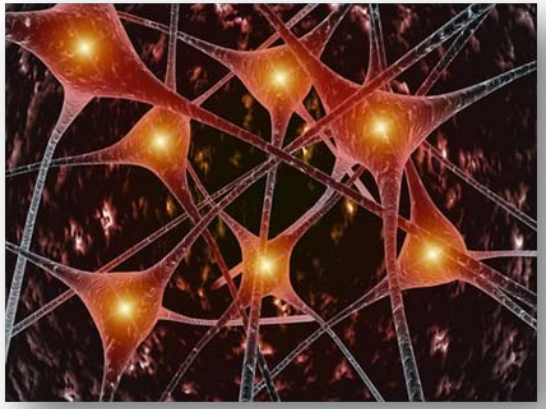
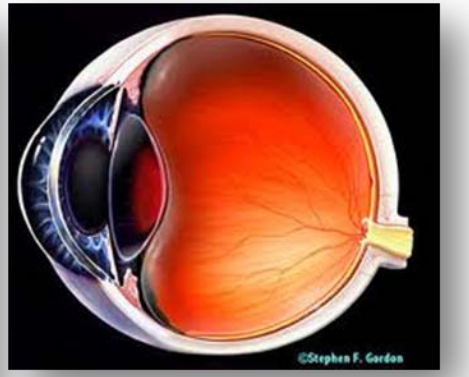
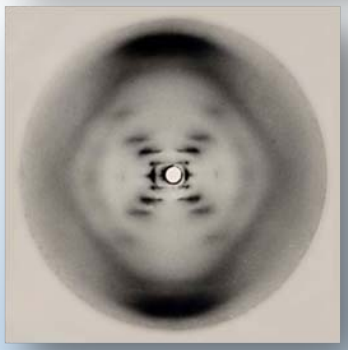
Welcome to Physics 102!

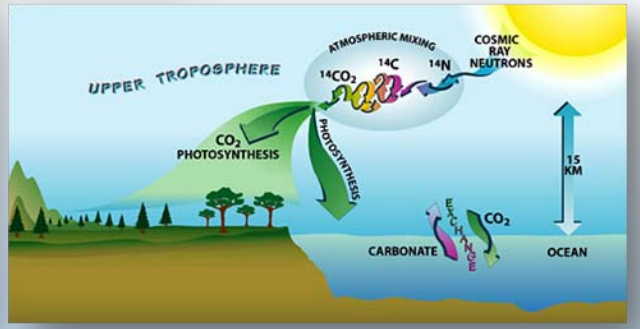
- Electricity & Magnetism

  (forces that hold atoms & molecules together, living cells)
- Optics
- Atomic & Nuclear Physics









Meet the course directors

- Lecturer:
  - Research:
  - Office Hours:

- Discussion coordinator:
- Lab & exam coordinator:

When emailing me:

- Email must be sent from @illinois.edu
- Subject line should begin with "PHYS102 question:"
- Message should contain:

  your full name, NetID, discussion section, TA name
- Questions about physics:

  Do not use email, use office hours (see course website)
- Before emailing:

  Verify information is not already on the course website

  The course directors reserve the right to penalize your HW score if you ask questions via email that are answered on the website

Course Website

- http://courses.physics.illinois.edu/phys102/
- First Discussion:
  - What you should be doing and when you should be doing it
  - Lectures posted after they are given
- First Lab:
- Exam dates:
- Course Description / Excused Absences
- Required Materials
  - Be sure to register your i-Clicker prior to lecture

Course Philosophy

- Think about it (pre-lecture & checkpoint)
- Untangle it (lectures)
- Play with it (labs)
- Challenge yourself (homework)
- Close the loop (discussion/quiz)

The order is important!

Prerequisite!

