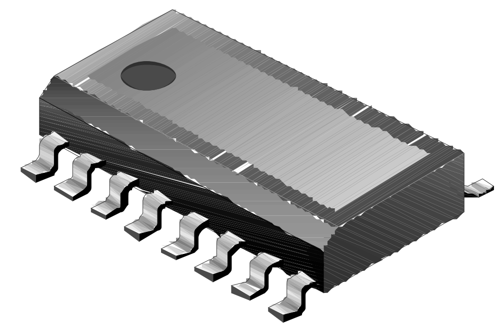
Conductance

- The ability of a substance to allow current flow measured in Siemens. (S)

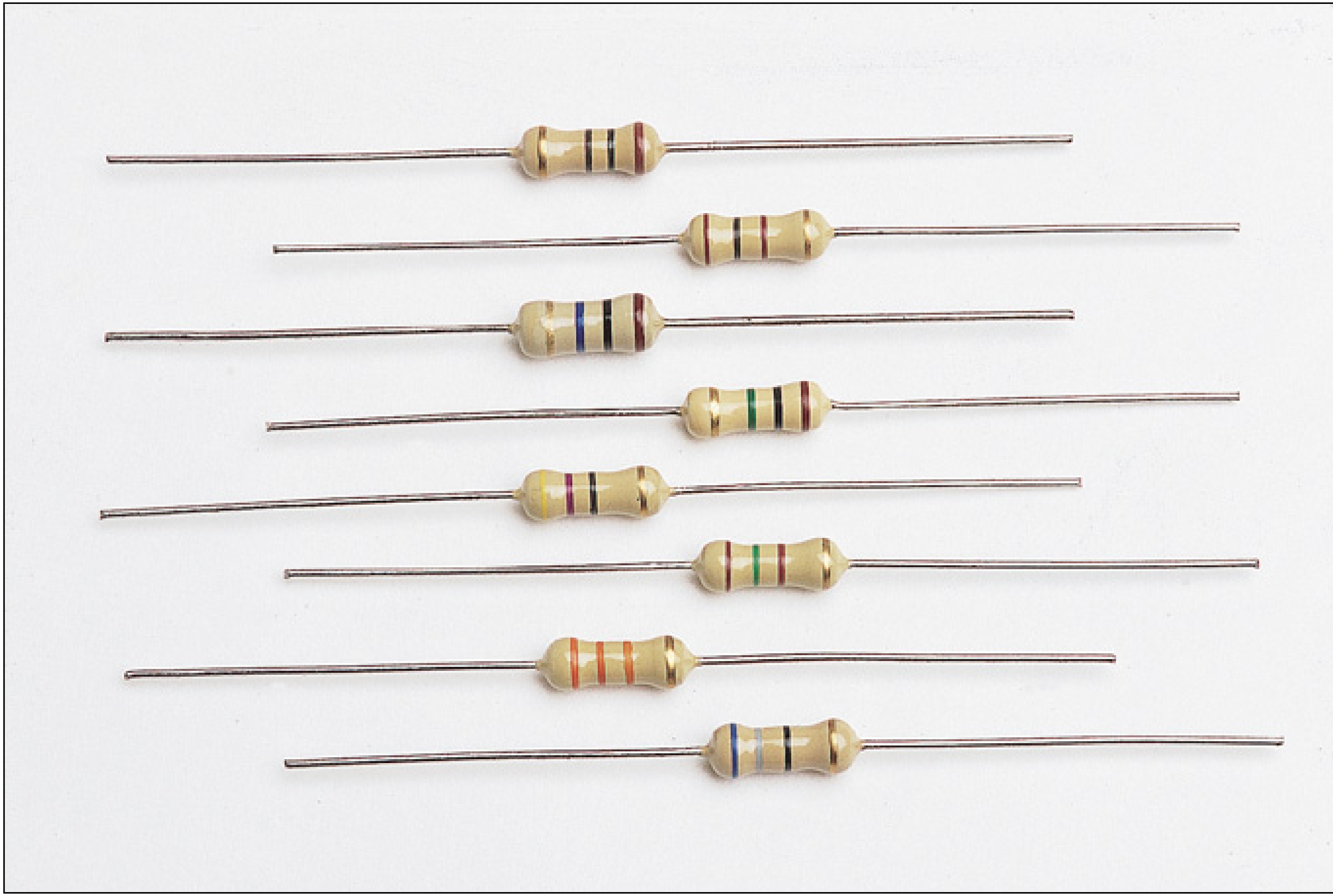
- **All materials have a resistance that is dependent on cross-sectional area, material type and temperature.**

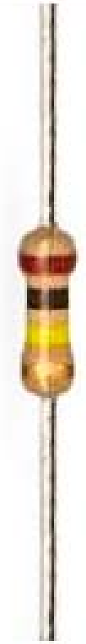
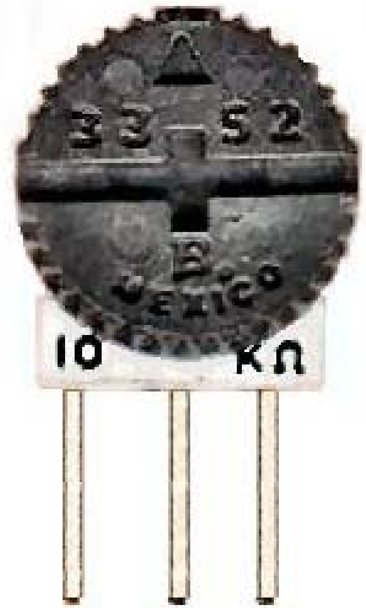
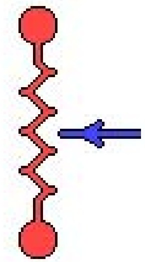
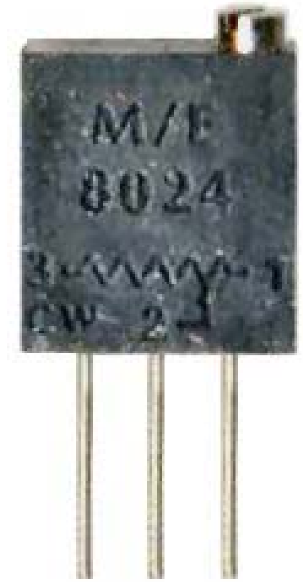
Resistors are devices that oppose the flow of electricity.





