

# Static Electricity

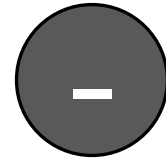
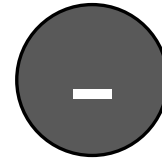
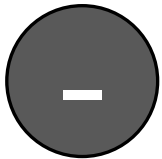
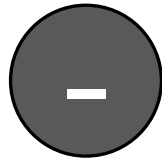
---

IB PHYSICS | FORCE FIELDS

# Many Types of Forces

<b>Normal Force</b>	$F_N$
<b>Surface Frictional Force</b>	$F_f$
<b>Tension</b>	$F_T$
<b>Elastic Restoring Force</b>	$F_H$
<b>Viscous Drag Force</b>	$F_d$
<b>Buoyant Force</b>	$F_b$
<b>Gravitational Force</b>	$F_g$
<b>Electric Force</b>	$F_e$
<b>Magnetic Force</b>	$F_m$

# Charge Interactions



Opposite Charges

Like Charges

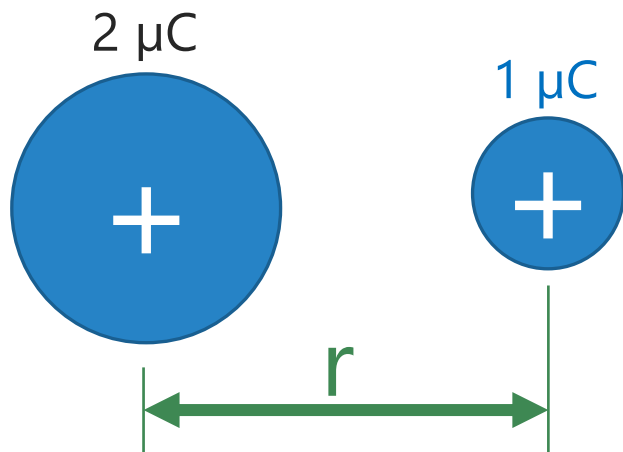
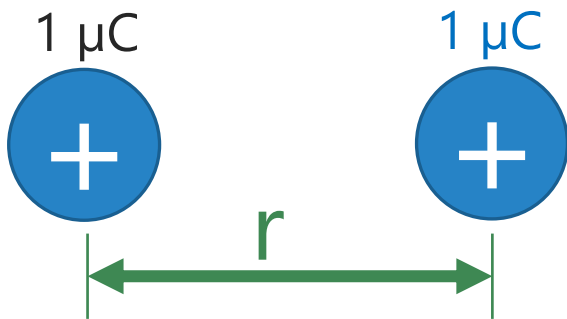
# Which one has more force?

Which charged pair has larger electrostatic forces acting?