Course content

Physics 101

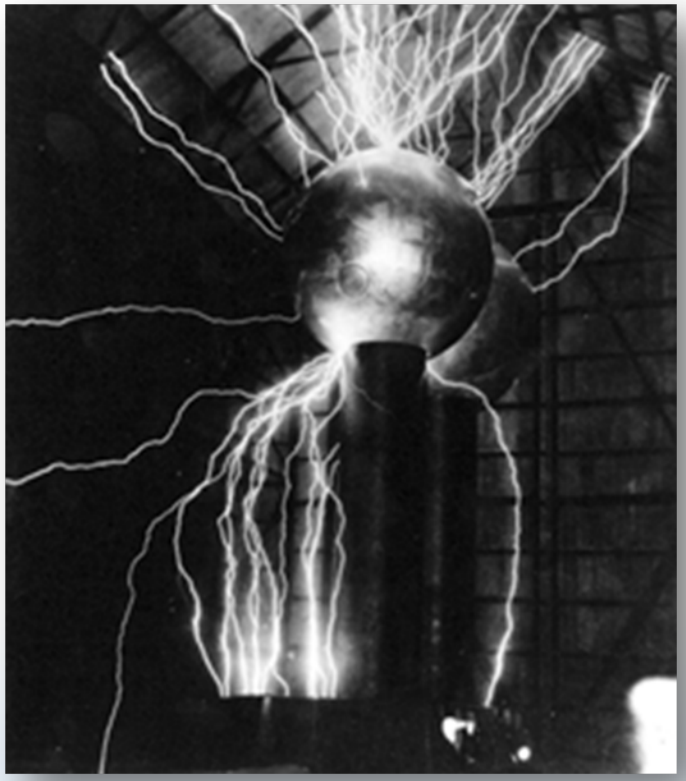
Macroscopic

- Kinematics
- Forces
- Energy
- Fluids
- Waves (Sound)

Physics 102

Microscopic

- Electricity & circuits
- Magnetism & induction
- Optics
- Modern Physics



Phys 102 – Lecture 1

Electric charge & Coulomb's law

4 Fundamental forces of Nature

Phys. 101 Gravitational force (solar system, galaxies)

Phys. 102
- Electromagnetic force (atoms, molecules)
- Strong force (atomic nuclei)
- Weak force (radioactive decay)

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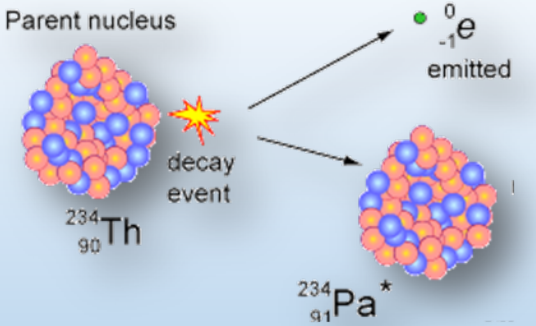

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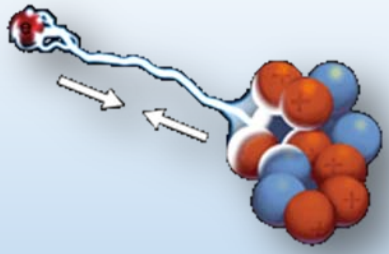

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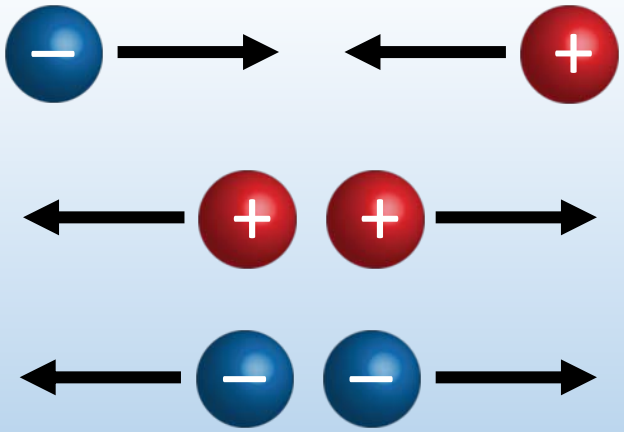
Gravitational Weak Electromagnetic Strong

weakest strongest

Electric charge

Charge is an intrinsic property of matter, like mass

- EM force -> *electric charge*
  - Positive & negative charge
  - Opposite charges attract, like charges repel
- Gravity -> *mass*
  - Mass always positive
  - Gravity always attractive