- **A resistor dissipates power in the form of heat**



1/4 Watt	"Fixed"	Single Turn Trimmer	"Pot"	Multi-turn Trimmer
				
Fixed	Symbol	Potentiometer (Pot)	Symbol	Potentiometer

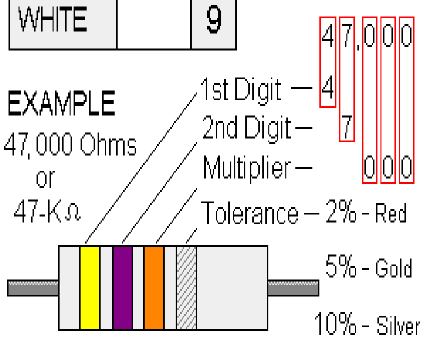
Potentiometer

Potentiometer

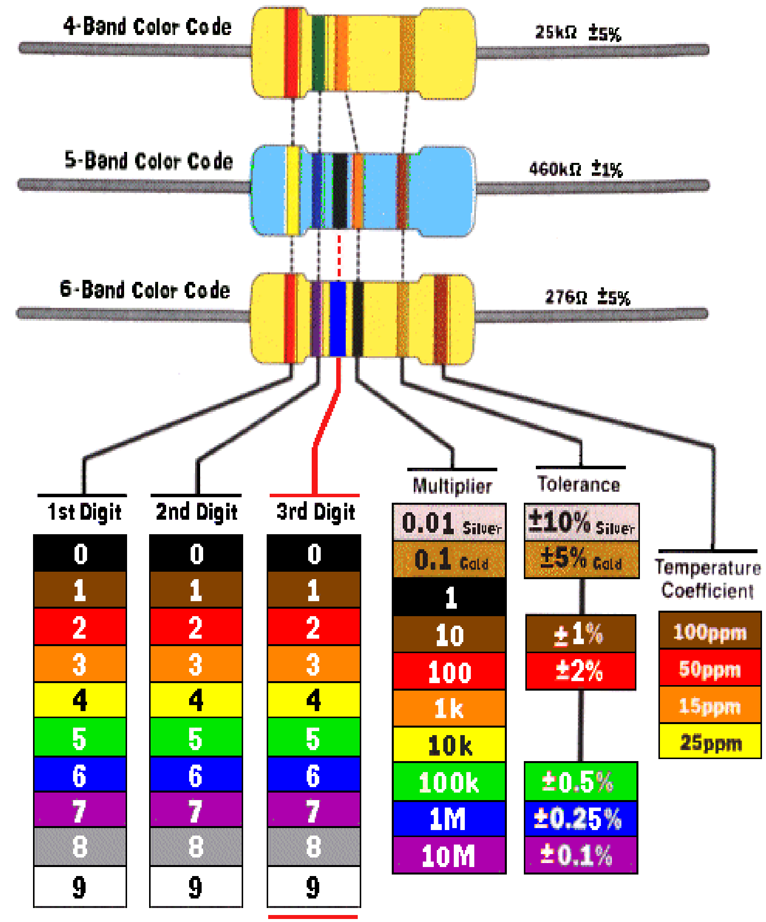
Sliding Potentiometer

Resistor Color Code

		Multiplier
BLACK	0	
BROWN	1	0
RED	2	00
ORANGE	3	000
YELLOW	4	0,000
GREEN	5	00,000
BLUE	6	000,000
VIOLET	7	
GRAY	8	
WHITE	9	



4 Band Color Code



Be Careful when reading 5 and 6 Band Resistors

Note: the 3rd Digit is not used when reading the 4 band resistor

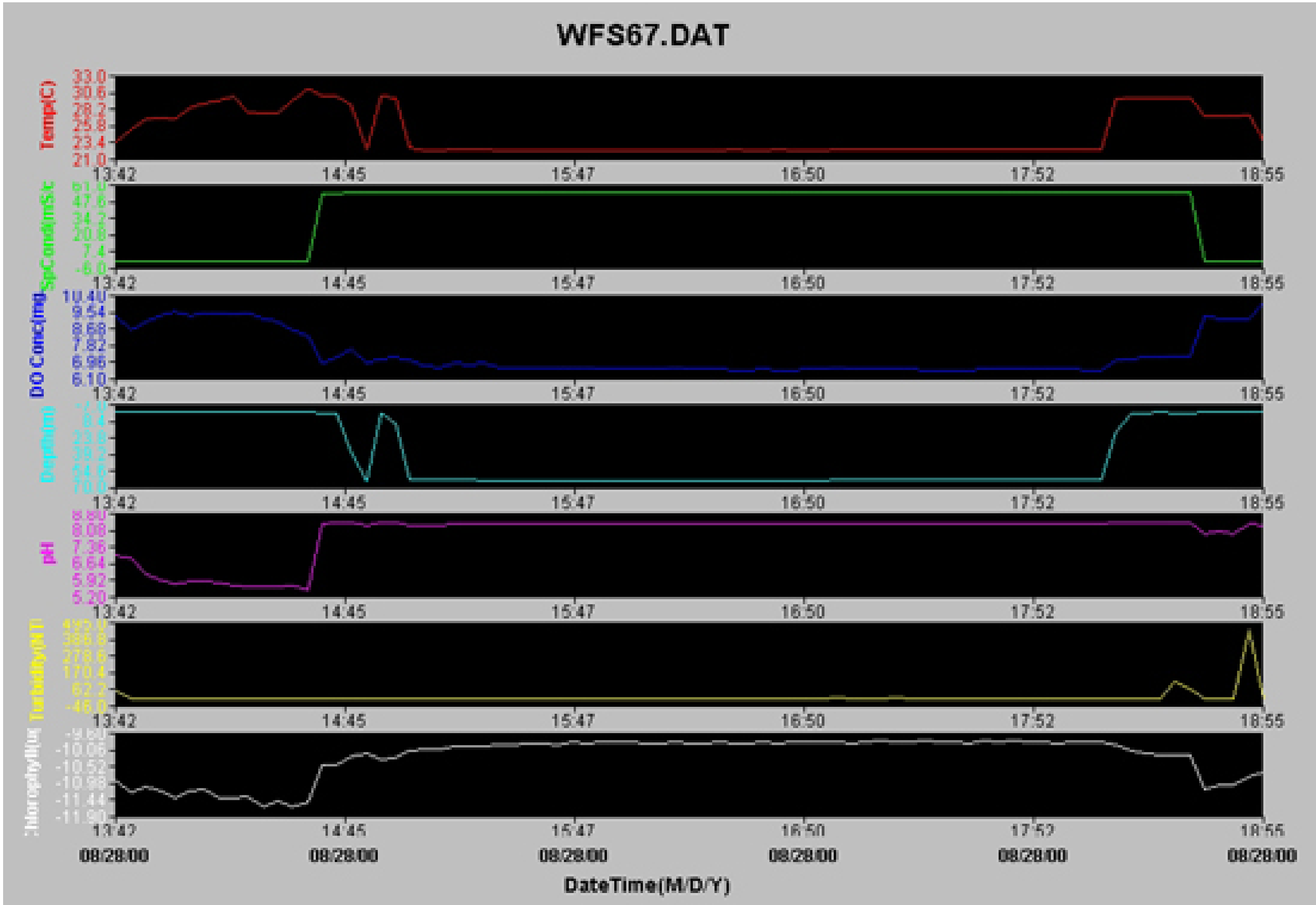
Conductance

- The inverse of resistance, it is the ability of a material to conduct electricity.

$$G = \frac{1}{R}$$

Unit is siemans (S)

