Basic Electricity

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Content:

- Electricity
- Electric Circuit, Ohm’s law and Power Law
- Wiring Materials

Electricity

Electricity

- **Greek word** – Elektron means amber
- **New Latin** – Electricus means amber-like
- Basic part of nature and it is one of our **most widely used forms of energy.**

Forms of Energy

- Heat
- Sound
- Chemical
- Nuclear
- Light
- Electrical
- Mechanical

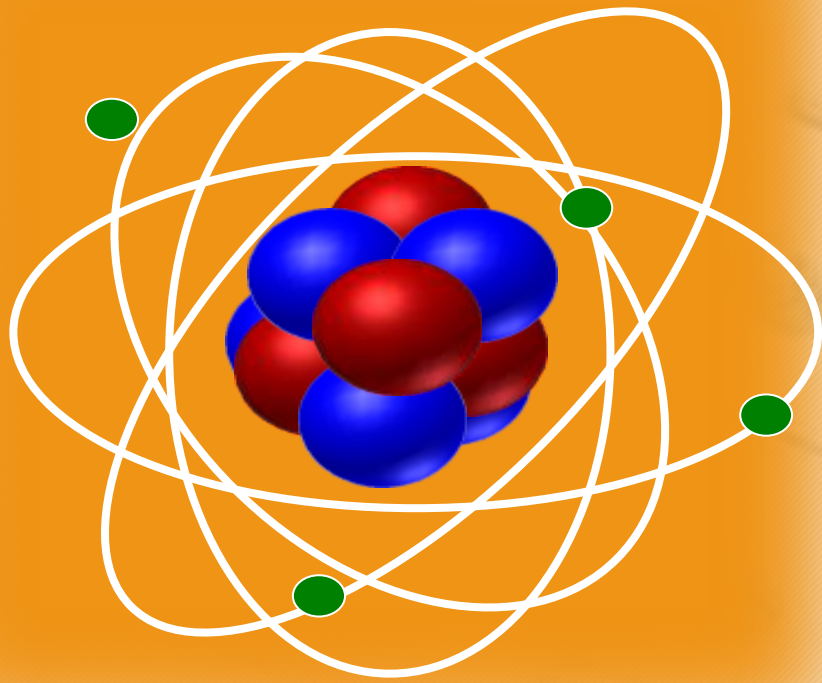
Electricity

- Movement of electrons
- Invisible force that provides light, heat, sound, motion . . .

Elements - The simplest form of matter

1 H																	2 He
3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
55 Cs	56 Ba	57 *La	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
87 Fr	88 Ra	89 +Ac	104 Rf	105 Ha	106 Sg	107 Ns	108 Hs	109 Mt	110 110	111 111	112 112	113 113					

58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr



Atoms - Smallest piece of an element containing all of the properties of that element

Electricity at the Atomic Level

Components of an Atom

Nucleus

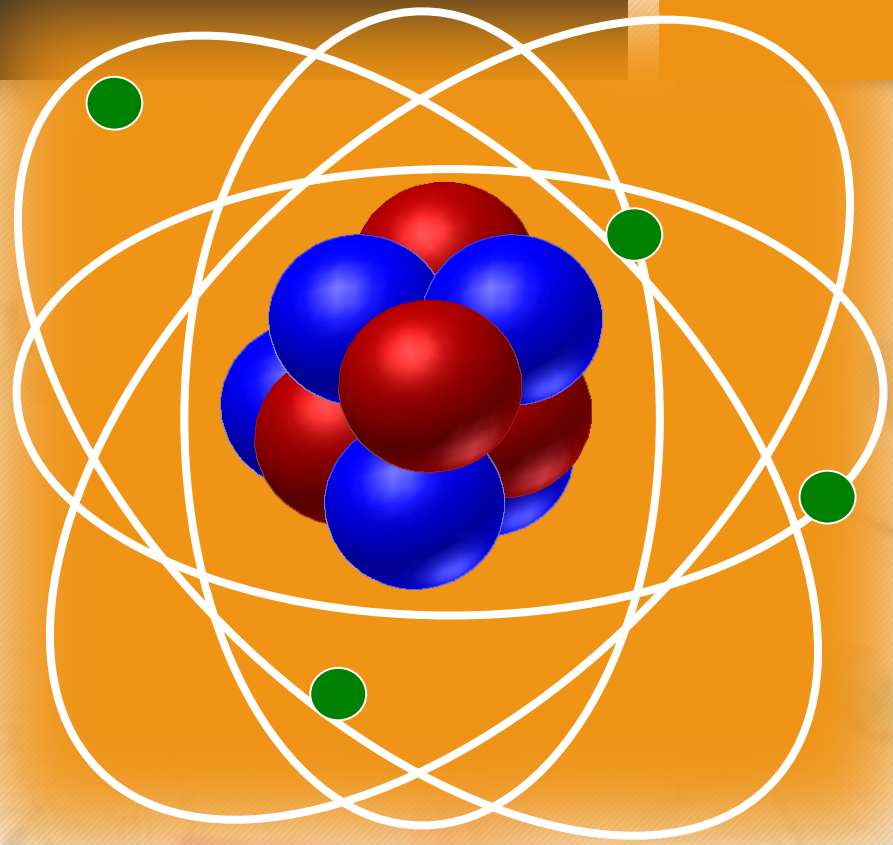
The center portion of an atom containing the protons and neutrons

Protons

Positively charged atomic particles

Neutrons

Uncharged atomic particles



Electricity at the Atomic Level

Electrons

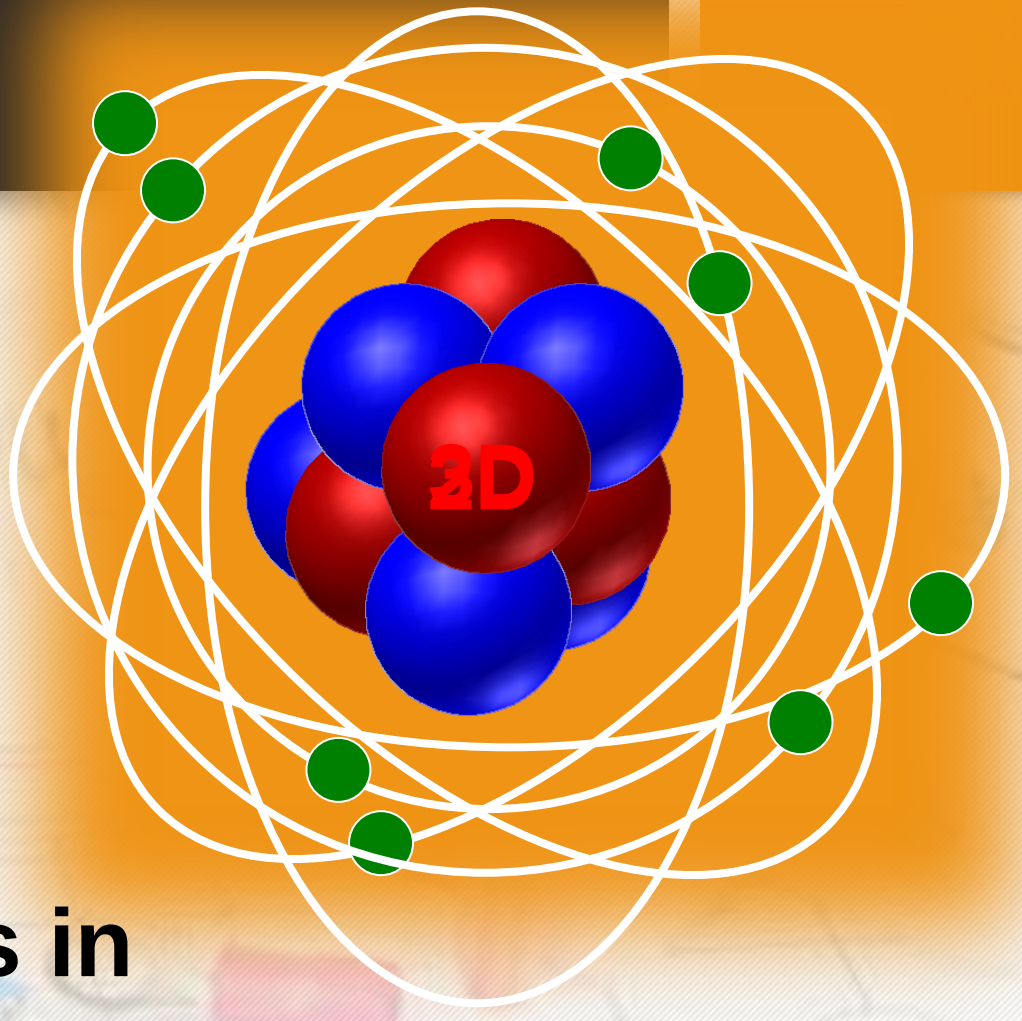
Negatively charged particles

Electron Orbitals

Orbits in which electrons move around the nucleus of an atom

Valence Electrons

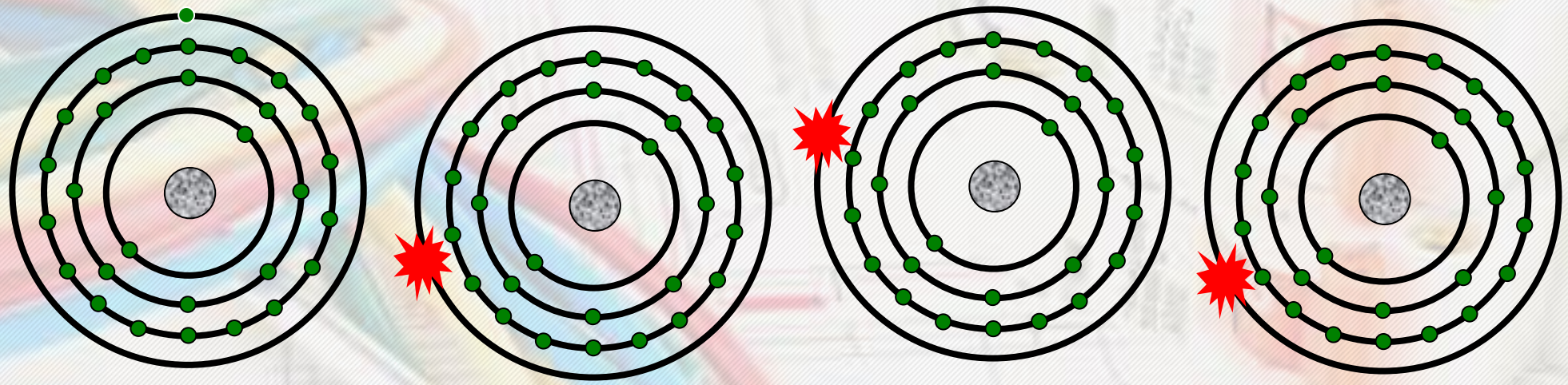
The outermost ring of electrons in an atom



Electricity at the Atomic Level

Electron Flow

Electricity is created as electrons collide and transfer from atom to atom.

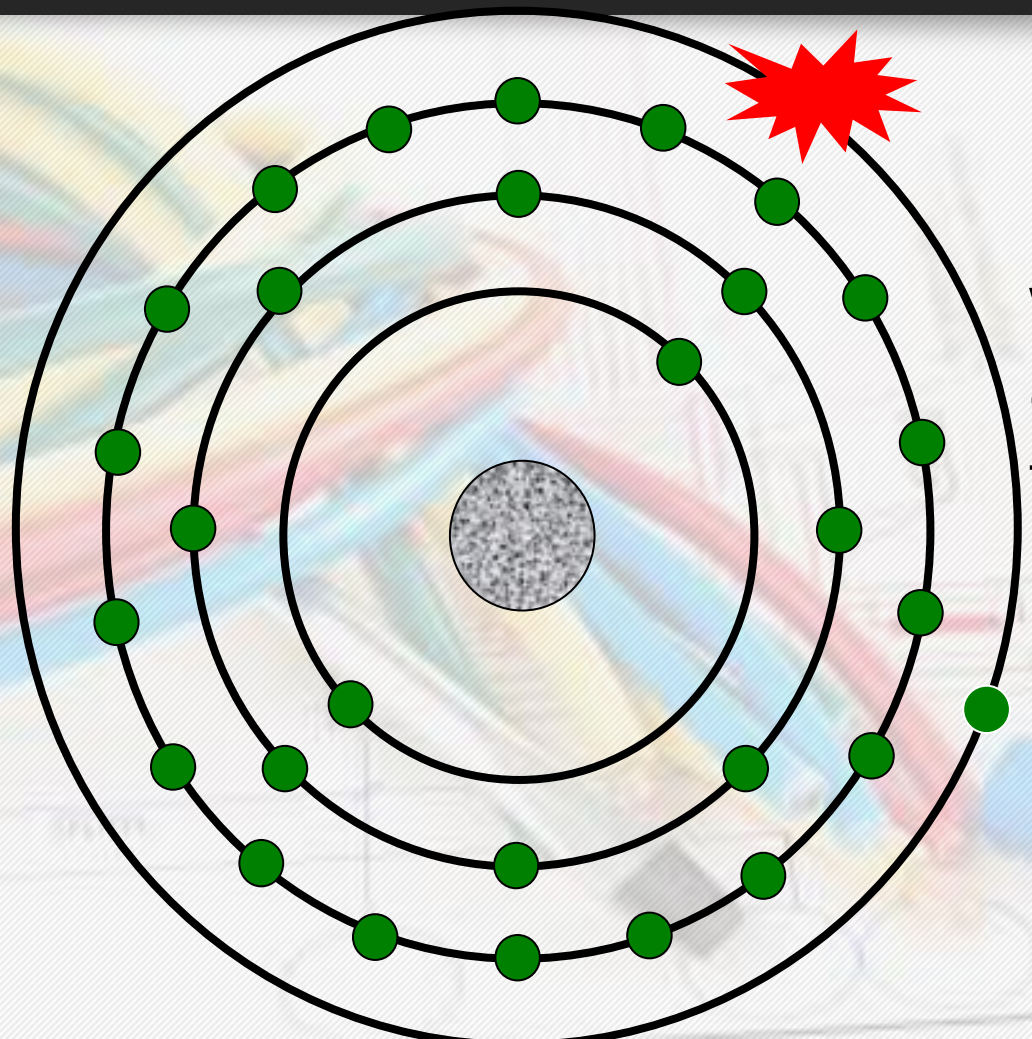


Play Animation

Electricity at the Atomic Level

Electron Flow

An electron from one orbit can knock out an electron from another orbit.



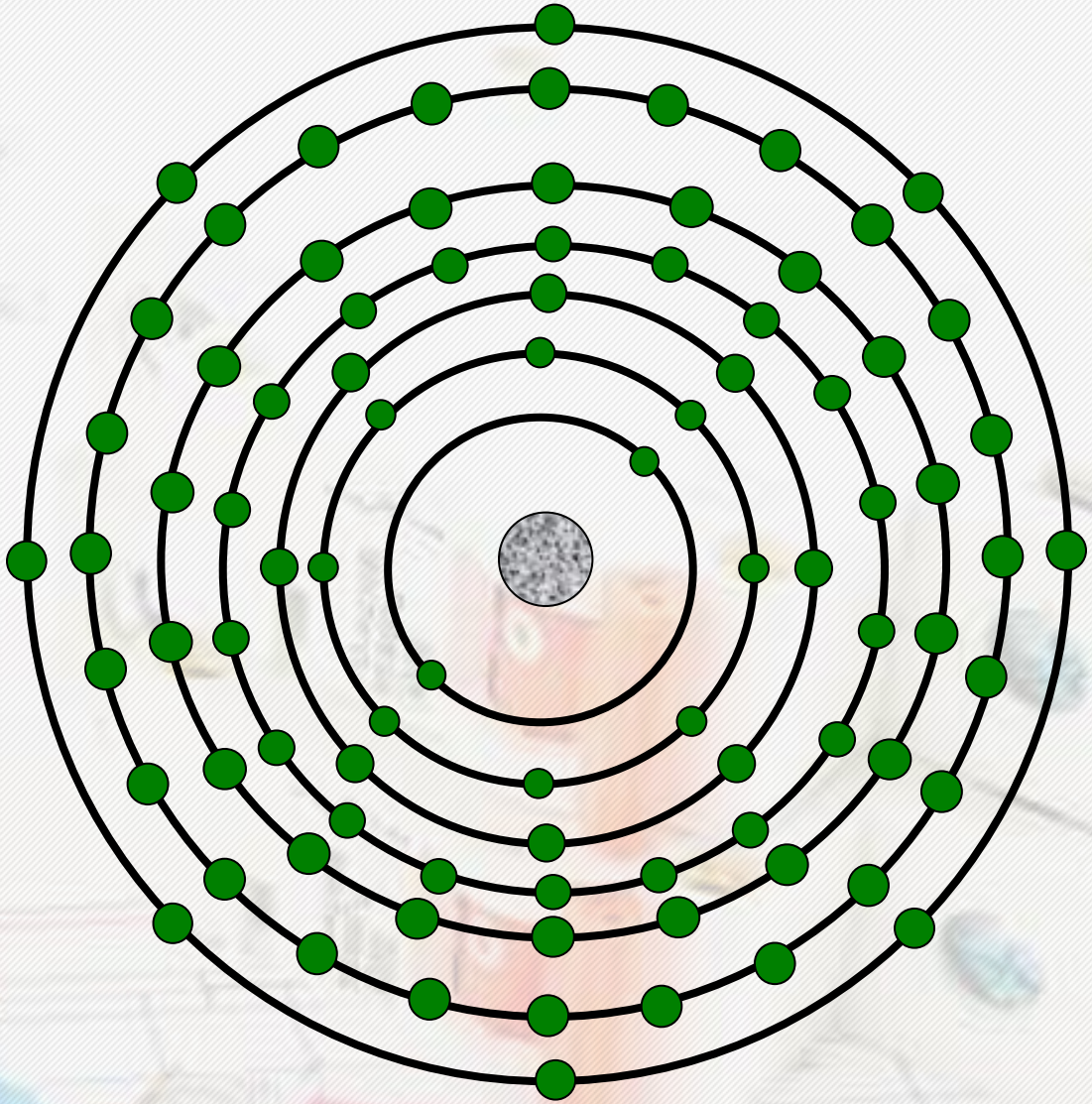
When an atom loses an electron, it seeks another to fill the vacancy.

