Electricity and Magnetism

15-1

Magnetics

- Naturally created – Loadstone
- North and South poles
- Opposites attract and Like repel
- Magnetic Field is produced

Demos

- - loadstone
- - items on cards
- - Ball and track
- - Cow magnet
- - Magnetic Cannon
- - Magnetic Fidget Spinner
- - Magnetic Putty

Magnetic Field Demos

- Iron Filings encased
- Iron Filing Zen Garden
- Iron Filing Hour Glass
- Ferrofluid in Glass

Electromagnetics

- Magnetics produced when you coil wire around metal and then add electricity.
- To produce electricity wrap wires around a magnet. Move magnet back in forth through the coil of wires.

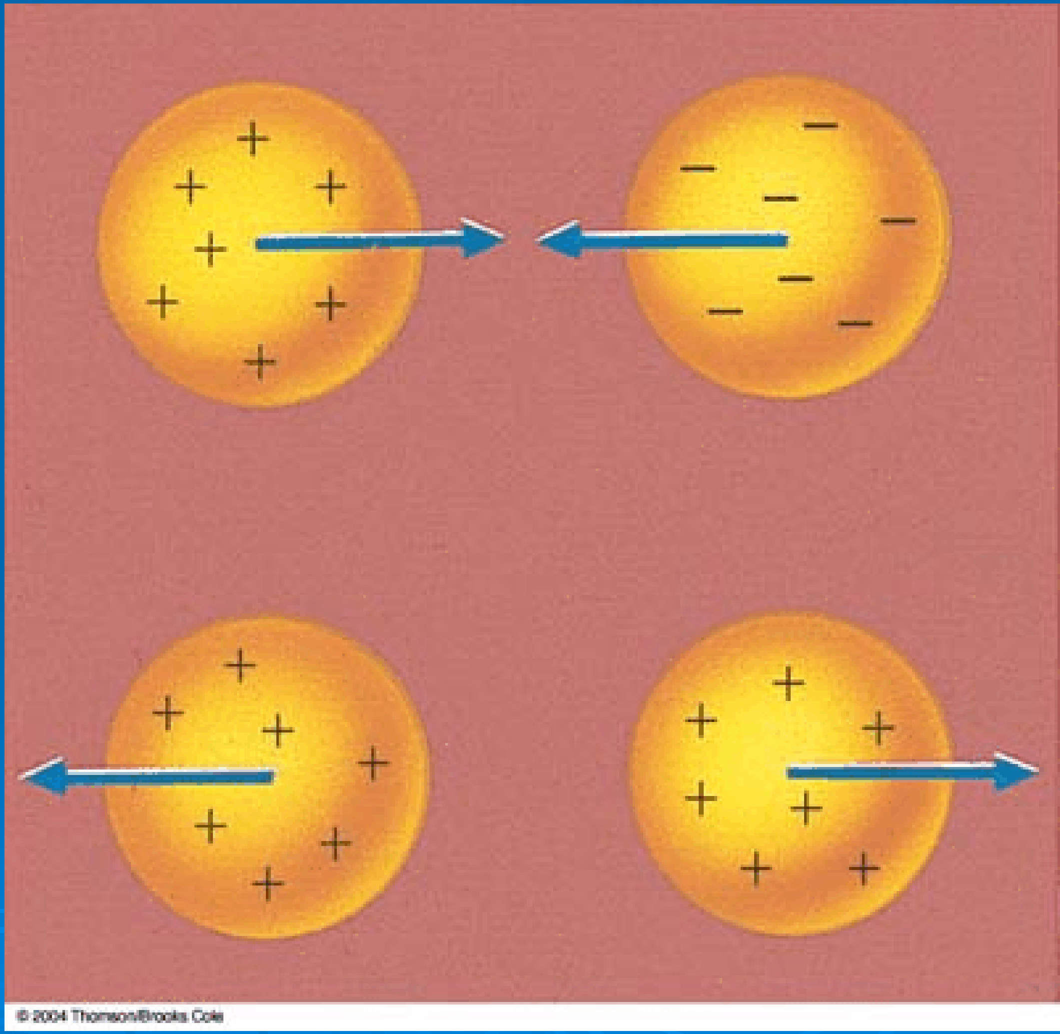
Demos

- - Launcher
- - Plug in magnet
- - Hand turn light
- - Shake Flashlight
- - Turn Generator

