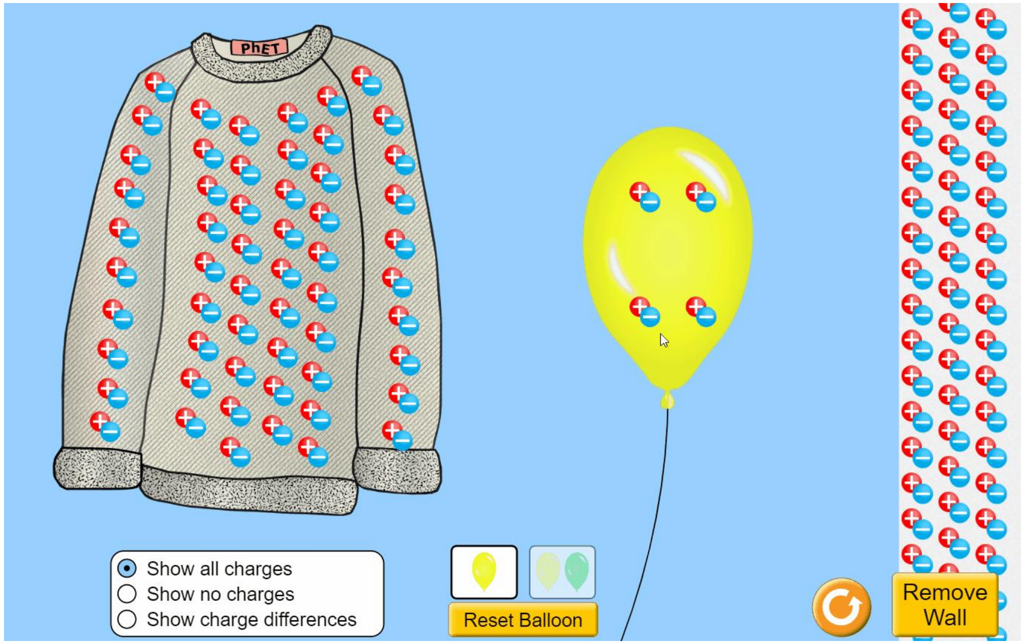
Static Electricity

IB PHYSICS | FORCE FIELDS

PhET Simulation



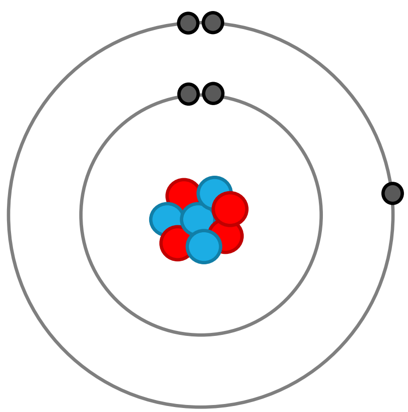
What happens when you rub the balloon on the sweater?

Electrons transfer from the sweater to the balloon

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	Contact	Induction

Click here for Simulation

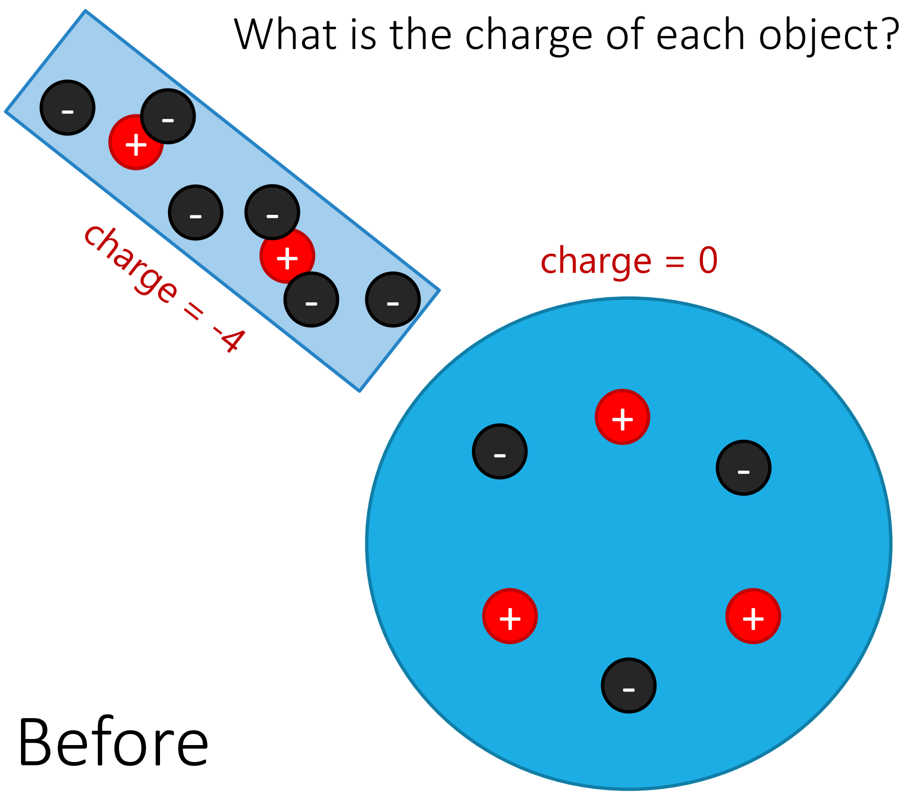
What happens when you rub John Travoltage's foot on the rug?

