Amateur Radio
Technician Class Training

Slideset created by Alan Wolke, W2AEW
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Based on the No-Nonsense Technician Class
Study Guide by Dan Romanchik, KB6NU

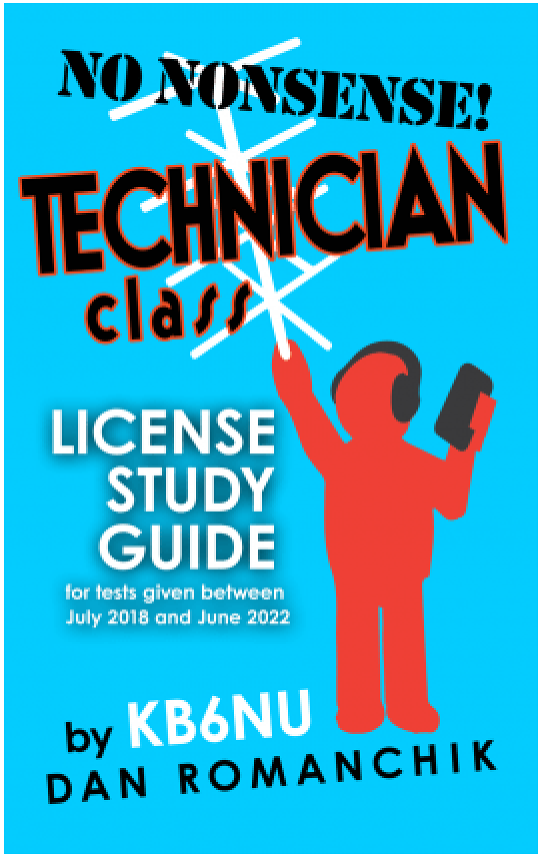
Updates by Rebecca Mercuri, Ph.D., K3RPM

Welcome to Session 2

Any Questions Before We Start?

Agenda

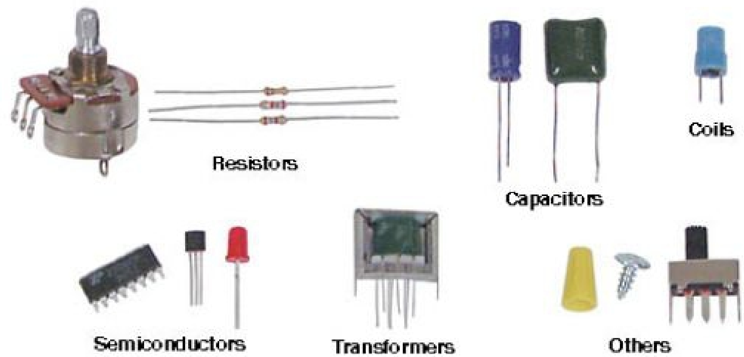
- Introduction
- Radio Wave Characteristics (RWC)
- **Electronic Components and Circuits (ECCD)**
- **Electrical Princlples (EP)**
- Antennas and Feed Lines (AFL)
- Amateur Radio Signals (ARS)
- Electrical Safety (ES)
- Radio Practices and Station Setup (RPSS)
- Station Equipment (SE)
- Operating Procedures (OP)
- Rules and Regulations (RR)

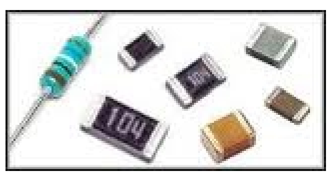


Electronic Components & Circuit Diagrams (ECCD)

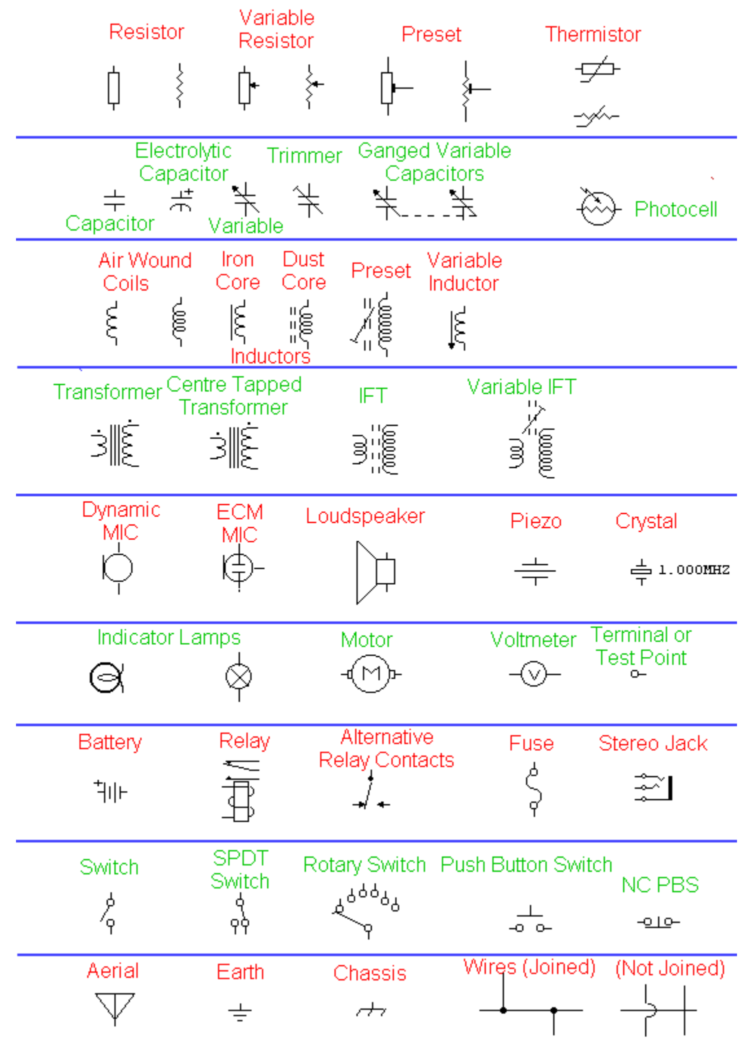
- Resistors, Capacitors, ...
- Semiconductors
- Circuit Diagrams
- Other Components

Electronic Components & Circuit Diagrams (ECCD)



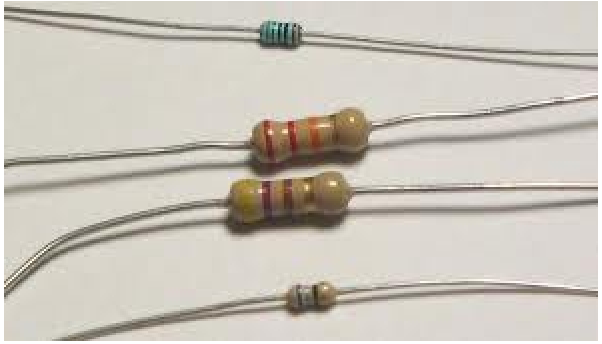


These are just examples -- only need to memorize the circuits and components on slides 16, 17, 18 in this set