Conductance in Use

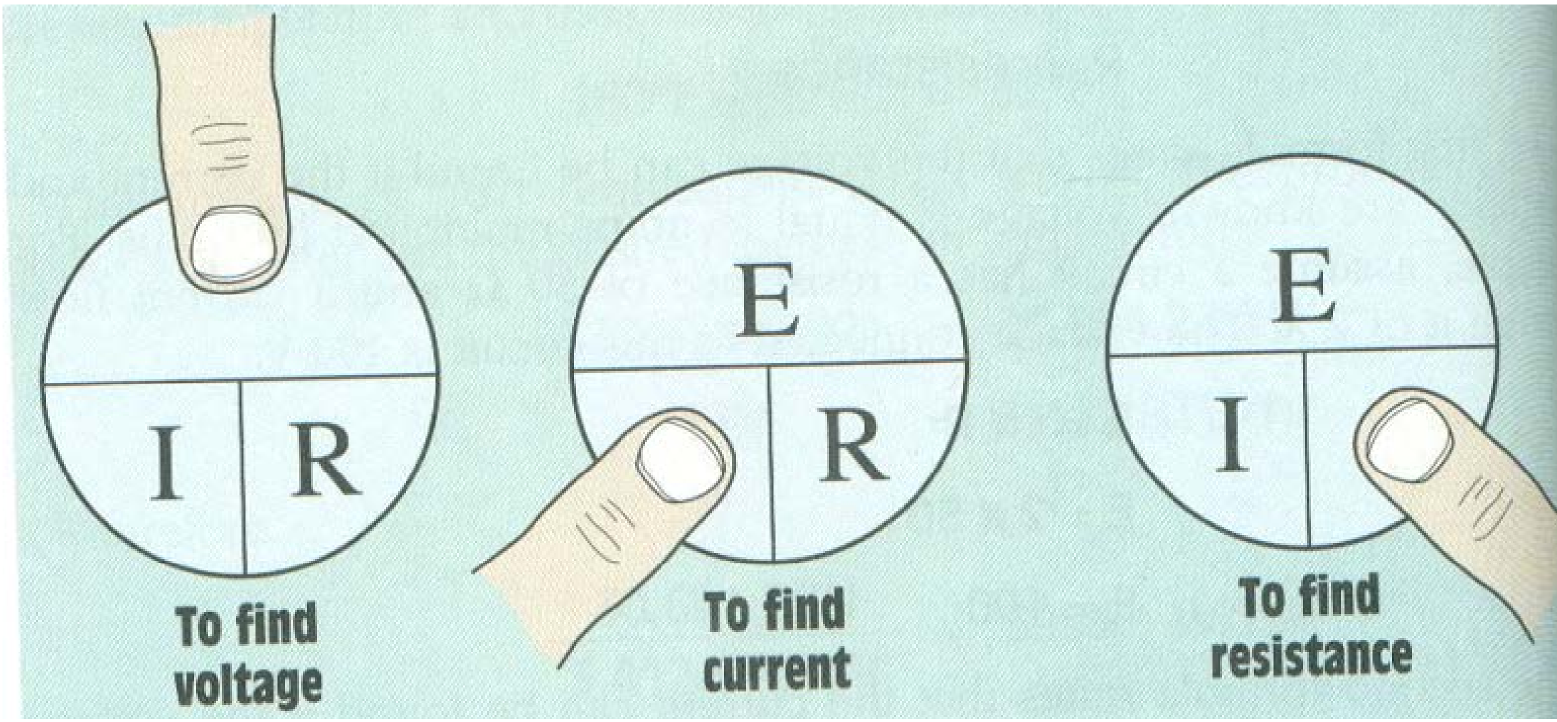


Even you have a resistance!

Ohms Law

- The most important fundamental law in electronics is Ohm's law, which relates voltage, current, and resistance.

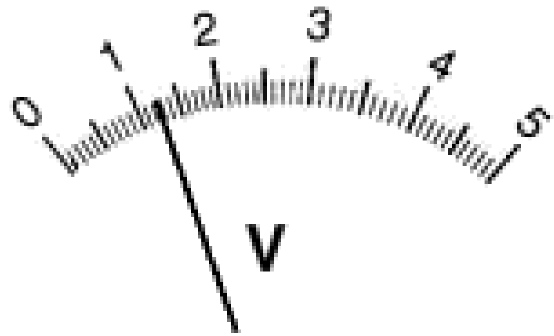
$$I = \frac{V}{R}$$

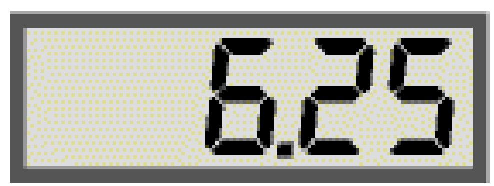

I
R
To find voltage
E
R
To find current
E
I
To find resistance

It takes one volt to push one amp through one ohm.

What is the current in from a 12 V source if the resistance is 10 Ω?