Charge versus Current

Electric Charges

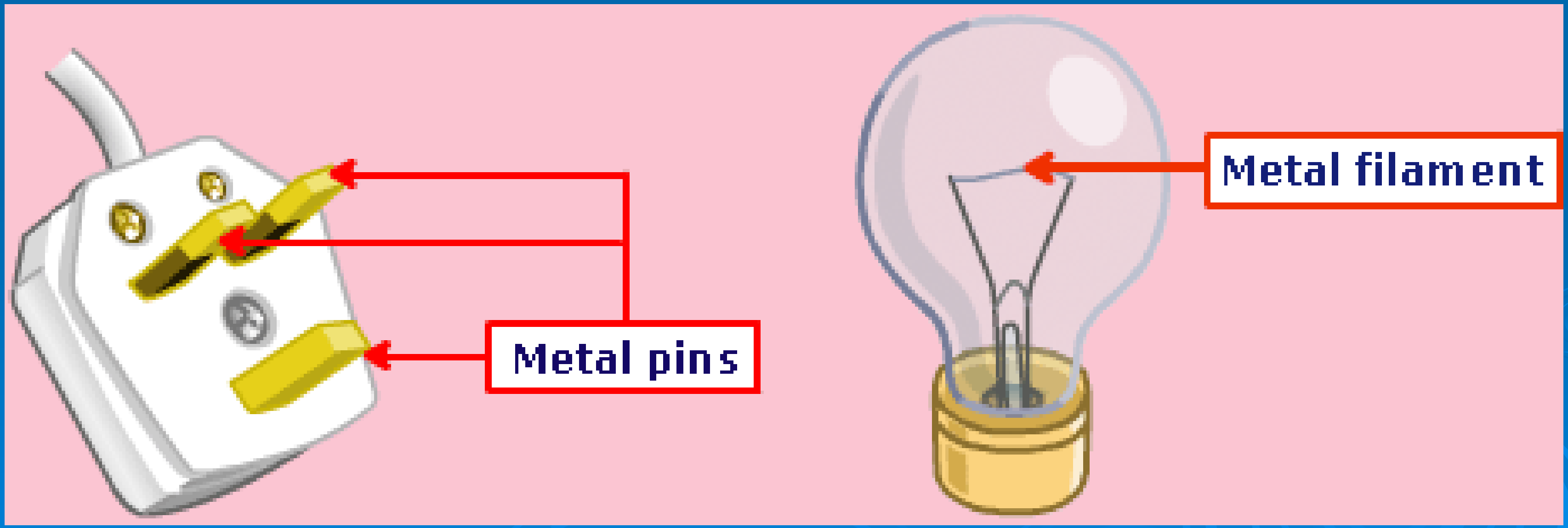
- Like charges repel
- Opposite charges attract



Van De Graff Demos

- Doll with hair
- String with cotton ball
- Tinsel
- Mini Van De Graff
- Wilmhurst Machine

- Conductors allow electric charges to move freely
- Examples include copper, aluminum, and gold.



- Insulators do no allow electric charges to move freely
- Examples include rubber, plastic, and glass.

Conductors / Insulator

- Examples on cards
- Energy Stick / Ball
- Plasma Ball and Pickle

Couloumb's Law

- The closer two charges are, the greater the force on them.
- Electric Force = Coulomb constant x ((charge 1 x charge 2) / distance^2)
- $F_{electric} = k_C \times ((c1 \times c2)/d^2)$
- $k_C = 8.99 \times 10^9$ N m^2/C^2
- Charge = Couloumb (C) – Units
- F = Newtons
- d = Meters

A balloon rubbed against denim has a charge of 8×10^{-9} C while the denim has a charge of 6×10^{-9} C when the two are separated by a distance of 5 cm. What is the Electrical Force between them?

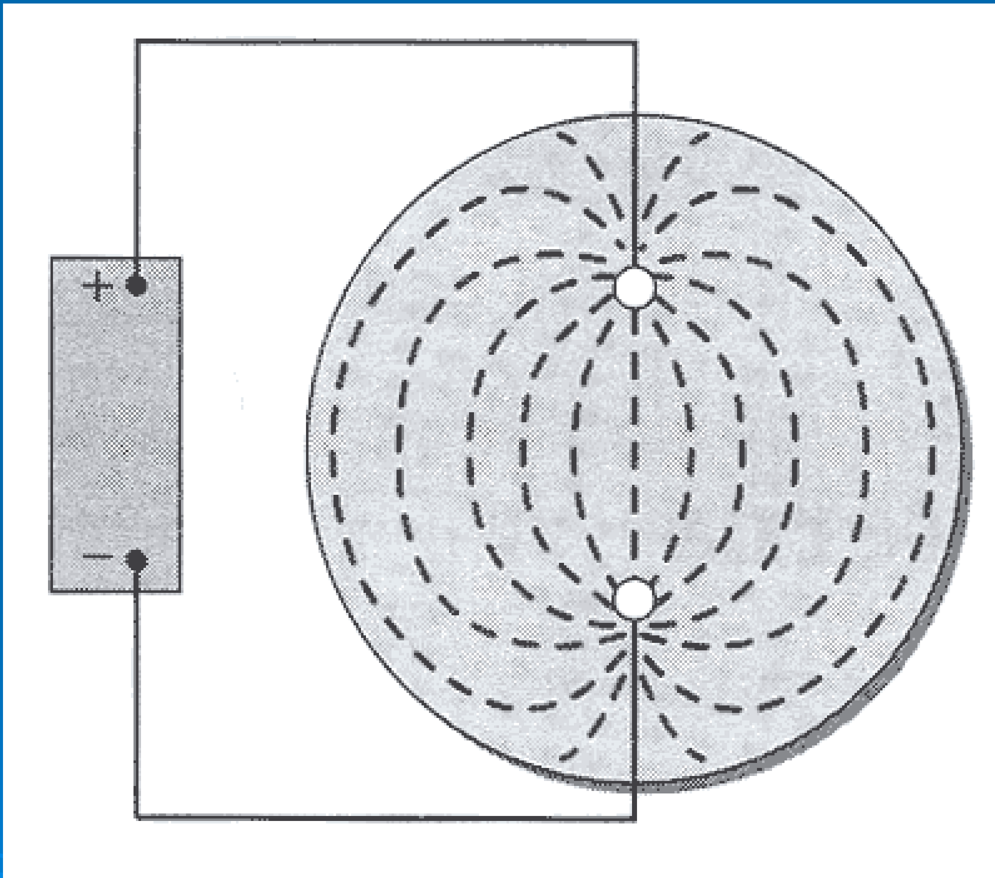
Electric Field

- A charged object has a charged field around it called the Electric Field.
- Electric Field Strength Equation
- Electric Field = Coulomb constant x (charge / distance^2)
- $E = k_C \times (c / d^2)$
- Electric Field Strength (Units) = N/C