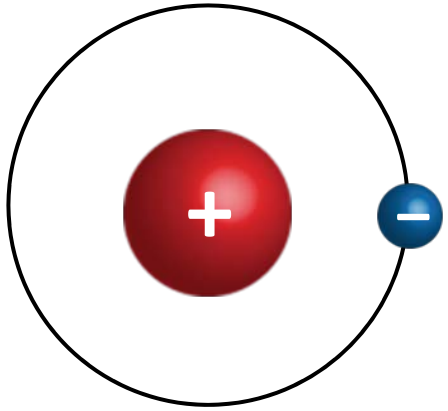
DEMO

Units of electric charge

- Symbol: *q* or *Q*
- Unit: [Coulomb] = [C]

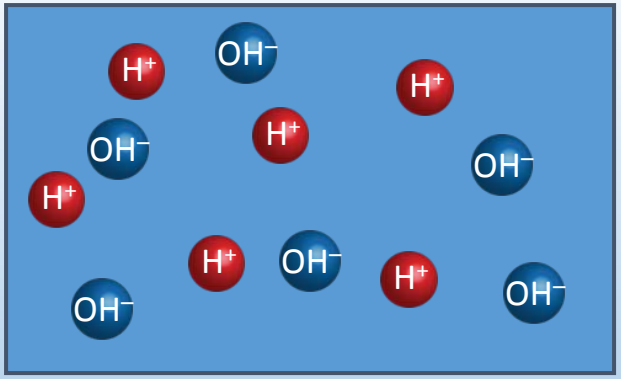
  Electron: $-e = -1.6 \times 10^{-19}$ C

  Proton: $+e = +1.6 \times 10^{-19}$ C



- How much charge is 1 C?

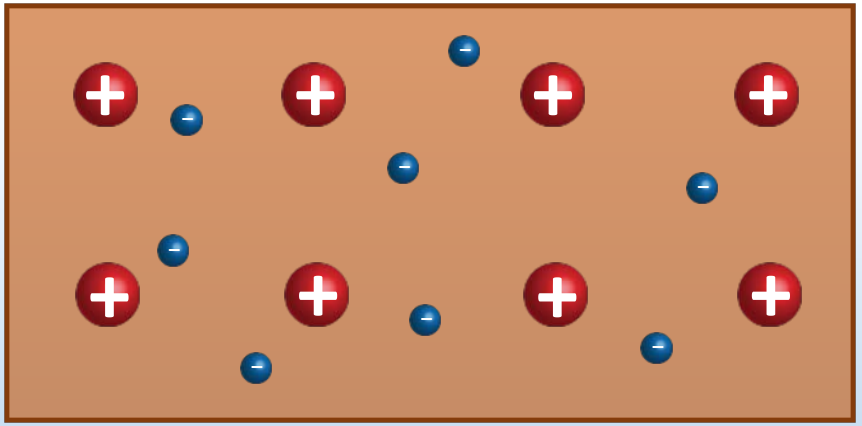
  Imagine you could separate H^+ and OH^- ions in pure water (pH 7.0)



Conductors & insulators

Q: How do electrons behave in a perfect conductor?

Q: How do electrons behave in a perfect insulator?

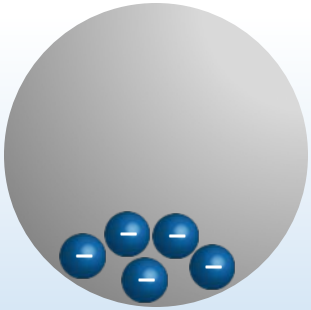


Most things are in between perfect conductor / insulator

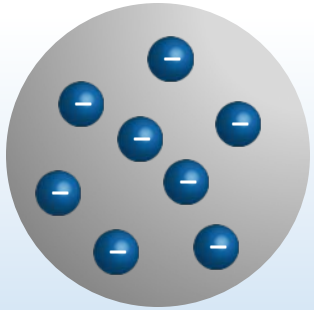
ACT: Conductors

Electrons are placed on a neutral conducting sphere. Which of the following diagrams correctly depicts how the charges are distributed?