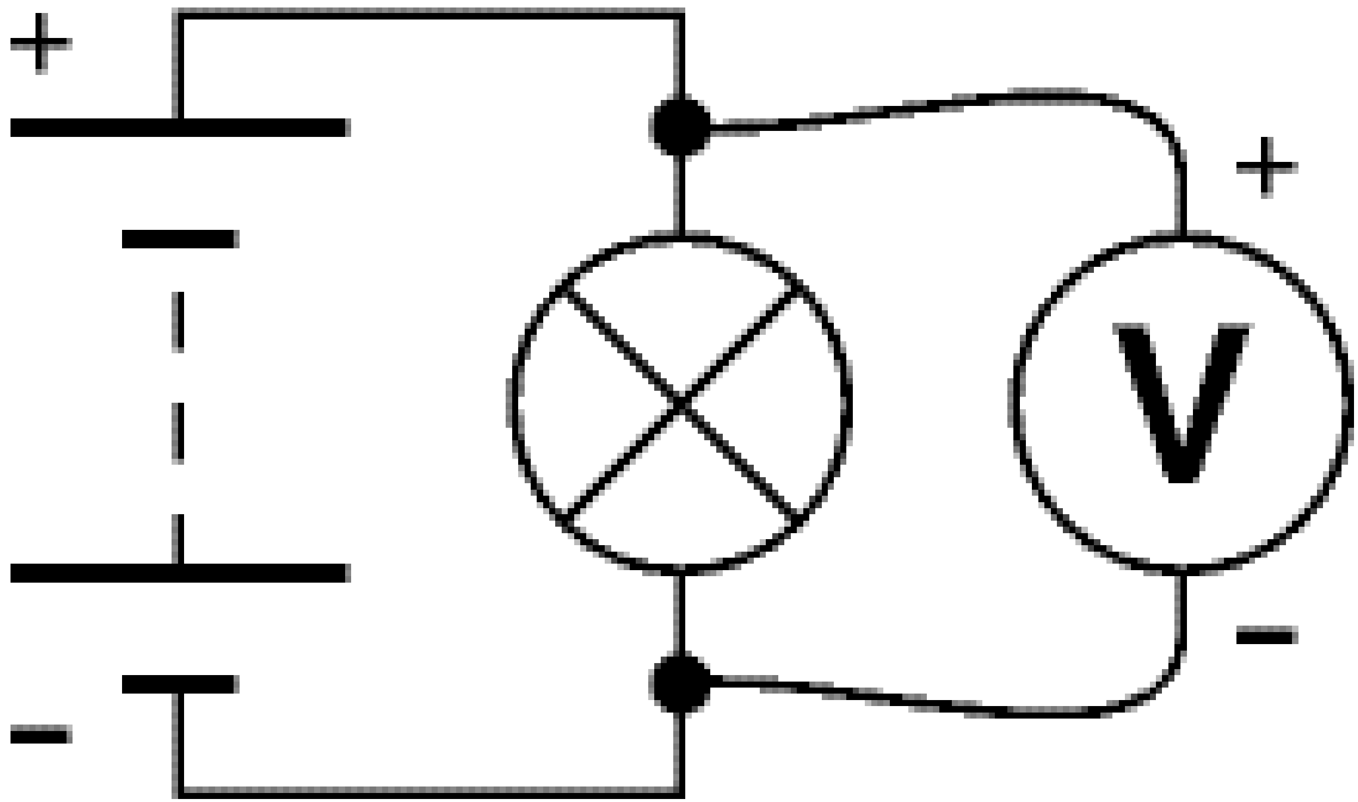
Multimeters





Measuring Voltage

- Connect the **black** (negative -) voltmeter lead to 0V, normally the negative terminal of the battery or power supply.
- Connect the **red** (positive +) voltmeter lead to the point you where you need to measure the voltage.
- The **black** lead can be left permanently connected to 0V while you use the **red** lead as a probe to measure voltages at various points.


+
–
V
+
–

- Voltmeters measure voltage.
- Voltage is measured in volts, V.
- Voltmeters are connected in parallel across components.
- Voltmeters have a very high resistance.

Measuring Current

- Ammeters measure current.
- Current is measured in amps (amperes), A.

- 1A is quite large, so mA (milliamps) and μA (microamps) are often used.

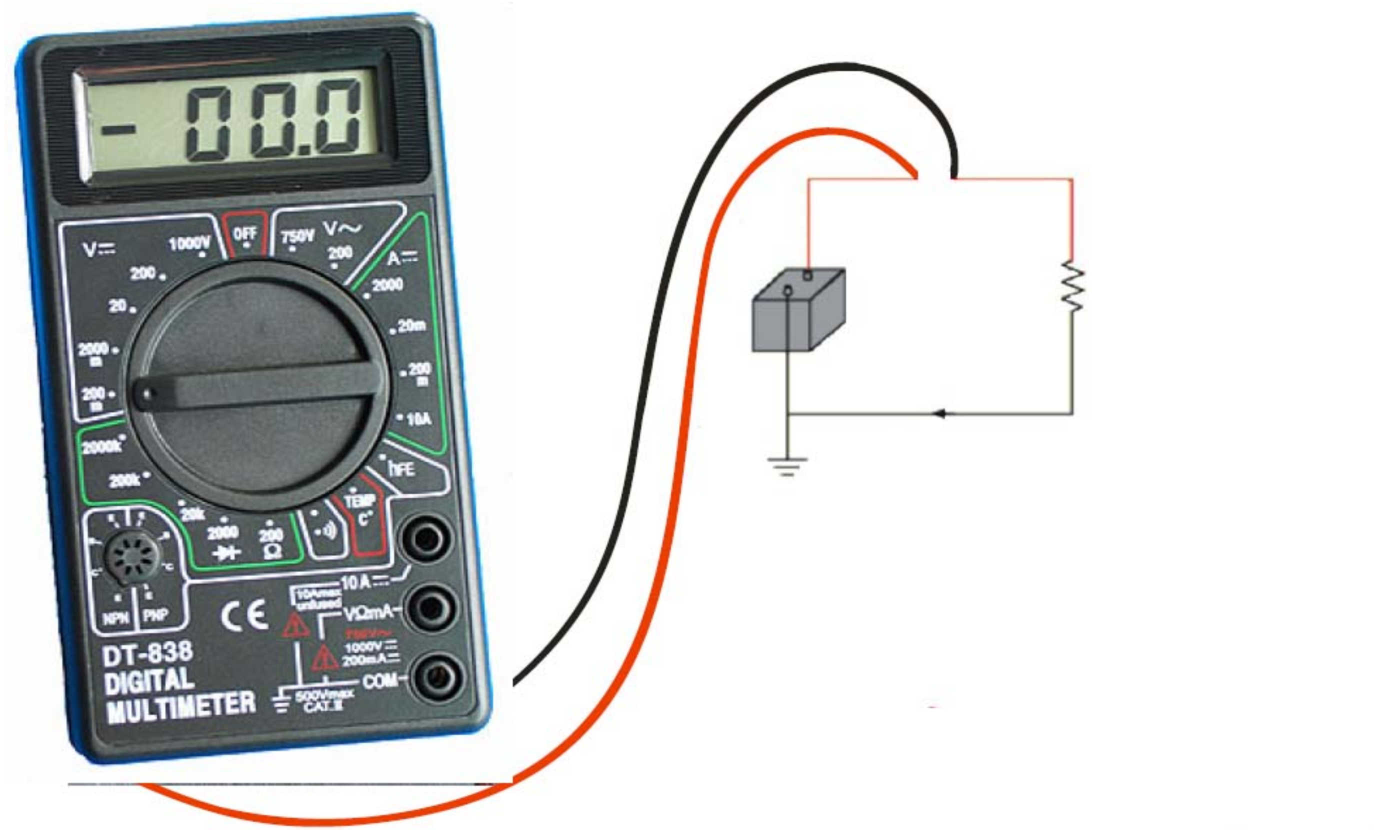
- 1000mA = 1A,
- 1000μA = 1mA,
- 1000000μA = 1A.

- To measure current, you must break circuit and install meter in line

- **Ammeters are connected in series.** ***To connect in series you must TURN OFF ALL POWER, break the circuit and***
  put the ammeter across the gap
-
- **Ammeters have a very low resistance.**

- The need to break the circuit to connect in series means that ammeters are difficult to use on soldered circuits.
- **Most** testing in electronics is done with voltmeters which can be easily connected without disturbing circuits.

Current Measurement



- Measurement is imperfect because of voltage drop created by meter.