The foot gains electrons from rubbing on the carpet and the electrons spread out

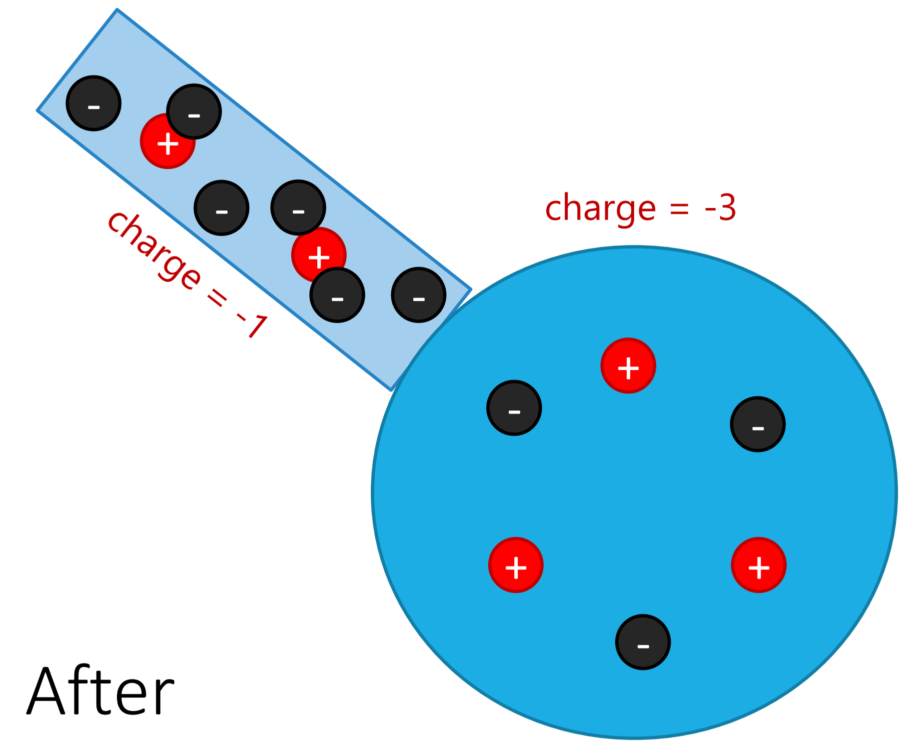
How do objects become charged?

Friction	Contact	Induction

What is the charge of each object?