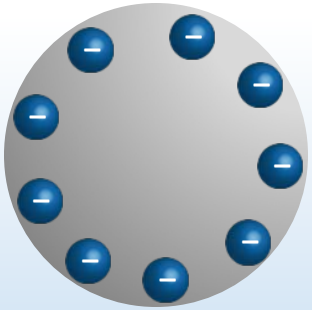
A. At the bottom



B. Spread uniformly



C. On the surface

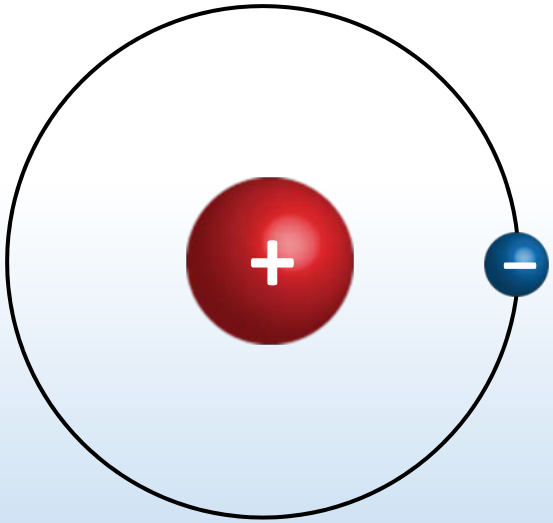


DEMO

Conservation of charge

Charges are physical entities (ex: electrons, protons)