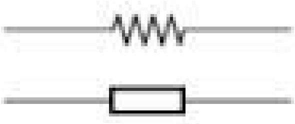


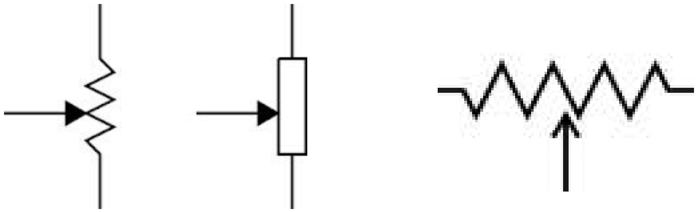
Resistors

Passive Components



- **Resistors** oppose the flow of current
- Variable resistors are called **Potentiometers** (or **Rheostats**)
- Resistor value expressed in **ohms**

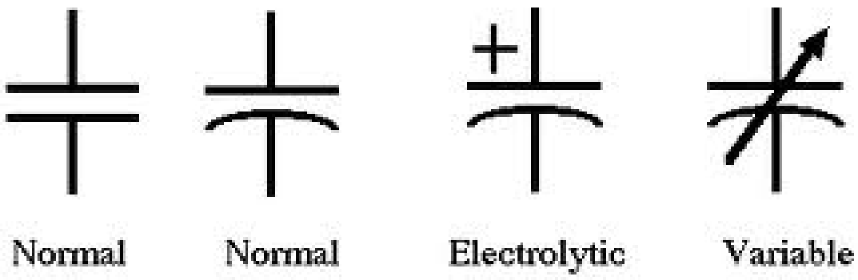


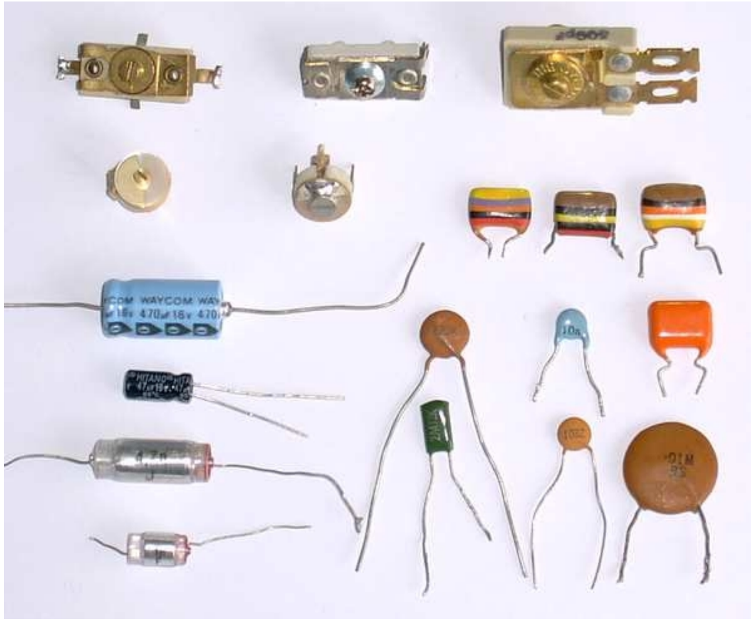


Capacitors

Passive Components

- Two conductors separated by an insulator (or dielectric) is a **Capacitor**
- Stores energy in an *electric* field
- Capacitance is the ability to store energy in an electric field
- The unit of measure is the **Farad**

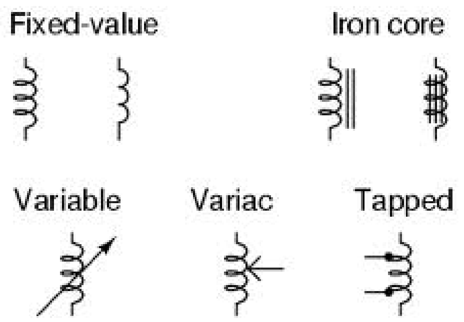




Inductors

Passive Components

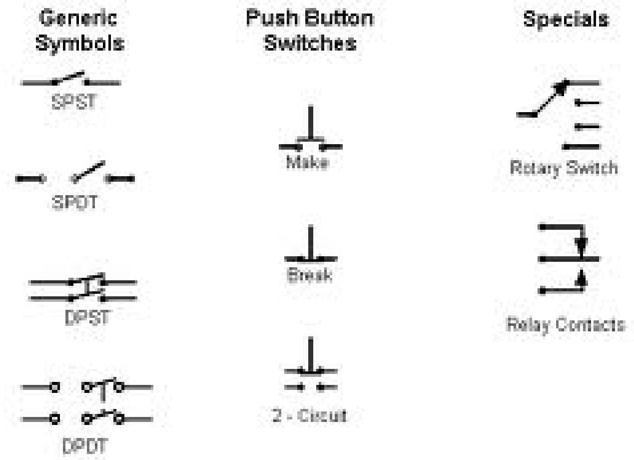
- An **inductor** stores energy in a *magnetic* field
- Often just a coil of wire!
- The ability to store energy in a magnetic field is called **Inductance**
- Unit of measure is **Henry**



Switches

Passive Components

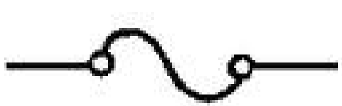
- Used to connect and disconnect electrical circuits
- **Pole**: "movable part"
- **Throw**: where the pole can get moved to
- SPST: single-pole, single-throw
- DPDT: double-pole, double-throw



Fuses

Passive Components

- Protects circuits from overload (excessive current)
- “Blown” fuse – breaks and has to be replaced, but circuit should be checked first to see what caused the overload
- Rated in **Amps**



Batteries

Primary batteries are not rechargeable:

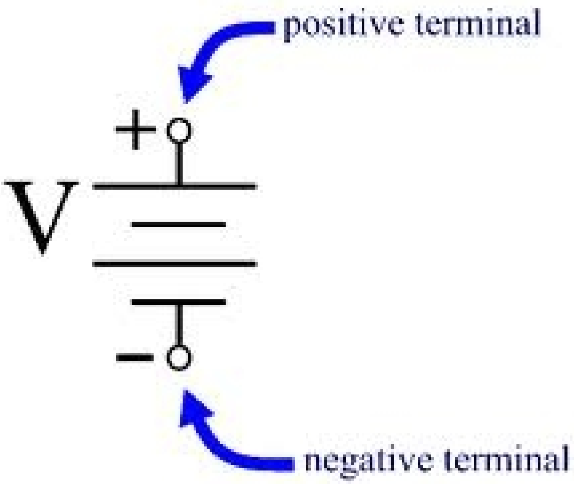
Carbon Zinc, Alkaline

Secondary batteries are rechargeable:

NiCad, NiMH, Lithium-ion, LiFePO4

Different types have different voltages

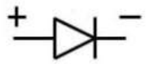
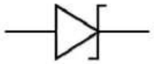
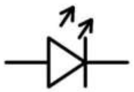
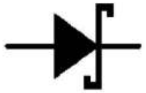
NiCad typically 1.2V



Diodes

Semiconductors

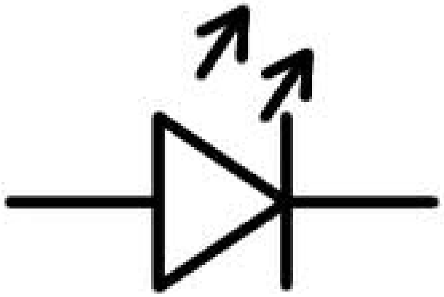
- Allows current to flow in only one direction
- Terminals are:
  - *Anode (+)*
  - *Cathode (-)*
- Cathode has the *stripe*
- Often called **Rectifier**