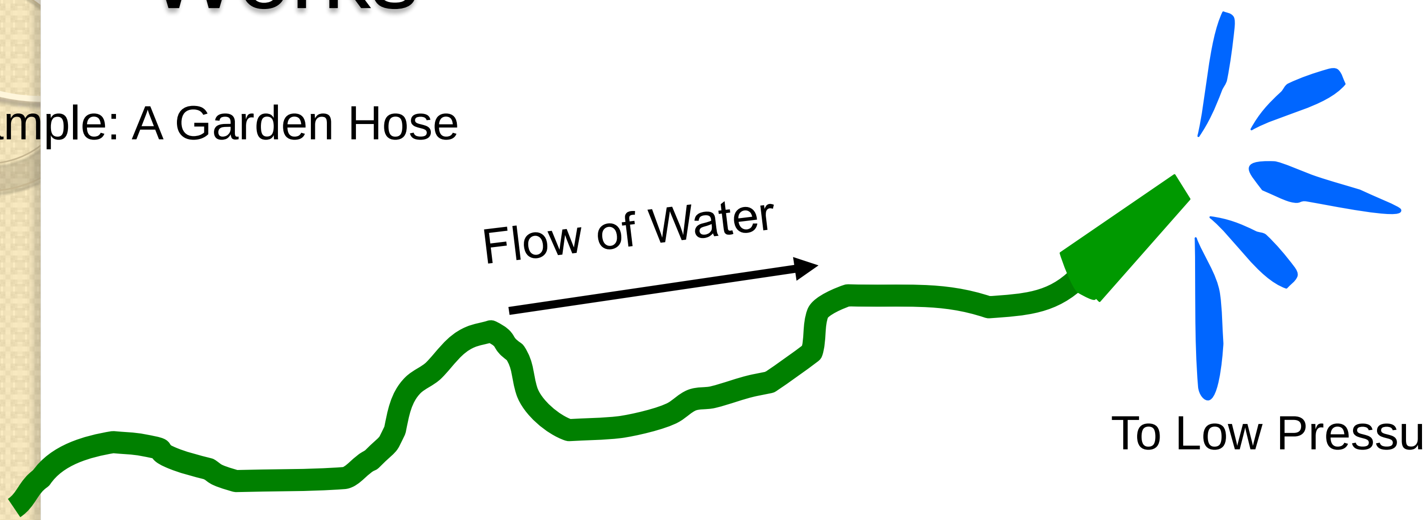
Electricity

- DC
- AC
- RF

General Electrical Safety

Basic Analogy of How Electricity Works

Example: A Garden Hose



To Low Pressure

Water Moves from
High Pressure

The same thing occurs in an Electrical Wire

Flow of Current

Current Moves from
High Voltage

To Low Voltage

Electrical Shocks

- Electricity travels in closed circuits, normally through a conductor
- Shock results when the body becomes part of the electrical circuit
- Current enters the body at one point and leaves at another

Note: Ground circuits provide a path for stray current to pass directly to the ground, and greatly reduce the amount of current passing through the body of a person in contact with a tool or machine that has an electrical short. Properly installed, the grounding conductor provides protection from electric shock.

How DC Electrical Current Affects the Body

Current (Amps)	Human Reaction
0.001	Perception level. Just a faint tingle.
0.005	Slight shock felt; not painful but disturbing. Average individual can let go.
0.006-0.025 (Women)	Painful shock, muscular control is lost.
0.009-0.030 (Men)	This is called the freezing current or "let-go" range.
0.050-0.150	Extreme pain, respiratory arrest, severe muscular contractions.
.15 - .43	Ventricular fibrillation.
>.43	Cardiac arrest, severe burns and probable death.

Note: some smaller microwave ovens use 10.0 Amps (10,000 milliamps) and common florescent lights use 1 Amp (1,000 milliamps)

AC

"At currents as low as 60 to 100 milliamperes, low-voltage (110-220 volts), 60-hertz alternating current traveling through the chest for a split second can cause life-threatening irregular heart rhythms.

About 300-500 milliamperes of direct current is needed to have the same effect."

"Electrical Injuries." *The Merck Manual of Medical Information: Home Edition*. Pennsylvania: Merck, 1997.

How AC Electrical Current Affects the Body

Current (Amps)	Human Reaction
0.001	Perception level. Just a faint tingle.
0.016	This is called the freezing current or "let-go" range.
0.020	Paralysis of respiratory muscles (Minimum)
0.100	Ventricular fibrillation threshold (Maximum)
2	Cardiac standstill and internal organ damage

From NIOSH.

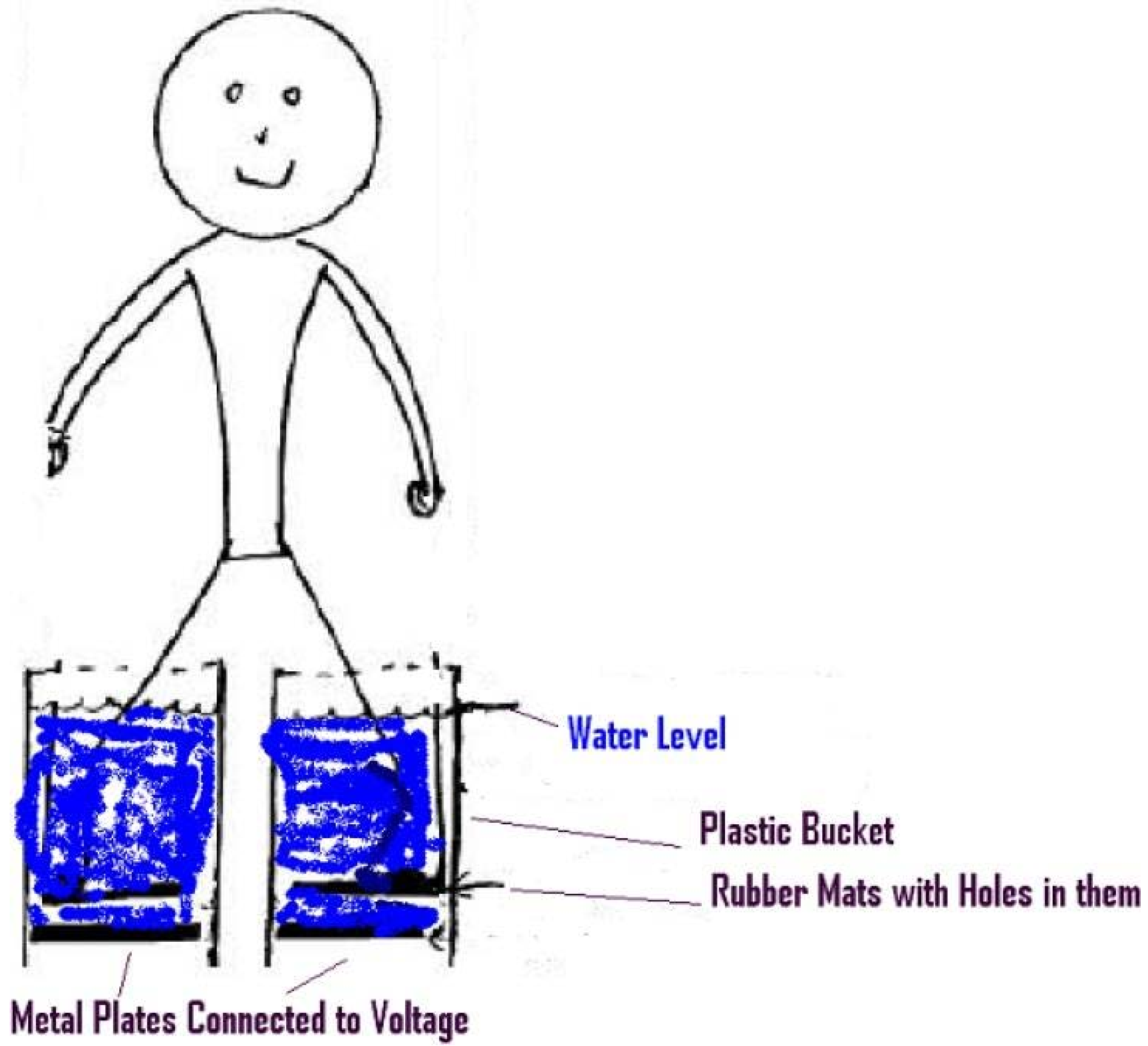
Note: Contact with 20 mA of current can be fatal. As a frame of reference, common household circuit breaker may be rated at 15, 20, and 30 A.