Cannot be created or destroyed

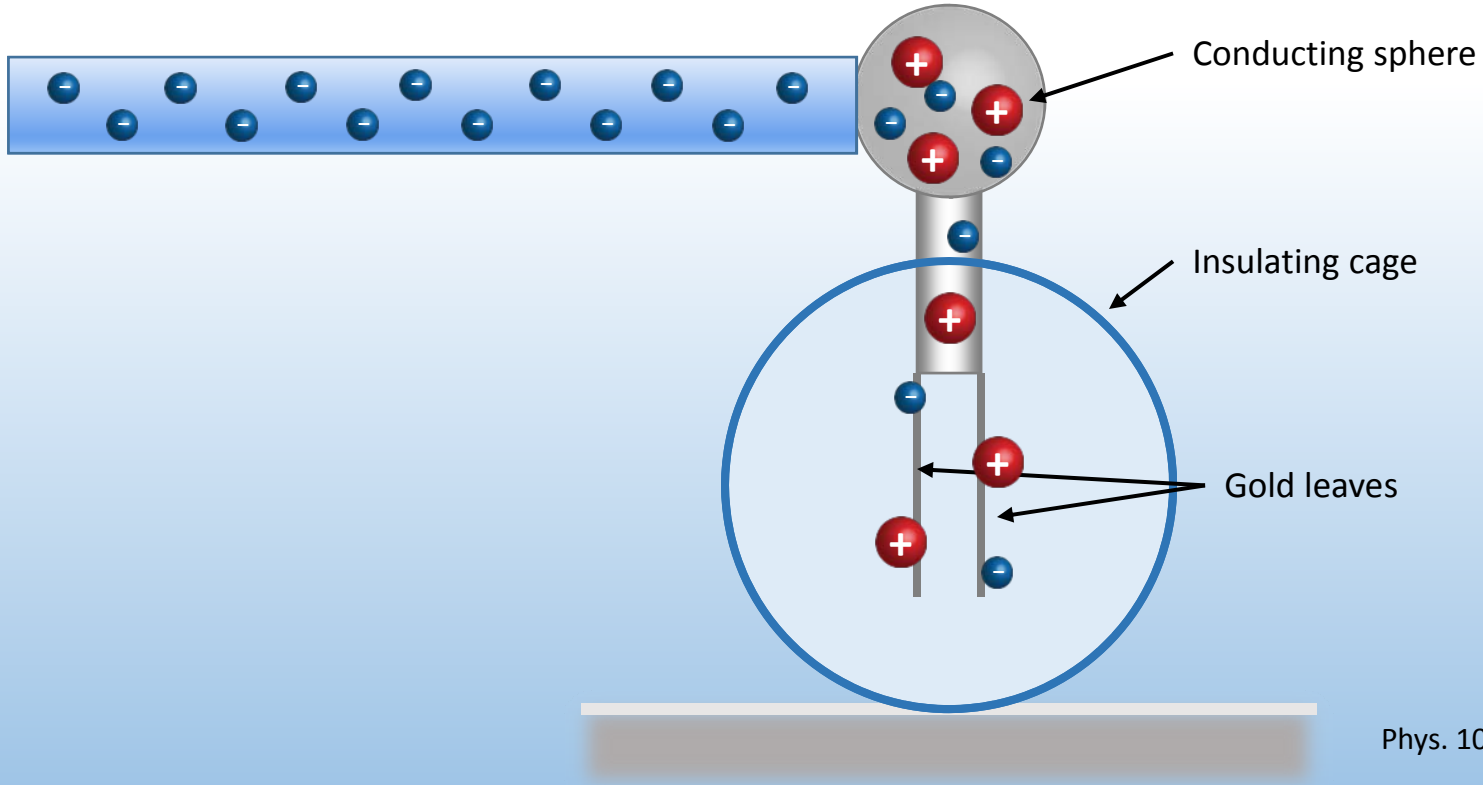


<u>The net charge in a closed system is conserved</u>

However, charges (often electrons) can be transferred from one object to another

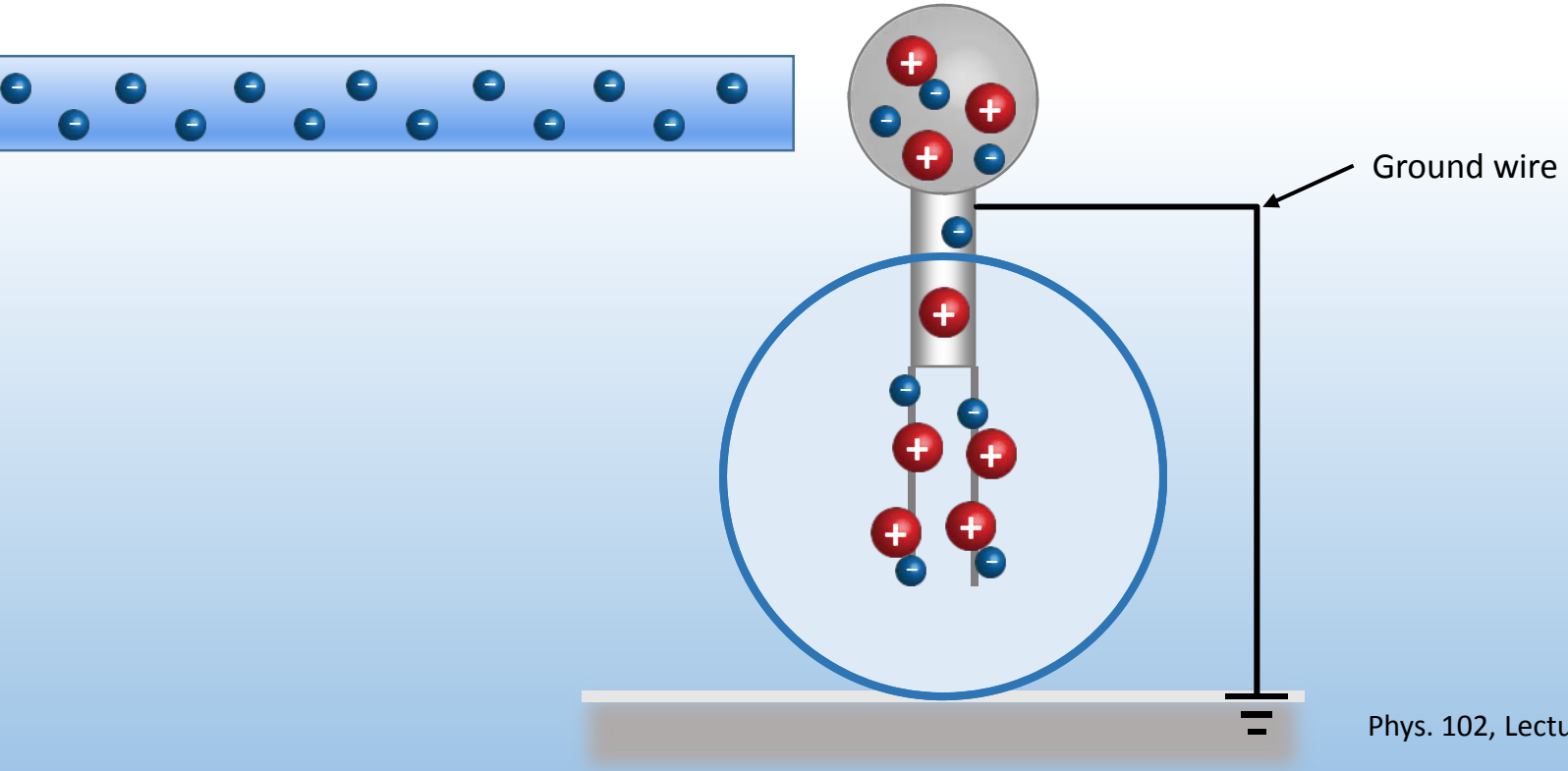
Demo: electroscope

- Charging by *conduction*
  - Charged rod is brought near scope
  - Charged rod touches scope transferring some charge
  - Scope is left with <u>same</u> charge as rod



Demo: electroscope

- Charging by *induction*
  - Charged rod is brought near scope (but does NOT touch)
  - Scope is briefly grounded allowing charge to flow on (or off)
  - Scope is left with <u>opposite</u> charge as rod



ACTs: Electroscope

A *positively* charged rod is used to charge an electroscope by *induction*. What is the resulting net charge on the electroscope?