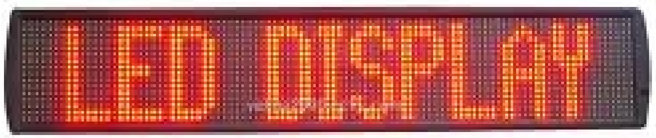
Name	Symbol	Image
Diode		
Zener Diode		
LED (Light Emitting Diode)		
Schottky Diode		

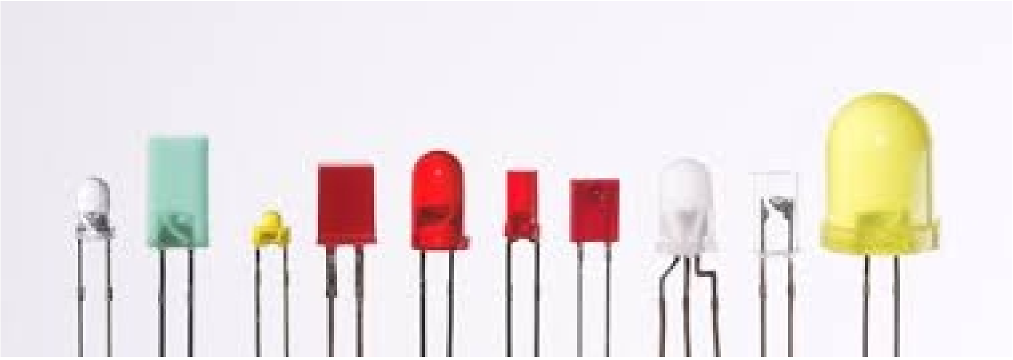
Light Emitting Diodes (LEDs)

Semiconductors

- A diode that creates light when current passes through it
- Commonly used as a *visual indicator*







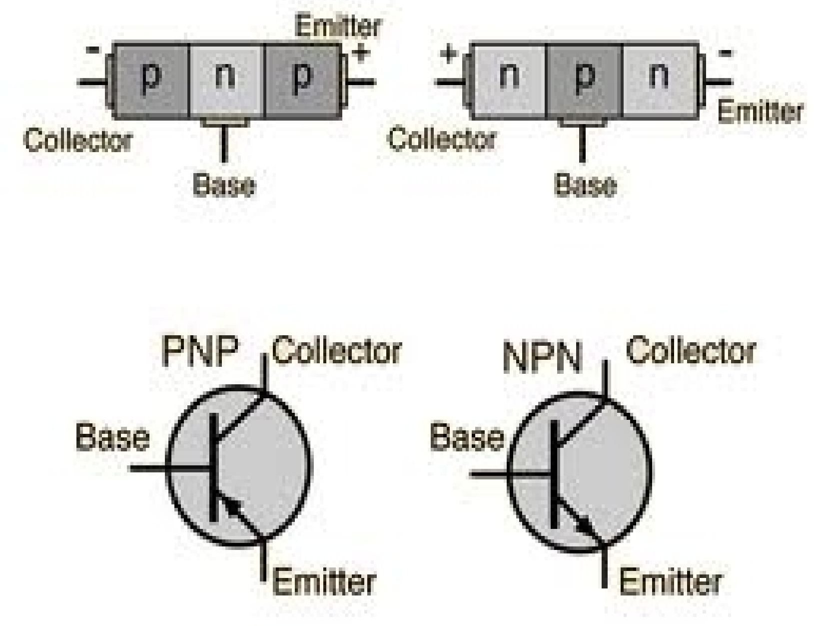
Transistors

Semiconductors

- Component where *current* flow is controlled by another *current or voltage*
- Used as a *switch* or *amplifier*
- **Gain** is a measure of the ability to amplify
- Ratio of output to input current (for example)

Some Transistor Types

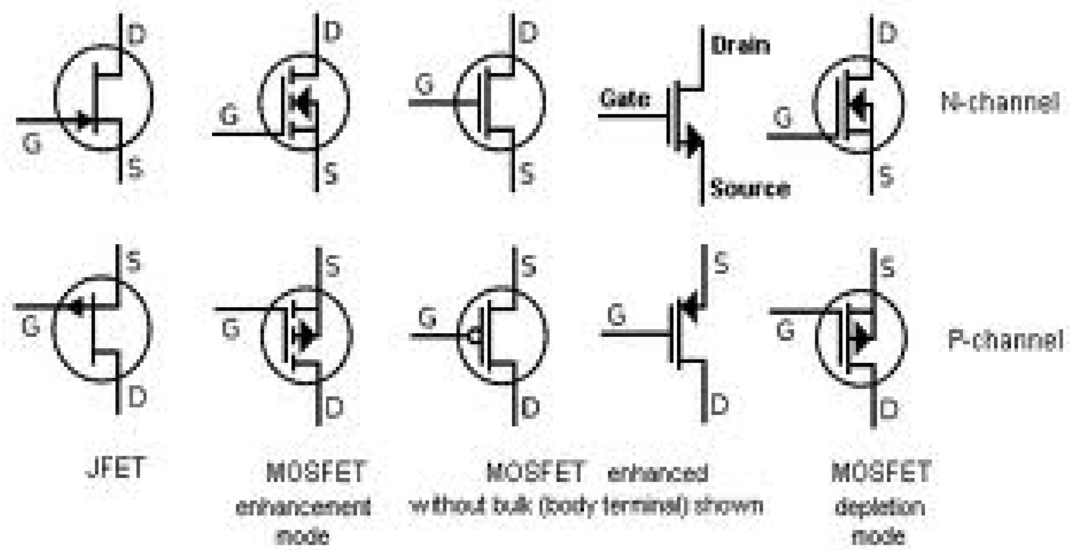
- **Bipolar transistors** are made of *three layers* of semiconductor
  - NPN or PNP
- Terminals are:
  - Base
  - Collector
  - Emitter