Skin Resistance can Change

- Significant physical skin damage: cuts, abrasions, burns
- Breakdown of skin at 500 V or more
- Rapid application of voltage to an area of the skin
- Immersion in water

RF

Current (Amps)	Human Reaction
0.001	Perception level. Just a faint tingle.
0.005	Slight shock felt; not painful but disturbing. Average individual can let go.
0.006-0.025 (Women)	Painful shock, muscular control is lost.
0.009-0.030 (Men)	This is called the freezing current or "let-go" range.
0.050-0.150	Extreme pain, respiratory arrest, severe muscular contractions.
.15 - .43	Ventricular fibrillation.
>.43	Cardiac arrest, severe burns and probable death.


Water Level
Plastic Bucket
Rubber Mats with Holes in them
Metal Plates Connected to Voltage

Burns

The most common shock-related injury is a burn. Burns suffered in electrical incidents may be one or more of the following three types:

- **Electrical Burns** cause tissue damage, and are the result of heat generated by the flow of electric current through the body. *Electrical burns are one of the most serious injuries you can receive and need to receive immediate medical attention.*
- High temperatures near the body produced by an electric arc or explosion cause **Arc or Flash Burns** (also need prompt medical attention)
- **Thermal Contact Burns** occur when skin comes in contact with overheated electric equipment, or when clothing is ignited in an electrical incident.

Note: the graphic pictures were not included. But if you would like to view them click http://www.osha.gov/SLTC/etools/construction/electrical_incidents/burns.html

Internal Injuries

- Our bodies use small electrical currents to transmit signals through the nervous system and contract muscles, extra electrical current flowing through the body can cause serious damage.

- Medical problems can include internal bleeding, tissue destruction, and nerve or muscle damage.

- Internal injuries may not be immediately apparent to the victim or observers; however, left untreated, they can result in death

Involuntary Muscle Contraction

- Muscles violently contract when stimulated by excessive amounts of electricity

- These involuntary contractions can damage muscles, tendons, and ligaments, and may even cause broken bones.

- If the victim is holding an electrocuting object, hand muscles may contract, making it impossible to drop the object.

Note: injury or death may result from a fall due to muscle contractions.

Water and Conduction

Conductors- Substances with relatively little resistance to the flow of electrical current (e.g., metals).

Water- influences the conductive properties of some materials

Dry wood is a poor conductor

Wood saturated with water becomes a ready conductor

Use ***extreme caution*** when working with electricity where there is water in the environment or on the skin.

Water as a Conductor

- Water quits being an excellent insulator once it starts dissolving substances around it.

Salts are the one we know best.

- In chemical terms, salts are ionic compounds composed of cations and anions.
- Even a small amount of ions in a water solution makes it able to conduct electricity.
- Too bad if there is a human body in the way.

- If the water contains very large amounts of solutes and ions, then the water becomes such an efficient conductor of electricity that an electrical current may essentially ignore a human body in the water.

- That is why the danger of electrocution in sea water is less than it would be in bath water – the over ability of the sea water to conduct electricity is far less than that of the human body.

- But the body is still part of the circuit and can react to the current still…

Human Skin & Resistance

Dry Conditions ⟶ Human Skin is Resistant

Current = Volts/Ohms = 120/100,000 = 1mA (0.001A)

-Barely perceptible level of current

Wet Conditions ⟶ Skin's Resistance drops dramatically

Current = Volts/Ohms = 120/1,000 = 120mA (0.12A)

-Sufficient current to cause ventricular fibrillation

A low voltage electrocution becomes much more hazardous in a wet condition

High voltage electrical energy greatly reduces the body's resistance by quickly breaking down human skin. Once the skin is punctured, the lowered resistance results in massive current flow.

Why immersion in water can be fatal with very low voltages

- Immersion wets the skin very effectively and greatly lowers skin resistance per unit area
- Contact area is a large percentage of the entire body surface area

- The total body resistance from hand to foot in water is considered to be 300 Ω
- Electric current may also enter the body through mucous membranes, such as the mouth and throat

- The human body is very sensitive to electricity.

  Very small amounts of current can cause loss of ability to swim, respiratory arrest, and cardiac arrest

Two ways of being a victim

- Direct contact – contacting an energized conductive object while exposed to the conductive water source.
- Gradients - being in an electric field because of an energized conductor that is in the water.

Low Voltage = Hazardous

- Muscular contraction caused by stimulation does not allow a victim to free himself from a circuit
- The degree of injury increases with the **length of time** the body is in the circuit.
- Thus even relatively low voltages can be extremely dangerous.

LOW VOLTAGE

DOES NOT IMPLY

LOW HAZARD!

An exposure of 100mA for 3 seconds can cause the same amount of damage as an exposure of 900mA for .03 seconds

Ground-Faults

(The Most Common Form of Electrical Shock)

A ground-fault occurs when current flowing to the load (drill, saw, etc.) does not return by the prescribed route.

A person's body can act as the path to ground when a fault occurs.

Ground-Fault Incidents

Use GFCI's for protection against ground-faults

1. A double insulated drill (no ground pin) was used in a wet location. Water entered the drill housing and current flowed through the water and user, and then back to its source.
2. An individual with moist hands was electrocuted while winding up a damaged extension cord when their skin contacted exposed wiring in the extension cord.

Ground-Fault Protection

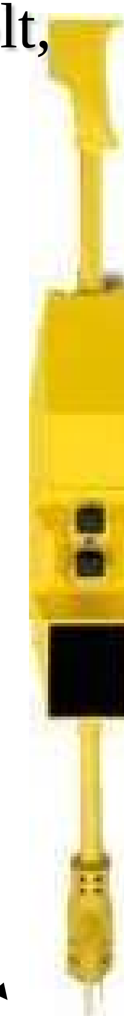
The ground-fault circuit interrupter (GFCI) works by comparing the amount of current *going to* and *returning from* equipment along the circuit conductors.

When the amount *going* differs from the amount *returning* by approximately 5 milliamperes, the GFCI interrupts the current within as little as 1/40 of a second.

Ground-Fault Protection

Use ground-fault circuit interrupters (GFCIs) on all 120-volt, single-phase, 15- and 20-ampere receptacles that will be used to supply temporary power (i.e. hand tools and other portable equipment).

-Portable GFCIs, like this one, are available for situations where GFCI protection is not otherwise provided-

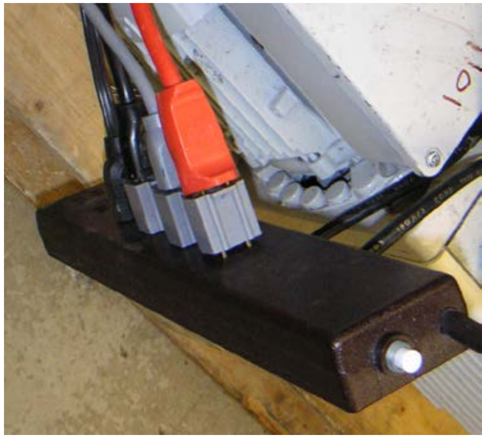


Follow manufacturers' recommended testing procedure to insure GFCIs are working correctly.