Copper
Cu
29

Electricity at the Atomic Level

Electron Orbits

Orbit Number	Maximum Electrons
1	2
2	8
3	18
4	32
5	50
6	72
Valence Orbit	8



Orbits closest to the nucleus fill first

Conductors and Insulators

Conductors

Electrons flow easily between atoms

1-3 valence electrons in outer orbit

Examples: Silver, Copper, Gold, Aluminum

Insulators

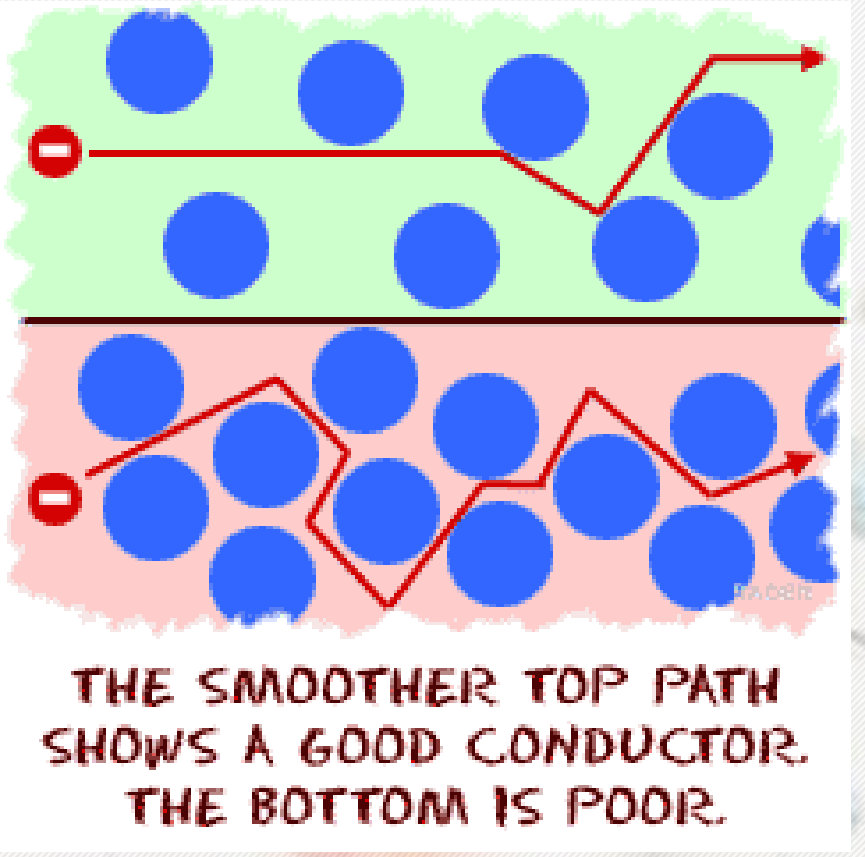
Electron flow is difficult between atoms

5-8 valence electrons in outer orbit

Examples: Mica, Glass, Quartz

- **Good conductor**
  electrons able to move freely within the atoms of the material

- **Poor conductor or insulator**
  electrons are not free to move about the atoms of the other material



Fission

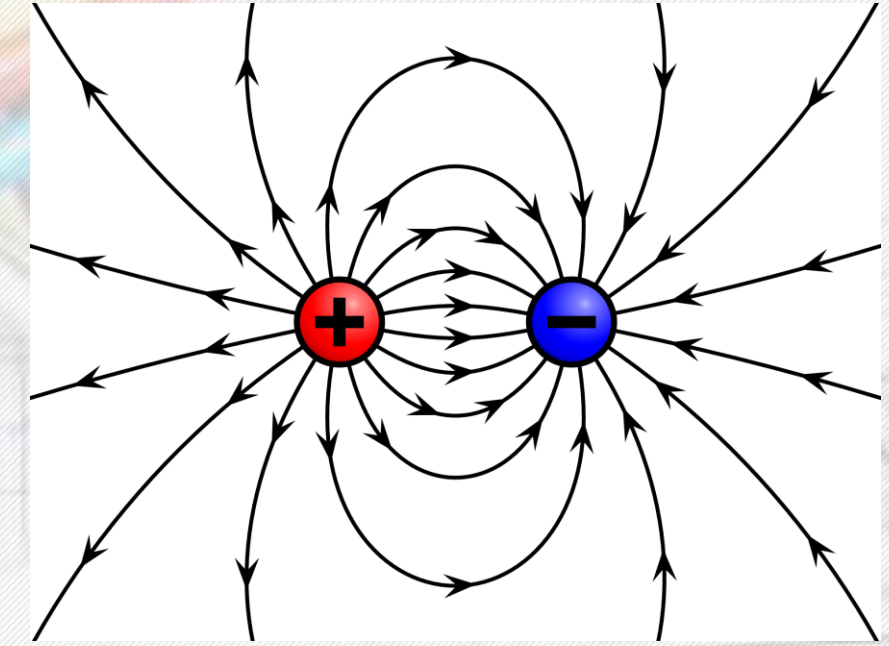
An atom that splits into two parts, either through natural decay or when instigated within a lab, it releases energy.

Fusion

is the process where two light nuclei combine together releasing vast amounts of energy

Electric field

- Defined as the electric force per unit charge.
- Electric charge on other charges in its vicinity.



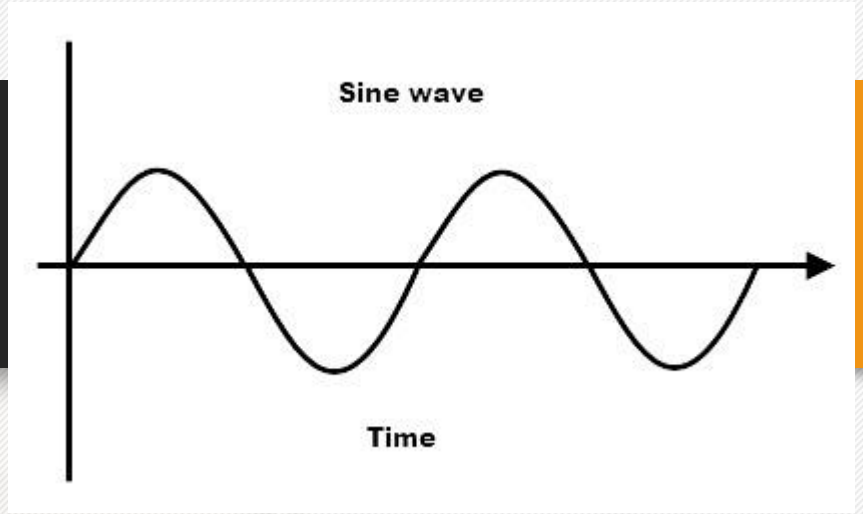
Electrical Energy

- A form of energy present in an electric field or magnetic field resulting from the flow of electric charge.

Electromagnetism

- Fundamental interaction between magnetic field and the presence and motion of an electric charge.

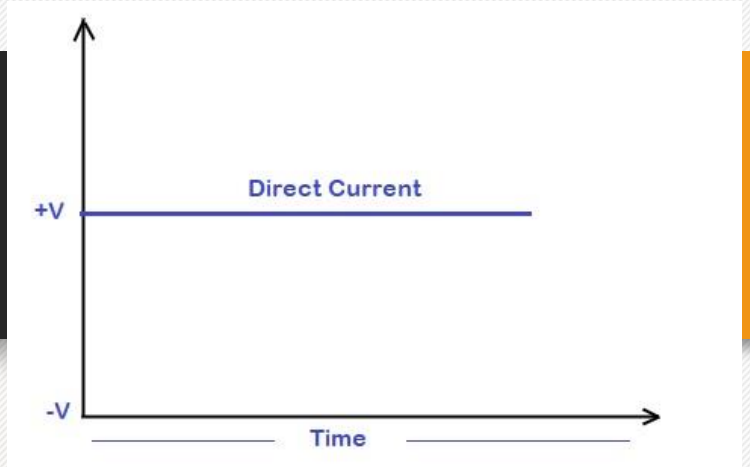
Types of Electric Current



Alternating Current (AC)

- Electric charge **moves forward and backward.**
- Voltage or current that **changes polarity** or direction, over time.
- **Back and forth motion** occurs between 50 and 60 times per second.
- It is called the frequency and is designated as either **50 Hertz or 60 Hertz.**

Types of Electric Current



Direct Current (DC)

- movement of electric charge is only in **one direction.**
- voltage or current that **maintains constant polarity** or direction, over time.
- Source of direct current: **Chemical battery** (electronic power supply, mechanical generator)

Factors that affects wire resistance

- Length
- Cross-sectional Area
- Temperature
- Material

Material

- Different materials have different resistivities, which is the ability of the material to allow electrons to move.
  - Best Conductor
    - Silver
    - Copper
    - Gold
    - Aluminum

Length

- The longer the wire, the greater its resistance.
- Voltage drop will start at **35 meters**.

Cross-sectional Area

- The greater the cross-sectional area of the wire, the less its resistance.

Temperature

- Heating the metal conductor causes atoms to vibrate more, which in turn makes it more difficult for the electrons to flow, increasing resistance.

Type of electricity

Dynamic Electricity

- Electricity at motion

Static Electricity

- Electricity at rest

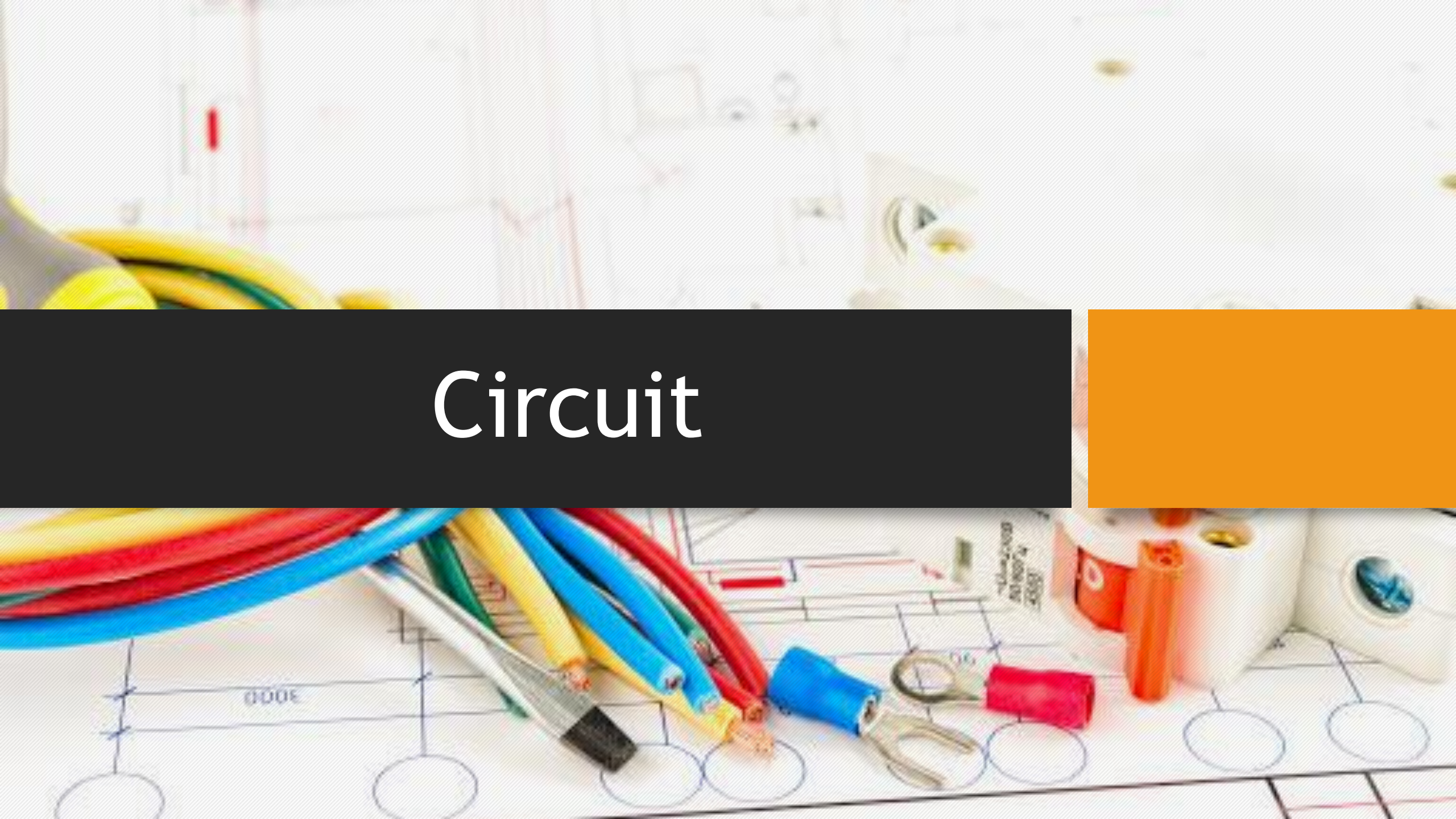
SOURCES OF ELECTRICITY

1. **Biomass** – all solid material of animal or vegetable origin.
2. **Geothermal** – *Geo* means earth and *thermal* means heat. Heat energy of the earth (volcanoes)
3. **Hydropower** – hydro comes from Greek word for water. Forces of moving water from rivers or storage reservoirs (falls, dam)
4. **Ocean power** – Marine currents. **Two-way current**: ocean tides caused by gravitational pull of the moon and sun, **One-way currents**: rivers of ocean water flowing within the ocean.

5. **Solar Energy** – from sun. most inexhaustible and cleanest source of energy.
6. **Wind Power** – wind is a form of solar energy.
7. **Coal energy** – coal is among the fossil fuels along with oil (petroleum) and natural gas
8. **Nuclear energy** – energy trapped inside atoms. Electricity is generated in a nuclear reactor by the fission of atomic nuclei
9. **Natural Gas –** made up mostly of methane. Methane is combination of hydrogen and carbon.

Quantity	Unit	Definition	Discoverer
Voltage	Volts	• Potential Difference. • Electrical Pressure.	Alessadro Volta
Current	Ampere	• Flow of electron.	Andre Marie Ampere
Resistance	Ohm	• Opposition to the flow of current.	Georg Simon Ohm
Power	Watts	• Rate of doing work.	James Watt

Post-test

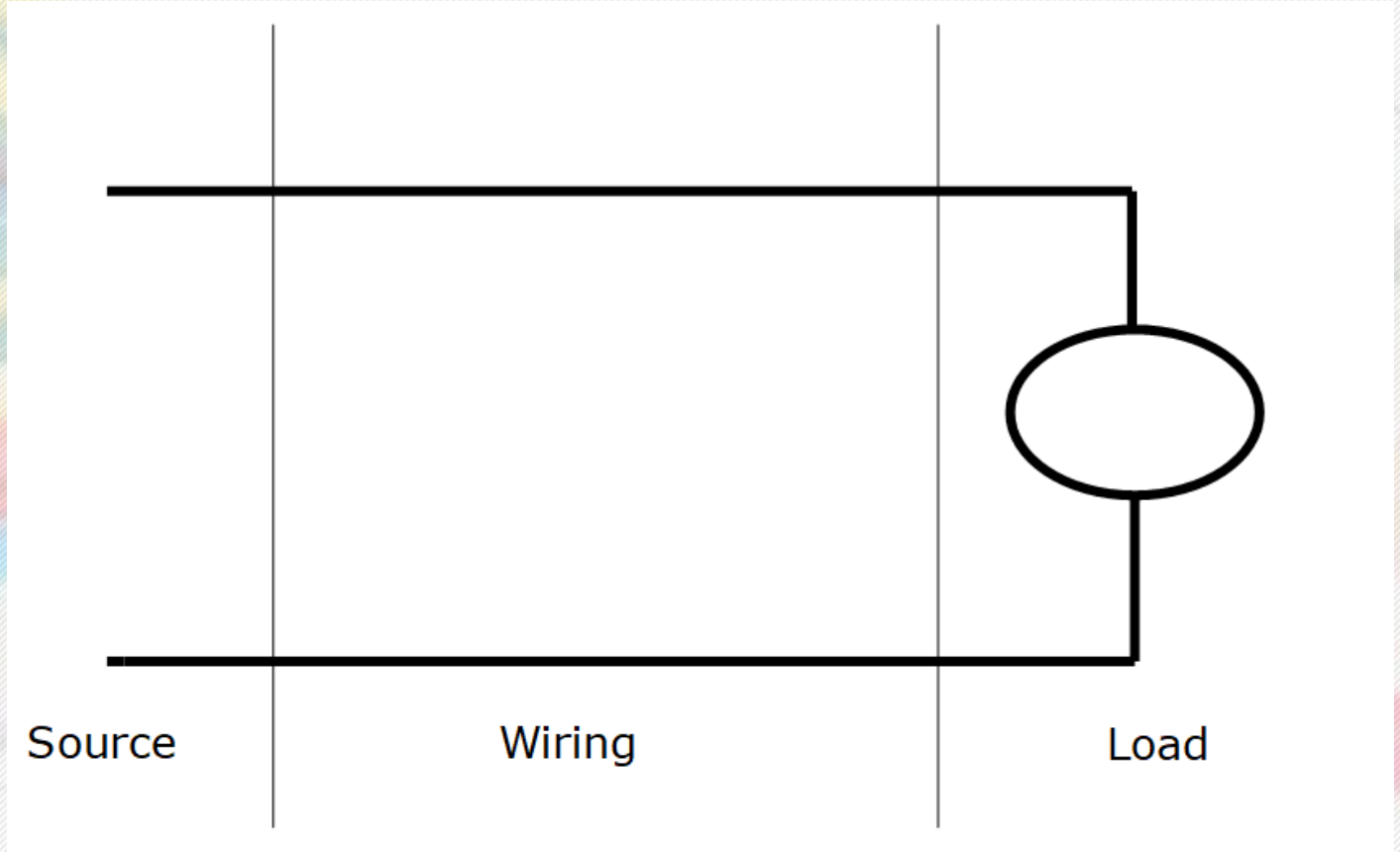


Circuit

Circuit

- A closed path that allows electricity to flow from one point to another.

Components of a circuit



Components of a circuit

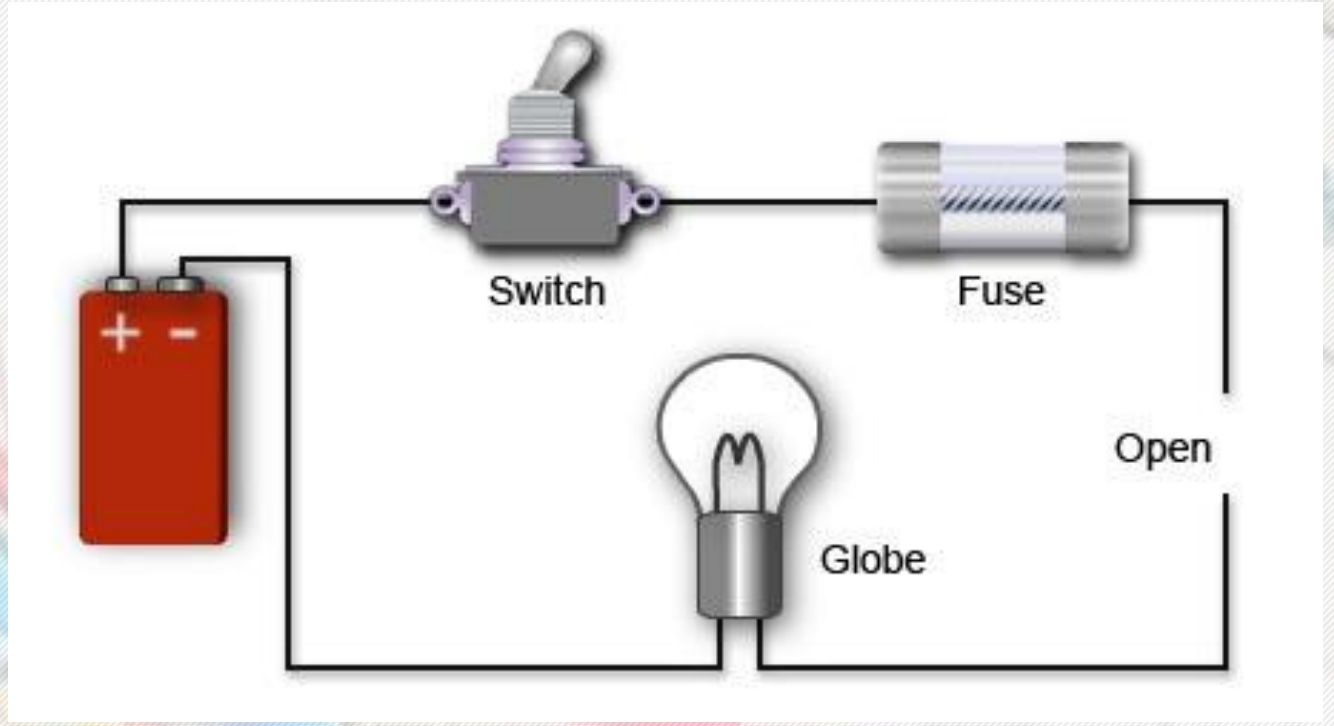
- **Load** – electrical device (fixture and appliances), that consumes electrical energy.
- **Path/Wiring** – are wire use as conductor; provides passage for electric current from source and back.
  - **Control** – device that control or turns the circuit on/off (switch).
- **Source** – provides electrical power (battery, dry cell, generators).