More Transistor Types

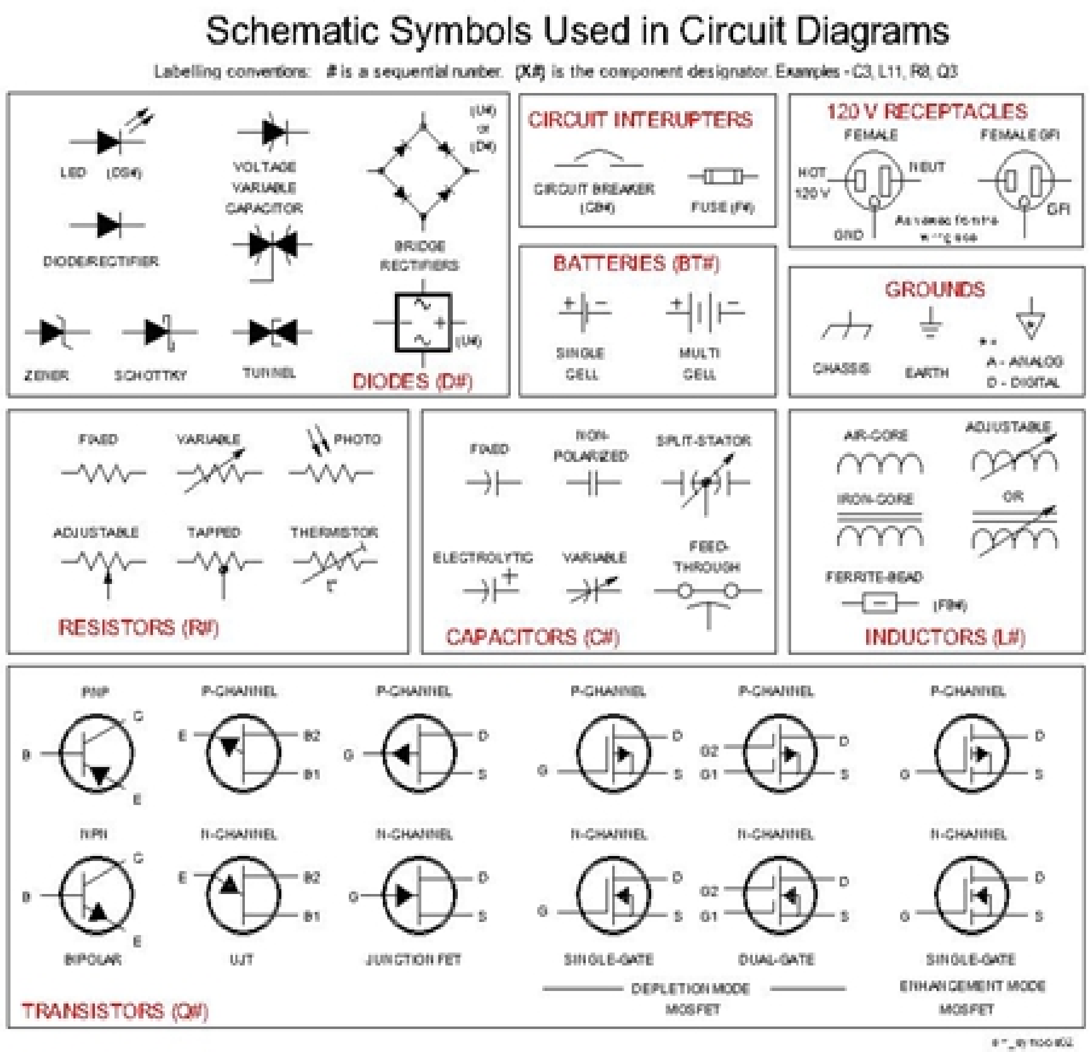
Field Effect Transistor (FET)

- Current is controlled by voltage on the Gate
- Terminals are:
  - Gate
  - Drain
  - Source



Schematic Symbols

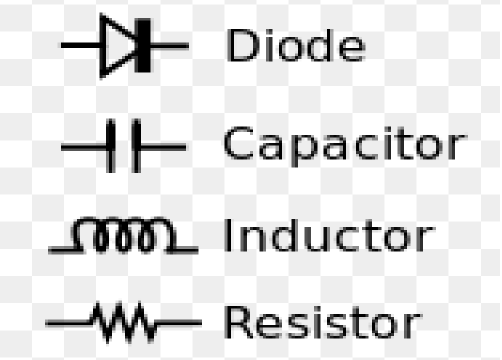
Examples of Circuit Diagrams
(do not memorize this page)



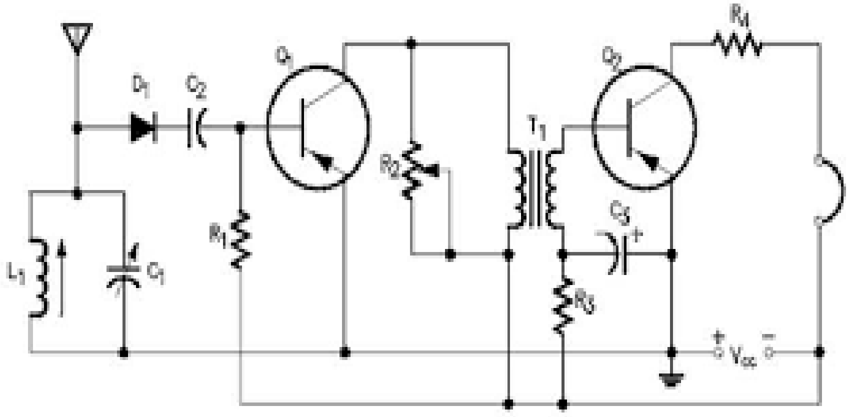
Schematic Symbols

Circuit Diagrams

- Schematic **symbols** are standardized representations for *components*

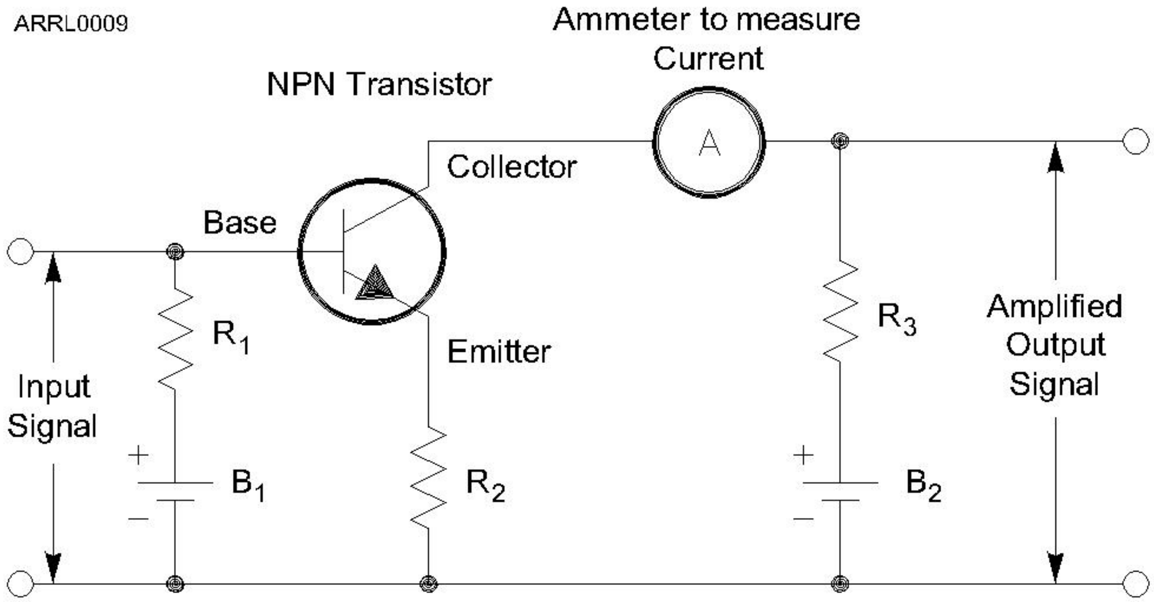


- Schematic **diagram** depicts the *interconnections* between components that make up a circuit