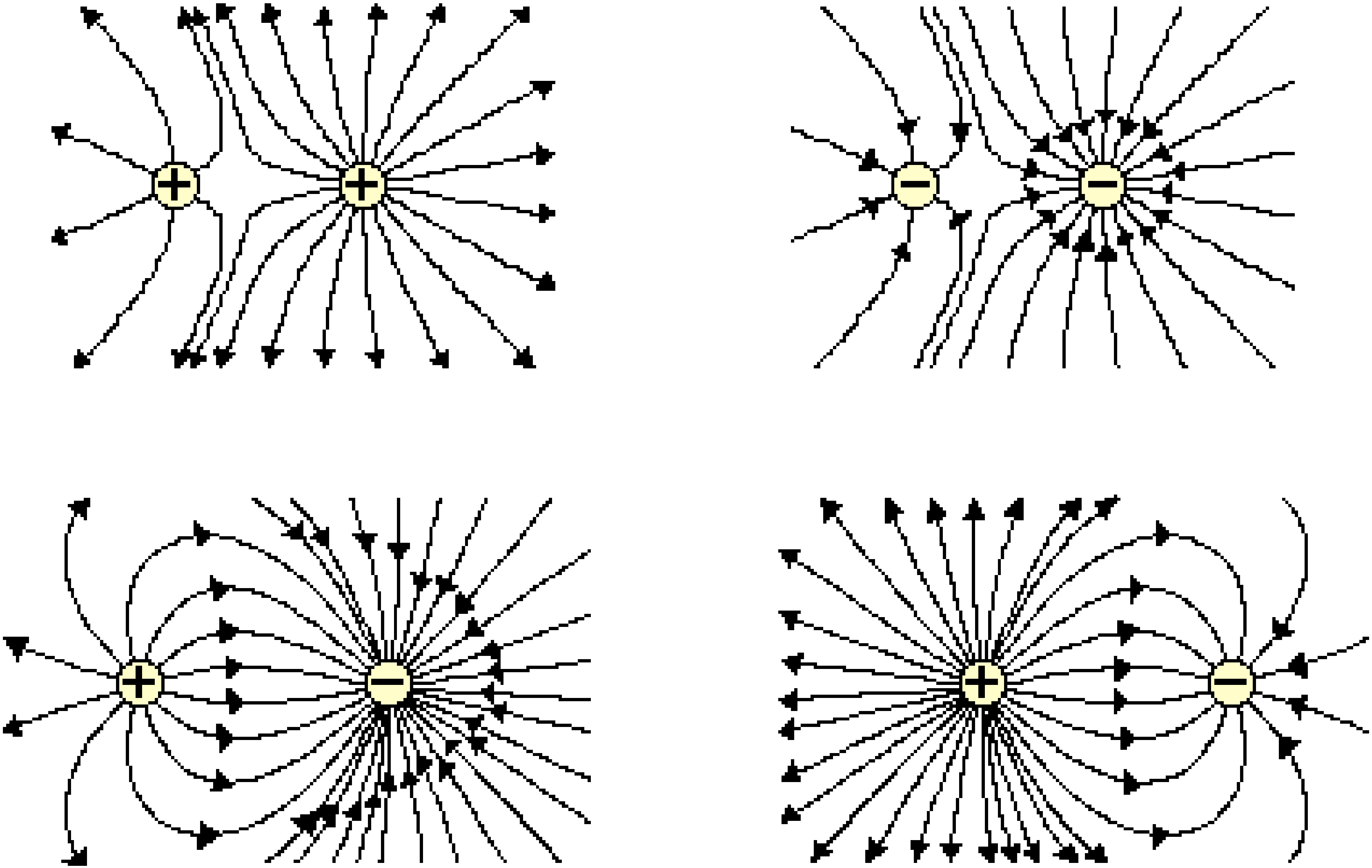
A particle with a charge of 7×10^{-6} C is separated from another particle at a distance of .5 m. How strong is the Electric Field?

Electric Field Lines

- The amount of electric field lines is proportional to the electric field strength.
- The electric field is stronger when there are more lines.



Electric Field Line Patterns for Objects with Unequal Amounts of Charge



Current, Capacitors Voltage

Chapter 16

Electric Potential Energy

- Potential Energy is stored energy.
- Electric Potential Energy is energy that is stored.
- Capacitors are the most common ways to store energy.

Electrical Potential Energy

- $PE_{electric}$ = - (charge x electric field strength x displacement)
- $PE_{electric} = -(qEd)$

As a particle moves 10 m along an electric field with a strength of 75 N/C, it's electrical potential energy decreases by 2.8×10^{-16}. What is the charge?

Potential Difference

- Also known as Voltage
- Units are Volts
- Potential Difference = change in Electrical Potential Energy / electric charge
- $V = \Delta PE_{electric} / q$