A. positive B. zero C. negative

If the conducting electroscope were replaced by an *insulating* ball and then charged by induction as above, what would be the net charge on the ball?

A. positive B. zero C. negative

Coulomb's Law
(1785)

Force between charges q_1 and q_2 separated a distance r:

Magnitude

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

"Coulomb constant"

$$k = 9\times10^9\ N\cdot m^2/C^2$$

Or: $$F = \frac{1}{4\pi\varepsilon_0}\frac{|q_1||q_2|}{r^2}$$

"Permittivity of free space"

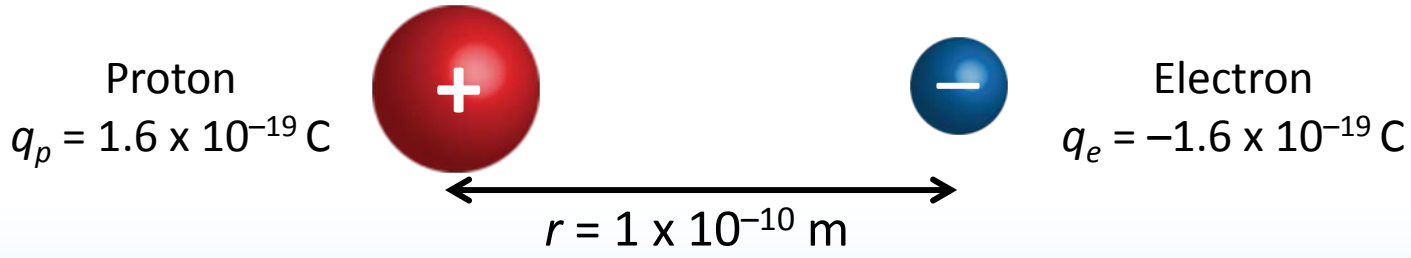
$$\varepsilon_0 = 8.85\times10^{-12}\ C^2/N\cdot m^2$$

Direction

Opposite charges attract, like charges repel

Coulomb's Law

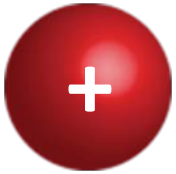
What is the magnitude of the force on the proton due to the electron in hydrogen?