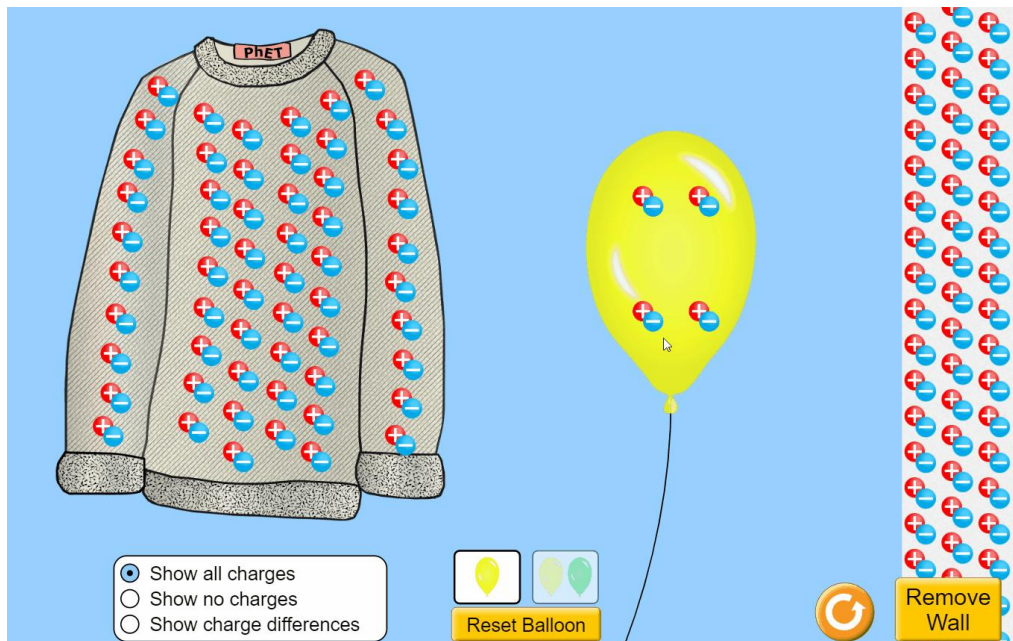


# Which one has more force?

Which charged pair has larger electrostatic forces acting?



# Conservation of Charge

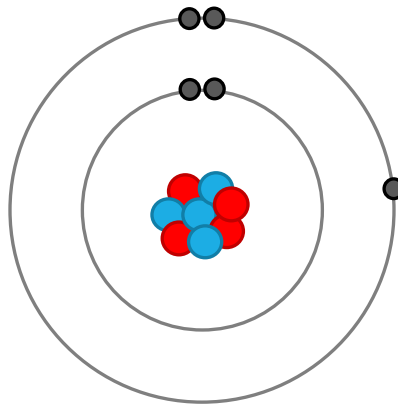


What happens when you rub the balloon on the sweater?

[Click here for Simulation](#)

# Charge on an Atom

The **protons** and **neutrons** are buried deep in the nucleus and cannot easily be touched



**electrons** orbiting the nucleus  
are easily lost or gained

# How do objects become charged?

Friction

Conduction

Induction



What happens when you rub John Travoltage's foot on the rug?

[Click here for Simulation](#)

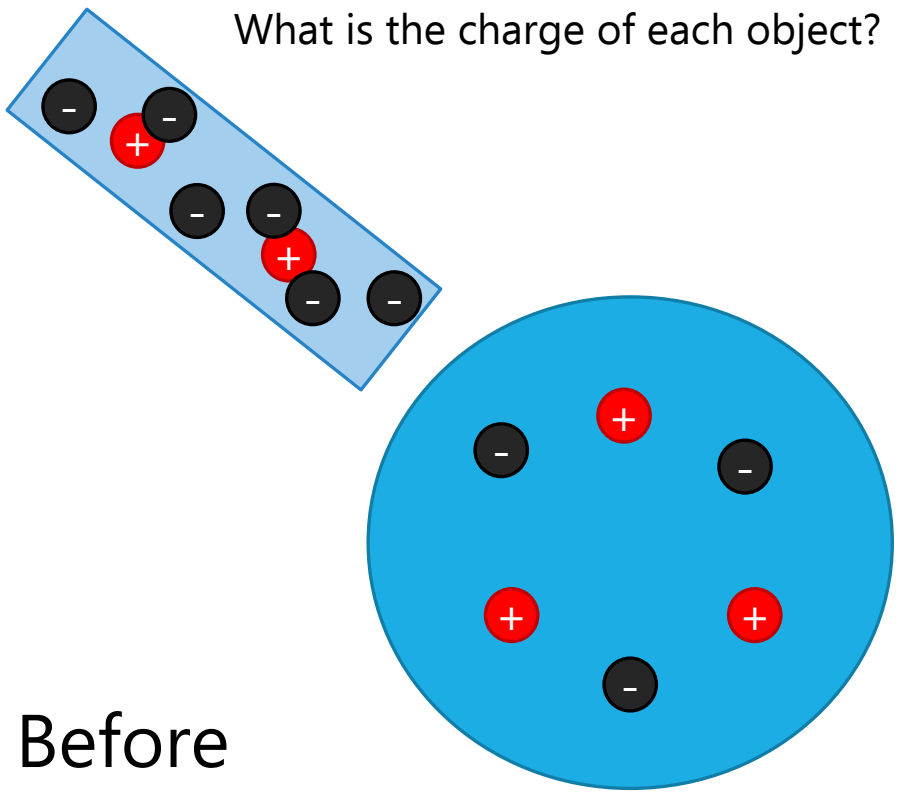
# How do objects become charged?