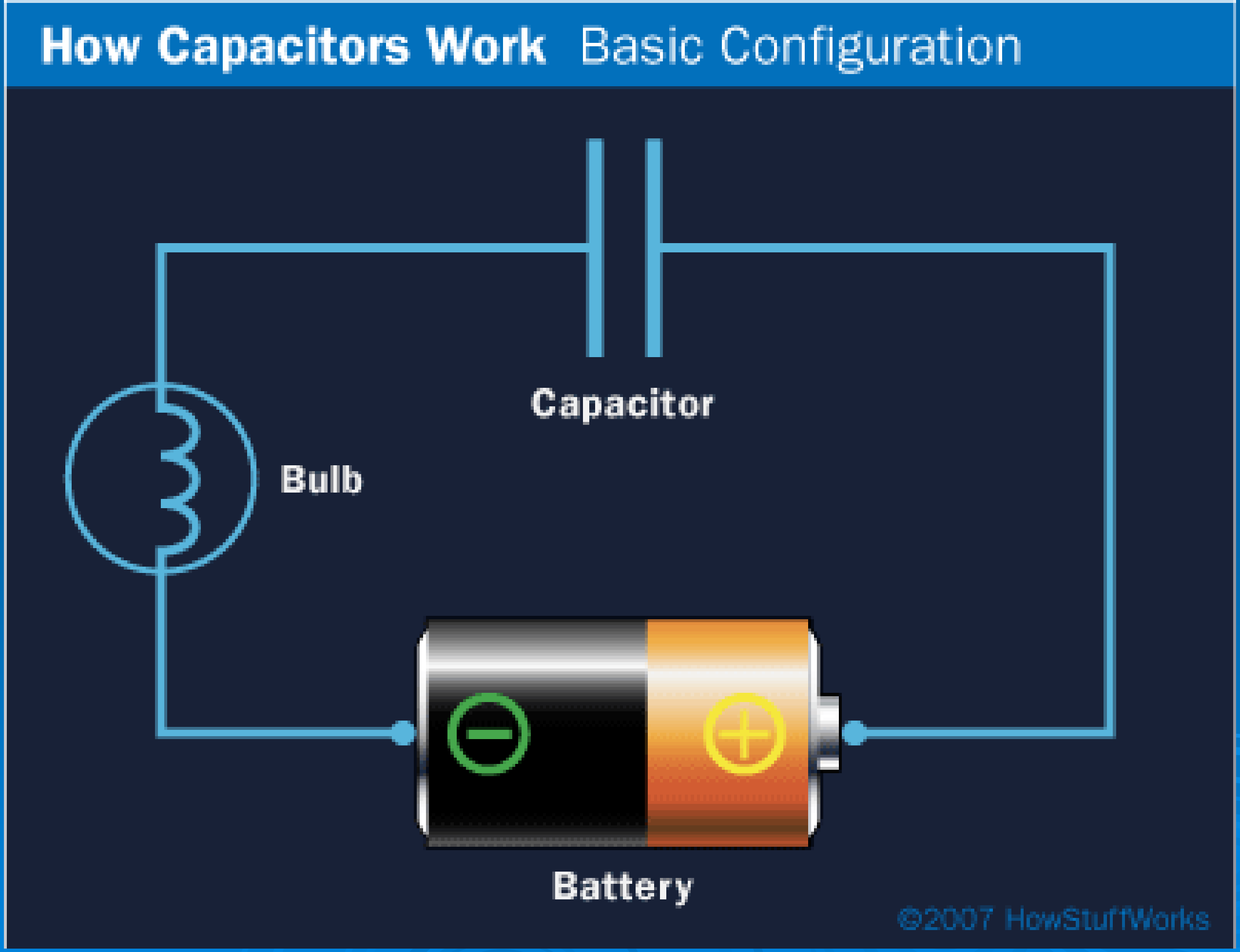
As a particle moves 5 m along an electric field with a strength of 20 N/C, it’s electrical potential energy decreases by 5×10^{-10}. First find the charge then the potential difference.

Capacitance

- A conductor can store energy by storing charges on separate plates
- The ability of a conductor to store energy is measured by the capacitance.
- The more electricity something can hold, the higher the capacitance.
- Capacitance has units of the Farad (F) which is equivalent to a coulomb/volt.

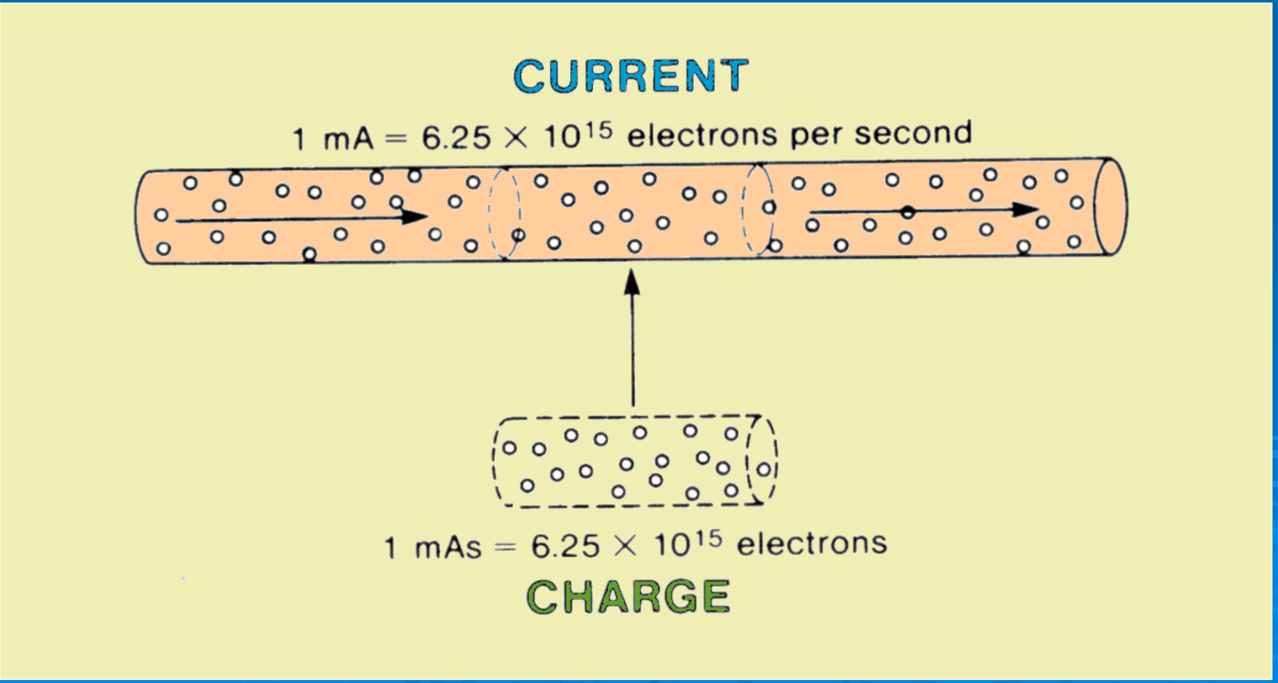
- Capacitance = Net Charge on each plate / potential Difference
- $C = Q / V$

Demo Camera Capacitor



Current

- How fast charges move is called Current.
- Current is measured in Amps (A).