Circuit Condition

- Open
- Close
- Shorted

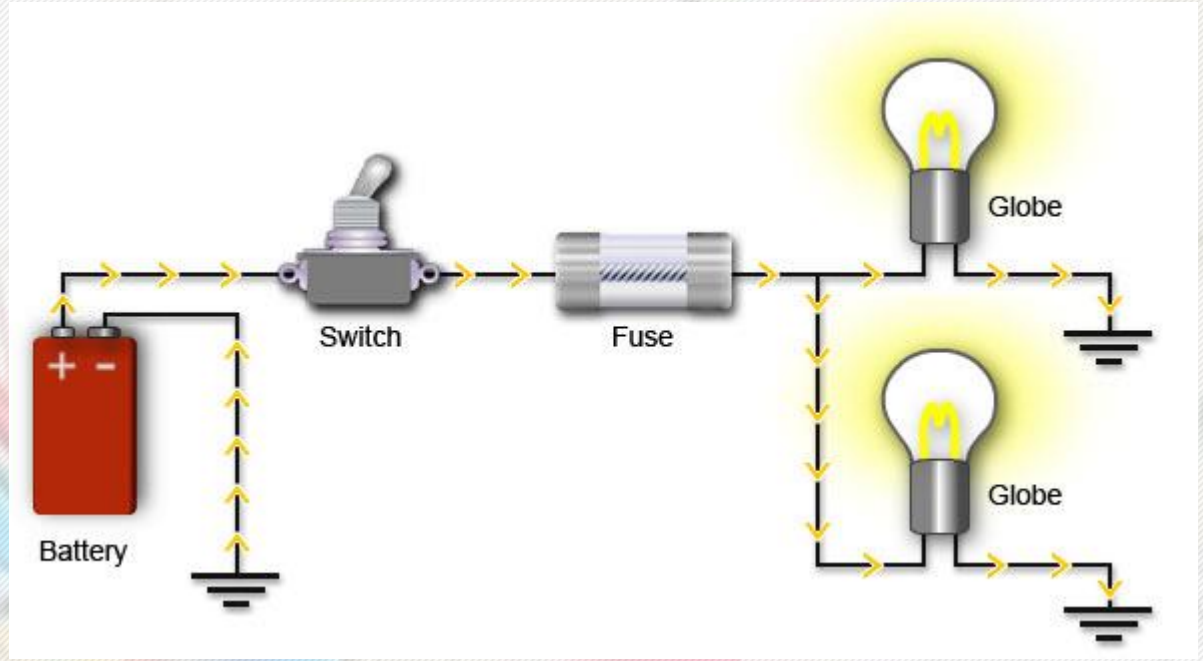
Open Circuit

- An 'open circuit' exists when there is a break or gap in the circuit.



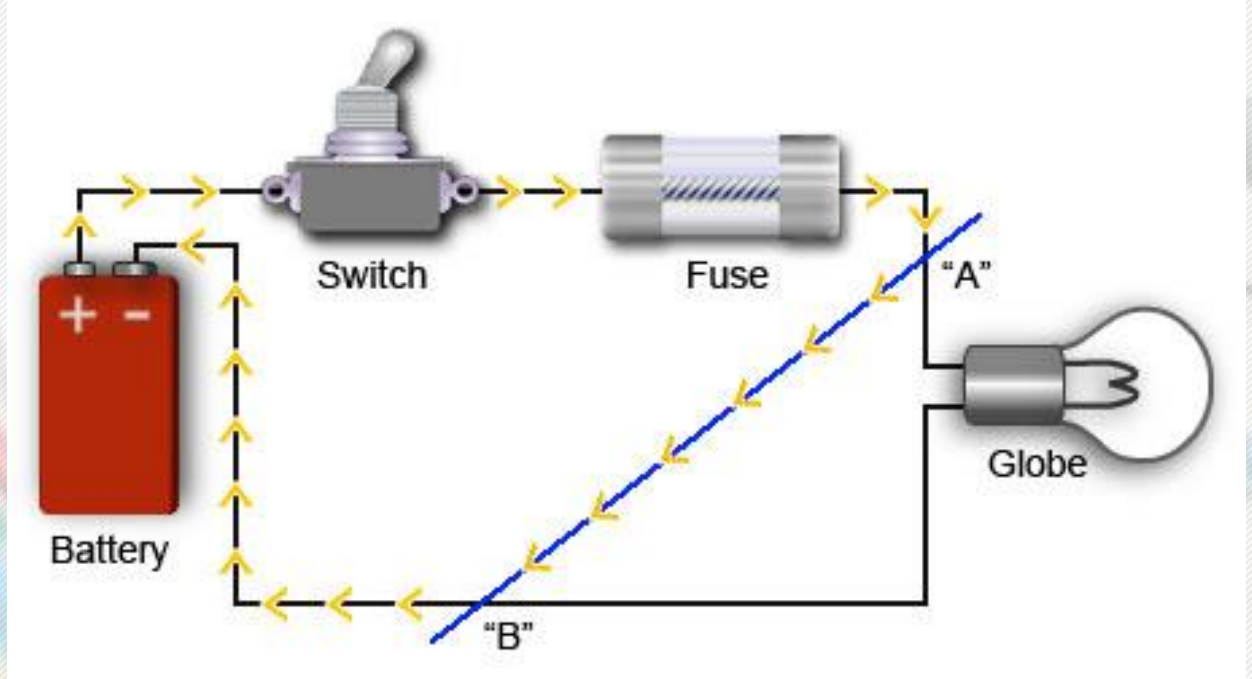
Closed Circuit

- A closed circuit condition exists when a circuit is complete allowing current to flow.



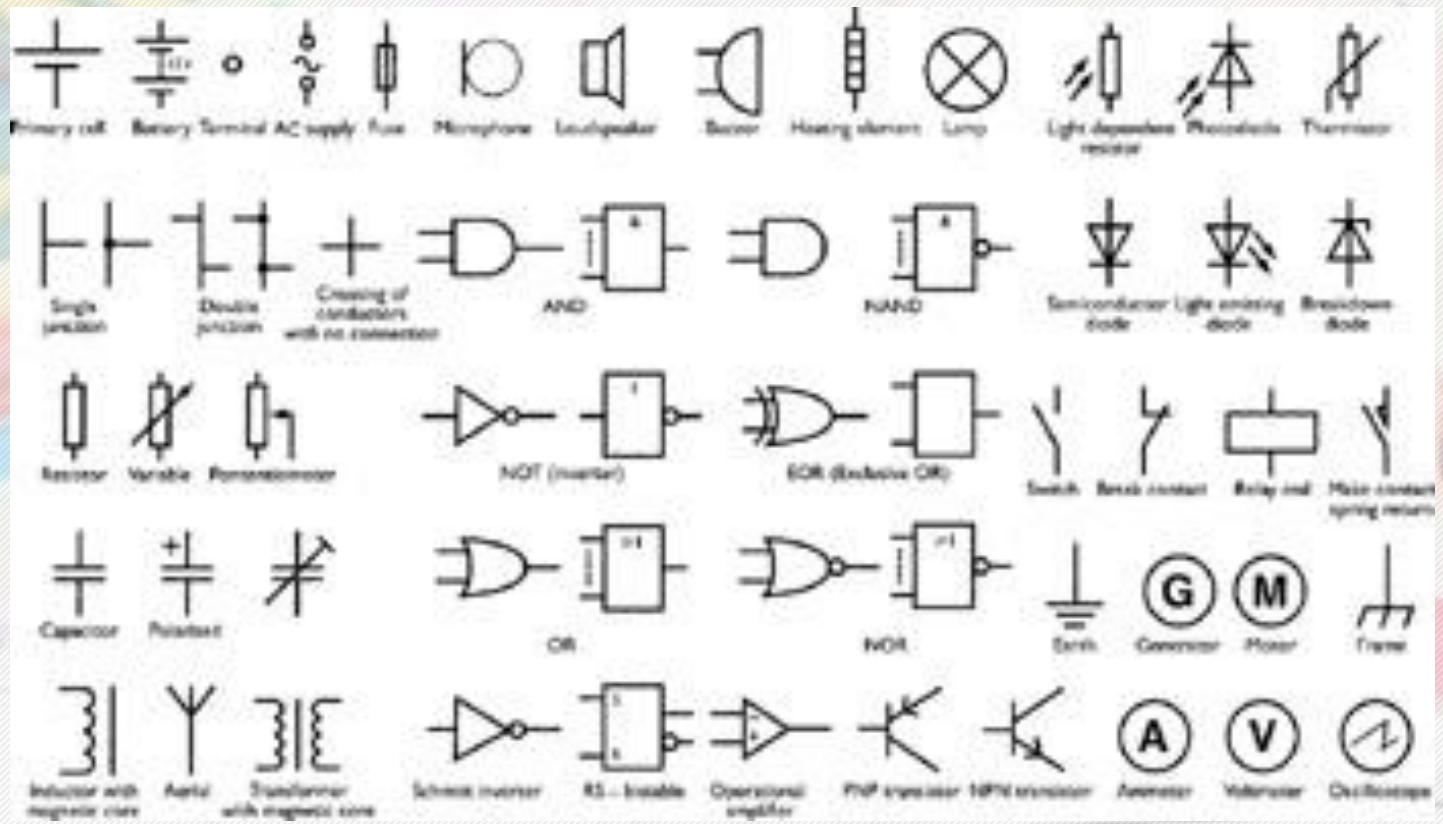
Short Circuit

- A short circuit exists when the original path of current flow is altered and a 'shorter' than normal path for current flow exists.



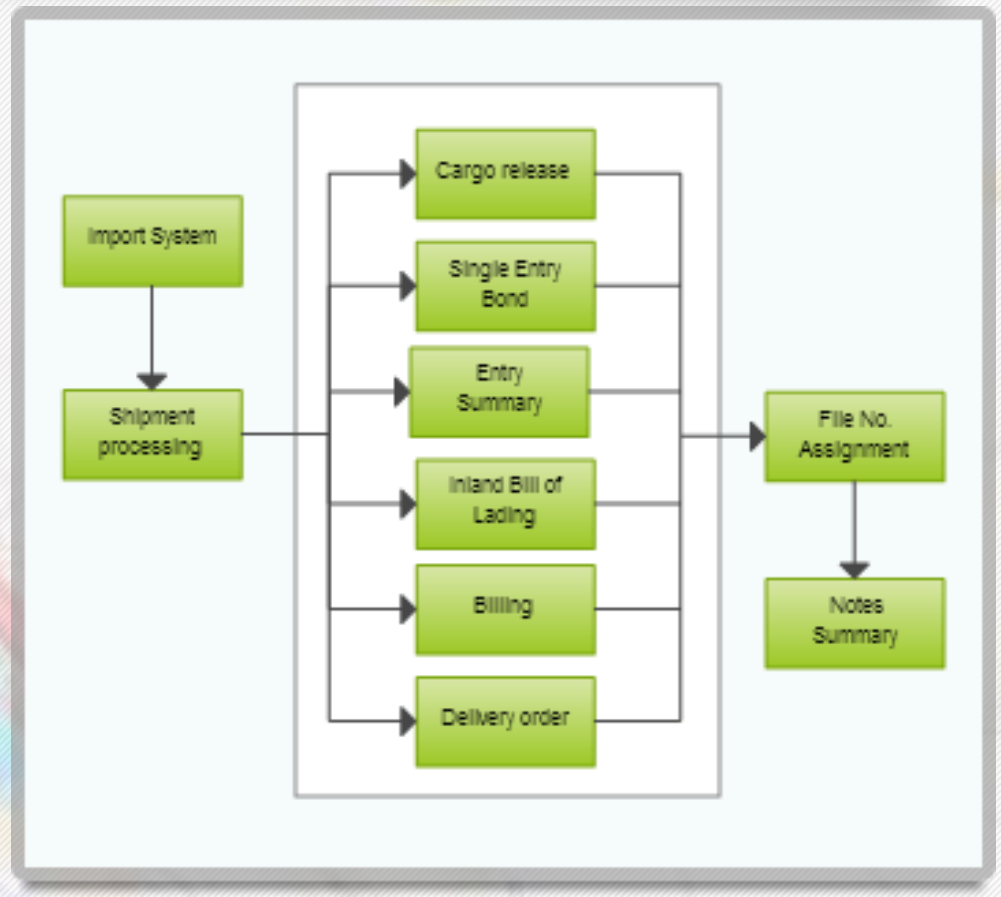
Symbols

- Is something that stands for something else.



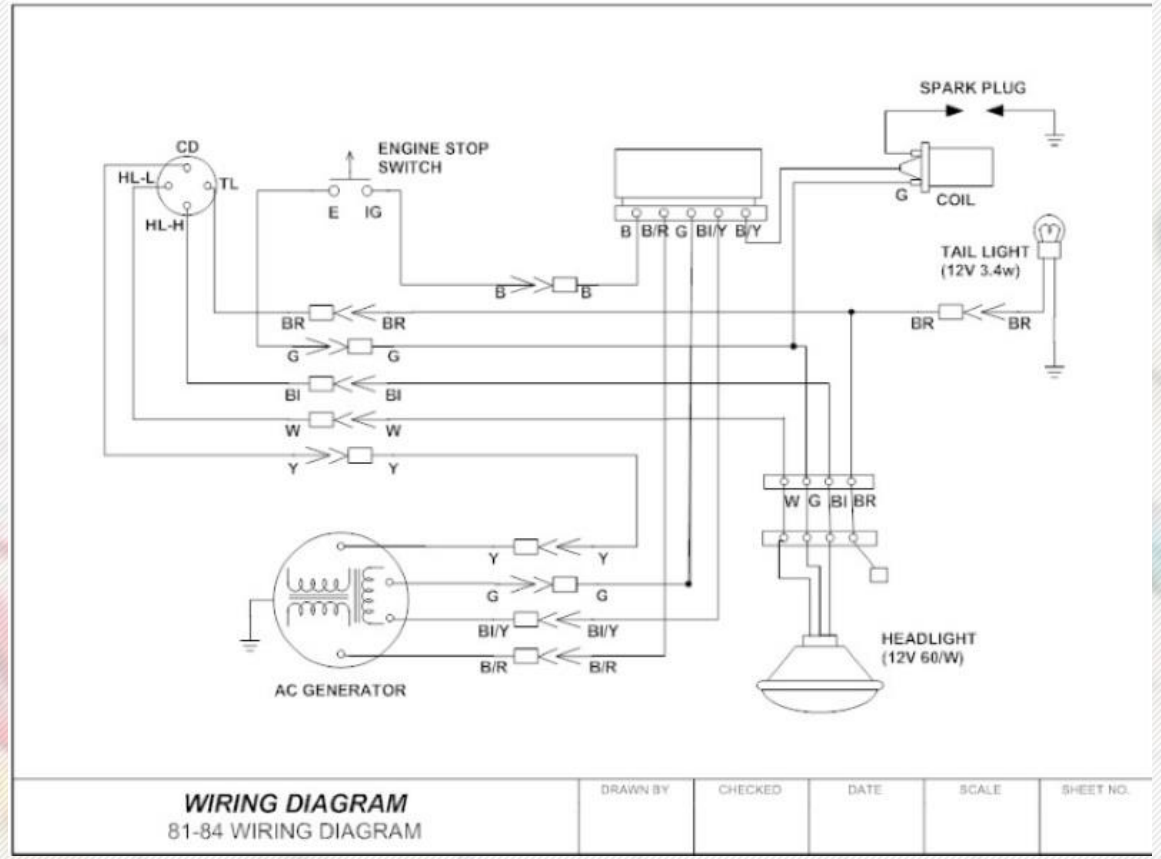
Diagram

- A diagram is a drawing that shows the different parts of something and how they work together.



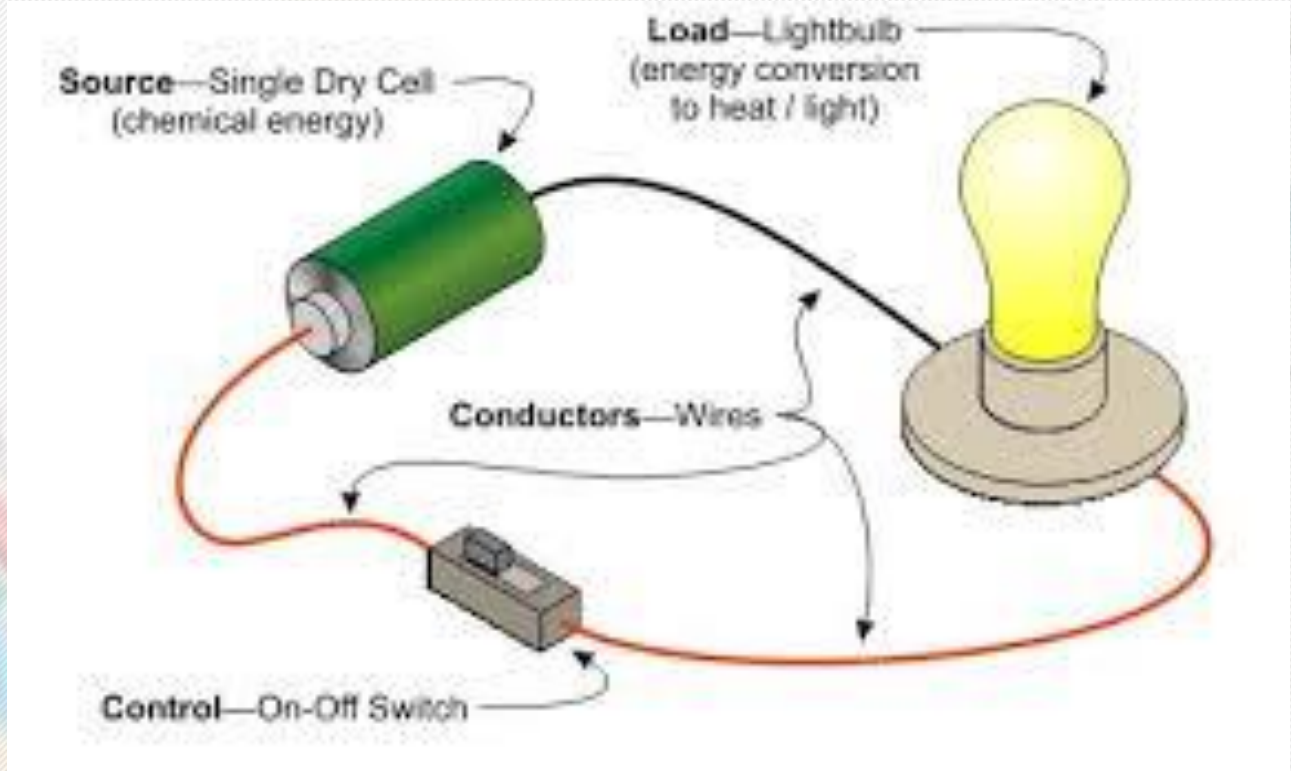
Schematic Diagram

- Schematic diagrams use symbols to show the layout of electrical or mechanical systems . A circuit diagram is a schematic that shows how components are connected up.