Friction

Conduction

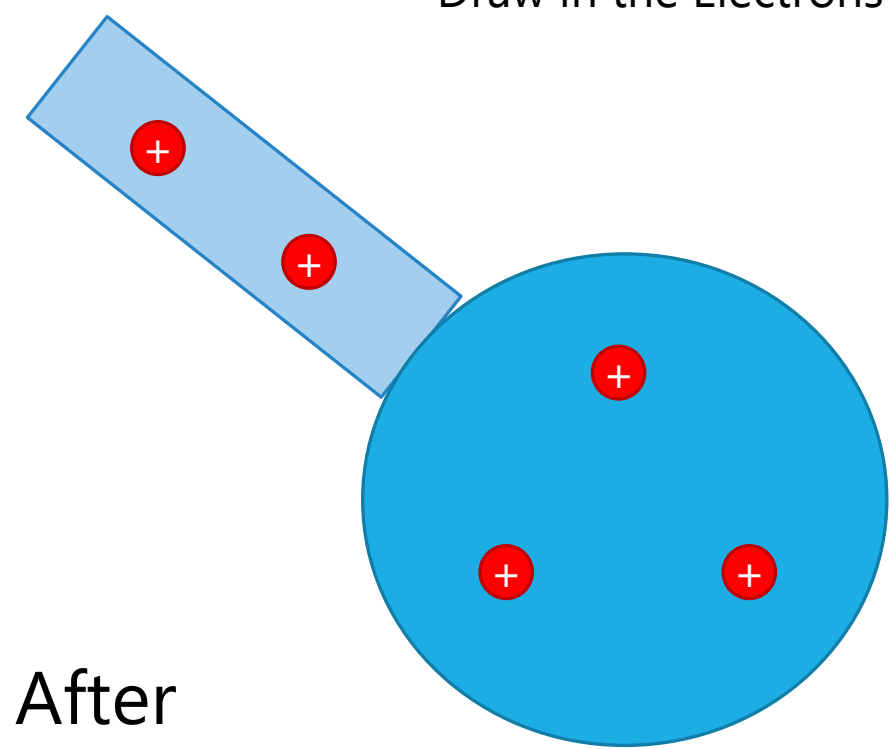
Induction

What is the charge of each object?



Before

Draw in the Electrons



After

# How do objects become charged?

Friction

Conduction

Induction



What happens when you bring the balloon over to the wall?

[Click here for Simulation](#)

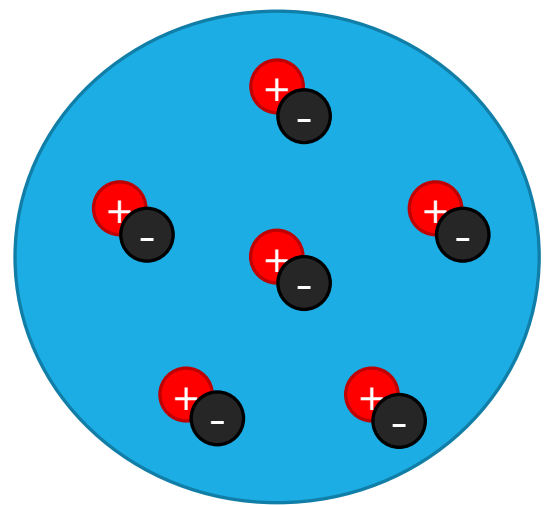
# How do objects become charged?