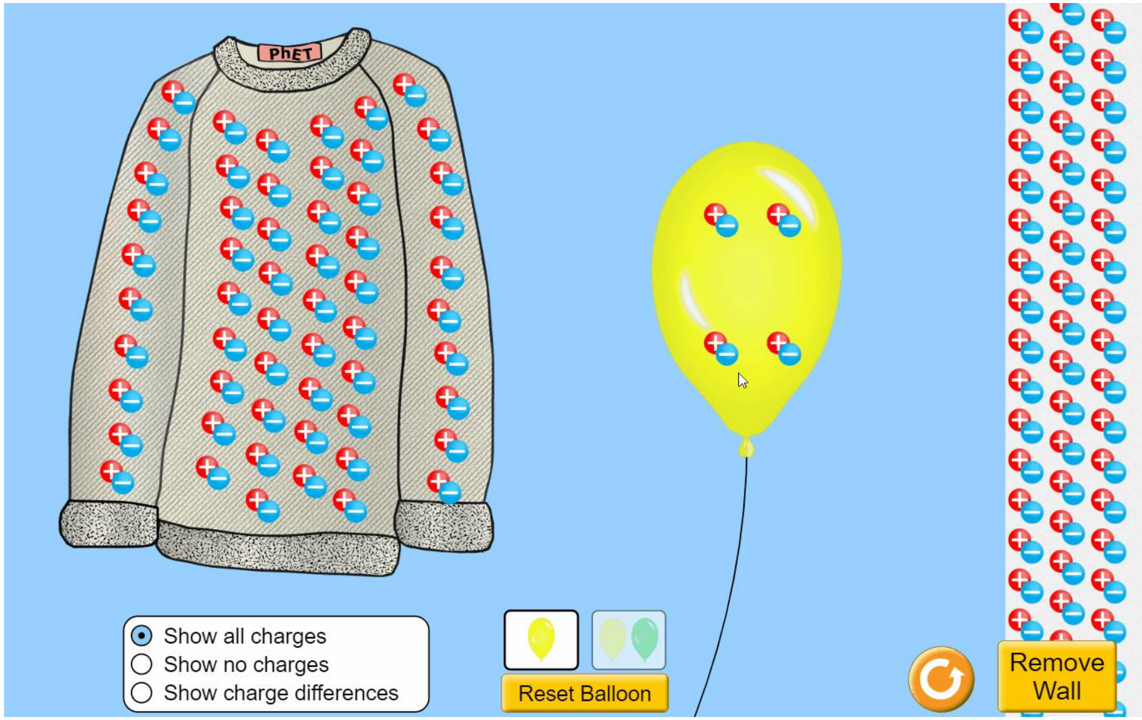


Draw in the Electrons



How do objects become charged?

Friction	Contact	Induction



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

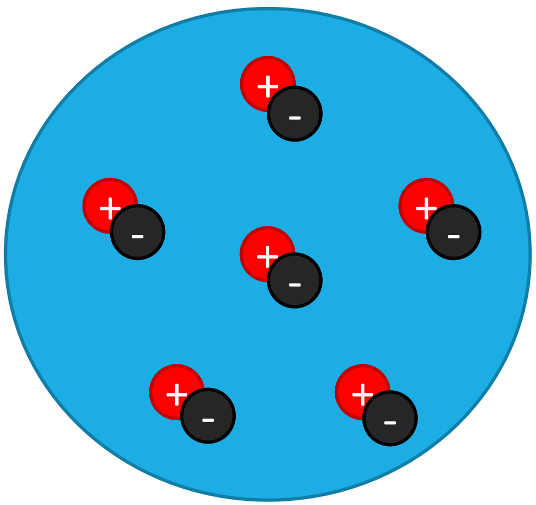
The electrons in the wall redistribute and move away from the negative source

Click here for Simulation

How do objects become charged?

