# PHY294H

- Professor: Joey Huston
- email:huston@msu.edu
- office: BPS3230
- textbook: Knight, Physics for Scientists and Engineers: A Strategic Approach,

  Vol. 4 (Chs 25-36), 3/E + MasteringPhysics

  0321844297

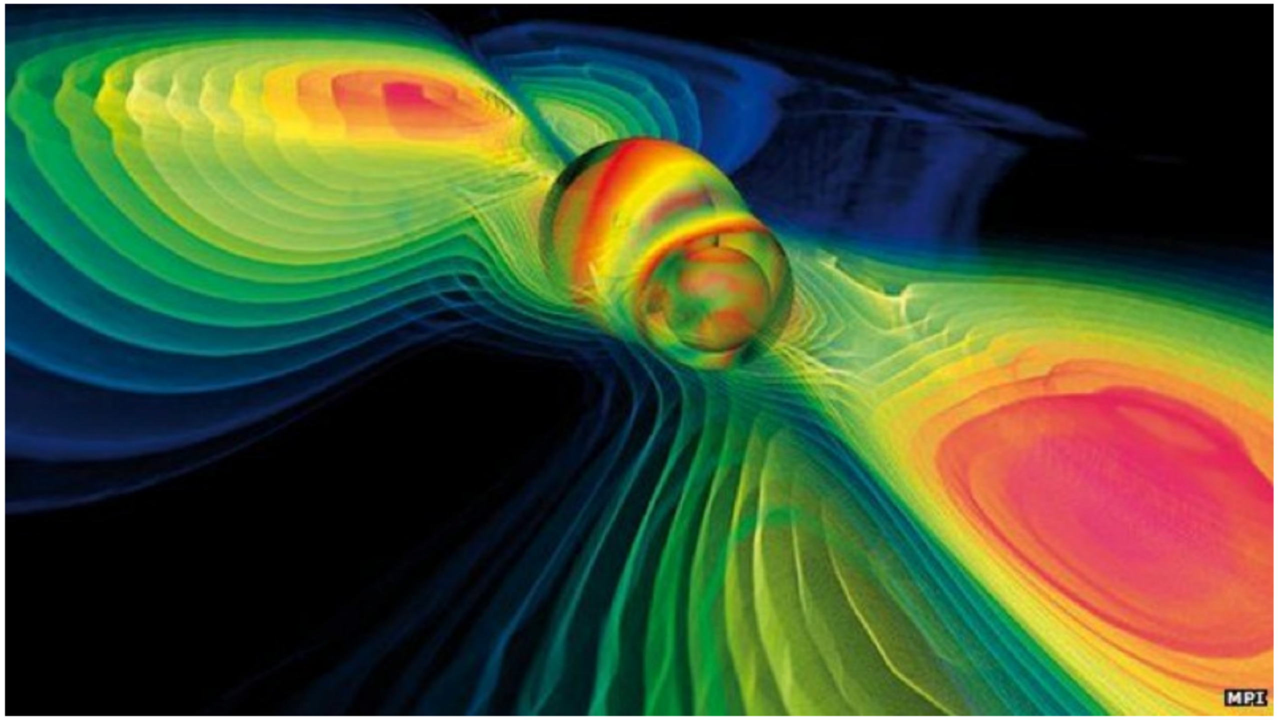
  MasteringPhysics (complete ebook) access card stand alone

  0321753054
- Homework will be with Mastering Physics (and an average of 1 hand-written problem per week)
  - first MP assignment due Wed Jan. 20; first hand-written problem as well
- Quizzes by iclicker (sometimes hand-written)
- Lectures: MTWTh 11:30-12:20
- Course website: www.pa.msu.edu/~huston/phy294h/index.html
  - lectures will be posted frequently, mostly every day if I can remember to do so

# Rumors Are Flying That We Finally Found Gravitational Waves

Jennifer Ouellette
Today 2:15pm · Filed to: GRAVITATIONAL WAVES






Excited rumors began circulating on Twitter this morning that a major experiment designed to hunt for gravitational waves—ripples in the fabric of spacetime first predicted by Albert Einstein—has observed them directly for the very first time. If confirmed, this would be one of the most significant physics discoveries of the last century.

Move a large mass very suddenly—or have two massive objects suddenly collide, or a supernova explode—and you would create ripples in space-

- Guest lecturer Wed and Thurs

# Charging by induction

- How can I see an effect when I haven't touched the electroscope?