Friction

Conduction

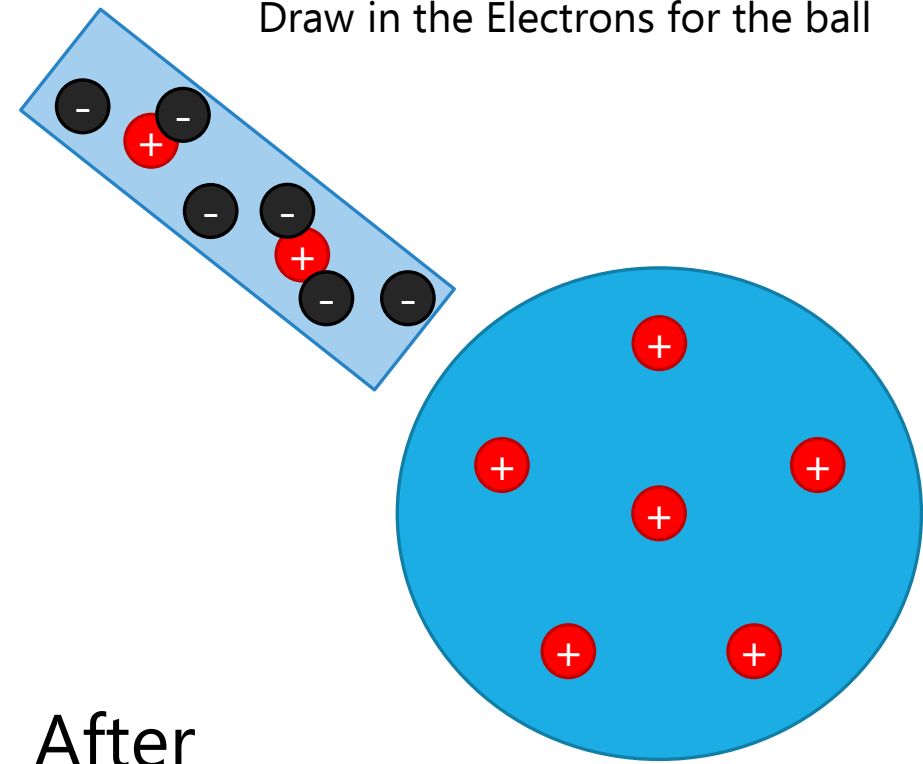
Induction

What is the charge of this object?



Before

Draw in the Electrons for the ball



After

# Quantifying Charge

Symbol	
--------	--

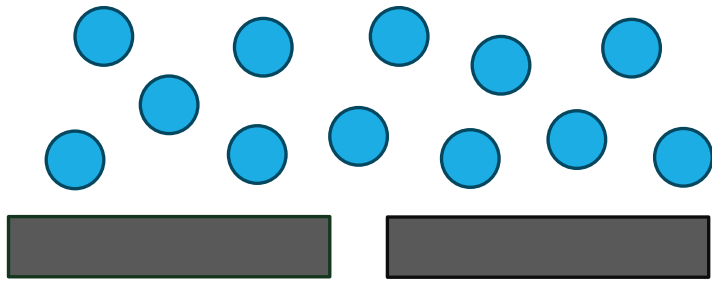
Unit		
------	--	--



kilo	k	$10^3$
hecto	h	$10^2$
deca	da	$10^1$
deci	d	$10^{-1}$
centi	c	$10^{-2}$
milli	m	$10^{-3}$
micro	$\mu$	$10^{-6}$
nano	n	$10^{-9}$

# Determining the Electron Charge

In an effort to quantify the charge of a single electron, Millikan studied falling oil drops