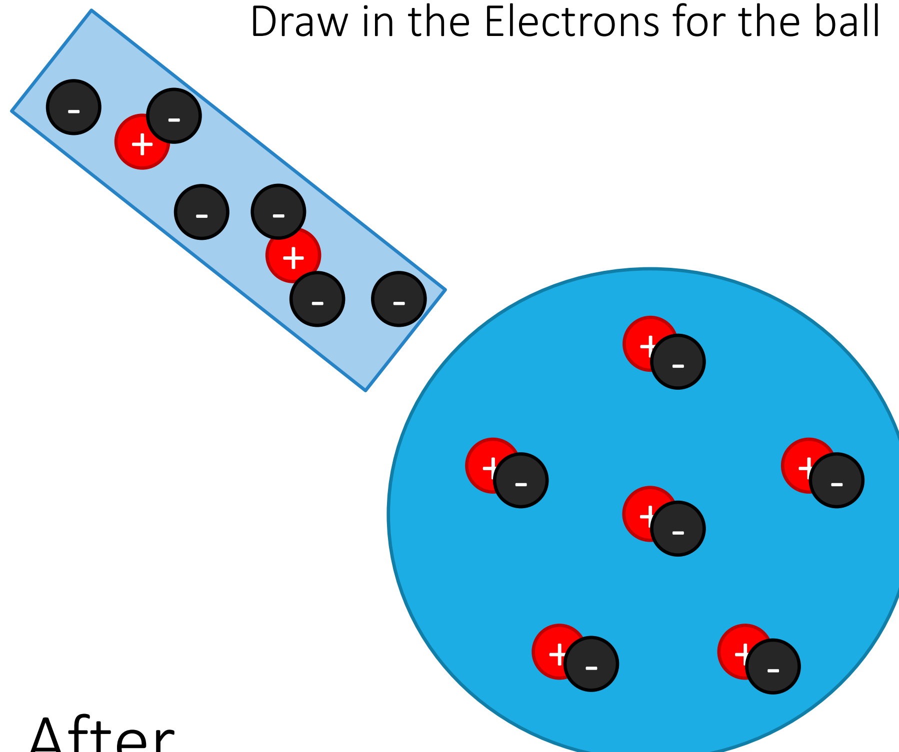
Friction	Contact	Induction

What is the charge of this object?