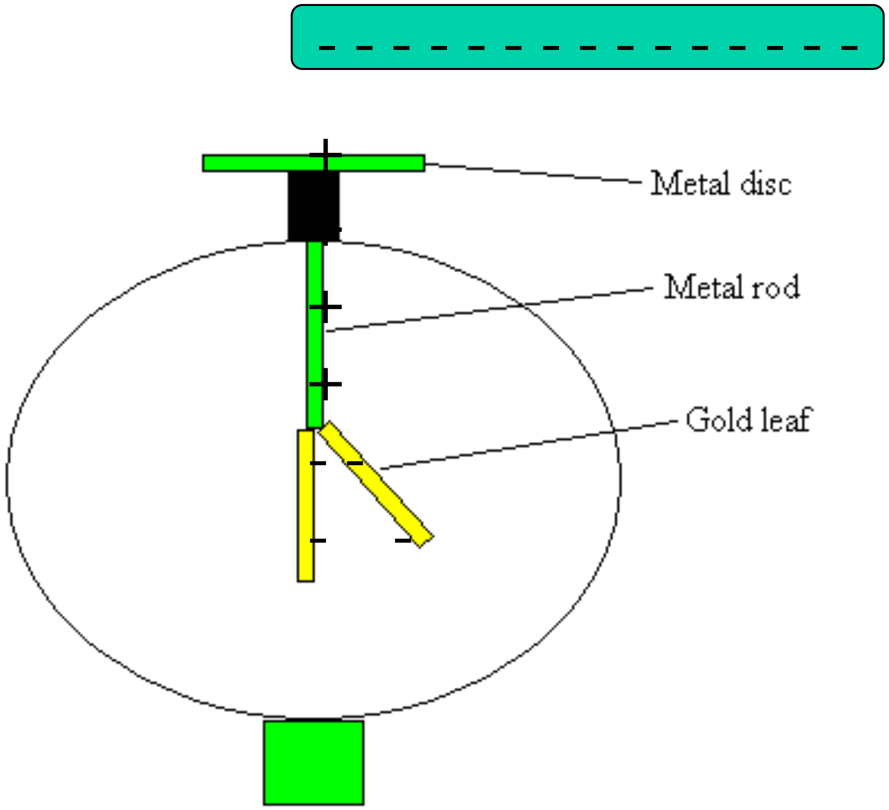



Figure 2: The classical electroscope

# Charging by induction

- How can I see an effect when I haven't touched the electroscope?
- What happens when I take away the rod?

  .

  .

  .
- Can I exert a force on a larger object, like a ruler, with Al foil on the ends?
  - demo
  - why does this happen?

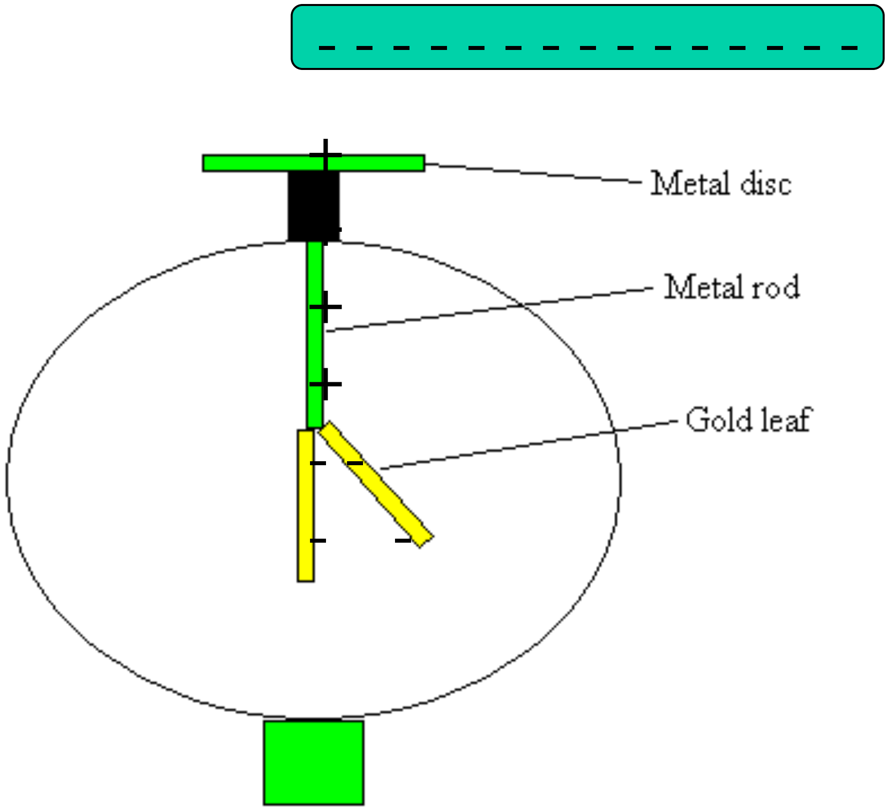
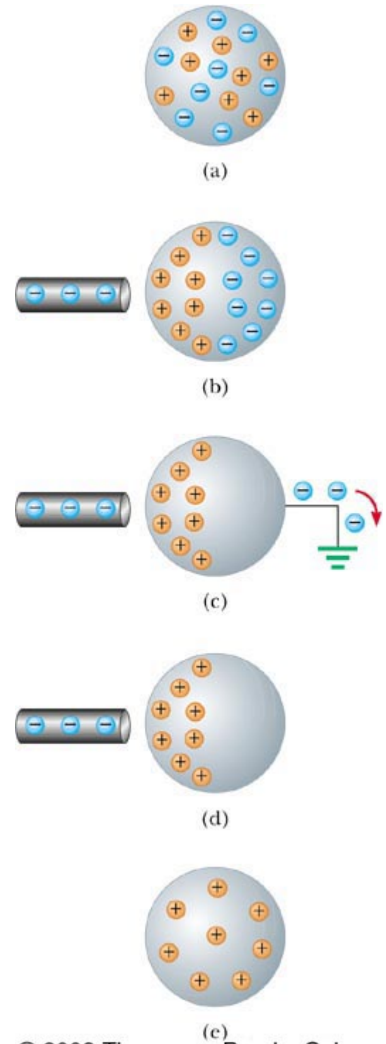