Compare to gravitational force between them (Phys. 101)

ACT: Coulomb's Law

What is the direction of the force on the proton due to the electron in the hydrogen atom?

proton   electron

A. Left B. Right C. Zero

What is the direction of the force on the *electron due to the proton*?

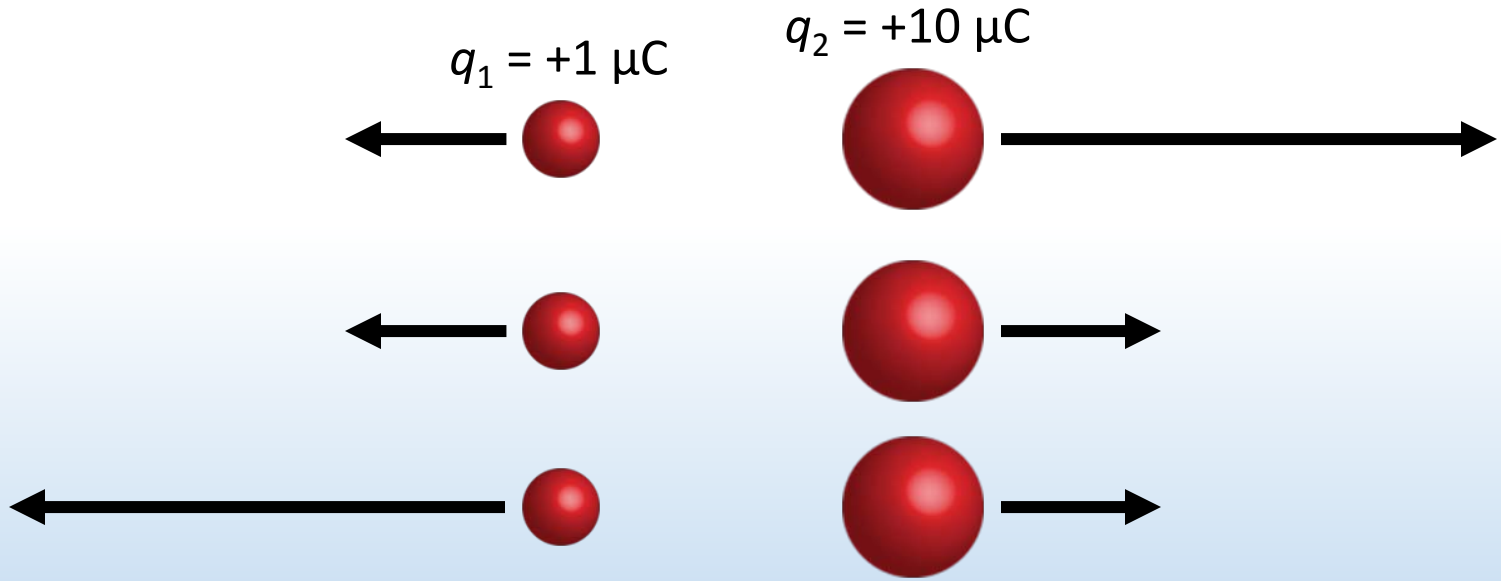
ACT: Coulomb's Law

Two charges q_1 = +1 µC and q_2 = +10 µC are placed near each other. Which of the following diagrams correctly depicts the forces acting on the charges?

A.

B.

C.



Summary of Today's Lecture

- Electric charge
- Conservation of charge
- Conductors and insulators
- Coulomb's Law for the force between charges

$$F = \frac{kq_1q_2}{r^2}$$

Much more on Coulomb's Law in next lecture