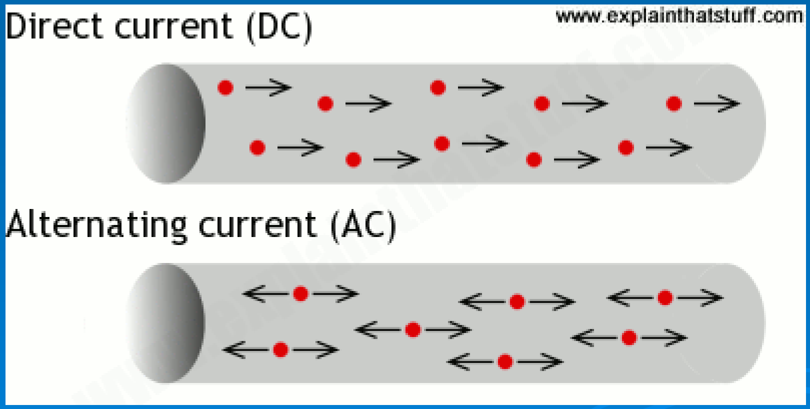
- Electric Current = Charge / Time
- $I = Q / t$

Tesla Coil

Pickle

AC versus DC

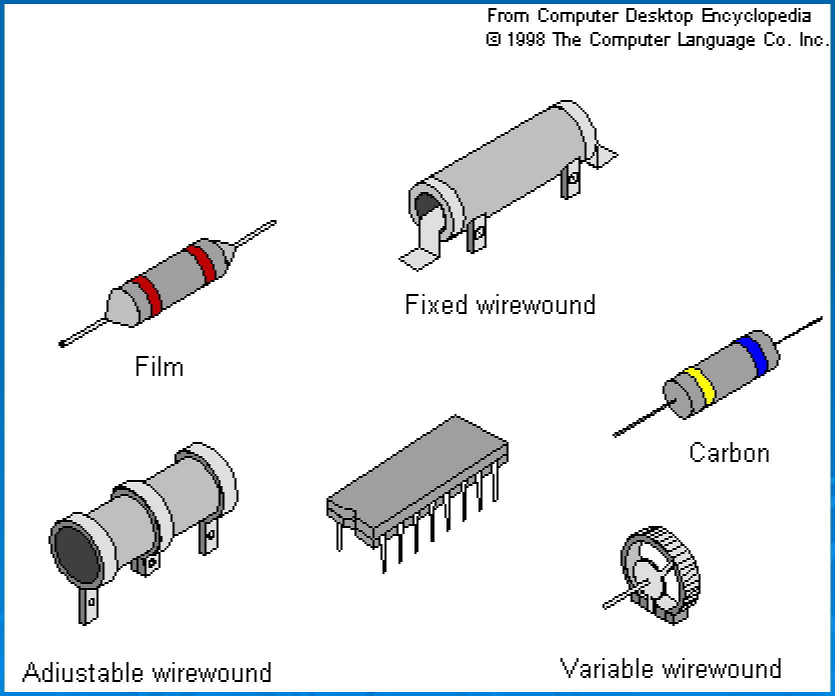
- AC – alternating current (electricity flows back and forth)
- DC – direct current (electricity flows only one direction)



Demo

Resistance

- The opposition to the flow of charges (current) is called resistance.
- Resistance is measured in Ohms (Ω)



Ohm's Law

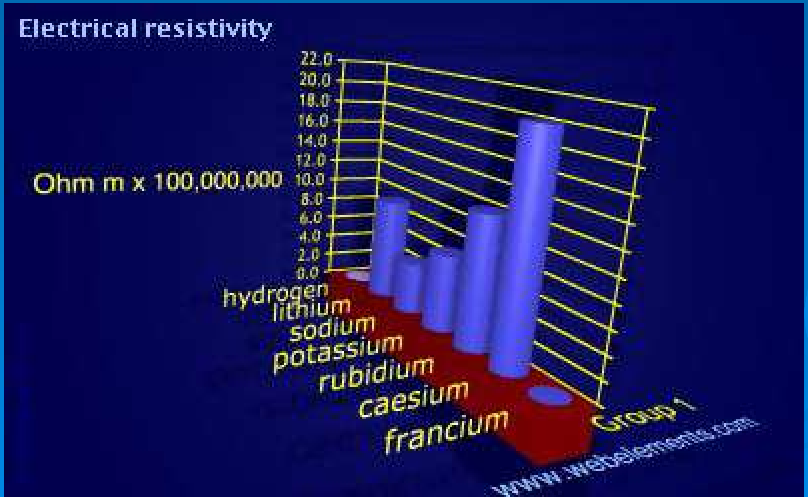
- Resistance = Potential Difference / Current
- R = V / I
- Ohm's Law is not true for all materials. However, most common materials do follow Ohm's Law so when working problems we assume the materials follow this law.

Resistance

- Resistance depends on length, area, material, and temperature.
- Longer wires have more resistance.
- Thinner (less radius) wires have more resistance.