Before

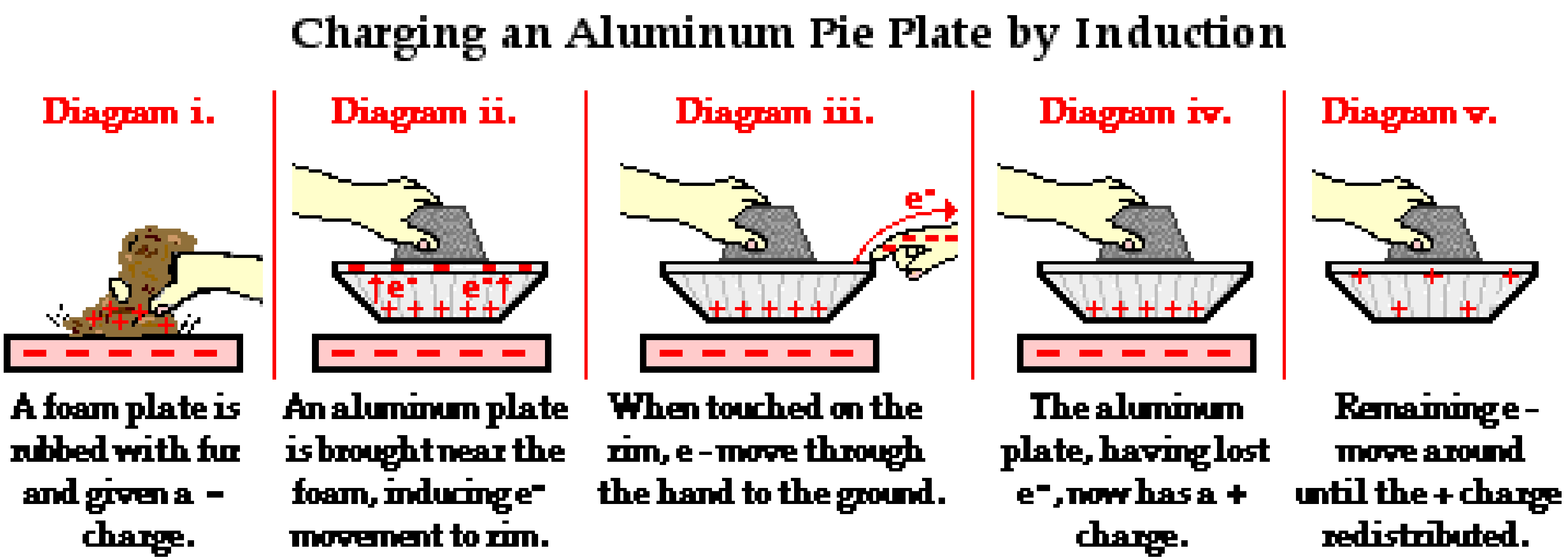
Draw in the Electrons for the ball



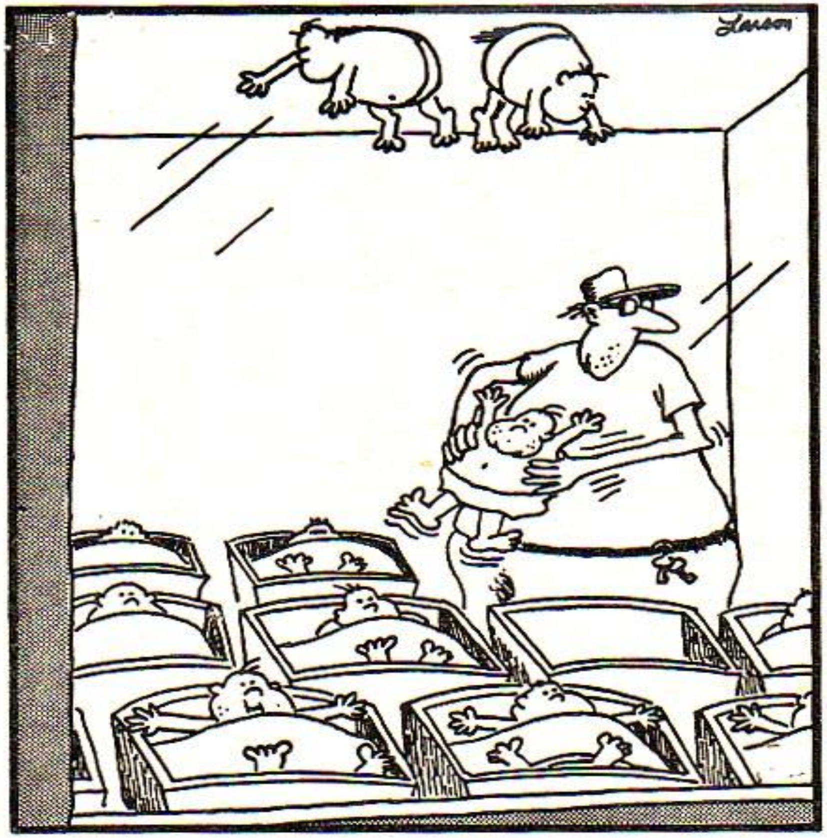
After

How do objects become charged?

