Circuits Basics

Circuits

- Electricity is the study of charges in motion
- The flow of charge is called *current*
- $I = \frac{Q}{t}$
- Conventional current is defined as the flow of positive charge, but in actuality, negative electrons are flowing the opposite direction.
- In order for current to flow, a voltage source (some type of battery) is required (also called potential or emf)
- Resistance (or load) slows the current

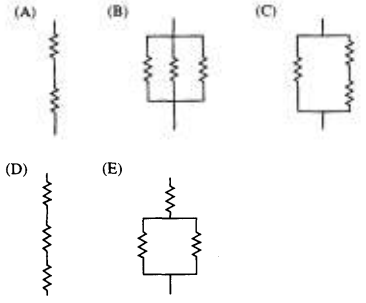
Ohm's Law

- $V = IR$
  - → *V:* Voltage (Volts/V)
  - → *I:* Current (Amperes/Amps/A)
  - → *R:* Resistance (Ohms/Ω)
- Ohm's law may only be used if the current I and the voltage V are experienced by the resistance R. (That means we can't randomly pick a voltage and a resistance from the problem and divide to get current; we must be sure the voltage we plugged in is actually measured across the resistance we're considering.

Power

- Power is energy dissipated per time
- $P = IV = I^2R = \frac{V^2}{R}$
  - → *P:* Power (Watts/W)
  - → *I:* Current (Amperes/Amps/A)
  - → *V:* Voltage (Volts/V)

61 Which of the following combinations of 4Ω resistors would dissipate 24 W when connected to a 12 Volt battery?



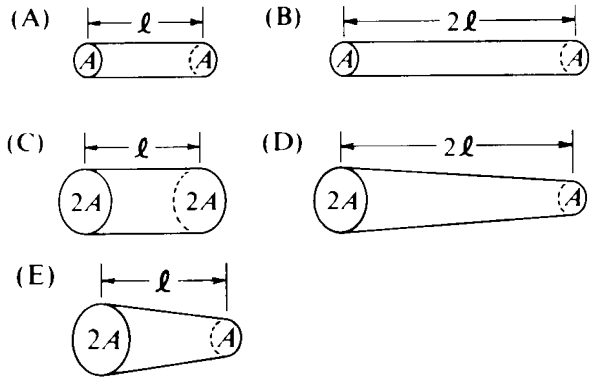
Light Bulbs and Lab Stuff

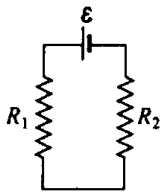
- To light a light bulb one side of the battery must touch the foot of the bulb and the other side of the battery must be touching the screw threads.
- The brightness of a bulb is determined by the power it dissipates
- The power rating of a light bulb generally assumes 120V potential
- A bulb has a known resistance which doesn't change no matter what the bulb is hooked to.
- An ammeter measures current and is connected in series with a circuit element
- A voltmeter measures voltage and is connected in parallel with a circuit element

Resistance of a wire

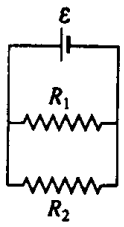
- $R = \frac{\rho L}{A}$
  - → ρ: resistivity (Ωm)
  - → *L:* length of wire (m)
  - → *A:* cross sectional area of wire (m^2)

4. The five resistors shown below have the lengths and cross–sectional areas indicated and are made of material with the same resistivity. Which has the greatest resistance?





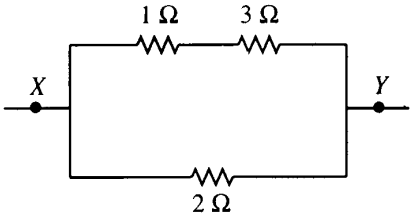
Series Connection



Parallel Connection

Series	Parallel
One current path	Multiple current paths
Same current through each resistor	Same voltage across each resistor
Voltage across each resistor adds up to battery voltage	Current through each resistor adds up to battery current
$R_{EQ} = R_1 + R_2 + R_3$	$\frac{1}{R_{EQ}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

Questions 22 – 23 refer to the following diagram that shows part of a closed electrical circuit.



22. The electrical resistance of the part of the circuit shown between point X and point Y is
(A) 4/3 Ω (B) 2 Ω (C) 2.75 Ω
(D) 4 Ω (E) 6 Ω

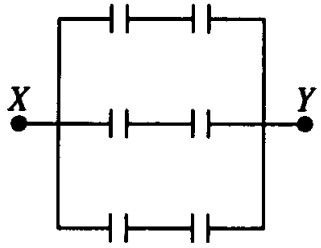
23. When there is a steady current in the circuit, the amount of charge passing a point per unit of time is
(A) the same everywhere in the circuit
(B) greater in the 1 Ω resistor than in the 2 Ω resistor
(C) greater in the 2 Ω resistor than in the 3 Ω resistor
(D) greater at point X than at point Y
(E) greater in the 1 Ω resistor than in the 3 Ω resistor

Capacitors:

- Capacitors store charge: +Q on one plate, -Q on the other.
- $C = \frac{\varepsilon_0 A}{d} = \frac{Q}{V}$
  - → *C:* Capacitance (Farrads/F)
  - → $\varepsilon_0 = 8.85 * 10^{-12} \frac{C^2}{Nm^2}$ is a constant
  - → *A:* surface area of one of the plates (m^2)
  - → *d:* separation distance of plates (m)
  - → *Q:* Charge store on one plate (Coulombs/C)
  - → *V:* Voltage (Volts/V)
- capacitance depends on <u>geometry of plates only</u>!
- Equivalent capacitance is the total or overall capacitance of a circuit.

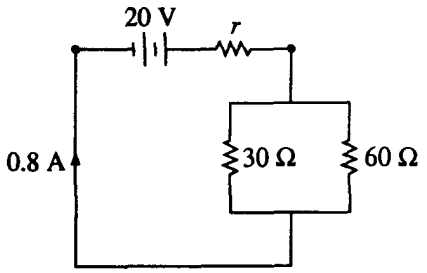
Series	Parallel
$\frac{1}{C_{EQ}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$	$C_{EQ} = C_1 + C_2 + C_3$

Below is a system of six 2–microfarad capacitors.



50. The equivalent capacitance of the system of capacitors is
(A) 2/3μF (B) 4/3 μF (C) 3 μF (D) 6 μF
(E) 12 μF

Internal Resistance & VIR Charts



57. A 30–ohm resistor and a 60–ohm resistor are connected as shown above to a battery of emf 20 volts and internal resistance *r*. The current in the circuit is 0.8 ampere. What is the value of *r*?
(A) 0.22 Ω (B) 4.5 Ω (C) 5 Ω (D) 16Ω
(E) 70 Ω

What is the terminal voltage of the battery?