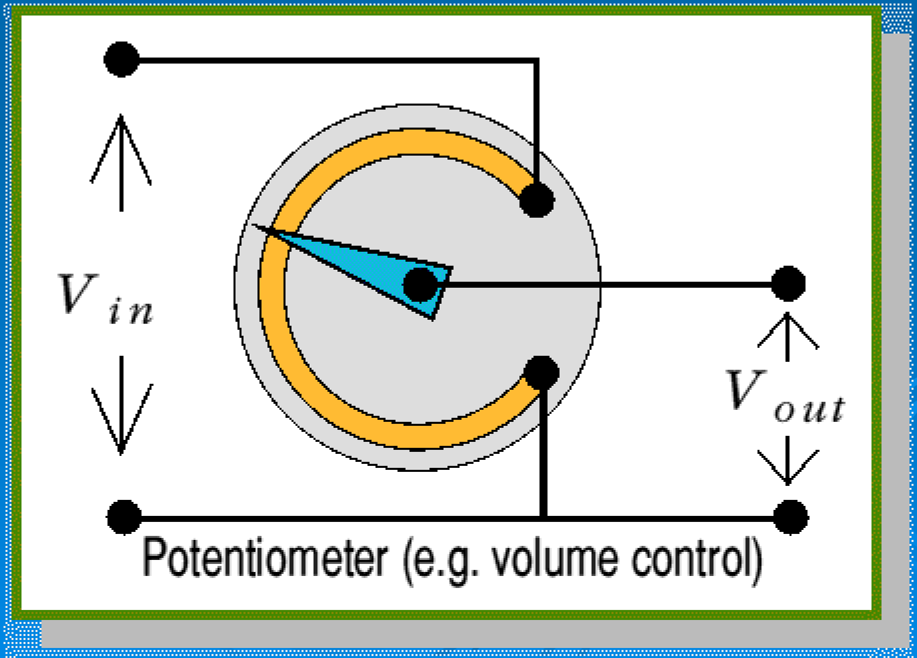
Resistance

- Certain materials, such as gold, have less resistance than others. This depends on the structure of the atom.
- As temperature increases, for most materials the resistance increases. When a material is hot, it's atoms vibrate faster and interfere with the flow of electrons.



Variable Resistors

- Resistors that can change their resistance are called Potentiometers.
- They have one fixed end and the other end slides to change the resistance.



Power

- Earlier, in this class, we learned that Power is the how fast something does work.
- Electrical power is how fast a charges do work.
- Electrical Power has Watts as units.

- Electric Power = Current x potential difference
- $P = I \times V$

Hand Crank

Chapter 17

Circuits

Electric Circuit

- Together, the bulb, battery, switch, and wire form the electric circuit.
- This is a path through which charges can flow.

Demo

- Operation Game

Short Circuits

- In a short circuit, the current can increase and become unsafe.
- The wires can’t withstand the increased current, and begin to overheat.

Short Circuit Demo

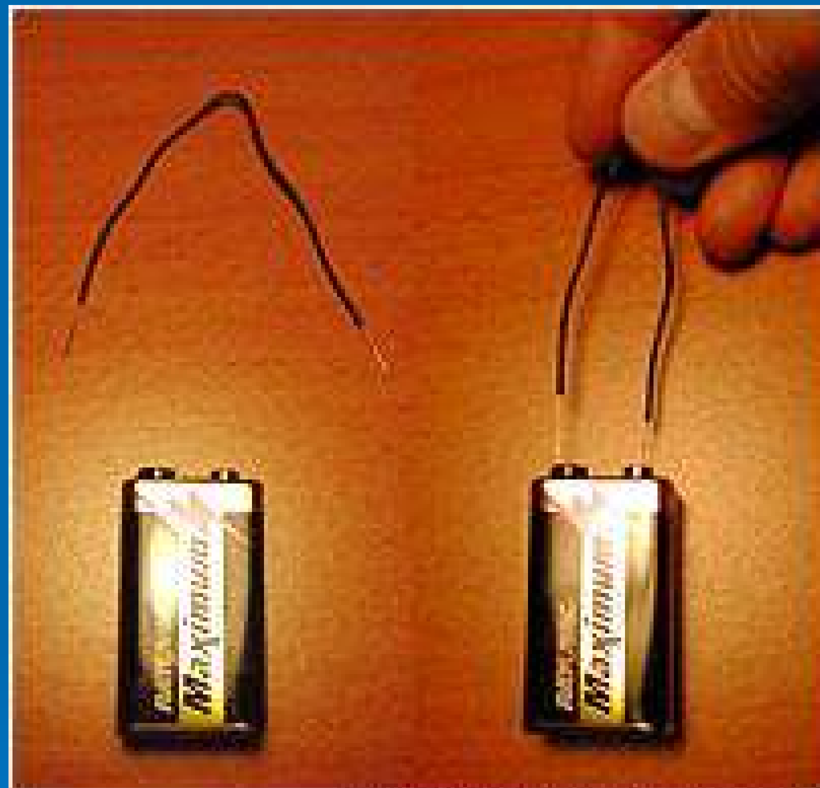
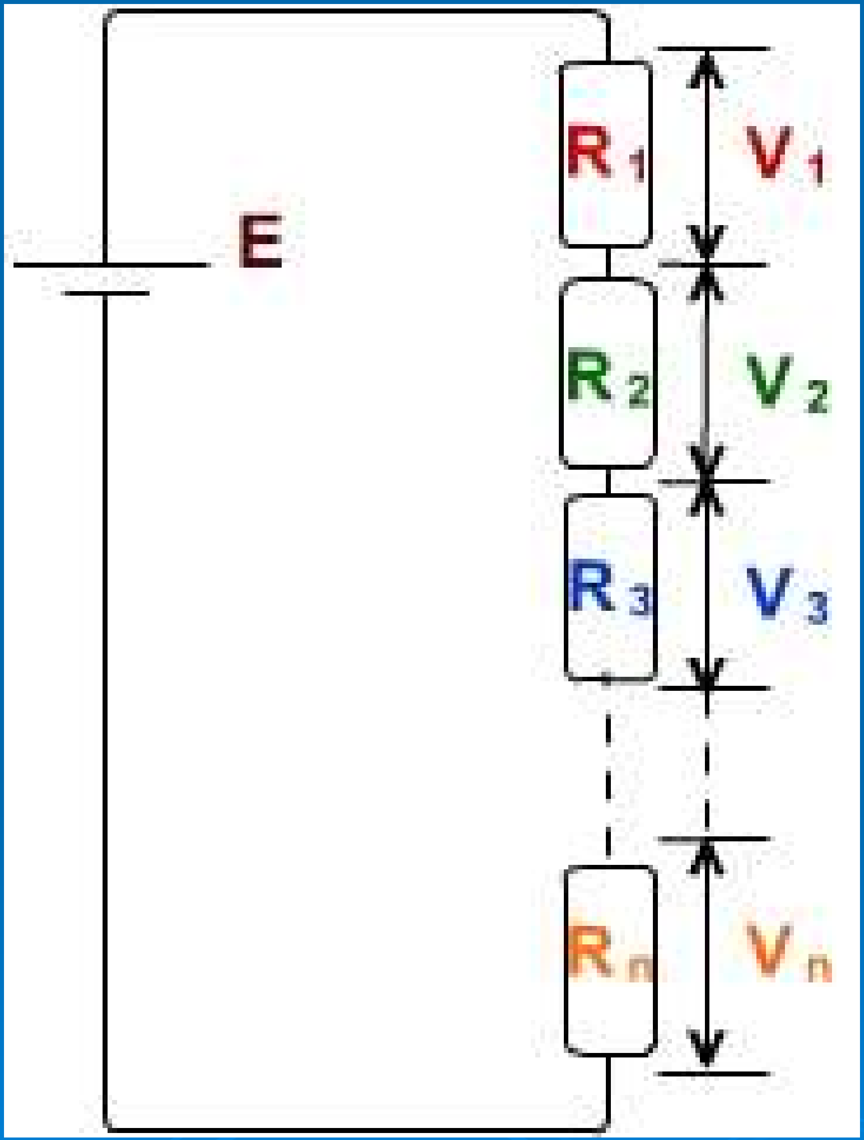