Friction	Contact	Induction

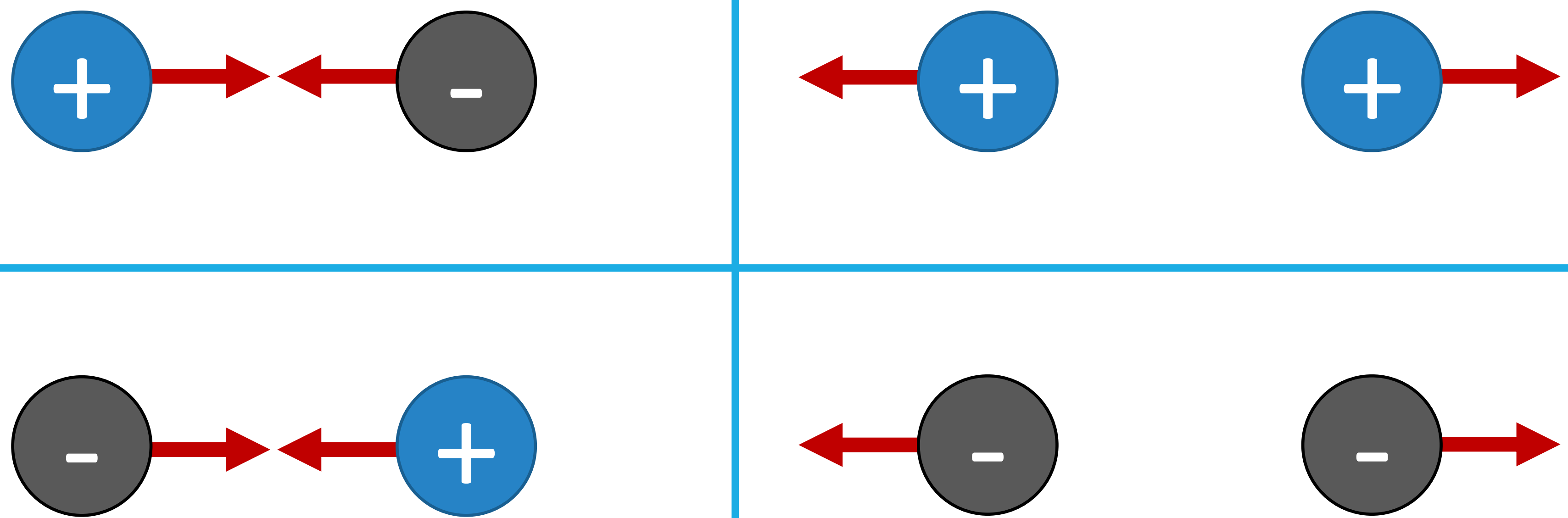


Use your knowledge responsibly



Late at night and without permission, Reuben would often enter the nursery and conduct experiments in static electricity.

Charge Interactions

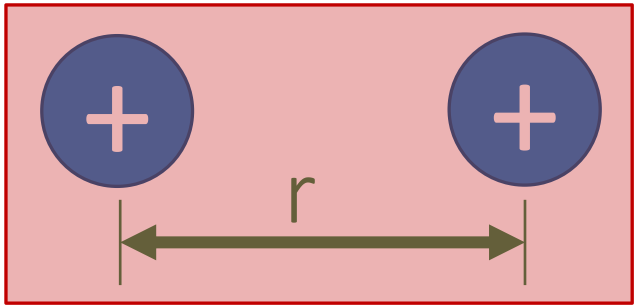


Opposite Charges
Attract

Like Charges
Repel

Which one has more force?

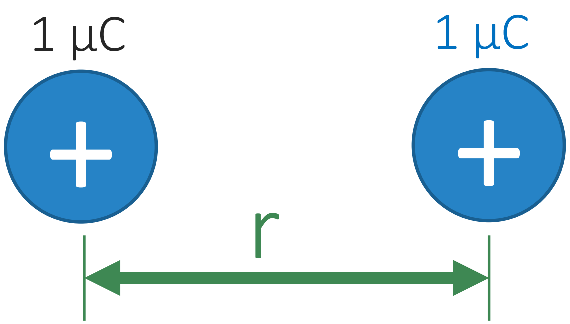
Which charged pair has larger electrostatic forces acting?

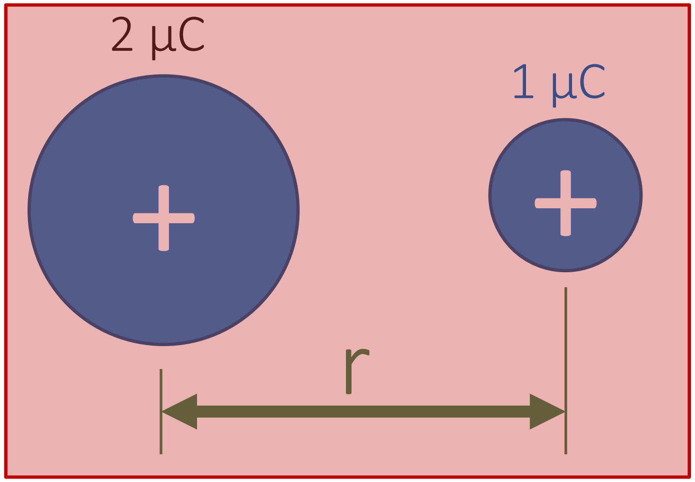


smaller distance = greater force

Which one has more force?

Which charged pair has larger electrostatic forces acting?