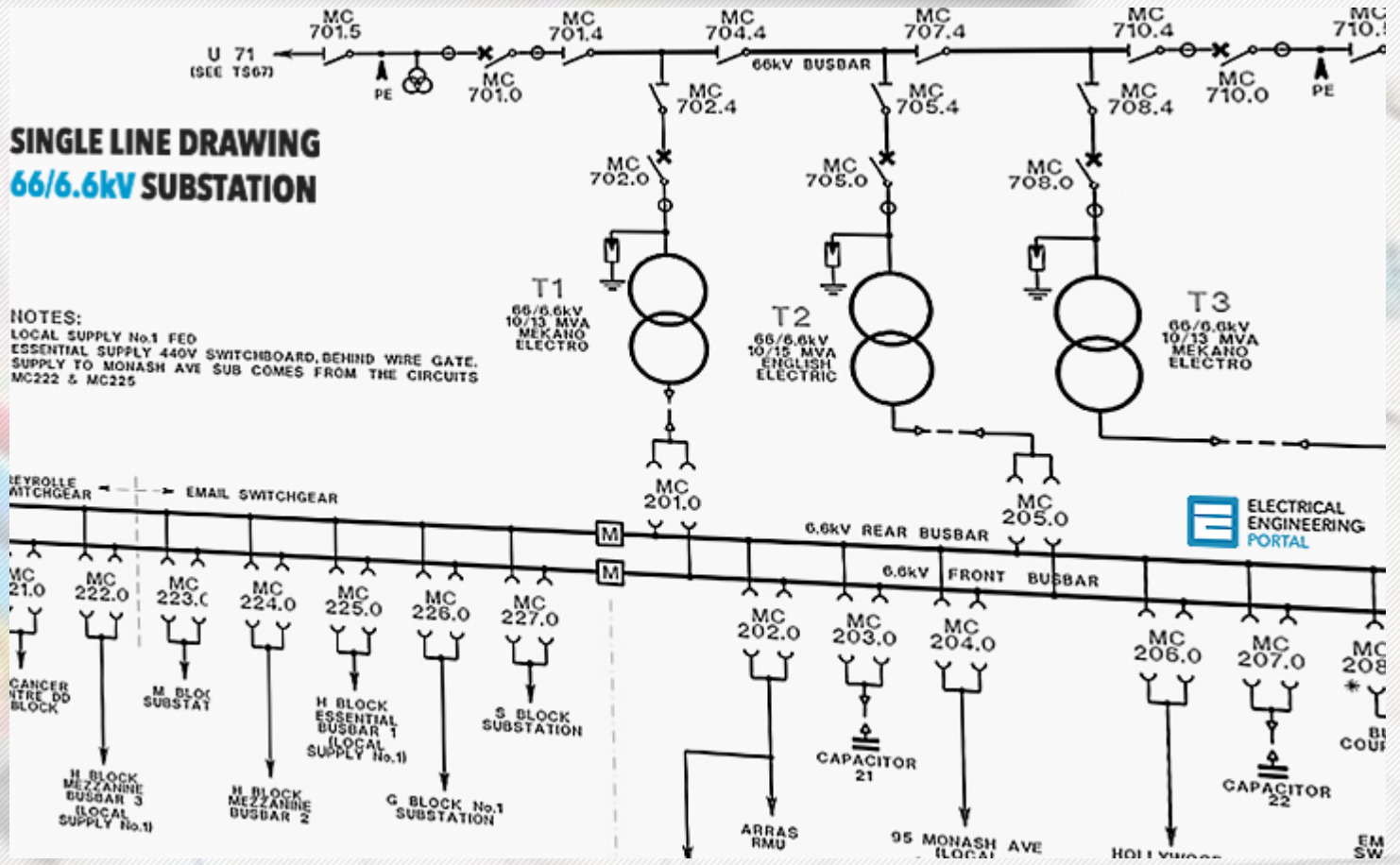
Pictorial Diagram

- A circuit diagram (also known as an electrical diagram, elementary diagram, or electronic schematic) is a simplified conventional graphical representation of an electrical circuit.

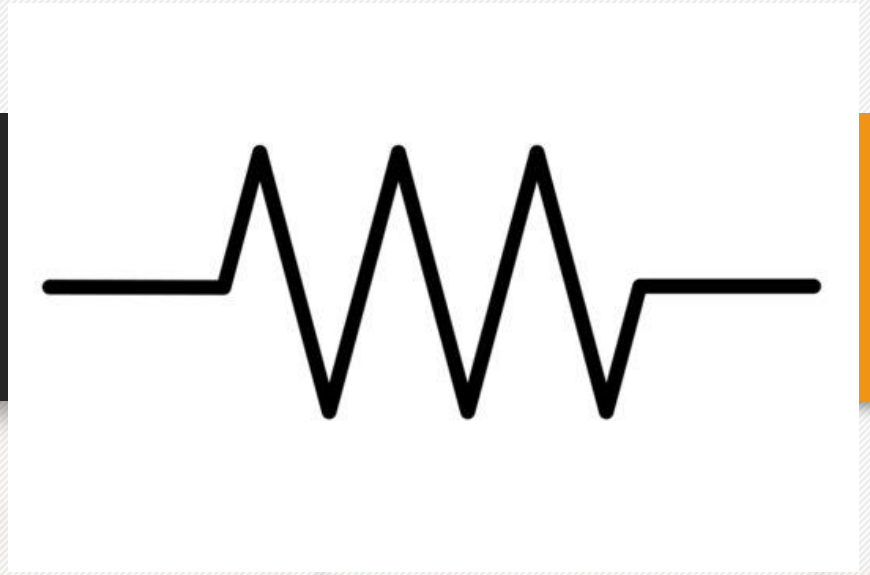


Single Line Diagram

- A single line diagram, also referred to as a one-line diagram, is usually a single page document that represents a facilities electrical distribution infrastructure.

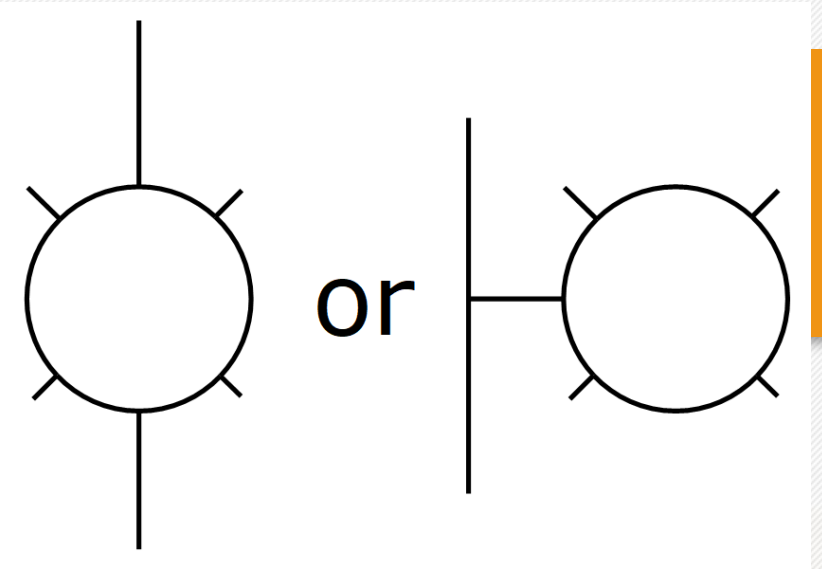


Resistor



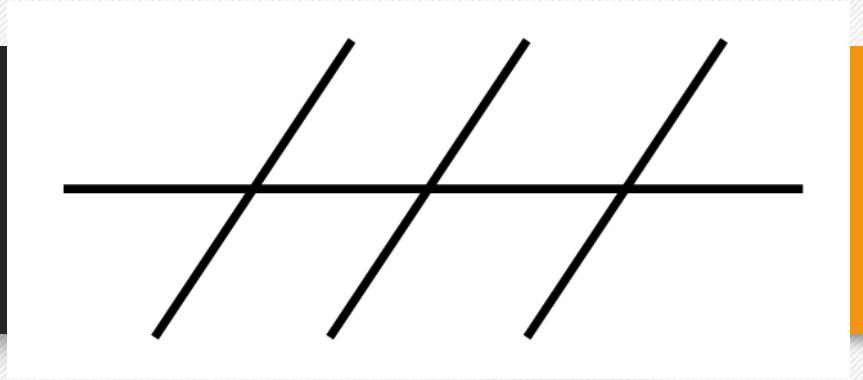
- An electrical device that opposes the flow of current.

Bulb



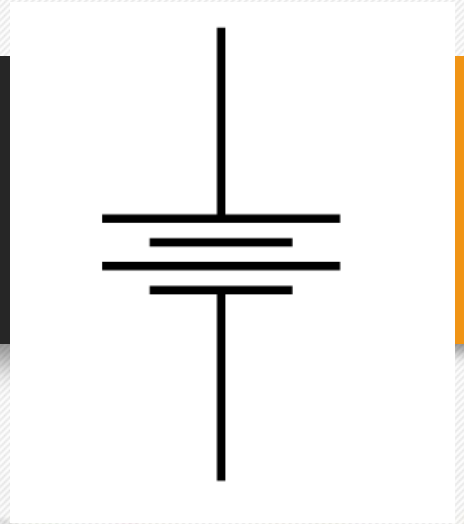
- An electric light with a wire filament heated until it glows.

Light and Power



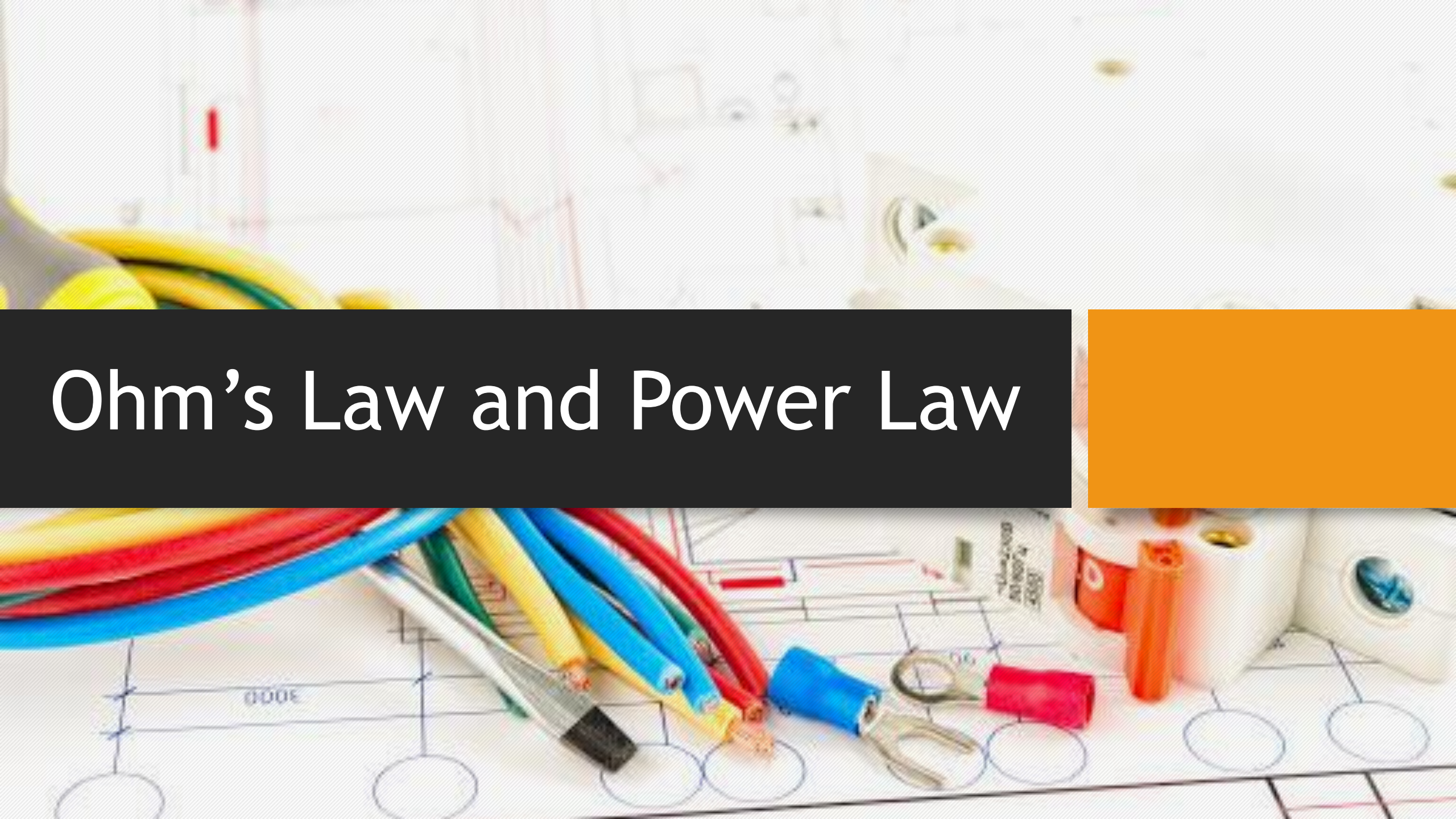
- A single line diagram of light or power that indicates the number of wires in a conduit run.

Battery



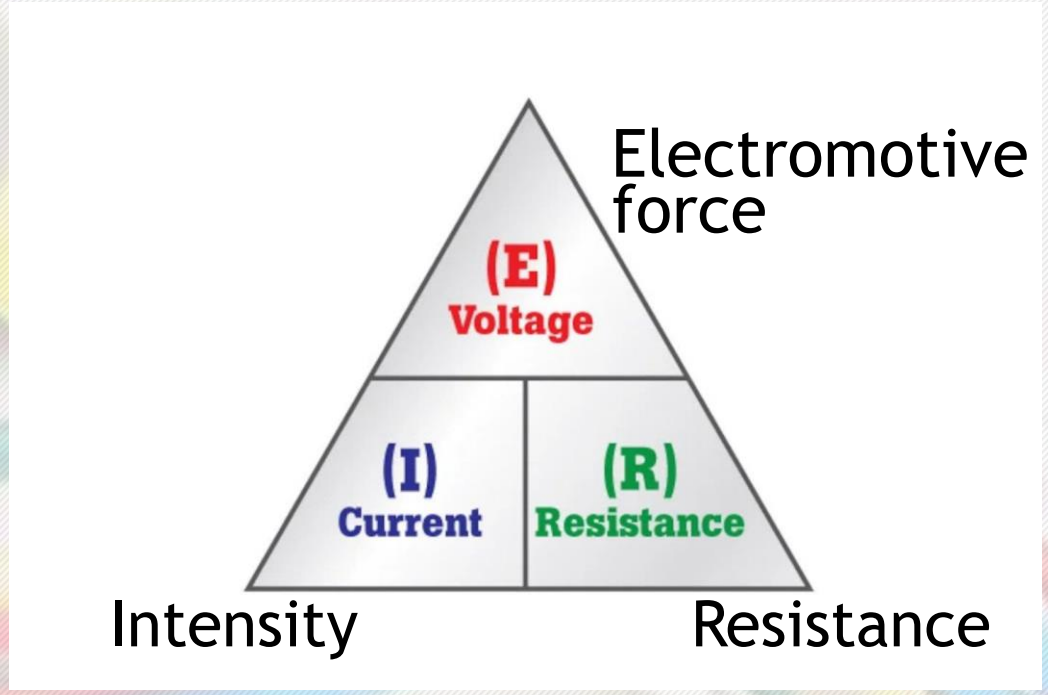
- a container consisting of one or more cells, in which chemical energy is converted into electricity and used as a source of power.

Ohm’s Law and Power Law



Ohm's Law

- The relationship between voltage, current and resistance.
- It states that "voltage and current are *directly proportional* and *inversely proportional* to resistance."

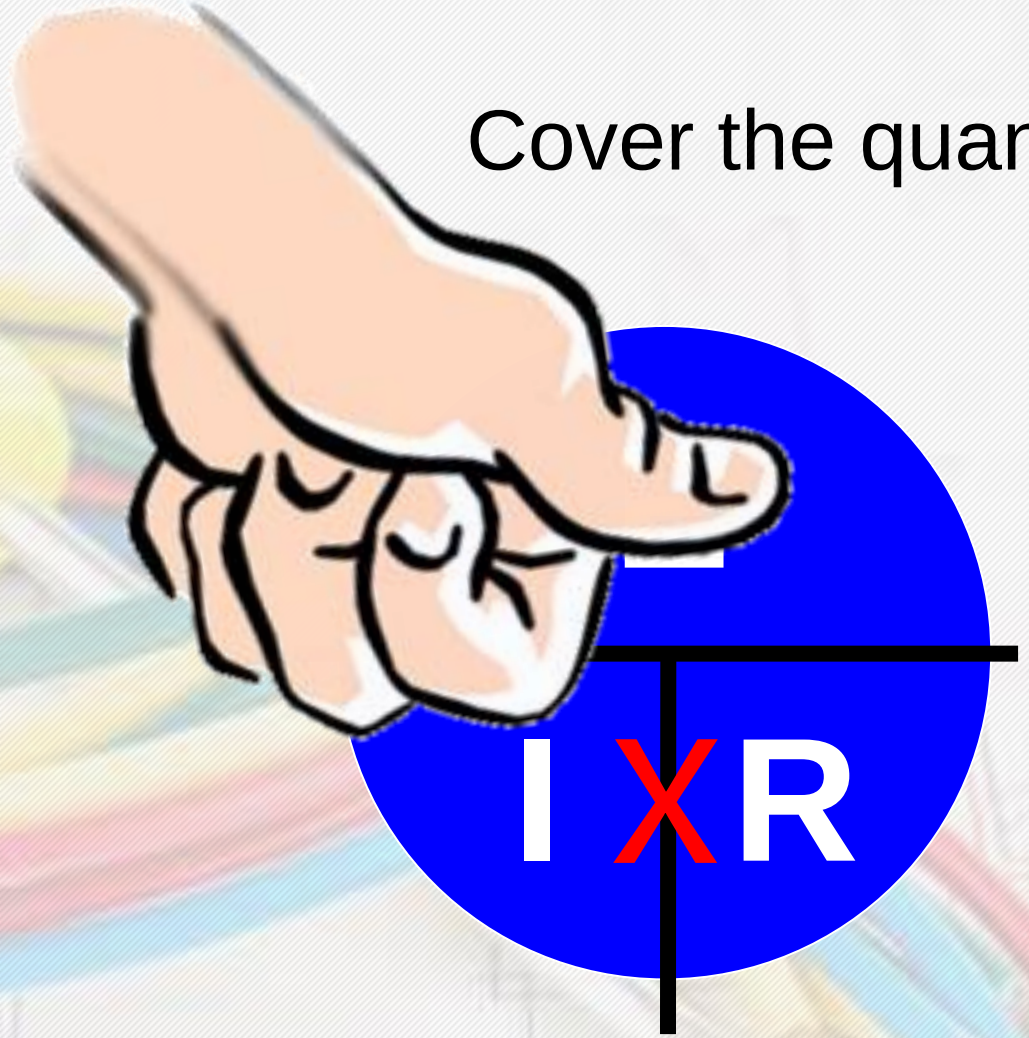

Electromotive force
(E)
Voltage
(I)
Current
(R)
Resistance
Intensity
Resistance

$$E=IR$$

$$I=E/R$$

$$R=E/I$$

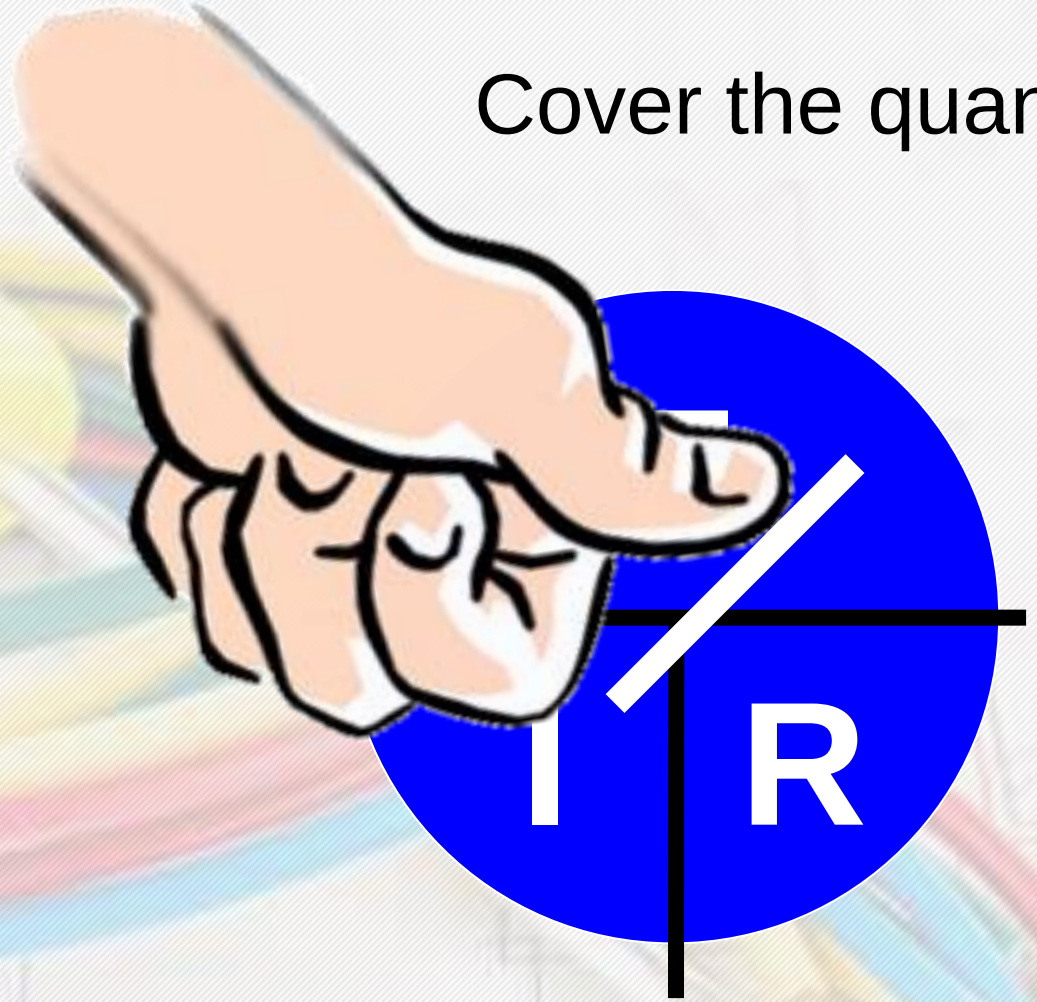
Cover the quantity that is unknown.