Image: The simplest example of a 'Short Circuit'. All you need is a battery and a piece of wire. If you do this in dark you may notice faint sparking when you connect + to - of the battery.

Resistors in Series

- In series, there is only one path for the current to flow.
- When many resistors are connected in series, the current in each resistor is the same.
- $R_1 + R_2 \ldots\ldots = R_{total}$

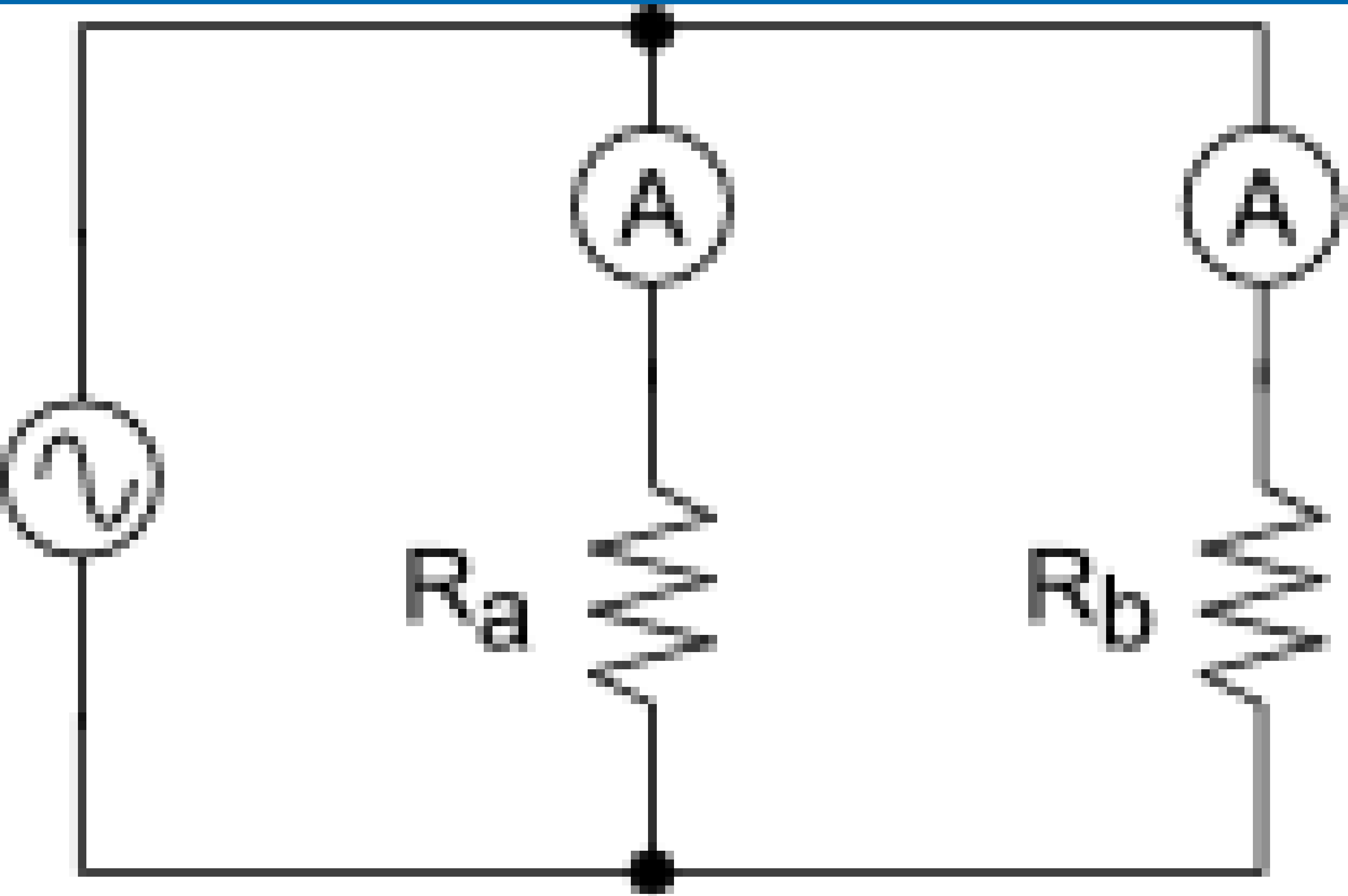

E
R 1
V 1
R 2
V 2
R 3
V 3
R n
V n

A 9 V battery is connect to 4 bulbs with resistance of 2, 4, 5, and 7. What is the current of the circuit?