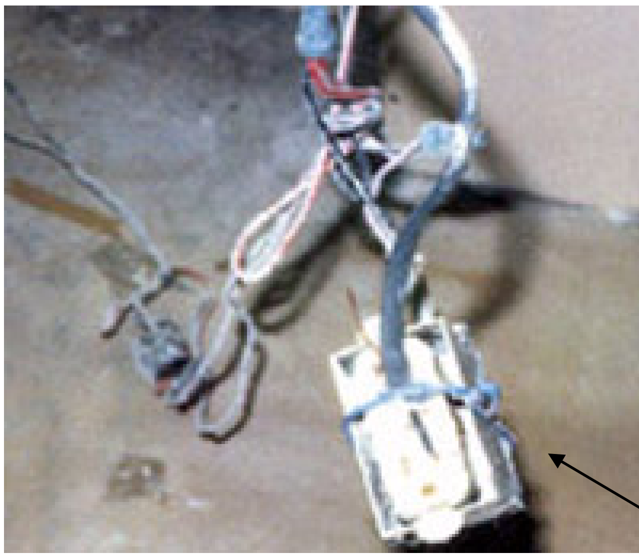
Important - Plug this end directly into the electrical source, not another flexible cord.

Grounding - How Do I Avoid Hazards

- Ground all power supply systems, electrical circuits, and electrical equipment
- Do not remove ground pins/prongs from cord- and plug-connected equipment or extension cords
- Use double-insulated tools
- Ground all exposed metal parts of equipment



Using Equipment in a Manner Not Prescribed By The Manufacturer



If electrical equipment is used in ways for which it is not designed, you can no longer depend on safety features built in by the manufacturer. This may damage property and cause employee injuries or worse

Shock, fire, loss of life and property?

Note: Junction boxes such as this one must be mounted properly.

Common Examples of Equipment Used in A Manner Not Prescribed

- Using multi-receptacle boxes designed to be *mounted* by fitting them with a power cord and placing them on the floor.
- Fabricating extension cords with ROMEX® wire.
- Using equipment outdoors that is labeled for use only in dry, indoor locations.
- Using circuit breakers or fuses with the wrong rating for over-current protection, e.g. using a 30-amp breaker in a system with 15- or 20-amp receptacles (protection is lost because it will not trip when the system's load has been exceeded).
- Using modified cords or tools, e.g., removing face plates, insulation, etc.
- Using cords or tools with worn insulation or exposed wires.

REMEMBER - ONLY USE EQUIPMENT IN A MANNER PRESCRIBED BY THE MANUFACTURER

Flexible Cords Not Used Properly

The following cords are improperly wired directly to the electrical circuit, are not protected by a GFCI, and are two-wire cords that are not grounded and not rated for hard- or extra-hard service.

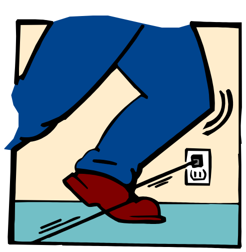
Temporary (flexible wiring) must not be used in place of permanent wiring. Multioutlet surge protection such as this can be used to supply power to equipment that needs surge protection, but not used to provide more outlets due to the lack of permanent wiring.

Note: a common OSHA violation.

Extension type cords that are not 3-wire type, not designed for hard-usage, or that have been modified, increase your risk of contacting electrical current, and should not be used.

Flexible Cord Safe Practices

- Only use factory-assembled cord sets.
- Use only extension cords that have a ground wire (3-wire type).
- Use only cords, connection devices, and fittings that are equipped with strain relief.
- Remove cords from receptacles by pulling on the plugs, not the cords.
- Remove from service flexible cords that have been modified or damaged



Protect flexible cords from damage.

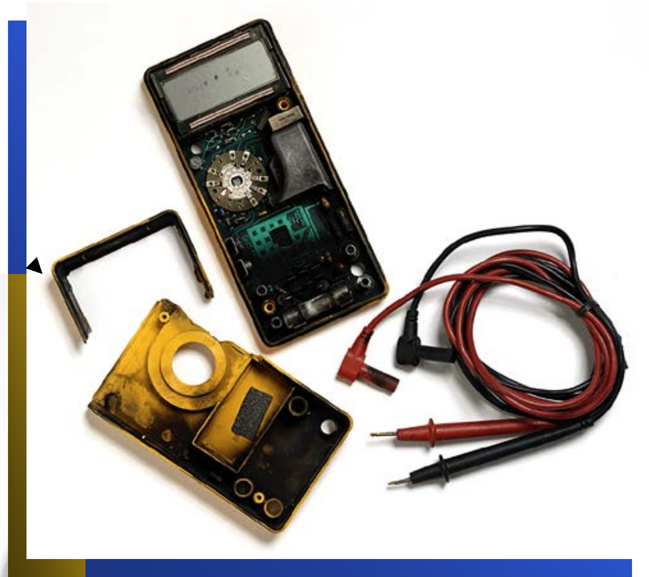
Remember

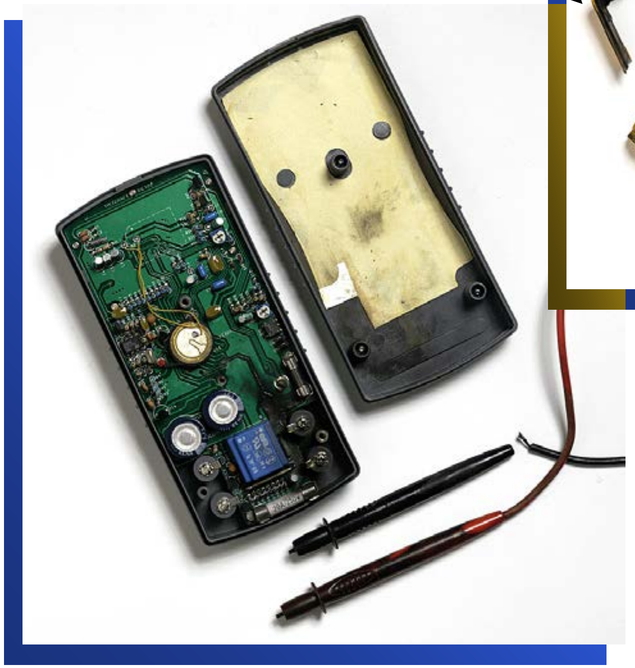
- Visually inspect all electrical equipment before use.

- Remove any equipment with frayed cords, missing ground prongs, cracked tool casings, etc. from service.

- Apply a warning tag to any defective tool and do not use it until it has been properly repaired.