Schematic Diagrams

Circuit Diagrams



Schematic Diagram Examples

Circuit Diagrams – **Need to Memorize**

1: **Resistor**, used to limit input current

2: **Transistor**, controls the flow of current through the lamp

3: **Lamp**

4: **Battery**, supplies current to light the lamp

5: **Ground** to chassis

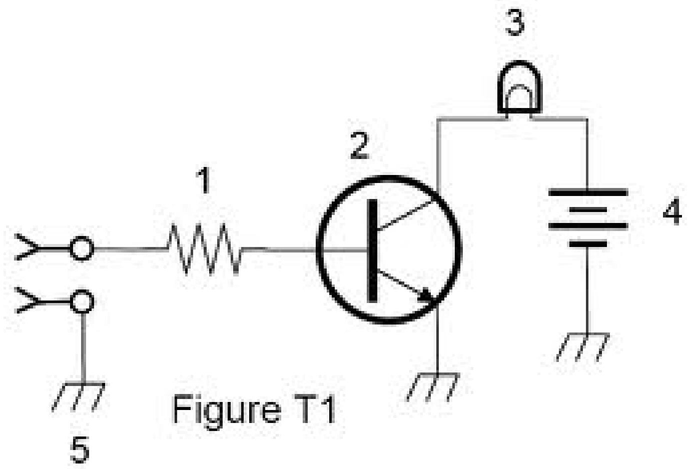


Figure T1

Turns on a light when a positive voltage is applied to the input

Schematic Diagram Examples

Circuit Diagrams – **Need to Memorize**

1: **Power Connector**

2: **Fuse**

3: **Single Pole, Single Throw switch** (SPST) to turn the power supply on/off

4: **Transformer**, used to change 120VAC to lower AC voltage

5: **Rectifier diode** to change AC to a varying DC signal

6: **Capacitor** helps to remove the 60Hz variation in the signal (filter)

7. **Resistor**

8: **LED** – pilot light to show it is on

9: **Variable Resistor** to vary the output current

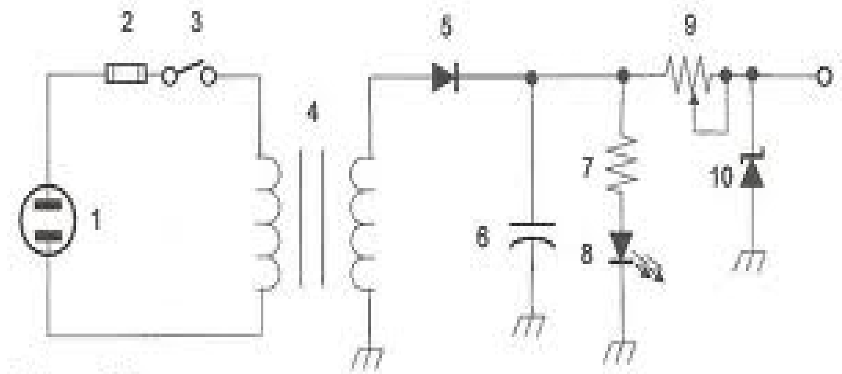


Figure T2

Simple AC – DC Power Supply

Schematic Diagram Examples

Circuit Diagrams – **Need to Memorize**

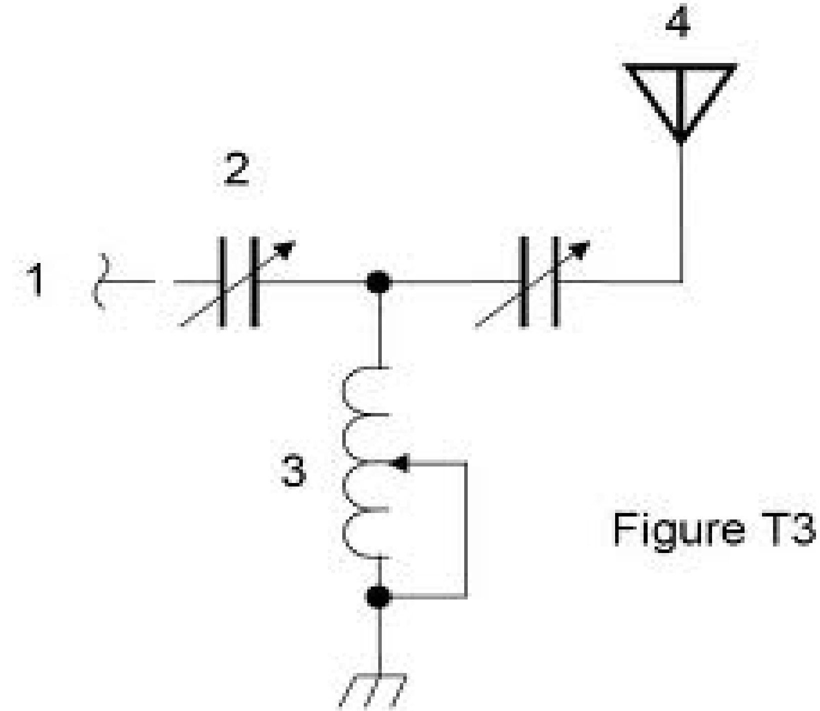
2: **Variable Capacitor**

3: **Variable Inductor**

The variable capacitors together with the variable inductor together create a *tuned circuit*

Capacitors and inductors connected together are often filters or tuned/resonant circuits

4: **Antenna**



Output circuit of a transmitter

Other Components

Circuit Diagrams

Relay: a switch controlled by an electromagnet

Meter: used to display a electrical quantity on a numeric scale

Shielded Wire: prevents coupling of unwanted signals to/from the wire

Regulator: controls the amount of voltage from a power supply

Integrated Circuit: combines many parts in one package, performs analog and/or digital functions

Electronic Components & Circuit Diagrams Chapter End

Questions?

Let's Practice for the Exam!

Electrical Principles (EP)

- Units and Terms
- Ohm's Law
- Series & Parallel
- DC Power
- Math
- Decibels

Why Do We Start With Electrical Principles?

- While Hams can operate amateur radios “out of the box” without modifications, it is important to know the underlying electrical fundamentals
- Designing, building and repairing amateur radio components is also an interest of many Hams
- This knowledge is required by the FCC -- the formulas we provide here will help you answer the exam questions on these topics
- This information is covered first in the MORE Course so that you will have the longest amount of time to review and remember it

Electrical Principles (EP)