- Current = V / R_{Total}

Resistance in Parallel

- Parallel means there are more than 1 path for a current to flow.
- $1/R_{total} = 1/R_1 + 1/R_2$…..

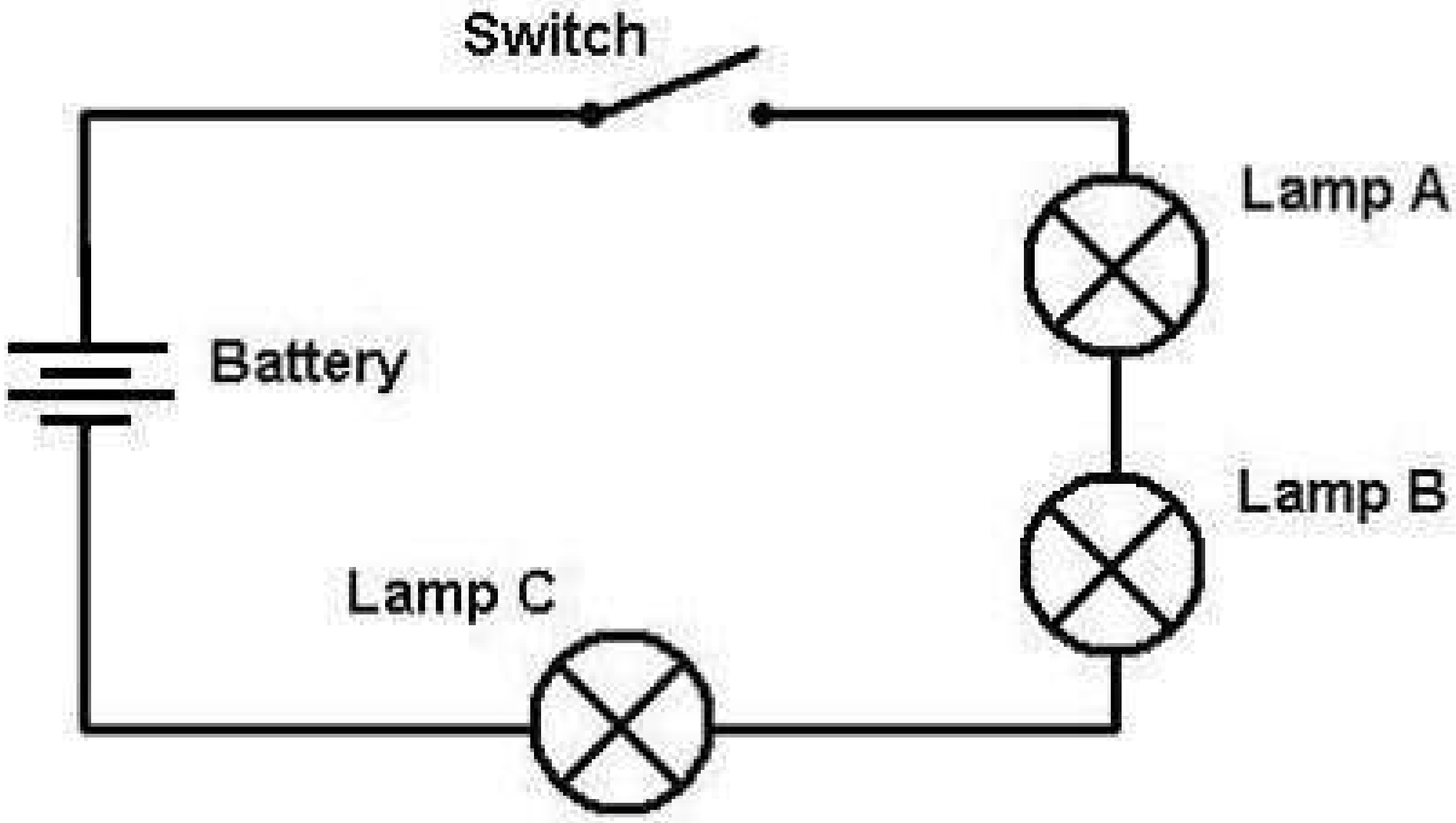

A
A
Ra
Rb

A 9 V battery is connected to 4 resistors connected in parallel. The resistors are 2, 4, 5, and 7. What is the current?

- Current = V / R

Schematic Diagram

- A diagram that depicts the construction of an electrical apparatus is called a schematic diagram.
- Diagrams use symbols to represent bulbs, batteries, and wires.


Switch
Battery
Lamp A
Lamp B
Lamp C