Solve for E

E=IR

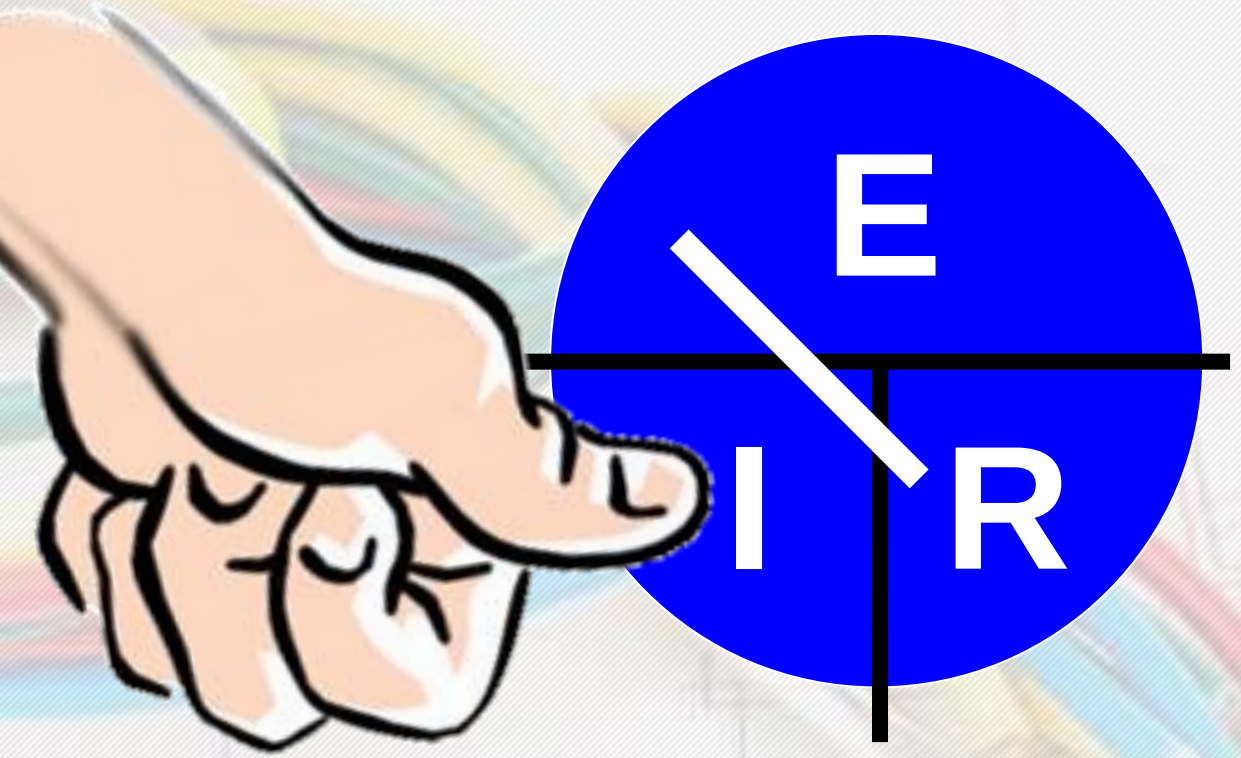
Cover the quantity that is unknown.



Solve for I

I=E/R

Cover the quantity that is unknown.



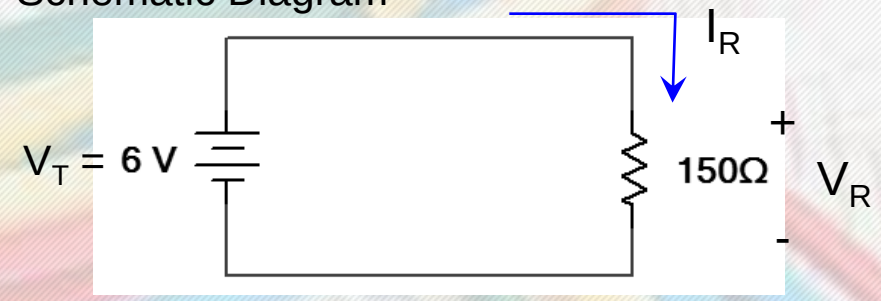
Solve for R

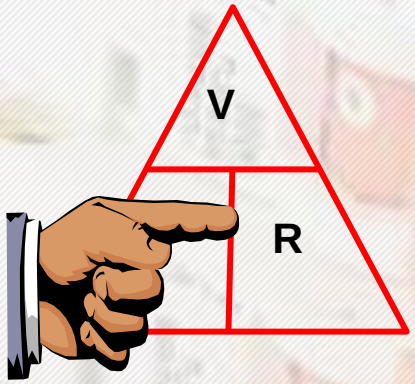
R=E/I

Example: Ohm's Law

The flashlight shown uses a 6 volt battery and has a bulb with a resistance of 150 Ω. When the flashlight is on, how much current will be drawn from the battery?

Schematic Diagram

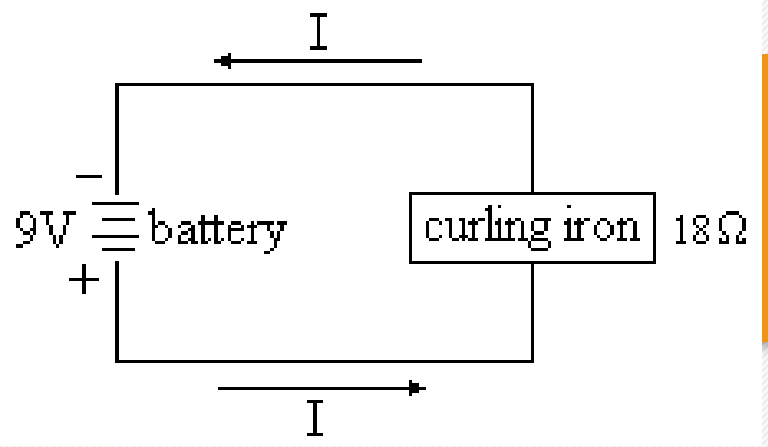




$$I_R = \frac{V_R}{R} = \frac{6\,V}{150\,\Omega} = 0.04\,A = 40\,mA$$

Example: Ohm's Law

A nine volt battery supplies power to a cordless curling iron with a resistance of 18Ω. How much current is flowing through the curling iron?



Given: $E = 9\,V$

$R = 18\,\Omega$

$I = ?$

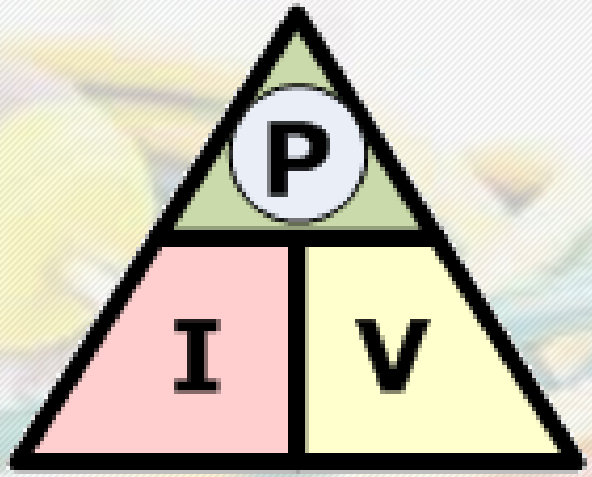
$$I = \frac{E}{R}$$

$$I = \frac{9V}{18\Omega}$$

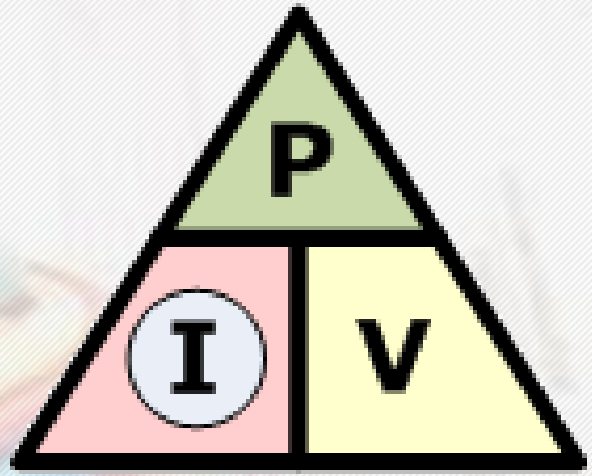
$$I = 0.5A$$

No.	Current	Voltage	Resistance
1.	5	[redacted]	12
2.	[redacted]	224	7
3.	9	720	[redacted]
4.	4	15	[redacted]
5.	8	[redacted]	16

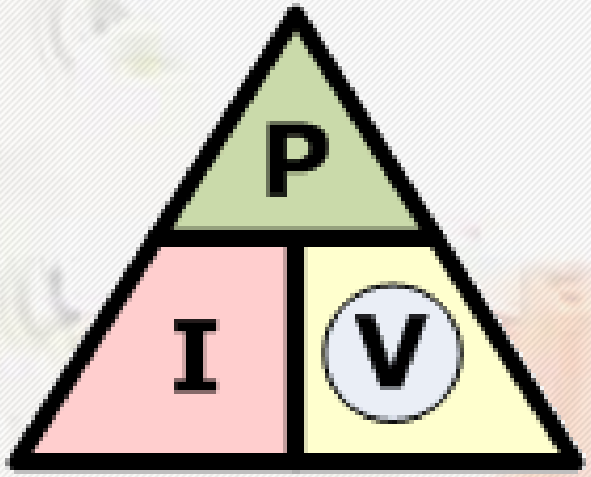
Power Law



$$P = I \times V$$



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



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

Example: Power Law

A group of lamps operates a current of 15 A and a voltage of 200v. What is the total power of the lamps?

Given: $I = 5A$

$E = 200V$

$P = ?$

$P = IE$ $\quad P = (5A)(200V)$ $\quad P = 1000W$

Kilowatt-hour

$$\text{kWh} = \frac{Watts\ x\ time(hrs)}{1000}$$

Horse Power

1hp = 746 watts

Example: kilowatt-hour

A kettle with a power rating of 2200 W is used to boil water for 6 minutes. What is the energy consumption?

Given: $P = 2200\ w$

$t = 6\ minutes$

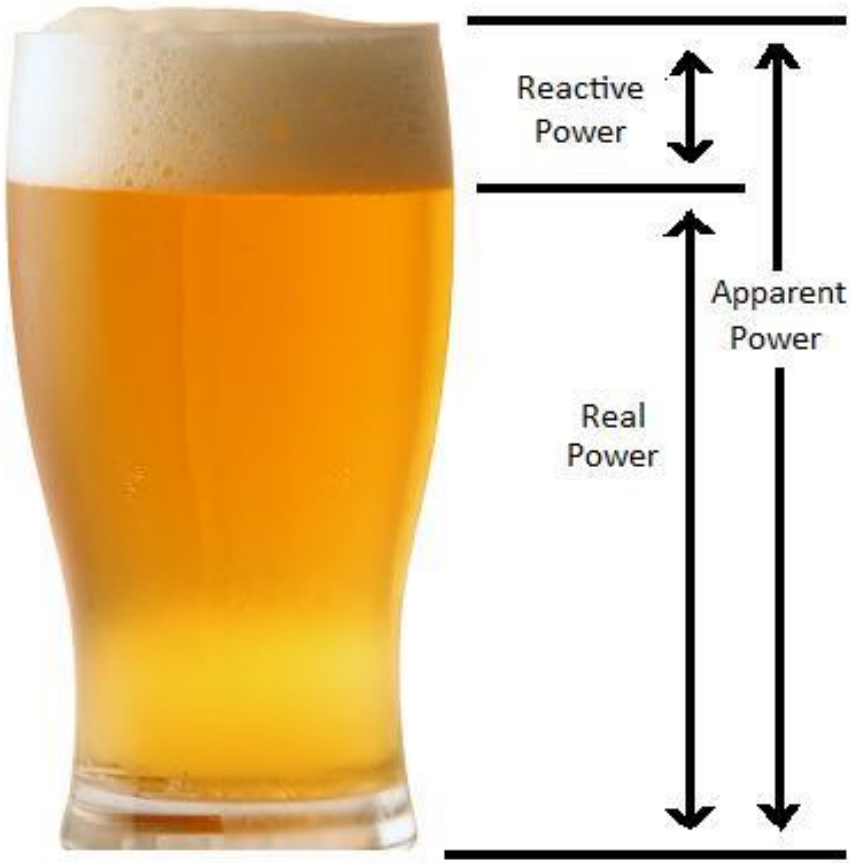
$kWh = ?$

$6\ minutes = (1\ hr)/(60\ minutes) = 0.1\ hr$

$kWh = ((2200w)(0.1hr))/1000 = 0.22\ kWh$

Power Factor

- **Power factor** (PF) is the ratio of working power, measured in kilowatts (kW), to apparent power, measured in kilovolt amperes (kVA). Apparent power, also known as demand, is the measure of the amount of power used to run machinery and equipment during a certain period.



$$\text{Power factor} = \frac{\text{True power}}{\text{Apparent power}}$$

$$\text{Power factor} = \frac{119.365\text{W}}{119.366\text{VA}}$$

$$\text{Power factor} = 0.9999887$$

Example: Power Factor

An Incandescent lamp unit connected to a 220v AC line takes 0.8A and requires 150w power. What is its power factor?

Given: $I = 5A$

$E = 200V\ AC$

$P = 150w$

$Pf = kW/kVA$

$$Pf = \frac{150w}{(5A)(200V)}$$

$$Pf = \frac{150w}{176VA}$$

$$Pf = 0.8522$$

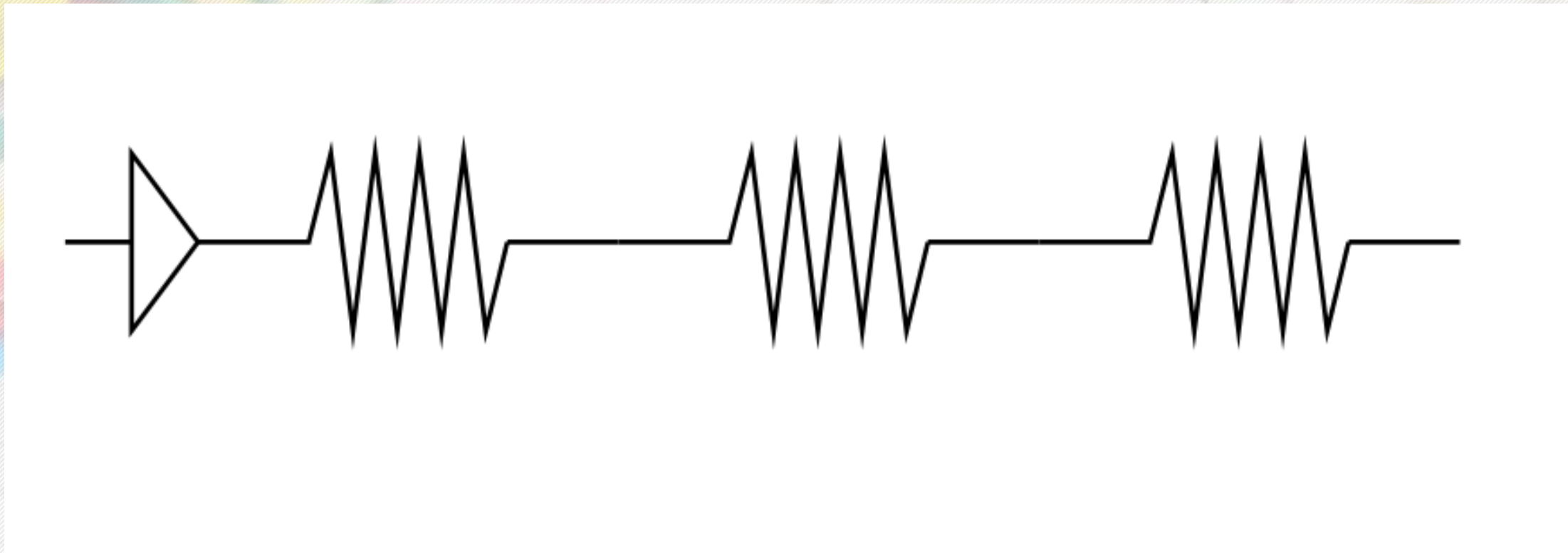
TYPES OF ELECTRICAL CIRCUIT

- **Series Circuit**
  - One current path
- **Parallel Circuit**
  - Two or more current path
- **Series and Parallel Circuit**
  - Combination of series and parallel connection in one circuit

Series Circuit

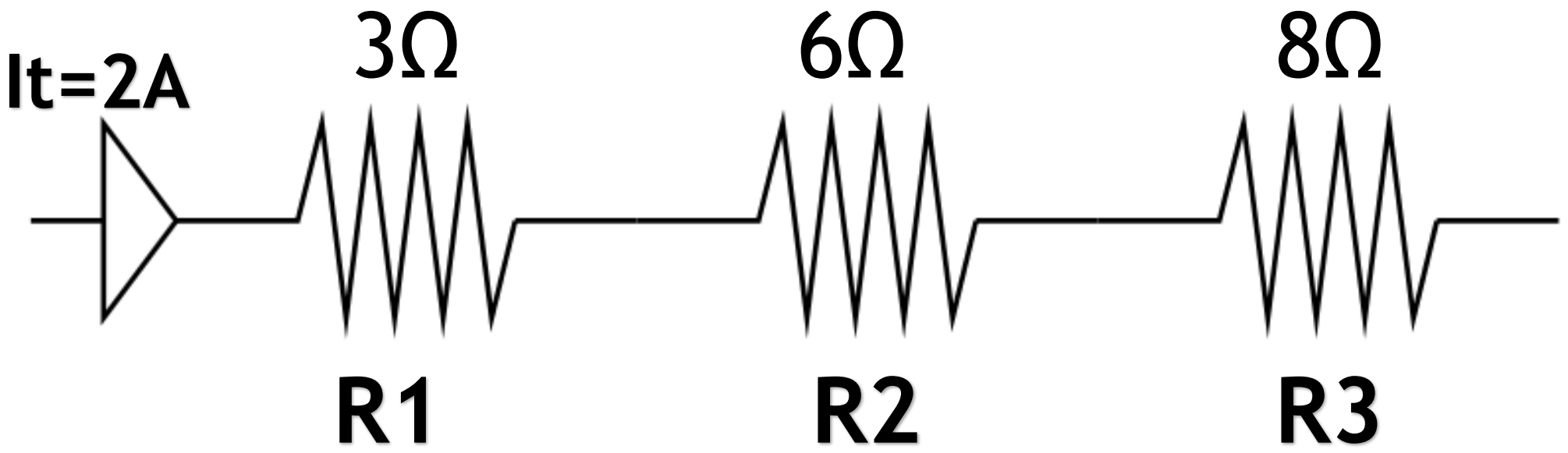
- A closed circuit in which the current follows in one path.
- It is connected end-to-end.