Voltage

Current

Resistance

Amps

AC

DC

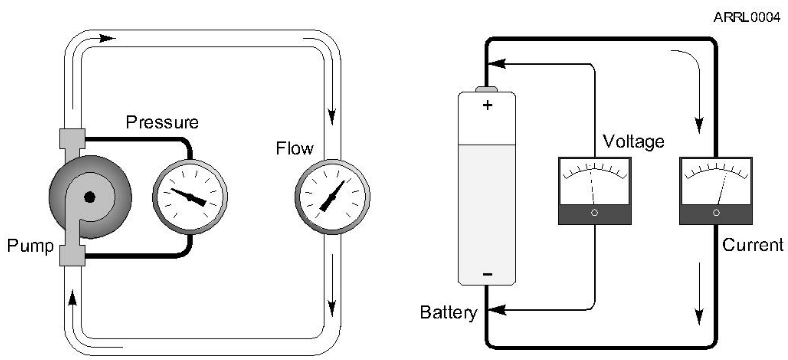
Volts

Insulator

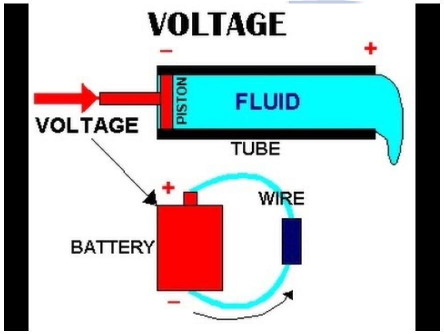
Ohms

Watts

Conductor

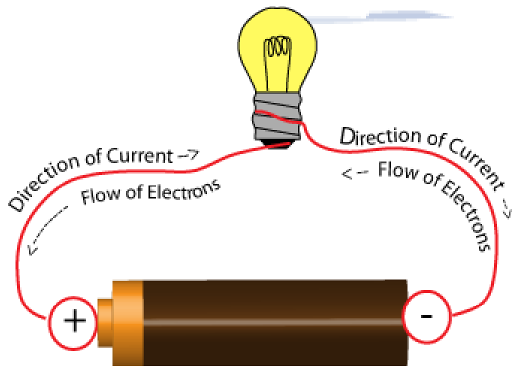


Voltage



- The **force** that pushes electrons around
- Also called Electro-Motive Force: **EMF**
- Measured in units called **VOLTS**
- Measured with a **Voltmeter**
- Symbol is **E**, unit symbol is **V**
- Typical mobile radios require 12 volts to operate

Current

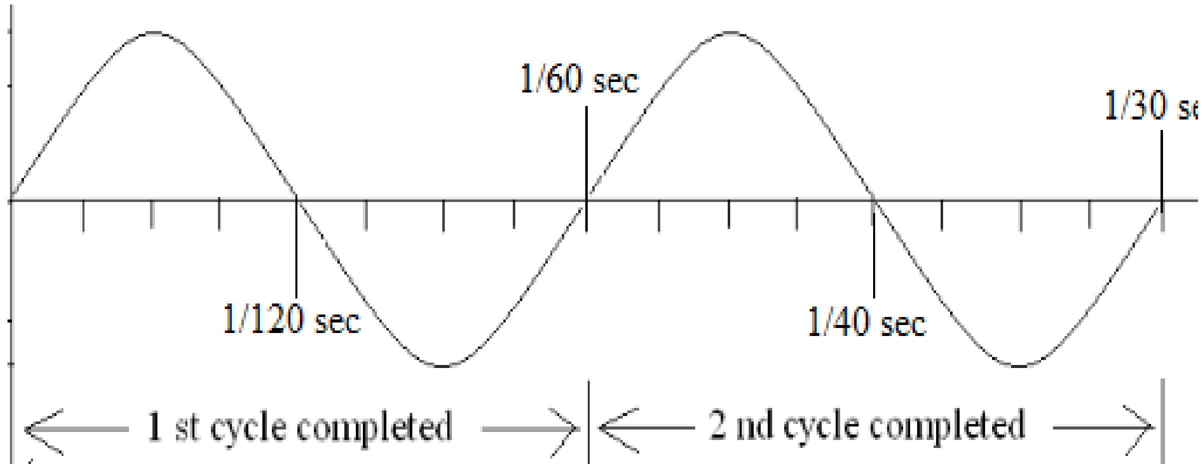


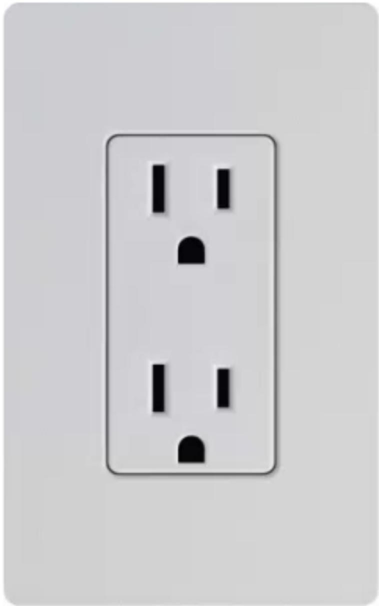
- The *flow of electrons* in a circuit
- Measured in units of **Amperes** (amps)
- Symbol is **I**, units symbol is **A**
- Measured with an **Ammeter**
- **DC**: Direct Current flows in one direction
- **AC**: Alternating Current flows back and forth, *changing direction on a regular basis*

AC = Alternating Current

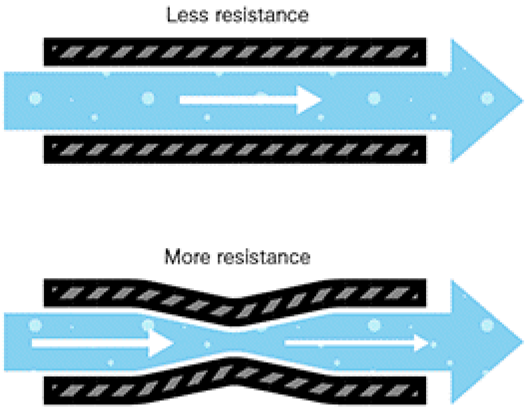
Frequency: number of times per second that an alternating current makes a complete cycle

Hertz: Unit of frequency



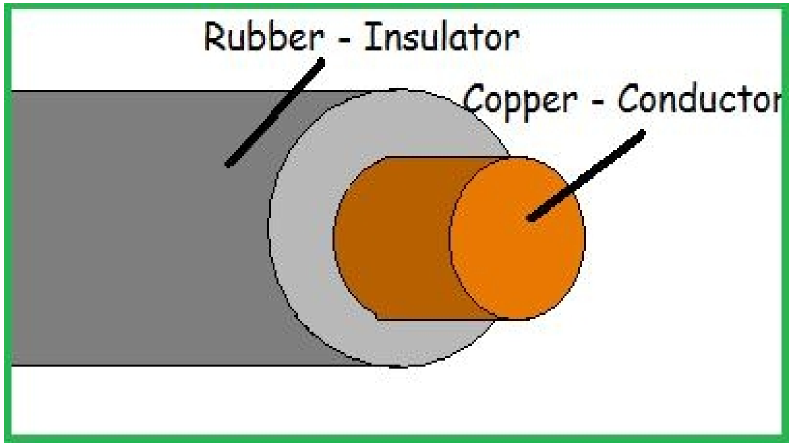


Resistance



- Opposes the flow of electrons
  - Higher resistance -> smaller current
- Measured in ***Ohms***
- Symbol is ***R***   Unit symbol is **Ω**
- Measured with an ***Ohmmeter***

Conductors & Insulators



- **Conductors**
  - Low resistance, allow current to flow
  - Copper, aluminum, gold, silver, etc.
- **Insulators**
  - High resistance, little/no current flow
  - Plastic, wood, glass, mica, paper, etc.