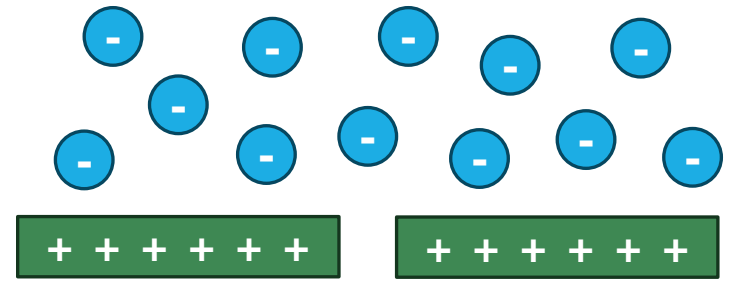
Uncharged



Used the measured terminal velocity to calculate the radius of the drop



Robert Millikan



Charged

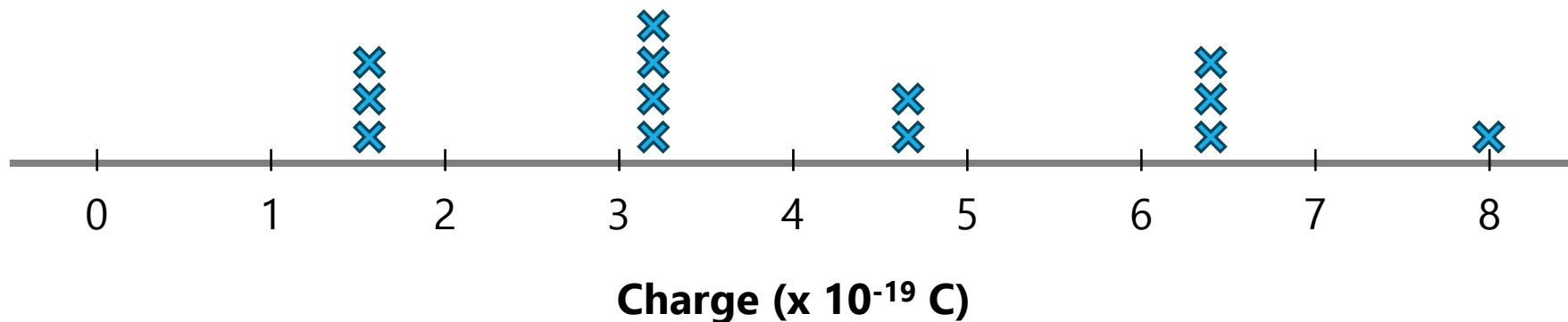


Used the radius/mass and voltage to make it "freeze" to calculate the charge



# Determining the Electron Charge

By analyzing the motion and forces, the charges of the oil drops were calculated



The resulting charges showed specific intervals

**Electron Charge =**

# Quantifying Charge

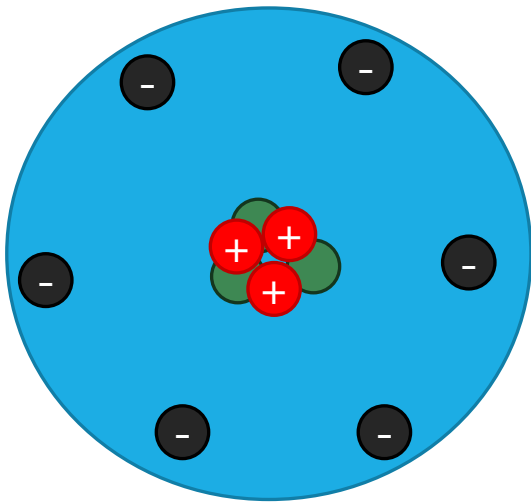
The total charge in Coulombs can be related to the number of electrons

## Fundamental constants

Quantity	Symbol	Approximate value
Acceleration of free fall	$g$	$9.8\text{ms}^{-2}$ (Earth's surface)
Gravitational constant	$G$	$6.67 \times 10^{-11}\text{Nm}^2\text{kg}^{-2}$
Avogadro constant	$N_A$	$6.02 \times 10^{23}\text{mol}^{-1}$
Gas constant	$R$	$8.31\text{JK}^{-1}\text{mol}^{-1}$
Boltzmann constant	$k_B$	$1.38 \times 10^{-23}\text{JK}^{-1}$
Stefan–Boltzmann constant	$\sigma$	$5.67 \times 10^{-8}\text{Wm}^{-2}\text{K}^{-4}$
Coulomb constant	$k$	$8.99 \times 10^9\text{Nm}^2\text{C}^{-2}$
Permittivity of free space	$\epsilon_0$	$8.85 \times 10^{-12}\text{C}^2\text{N}^{-1}\text{m}^{-2}$
Permeability of free space	$\mu_0$	$4\pi \times 10^{-7}\text{TmA}^{-1}$
Speed of light in vacuum	$c$	$3.00 \times 10^8\text{ms}^{-1}$
Planck constant	$h$	$6.63 \times 10^{-34}\text{Js}$
Elementary charge	$e$	$1.60 \times 10^{-19}\text{C}$

# What is the charge??

An atom has an imbalance of protons and electrons as shown. What is the charge in C?



Elementary Charge =  $1.60 \times 10^{-19} \text{ C}$

# How many electrons??

A small cork carries a charge of  $-3.2 \mu\text{C}$ .  
How many excess electrons does it have?

milli	m	$10^{-3}$
micro	$\mu$	$10^{-6}$
nano	n	$10^{-9}$

Elementary Charge =  $1.60 \times 10^{-19} \text{ C}$

# Lesson Takeaways

- I can describe the conservation of charge and the types of charging
- I can describe the process for how Millikan experimentally determined the charge of an electron
- I can calculate the charge on an object based on the number of electrons and protons