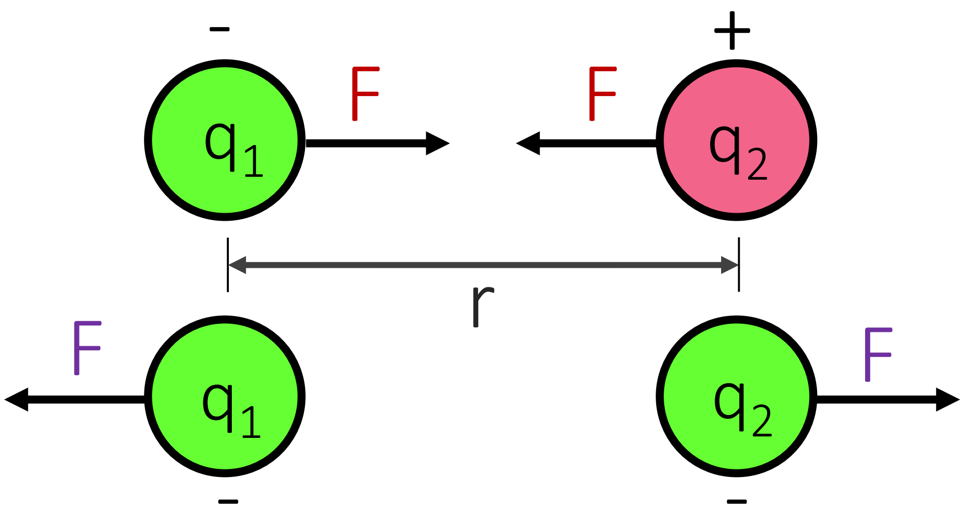


greater charge = greater force

Coulomb's Law

$$F = k\frac{q_1 q_2}{r^2}$$

The force of attraction or repulsion between two point charges is directly proportional to the product of the two charges and inversely proportional to the square of the distance between them.



	Symbol	Unit
Electrostatic Force	F	[N]
Object 1 Charge	q_1	[C]
Object 2 Charge	q_2	[C]
Separation Distance	r	[m]

Coulomb's Constant

$$F = k\frac{q_1 q_2}{r^2}$$

$k = 8.99 \times 10^9\ N\ m^2\ C^{-2}$

Use unit analysis to prove the units of k:

$$k = \frac{Fr^2}{q_1 q_2} = \frac{Nm^2}{CC} = Nm^2C^{-2}$$

Solve for k — Plug in units — Simplify

IB Physics Data Booklet

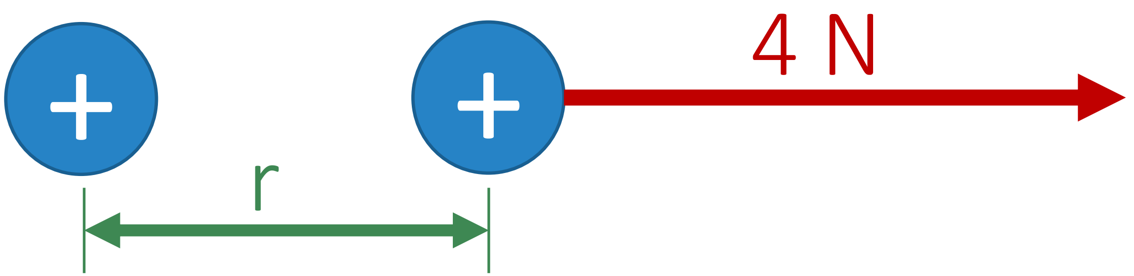
Sub-topic 5.1 – Electric fields	Sub-topic 5.2 – Heating effect of electric currents
$I = \frac{\Delta q}{\Delta t}$	Kirchhoff's circuit laws:
$F = k\frac{q_1 q_2}{r^2}$ *Coulomb's Law	$\Sigma V = 0$ (loop)
$k = \frac{1}{4\pi\varepsilon_0}$	$\Sigma I = 0$ (junction)
$V = \frac{W}{q}$	V
$E = \frac{F}{q}$	
$I = nAvq$	

Sub-topic 5.3 – Electric cells
$\varepsilon = I(R + r)$

Quantity	Symbol	Approximate value
Acceleration of free fall (Earth's surface)	g	$9.81\ \text{m s}^{-2}$
Gravitational constant	G	$6.67 \times 10^{-11}\ \text{N m}^2\ \text{kg}^{-2}$
Avogadro's constant	N_A	$6.02 \times 10^{23}\ \text{mol}^{-1}$
Gas constant	R	$8.31\ \text{J K}^{-1}\ \text{mol}^{-1}$
Boltzmann's constant	k_B	$1.38 \times 10^{-23}\ \text{J K}^{-1}$
Stefan–Boltzmann constant	σ	$5.67 \times 10^{-8}\ \text{W m}^{-2}\ \text{K}^{-4}$
Coulomb constant	k	$8.99 \times 10^{9}\ \text{N m}^2\ \text{C}^{-2}$
Permittivity of free space	ε_0	$8.85 \times 10^{-12}\ \text{C}^2\ \text{N}^{-1}\ \text{m}^{-2}$
Permeability of free space	μ_0	$4\pi \times 10^{-7}\ \text{T m A}^{-1}$
Speed of light in vacuum	c	$3.00 \times 10^{8}\ \text{m s}^{-1}$

Conceptual Math

What is the repulsion force on the positive charge below?