Series Circuit



Series Circuit

- **Current -** same throughout the circuit
  - $I_t = I_1 = I_2 = I_3 = \ldots$
- **Voltage -** equal to the sum of individual voltage
  - $E_t = E_1 + E_2 + E_3 + \ldots$
- **Resistance -** equal to the sum of individual resistance
  - $R_t = R_1 + R_2 + R_3 + \ldots$


It=2A
3Ω
6Ω
8Ω
R1
R2
R3

Find:

Given:
It=2A
R1=3 Ω
R2=6 Ω
R3=8 Ω

R_t=?
E_t=?
P_t=?
E_1=?
E_2=?
E_3=?
P_1=?
P_2=?
P_3=?

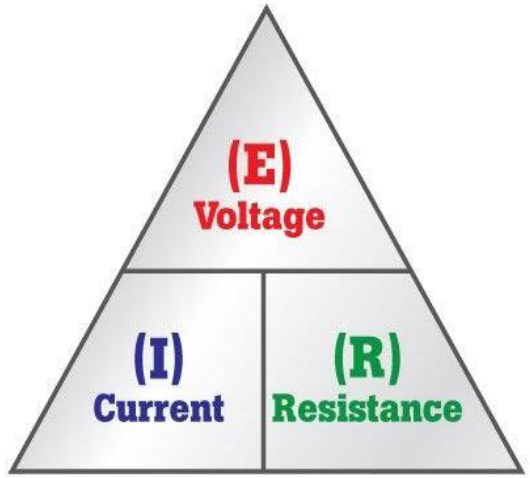
$I_t = I_1 = I_2 = I_3 = \ldots$

$E_t = E_1 + E_2 + E_3 + \ldots$

$R_t = R_1 + R_2 + R_3 + \ldots$

$P_t = P_1 + P_2 + P_3 + \ldots$

P = I x E



	1	2	3	T
P	12W	24W	32W	68W
E	6V	12V	16V	34V
I	2A	2A	2A	2A
R	3Ω	6Ω	8Ω	17Ω


It=3A
4Ω
15V
R1
E2

Find:

Given: R1=4 Ω
It=3A E2=15V

R_t=?
E_t=?
P_t=?
E_1=?
R_2=?
P_1=?
P_2=?

	1	2	T
P	36W	45W	81W
E	12V	15V	27V
I	3A	3A	3A
R	4Ω	5Ω	9Ω

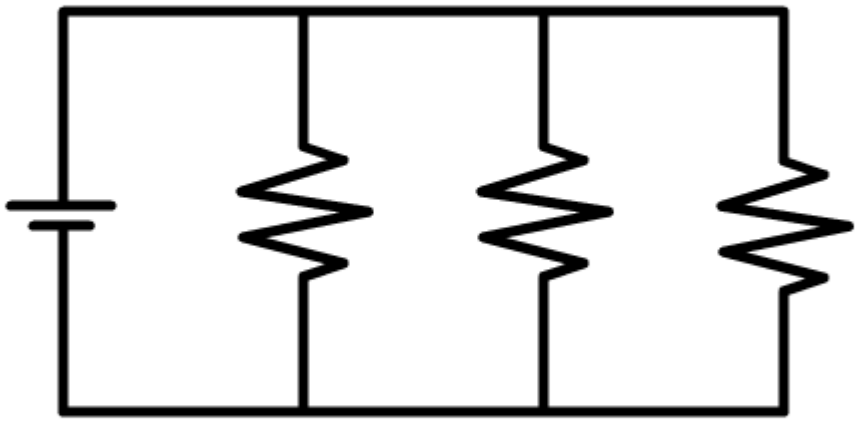
Parallel Circuit

- **Current** – equal to the sum of individual current
  - $I_t = I_1 + I_2 + I_3 + \ldots$
- **Voltage** – drop across each load is the same
  - $E_t = E_1 = E_2 = E_3 = \ldots$
- **Resistance** – product over sum
  - $R_t = \dfrac{(R1)\,(R2)}{R1 + R2}$ or $\dfrac{1}{R_{Total}} = \dfrac{1}{R_1} + \dfrac{1}{R_2} + \dfrac{1}{R_3} + \ldots$

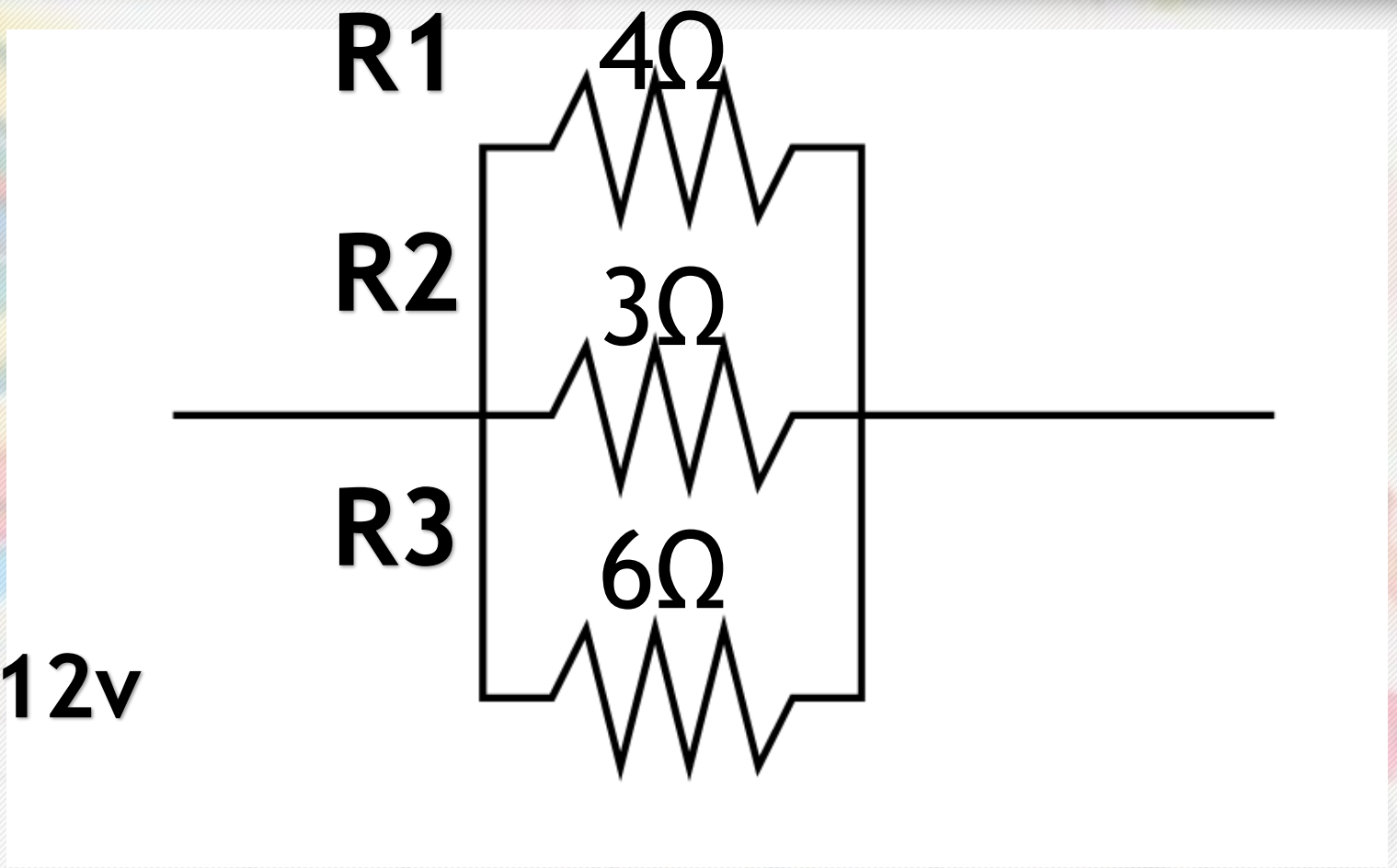
Parallel Circuit

- Is a closed circuit in which the current follows in two or more path.
- It is connected side-by-side.

Parallel Circuit



Parallel Circuit



Et=12v

Find:

Given:
Et=12v
R1=4 Ω
R2=3 Ω
R3=6 Ω

R_t=?
I_t=?
P_t=?
I_1=?
I_2=?
I_3=?
P_1=?
P_2=?
P_3=?

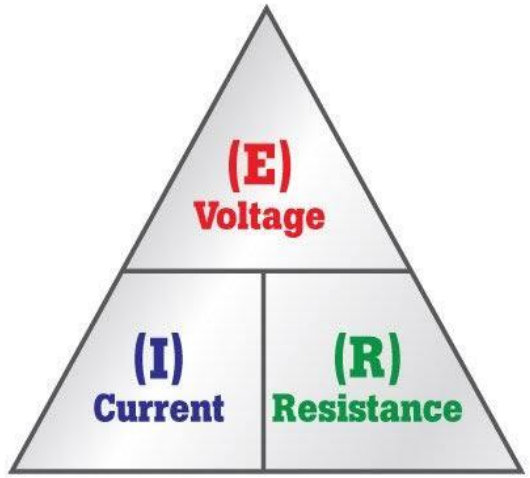
$I_t = I_1 + I_2 + I_3 + \ldots$

$E_t = E_1 = E_2 = E_3 = \ldots$

$1/R_t = 1/R_1 + 1/R_2 + 1/R_3 + \ldots$

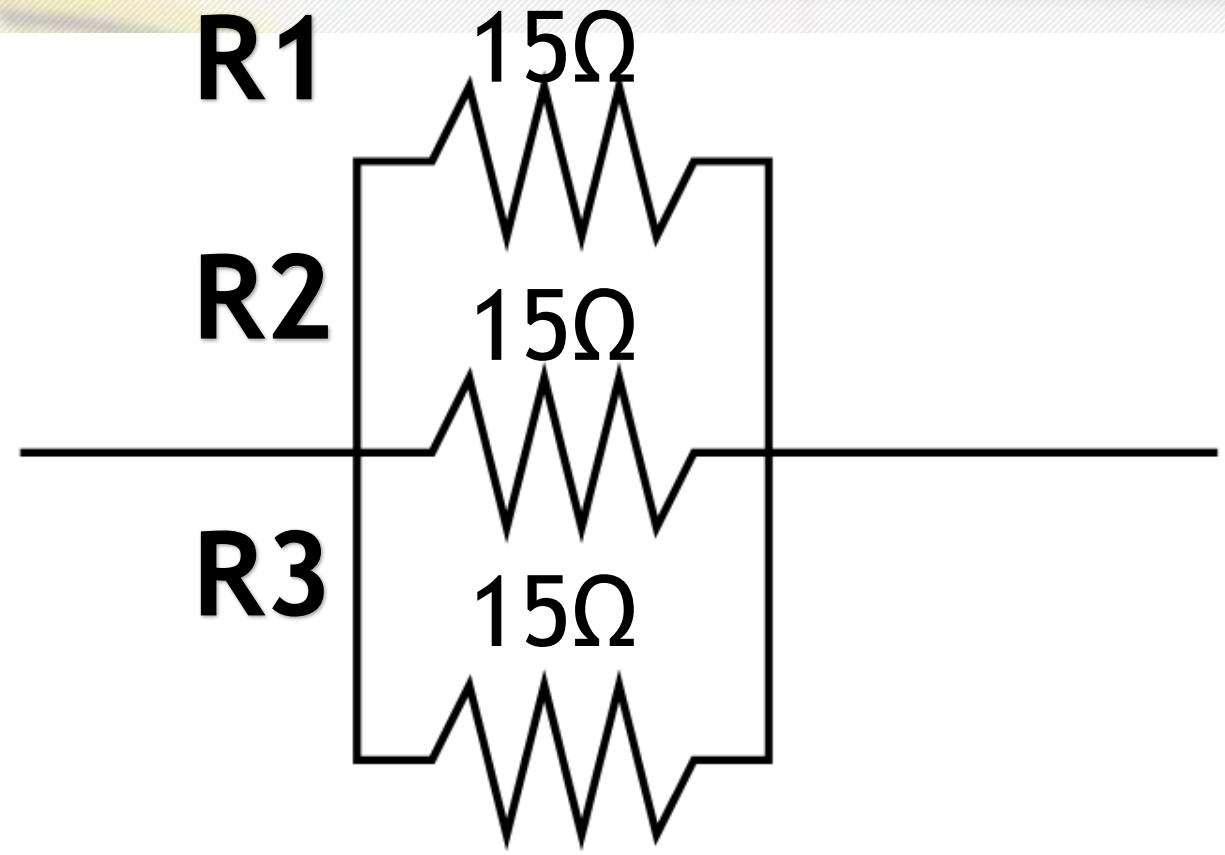
$P_t = P_1 + P_2 + P_3 + \ldots$

$P = I \times E$



	1	2	3	T
P	36W	48W	24W	108W
E	12V	12V	12V	**12V**
I	3A	4A	2A	9A
R	**4Ω**	**3Ω**	**6Ω**	1.33Ω

3 Identical Resistors



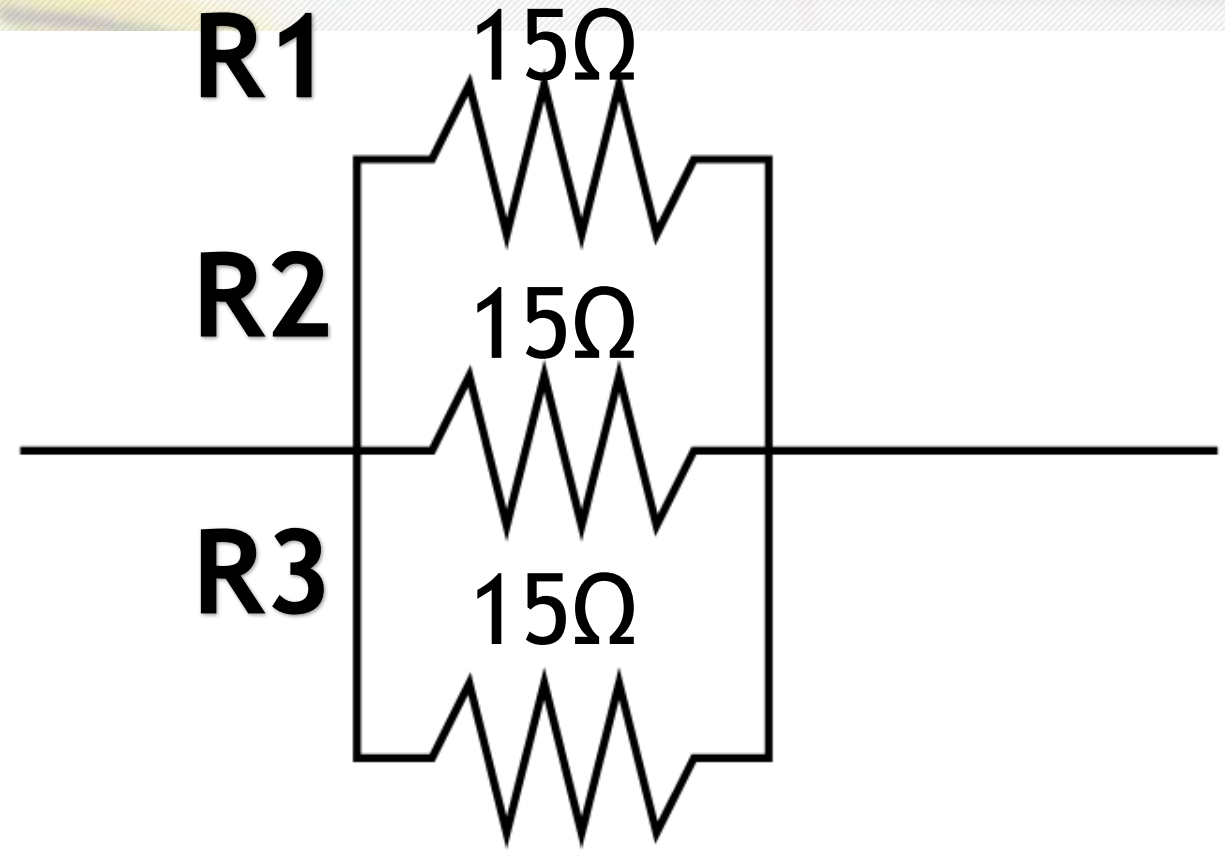
$$Rt = R/N$$

Where:

R – Resistance

N – the number of resistor

3 Identical Resistors

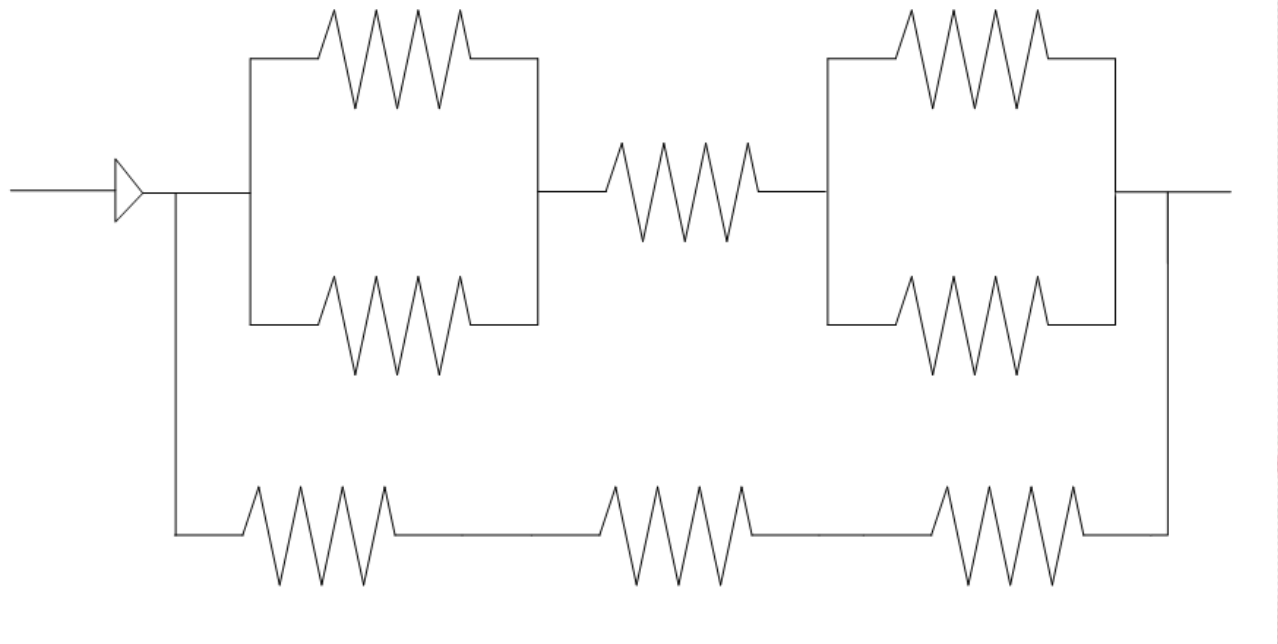


Rt= R/N

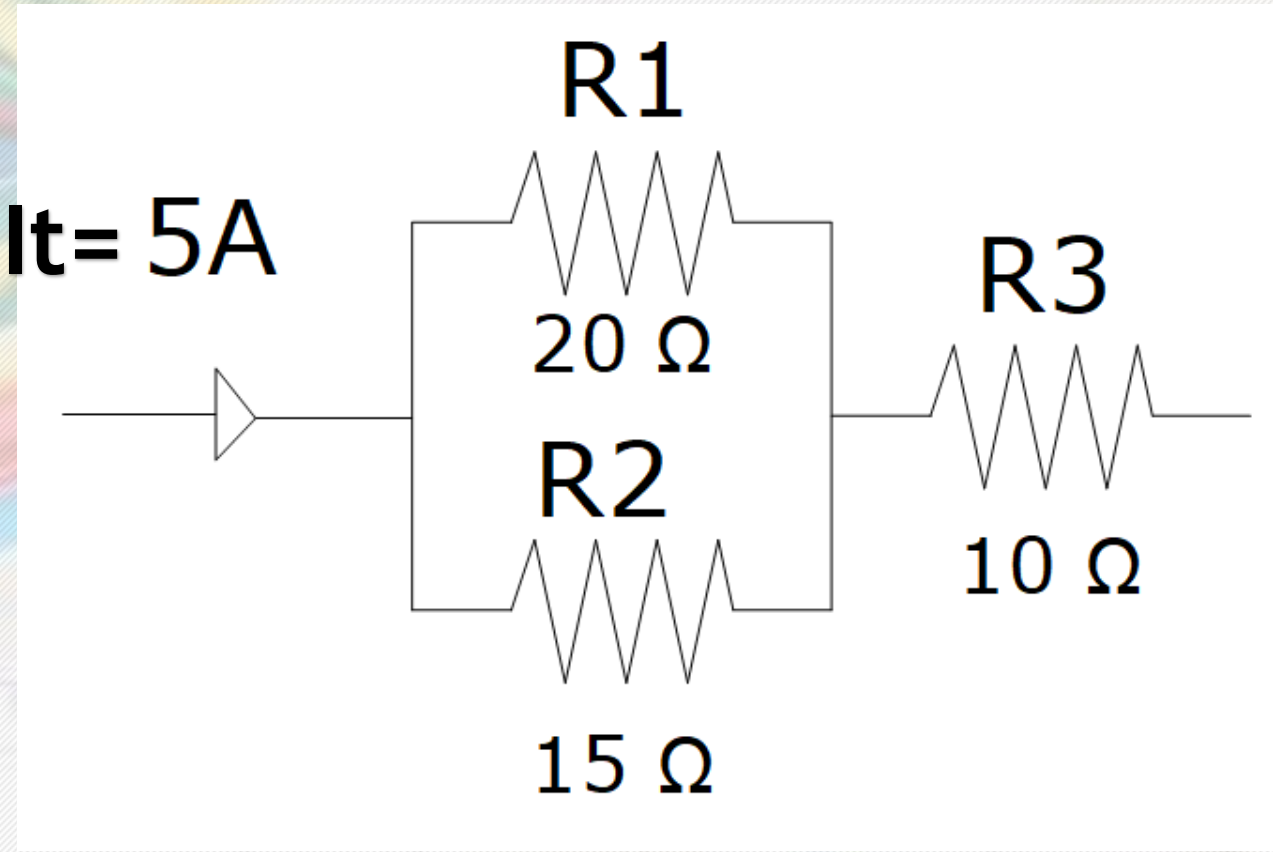
Rt= 15 Ω /3

Rt= 5 Ω

Series-Parallel Circuit



Series-Parallel Circuit



Find:

Given:
It=5A
R1=20 Ω
R2=15 Ω
R3=10 Ω

R_t=?
P_t=?
E_t=?
E_1=?
E_2=?
E_3=?
P_1=?
P_2=?
P_3=?

Post-test

Wiring Materials

Battery

- A battery is a device that stores chemical energy and converts it to electrical energy.

Classification of Battery

- **Primary batteries**
  - Non-rechargeable batteries
- **Secondary batteries**
  - Rechargeable batteries

Formula

$$Hours = ((mAh))/((Amps*1000))$$

For example

a 3000 mAh battery that runs at 0.2 Amps. How long will the battery will last?

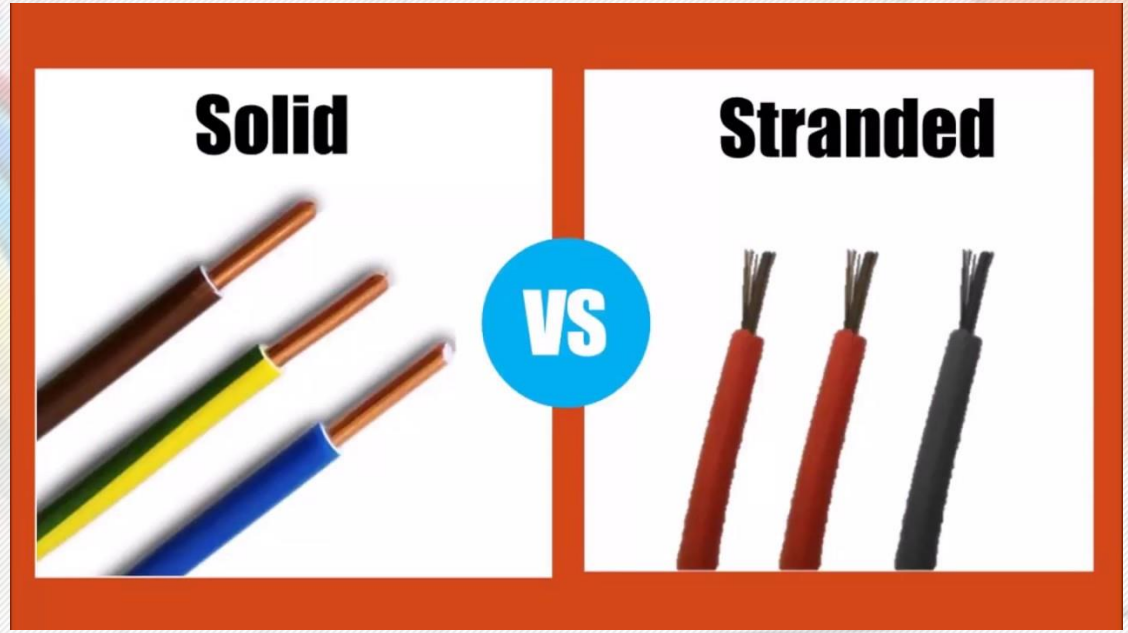
hours = (3000)/(0.2*1000) = (3000)/(200)= 15 Hours.

Wire

- A wire is a long thin piece of metal that is used to fasten things or to carry electric current.

Types of wire

- Solid
- Stranded



AWG	Stranded	Solid	Outlet	Protective Device
14	2.0 mm^2	1.6 mm	Lighting Outlet	15 A
12	3.5 mm^2	2.0 mm	Convenience Outlet	20 A
10	5.5 mm^2	2.6 mm	Special Purpose Outlet	30 A
8	8.0 mm^2	3.2 mm	Service Entrance	60 A

THERE ARE ALSO WIRING ACCESSORIES SUCH AS:

1. Junction Box
2. Receptacle
3. Pull box
4. Switches etc.

Junction box

- It is used for wiring termination or connections.

Pull box

- A box with a blank cover which is inserted in one or more runs or raceways to facilitate pulling in the conductors.

Receptacle

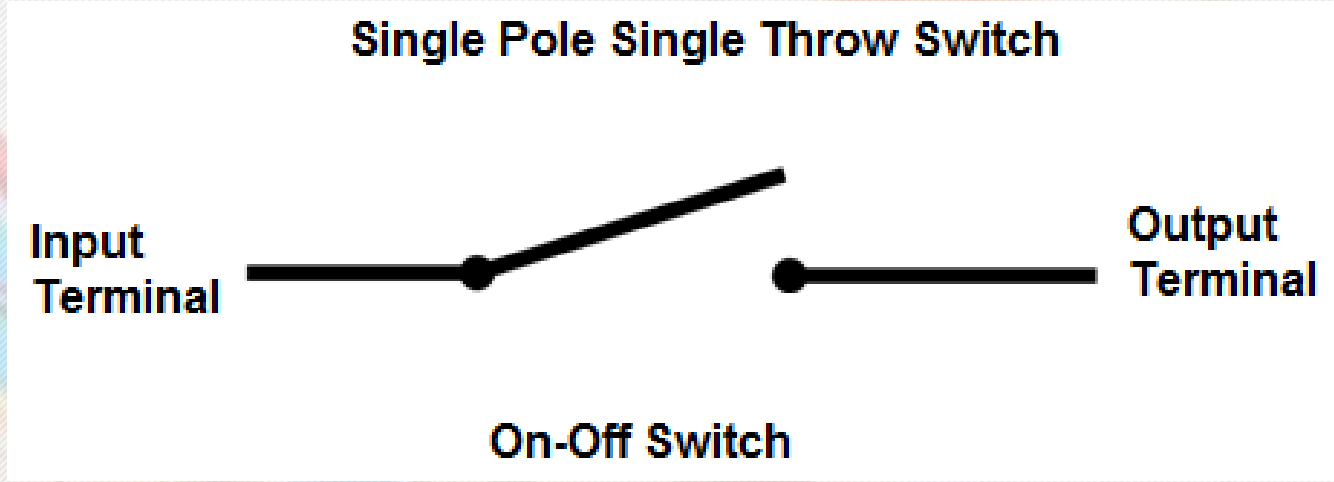
- As defined by NEC “Receptacles are contact devices installed at the outlet for the connection of single attachment plug”

Switches

- Switches are devices which open or close the circuitry in an electric circuit.

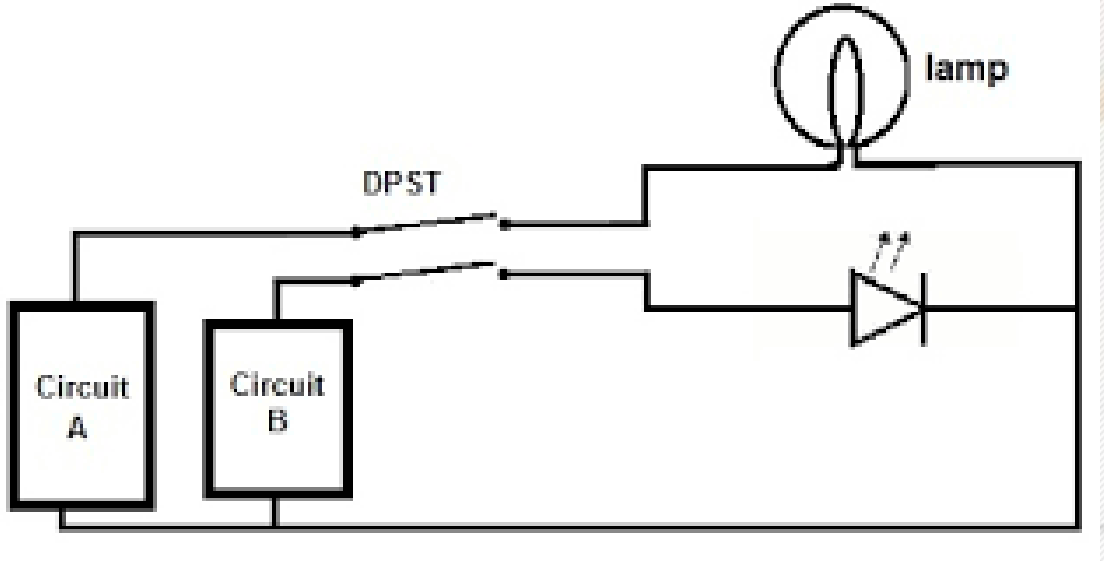
Single Pole Single Throw

- A switch that only has a single input and can connect only to one output.



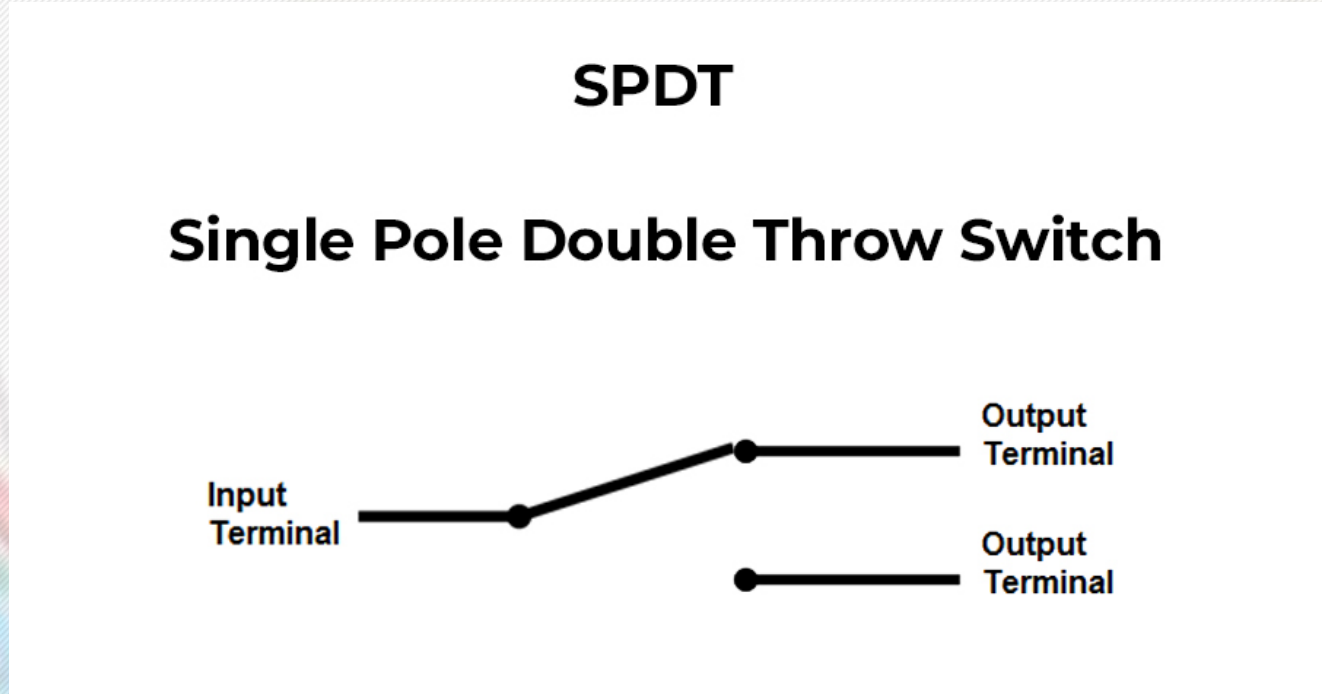
Double Pole Single Throw

- It has four different terminals and is often used to connect two source terminals to their respective output terminals (but never to each other).

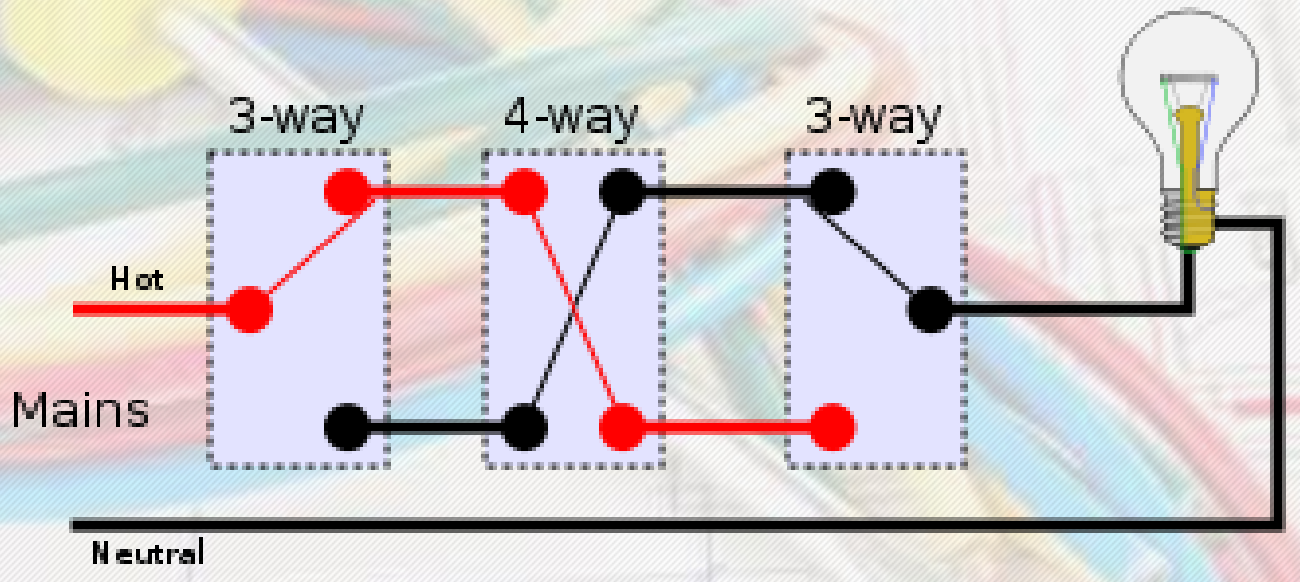


Single Pole Double Throw/Three-way Switch

- A switch that only has a single input and can connect to and switch between the 2 outputs.

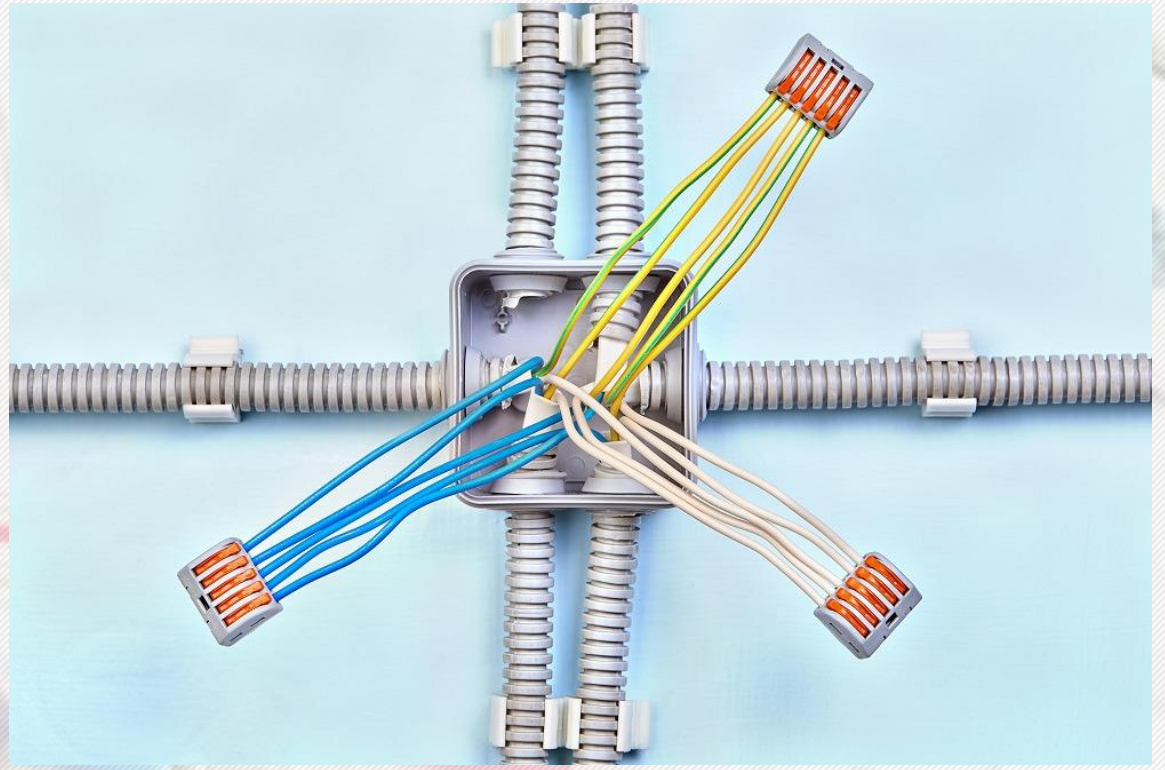


Four-way Switch



- Are used to control lighting from three or more locations

- At least **6 inch** or **150mm** of free conductor shall be left at each outlet, junction and switch point for splices or connection of fixture or devices.