Power

- *Rate* at which electrical energy is used
- Measured in **Watts**
- Symbol is **P**   Unit symbol is **W**

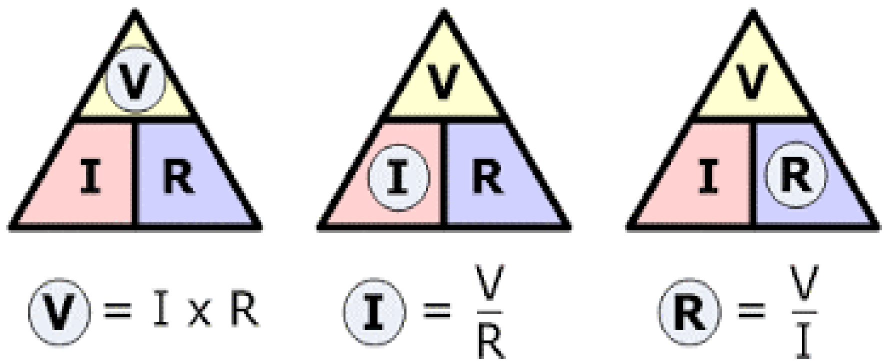
- Often not measured directly, but calculated – *more on this shortly…*

Summary of Terms

- EMF (E) is measured in Volts (V)
- Current (I) is measured in Amps (A)
- Resistance (R) is measured in Ohms (Ω)
- Power (P) is measured in Watts (W)

Memorize this!

Ohm's Law



Relationship between:

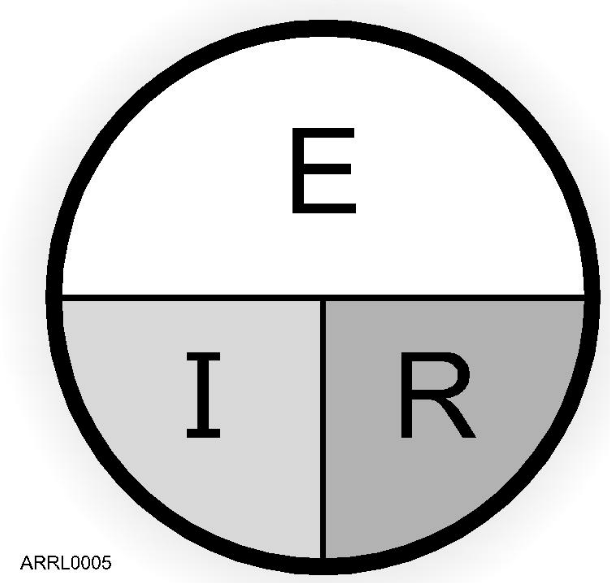
- Voltage
- Current
- Resistance

Voltage = Current x Resistance

E = I x R

I = E / R

R = E / I



Ohm's Law Calculations

USING THE "MAGIC" FORMULA CIRCLE TO DO MATH.

TOP TO BOTTOM <u>DIVIDE</u>.

SUCH AS:

$12 \div 8 = 1.5$

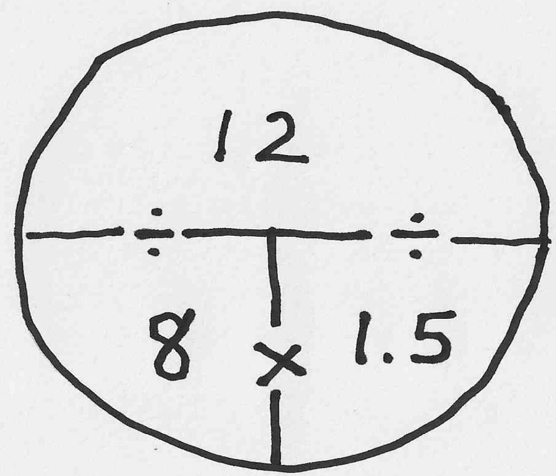
$12 \div 1.5 = 8$

SIDE TO SIDE <u>MULTIPLY</u>.

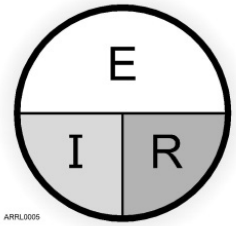
SUCH AS:

$8 \times 1.5 = 12$

$1.5 \times 8 = 12$



Ohm's Law Examples



- 90 volts is applied across a resistor resulting in 3 amperes of current. What’s the resistance?

  R = E / I   90V/3A = **30Ω**

- 12 volts applied to a circuit with 8 ohms of resistance – how much current flows?

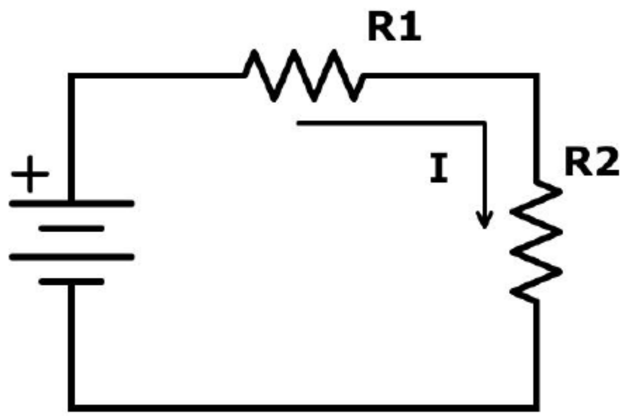
  I = E / R   12V/8Ω = **1.5 amperes**

- 2A flowing through 10Ω resistor – what voltage appears across the resistor?

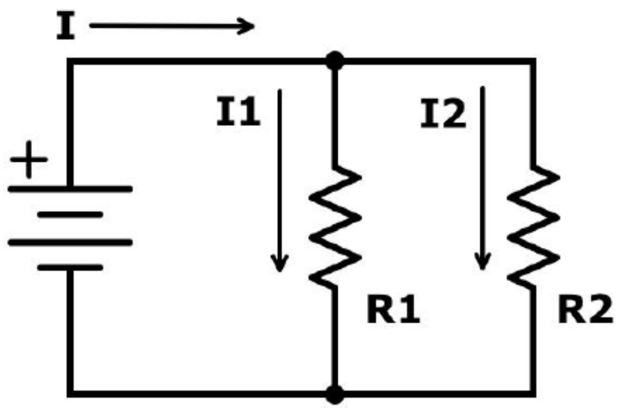
  E = I x R   2A x 10 Ω = **20 Volts**

Series and Parallel Circuits

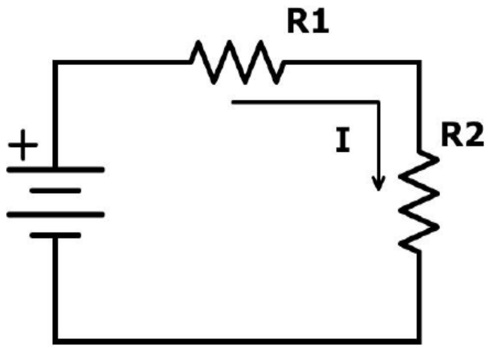
- **Series**: devices are end-to-end



- **Parallel**: devices are next to each other

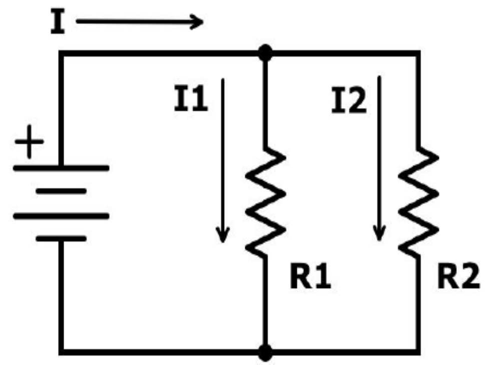


Series Circuits



- There is *one path* for current to flow
- **Current** is:
  - the *same through all components*
  - is *unchanged* at component junctions
- **Voltage** across each component is *determined by type and value* of each component.
- Sum of voltages across components equals the voltage source