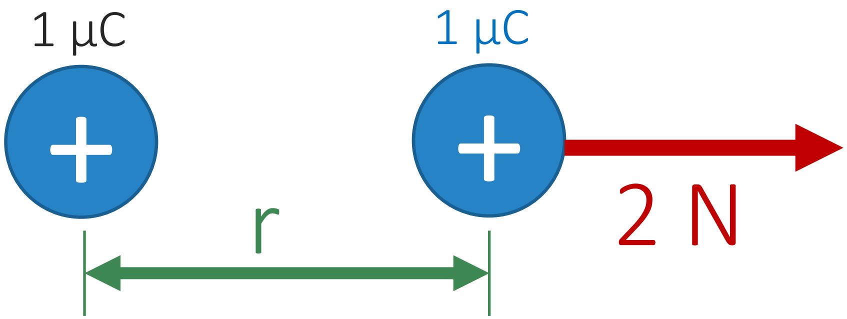


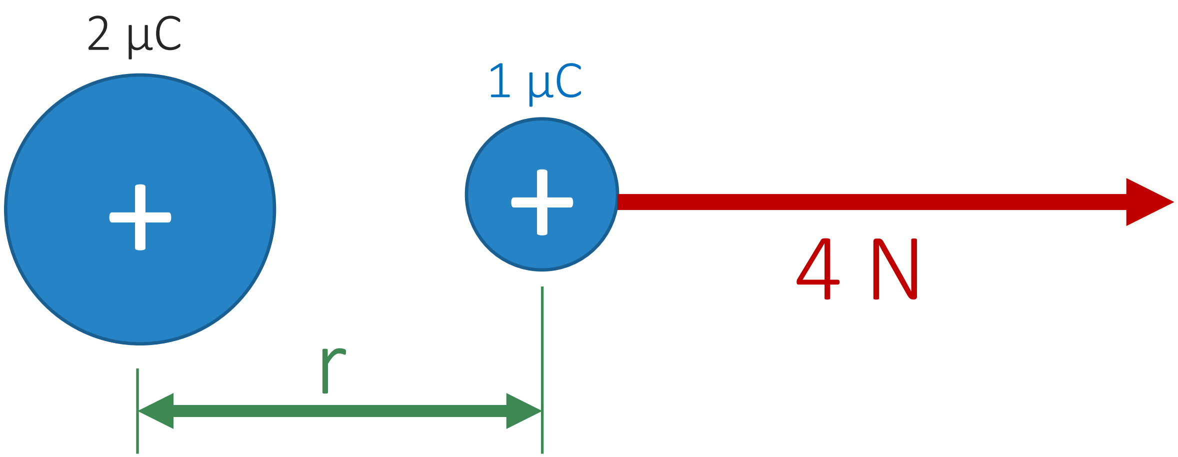
$$F = k\frac{q_1 q_2}{(2r)^2}$$

$$F = k\frac{q_1 q_2}{4r^2}$$

Conceptual Math

What is the repulsion force on the positive charge below?

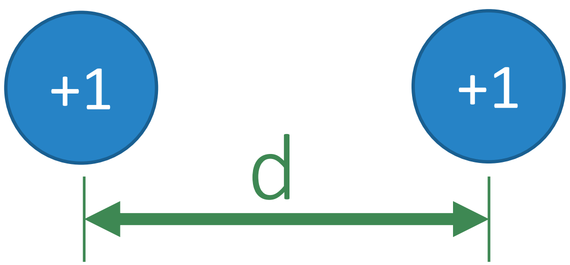




$$F = k\frac{2q_1q_2}{r^2}$$

Conceptual Math

Which pair has the greater electrostatic force? **Same!**



$$F = k\frac{2q_1 2q_2}{(2r)^2} = k\frac{4q_1 q_2}{4r^2} = k\frac{q_1 q_2}{r^2}$$