Mounting Receptacle:

- wall convenience receptacle vertically mounted between 30 to 40 centimeters above the finished floor line.

Mounting Receptacle:

- In industrial area, shop, workroom, home. The mounting height is from 105 to 110 centimeters horizontally mounted so the that cords will not hang on top of each other.

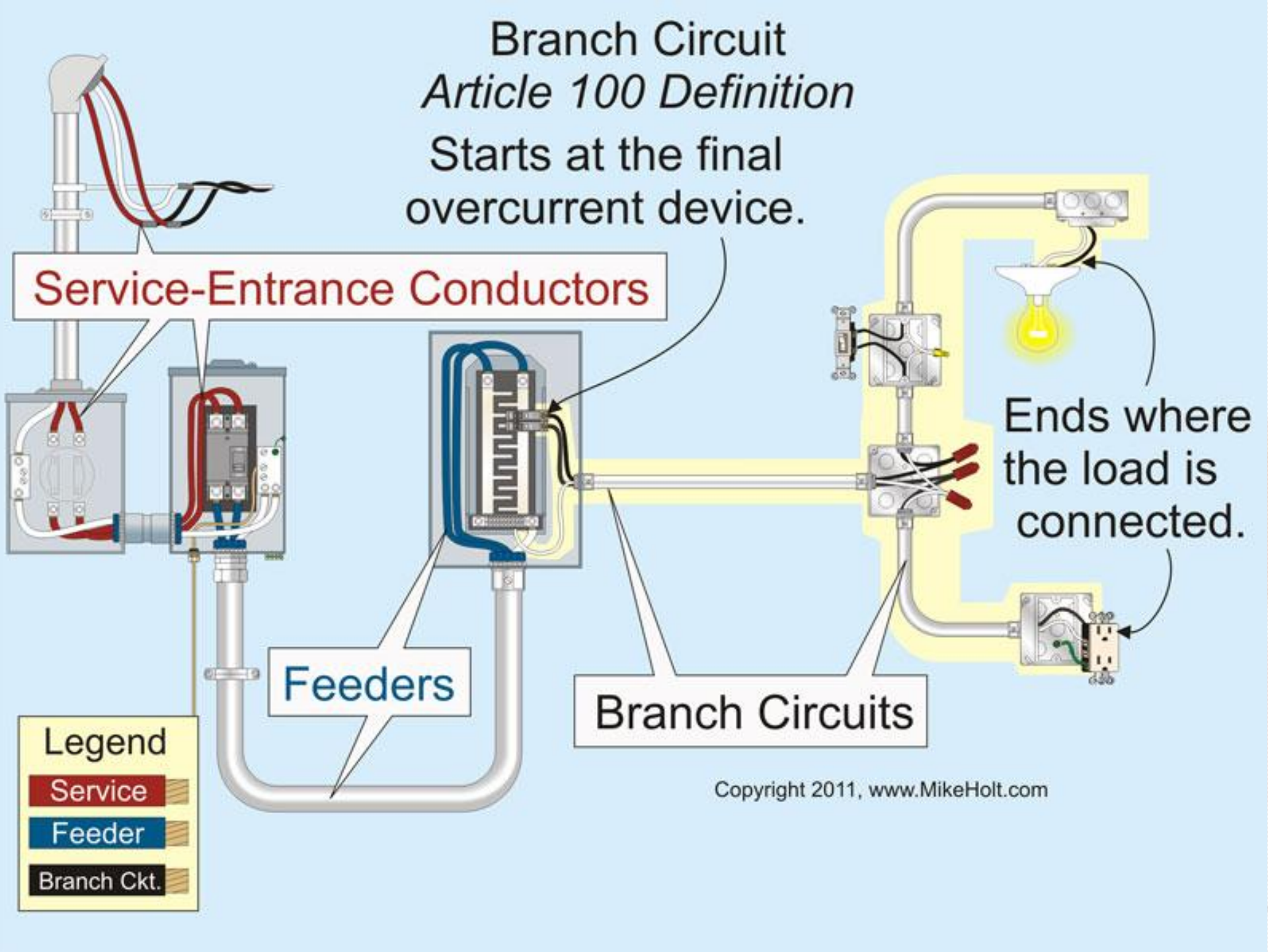
Mounting Receptacle:

- The GFI/GFCI (Ground Fault Interrupter/Ground Fault Circuit Interrupter) receptacle should be installed on location where sensitivity as in wet areas.

Branch Circuit

the circuit conductors between the final over current device protecting the circuit and the outlet(s).

-PEC-

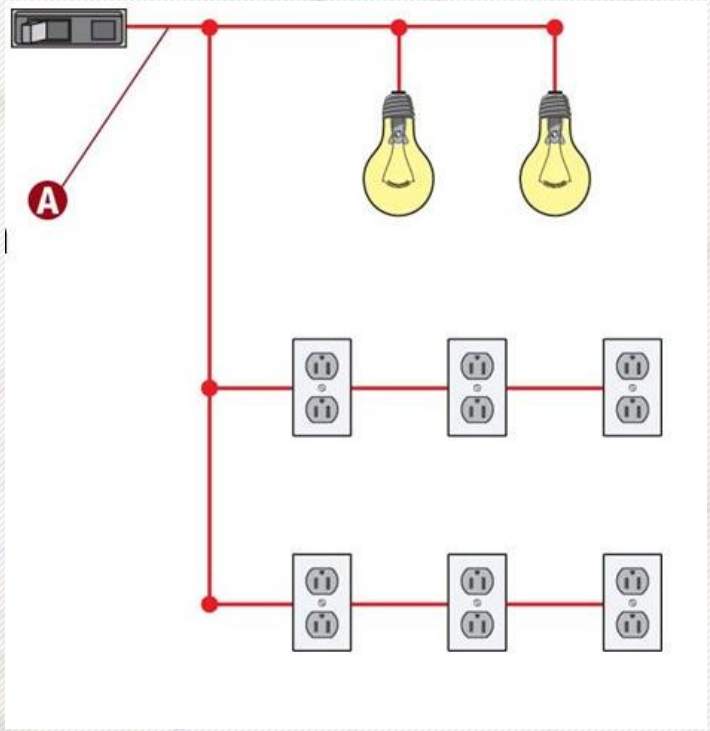

Branch Circuit
Article 100 Definition
Starts at the final overcurrent device.
Service-Entrance Conductors
Ends where the load is connected.
Feeders
Branch Circuits
Legend
Service
Feeder
Branch Ckt.
Copyright 2011, www.MikeHolt.com

Types of Branch Circuit

A. General Purpose Branch Circuit
B. Appliance Branch Circuit
C. Individual Branch Circuit
D. Multi wire Branch Circuit

General Purpose Branch Circuit

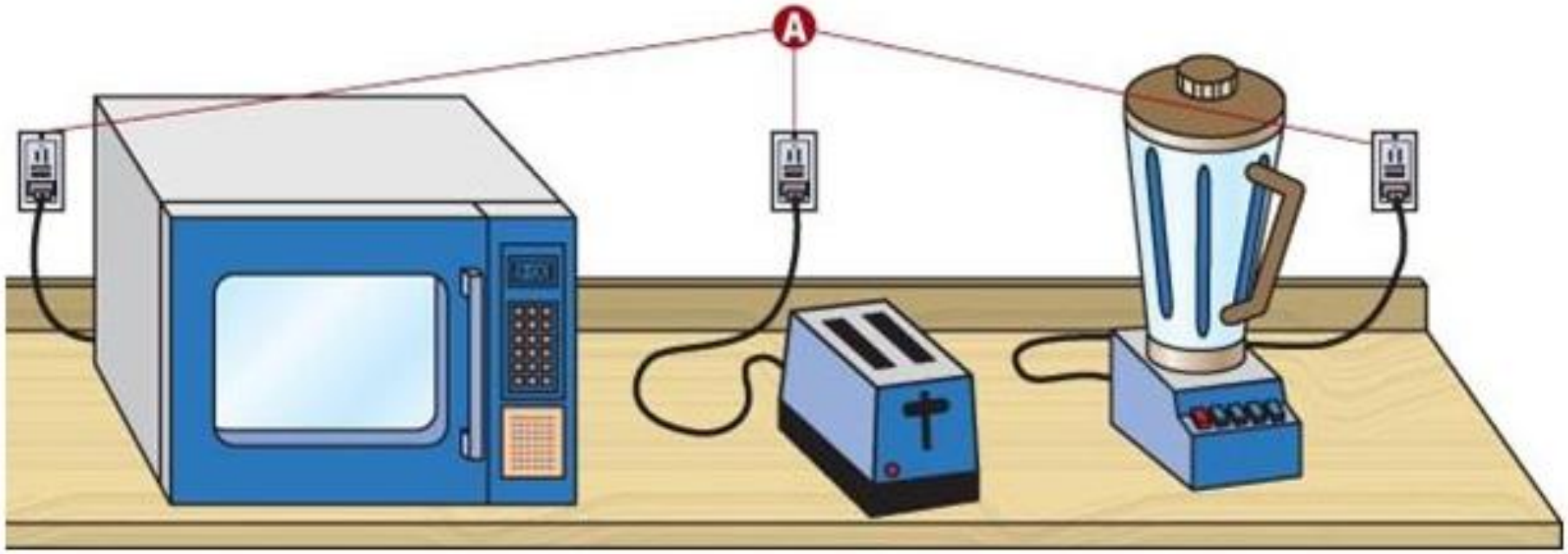
Supplies a number of outlets for lighting and appliance.



Appliance Branch Circuit

Supplies energy to one or more outlets to which appliances are to be connected.

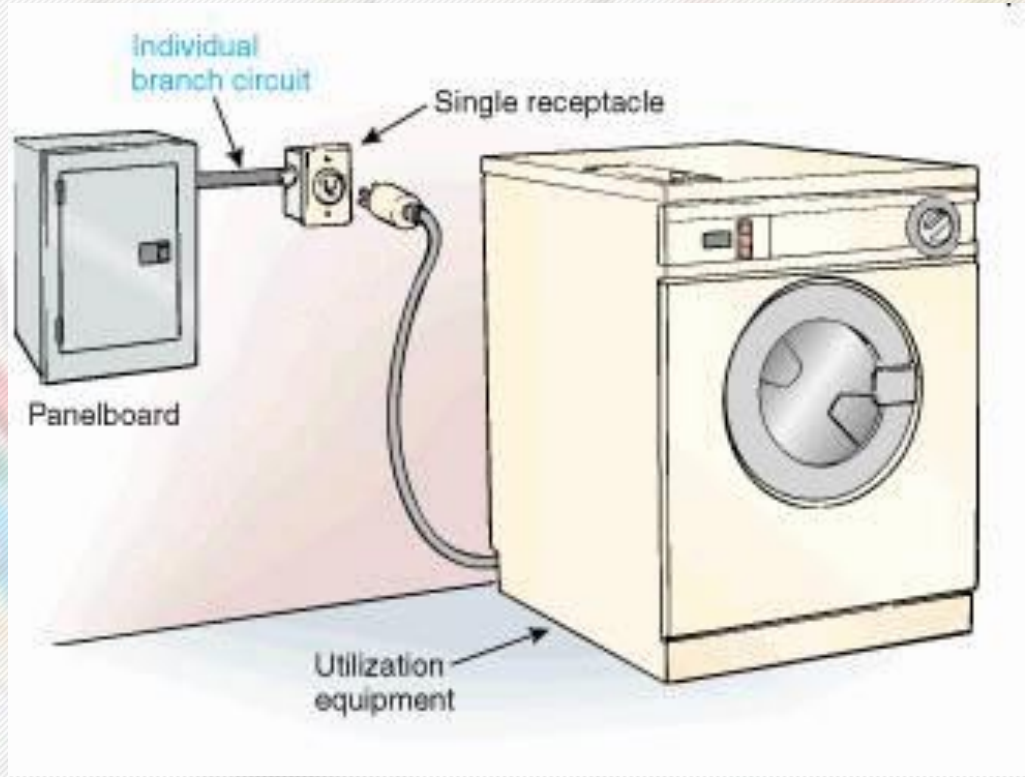
Permanently connected lighting fixtures ONLY if part of an appliance



These circuits exclude the connection of luminaires (lights) unless they are part of the appliance being connected.

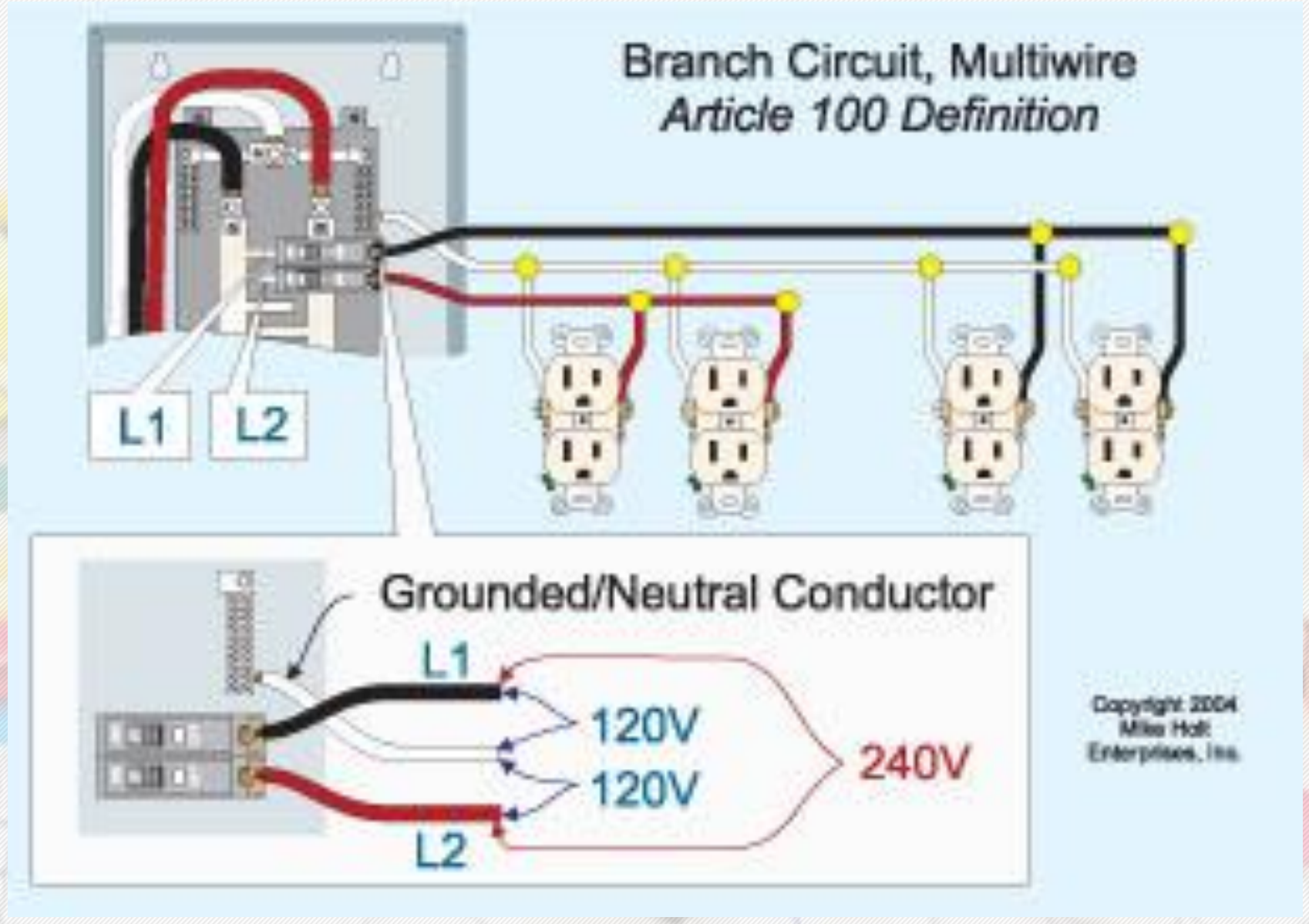
Individual Branch Circuit

Supplies only ONE utilization equipment



Multi wire Branch Circuit

- Supplies only line-to neutral connected loads.
- Consist of two or more ungrounded conductors THAT HAVE a potential difference between them, and a Grounded conductor having equal potential difference between it and each ungrounded conductor of the circuit and which is connected to the neutral (grounded) conductor of the system.


Branch Circuit, Multiwire
Article 100 Definition
L1
L2
Grounded/Neutral Conductor
L1
120V
120V
240V
L2
Copyright 2004
Mike Holt
Enterprises, Inc.

Common Types of Branch Circuit

1. 240/120V, Single-phase, 3 wire
2. 400/230V (or 480/277V), Three-phase,4-wire

Branch Circuit Classification

Classified in accordance with the maximum permitted ampere rating or setting of the branch circuit OCP: 15A, 20A, 30A, 40A, & 50A.

Wiring Methods

CLASSIFICATION OF CONDUIT

According to the type of materials used, conduit my be classified into:

1. Metallic such as steal pipes, aluminum etc.
2. Non-metallic such as plastic

Metallic

- RSC ---- Rigid steel conduit
- IMC ---- Intermediate metallic conduit
- EMT---- Electrical Metallic tubing
- BX ---- Armored cable
- Metal Molding

Non-metallic

- PVC---- Polyvinyl conduit
- CPC---- Corrugated Plastic conduit
- PM---- Plastic Molding

Flexible Metallic Conduit

A raceway of circular cross section made of helically wound, formed, interlocked metal strip.

Connector

Flexible Metallic Tubing

A raceway that is circular in cross section, flexible, metallic, and liquidtight without a nonmetallic jacket.

Rigid Metal Conduit

A threadable raceway of circular cross section designed for the physical protection and routing of conductors and cables and for use as an equipment grounding conductor when installed with its integral or associated coupling and appropriate fittings.

Rigid Nonmetal Conduit

- A nonmetallic raceway of circular cross section, with integral or associated couplings, connectors, and fittings for the installation of electrical conductors and cables.
- Conduit shall be supported within **900 mm** of each box.

100mm Orange Heavy Duty Conduit 4 M

Amored Cable AC

- A fabricated assembly of insulated conductors in a flexible metallic enclosure.
- Type AC cable shall be secured by approved staples, straps, hangers or similar fittings at intervals NOT exceeding **1300 mm**.


Aluminum Interlocked Armor
Continuously Corrugated Weld
TECK 90

Concealed knob-and-tube wiring

- A wiring method using knobs, tubes, and flexible nonmetallic tubing for the protection and support of single insulated conductors.
- The clearance to be maintained between conductors is **76 mm**.

Electrical Nonmetallic Tubing

A pliable raceway is a raceway that can be bent by hand with a reasonable force but without other assistance.

Electrical Metallic Tubing

- An *unthreaded* thin wall raceway of circular cross section designed for the physical protection and routing of conductors and cables and for use as an equipment grounding conductor when installed utilizing appropriate fittings.
- Electrical metallic tubing conduit minimum size will be **15 mm**.

Intermediate Metal Conduit

- A steel threadable raceway of circular cross section designed for the physical protection and routing of conductors and cables and for use as an equipment grounding conductor when installed with its integral or associated coupling and appropriate fittings.

Content:

- Electricity
  - Sources of electricity
- Circuit
  - Component of a circuit
  - Symbols
- Ohm’s law and Power Law
  - Series and Parallel Circuit
- Wiring Materials
  - Battery
  - Wire
  - Lamps
  - Boxes
  - Wiring Methods