New IEC Safety Standards





International Electrotechnical Commission

- IEC 61010 is the new standard for low voltage “test, measurement and control equipment”.
- IEC 61010 provides much improved protection against “overvoltage impulse transients” - voltage spikes.
- IEC 61010 is the basis for:
  - ANSI/ISA-S82.01-94 (US)
  - CAN C22.2 No. 1010.1-92 (CAN)
  - EN61010-1:1993 (EUR)

Myths

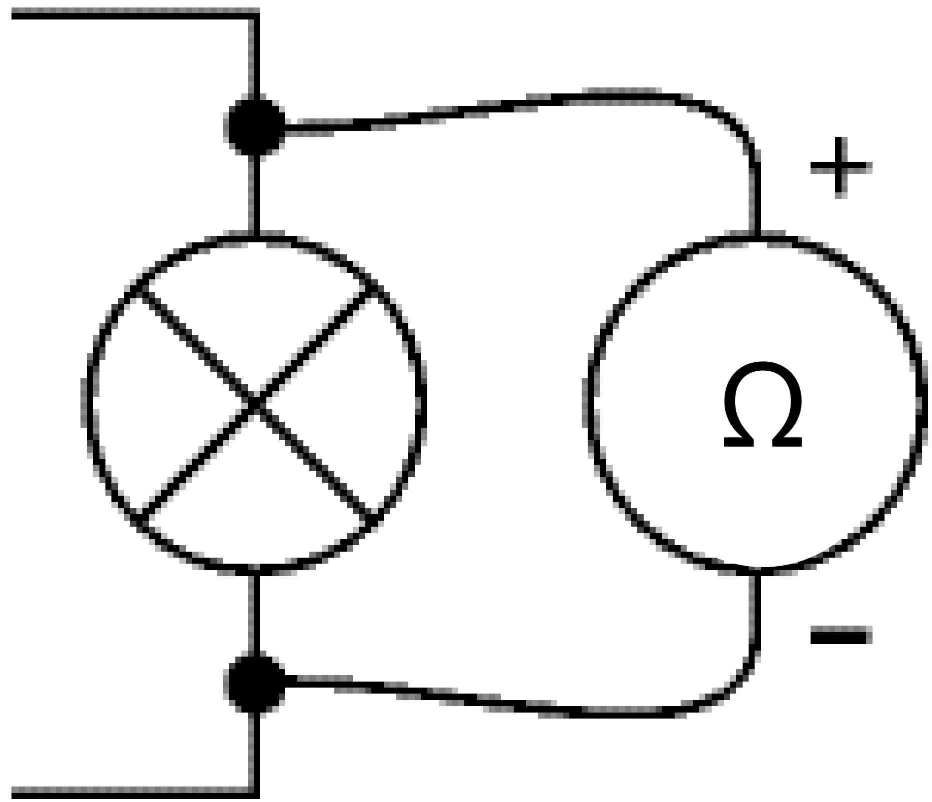
- Electricity takes the path of least resistance
  - Truth: It will take ALL paths that return to neutral.
- Electricity want to go to ground
  - Truth: It is only looking for a path that is different in potential.
- If an electric tool is in water it will short out
  - Truth: The water may not provide a return or path and may just become an energized potential.

Myths

- It takes a high voltage to kill
- Double insulated tools are safe to use in wet and damp locations

Measuring Resistance

- Power to device must be OFF
- Device must be isolated from the circuit.
- Connect the **black** (negative -) volt-ohm meter lead to one side of the device.
- Connect the **red** (positive +) volt-ohm meter lead to the point you where you need to measure the voltage.
- If the meter is not an auto scaling meter, then you must select the proper scale.


+
Ω
−

Measuring Resistance with a Multimet

To measure the resistance of a component it must not be connected in a circuit. If you try to measure resistance of components in a circuit you will obtain false readings (even if the supply is disconnected) and you may damage the multimeter.

The techniques used for each type of meter are very different so they are treated separately.

An ohmmeter is used to measure resistance in ohms (Ω). Ohmmeters are rarely found as separate meters but all standard multimeters have an ohmmeter setting.

1 Ω is quite small so kΩ and MΩ are often used.
1kΩ = 1000Ω , 1MΩ = 1000kΩ = 1000000Ω .

Measuring Resistance with a Digital Multimeter

1. **Set the meter to a resistance range greater than you expect the resistance to be.**
   Notice that the meter display shows "off the scale" (usually blank except for a 1 or ! on the left). Don't worry, this is not a fault, it is correct - the resistance of air is very high!

2. **Touch the meter probes together and check that the meter reads zero.**
   If it doesn't read zero, turn the switch to 'Set Zero' if your meter has this and try again.

3. **Put the probes across the component.**
   Avoid touching more than one contact at a time or **your** resistance will upset the reading!

Measuring Resistance with a Analog Multimeter

The resistance scale on an analog meter is normally at the top, it is an unusual scale because it reads **backwards** and is **not linear** (evenly spaced). This is unfortunate, but it is due to the way the meter works.

1. **Set the meter to a suitable resistance range.**
   Choose a range so that the resistance you expect will be near the middle of the scale. For example: with the scale shown below and an expected resistance of about 50kΩ choose the × 1kΩ range.

2. **Hold the meter probes together and adjust the control on the front of the meter which is usually labeled** "0Ω ADJ" **until the pointer reads zero (on the RIGHT remember!).**
   If you can't adjust it to read zero, the battery inside the meter needs replacing.

3. **Put the probes across the component.**
   Avoid touching more than one contact at a time or **your** resistance will upset the reading!

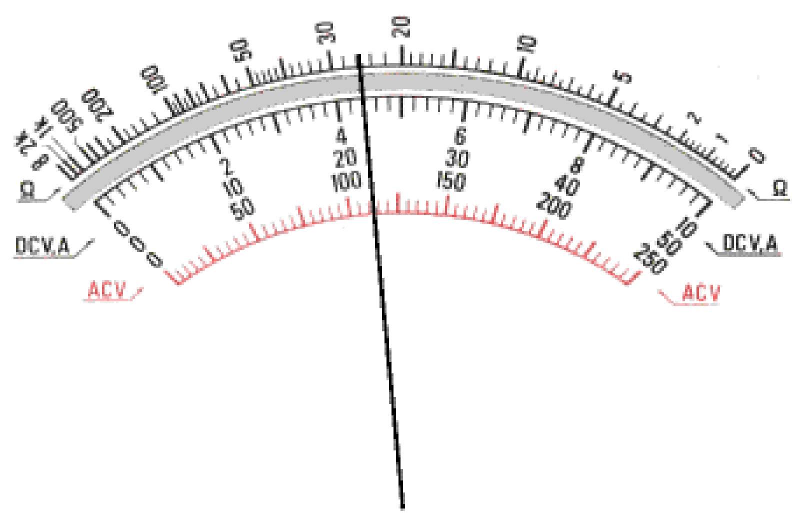
Reading Analog Resistance Sca

For **resistance** use the **upper scale**, noting that it reads backwards and is not linear (evenly spaced).

Check the setting of the range switch so that you know by how much to multiply the reading.

Sample readings on the scales shown:

- × 10Ω range: 260Ω
- × 1kΩ range: 26kΩ



Analog Multimeter Scales

The resistance scale is at the top, note that it reads backwards and is not linear (evenly spaced).

“Meggers”

- Nickname of high resistance measurement devices.
- Can measure very high resistances
  - >1M Ohm

Fast and Furious Overview