Parallel Circuits



- Each component connected to voltage source (in this example)
- **Voltage** across each component is the *same*
- **Current** divides at component junctions, *dependent on component values*
- Sum of currents in each component equals total current from the source

Calculating Power

Relationship between:

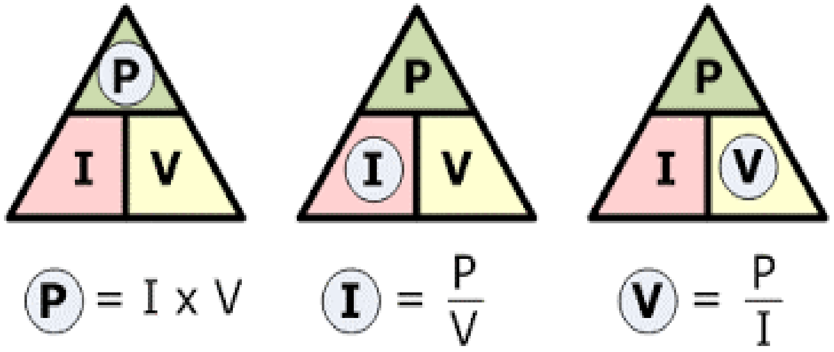
- Power
- Voltage
- Current

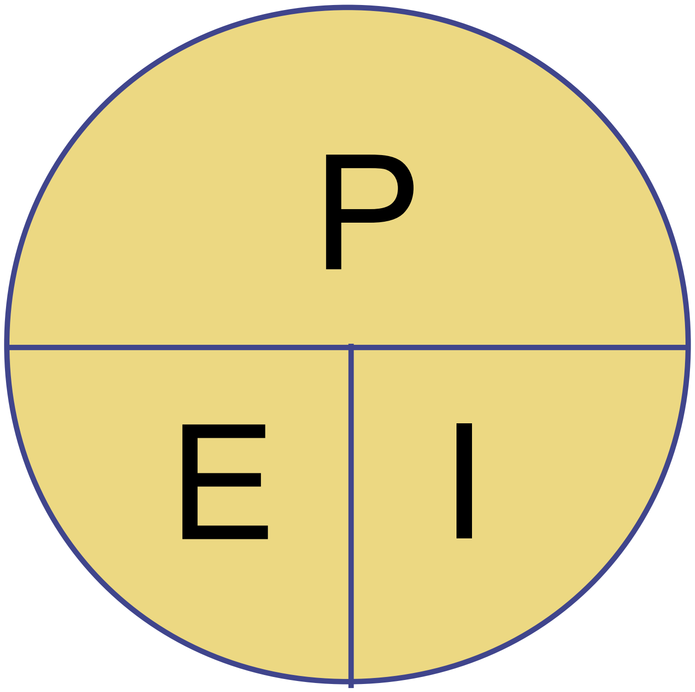
Power is Voltage x Current

P = E x I

E = P / I

I = P / E





Power Law Calculations

USING THE "MAGIC" FORMULA CIRCLE TO DO MATH.

TOP TO BOTTOM DIVIDE.
SUCH AS:

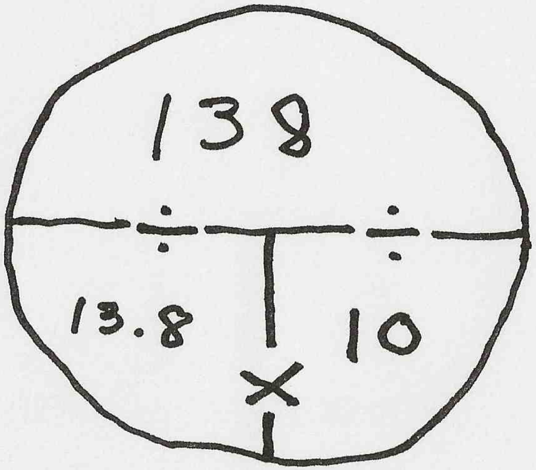
$138 \div 10 = 13.8$

$138 \div 13.8 = 10$

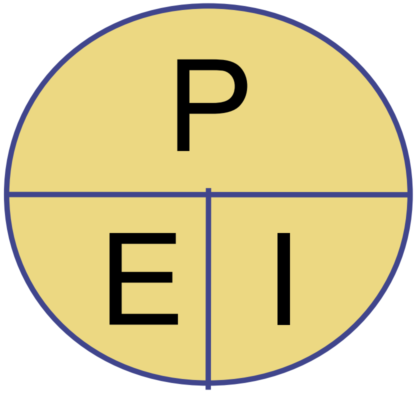
SIDE TO SIDE MULTIPLY.

$13.8 \times 10 = 138$

$10 \times 13.8 = 138$



Power Examples



- How much power is being used by a circuit that draws 10A from a 13.8V source?

  P = E x I   13.8V * 10A = **138 Watts**

- Applied voltage is 12V and current is 2.5A, what is the power?

  P = E x I   12V x 2.5A = **30W**

- With 12V applied and 120W used, what is the current?

  I = P / E   120W / 12V = **10 A**

Math for Electronics: Prefixes

Used with electrical quantities

milli = 1/1000th, such as 1**mA** is 1/1000th of an ampere, or 0.001A

micro = 1/1,000,000th (one millionth), such as 3**µV** which is 0.000003V

pico = 1 trillionth (millionth of a millionth) such as 5**pA** = 0.000005µA

Prefixes continued

kilo = 1000x, such as 1**kV** = 1000V

mega = 1 million times (1,000,000x) such as 1**MΩ** = 1,000,000Ω

giga = 1 billion times, such as **2.4GHz**

Prefixes are often used on many different electrical quantities

Prefix Examples

- 1,500 milliamperes = 1.5 amperes
- 1,000 volts = 1 kilovolt (1kV)
- 1 millionth of a volt = 1 microvolt (1µV)
- 3000mA = 3A
- 3500 kilohertz = 3.5 megahertz (**MHz**)
- 2425 MHz = 2.425 GHz

Decibels (dB)

- When dealing with loudness and power ratios we use decibels
- Easy to express large ratios with small numbers
- Decibels use a logarithmic (log) scale
- Cascading ratios multiply or divide but cascading decibels add or subtract
- +dB represents an “increase”
  - dB represents a “decrease”

Decibel Ratios to Remember

- **3dB** is a factor of **2x**

  A change from 5W to 10W is a 3dB increase, a ratio of 2 to 1

- **6dB** is a factor of **4x**

  A change from 12W to 3W is a 6dB decrease
  (-6dB change), ratio of 4 to 1

- **10dB** is a factor of **10x**

  20W to 200W is a 10dB increase, ratio of 10 to 1

- Combinations (dB values add and subtract)

  13dB change is a factor of 20x (10 x 2)

Electrical Principles
Chapter End

Questions?

Let's Practice for the Exam!