Figure 2: The classical electroscope

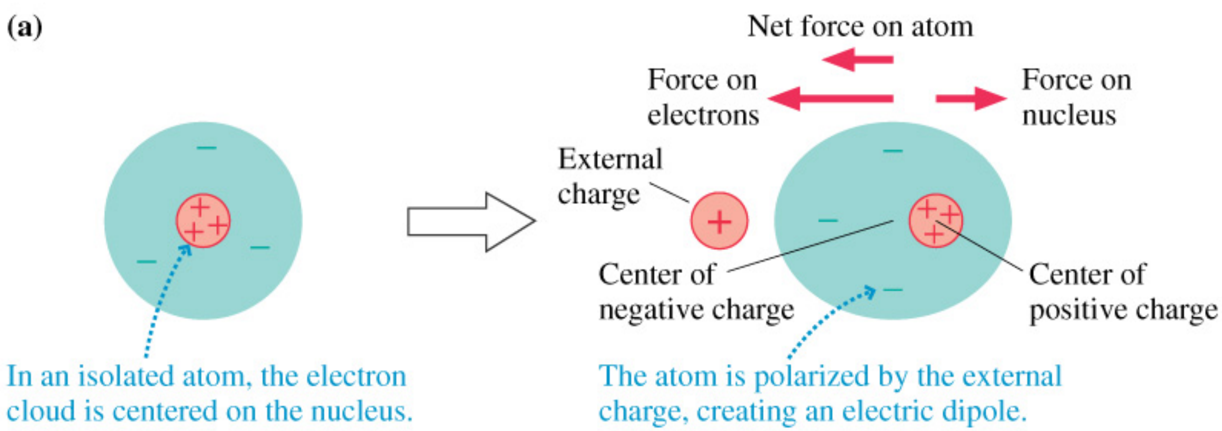
# Can I give an object a permanent charge using induction?

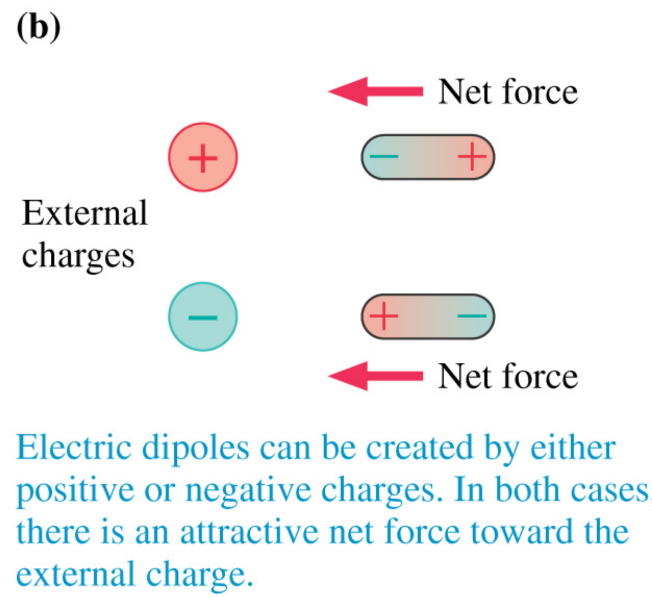
- Yes, if it's connected to "ground", so that charge can be transferred
- And then I break the connection before I remove the rod



# Electric dipoles

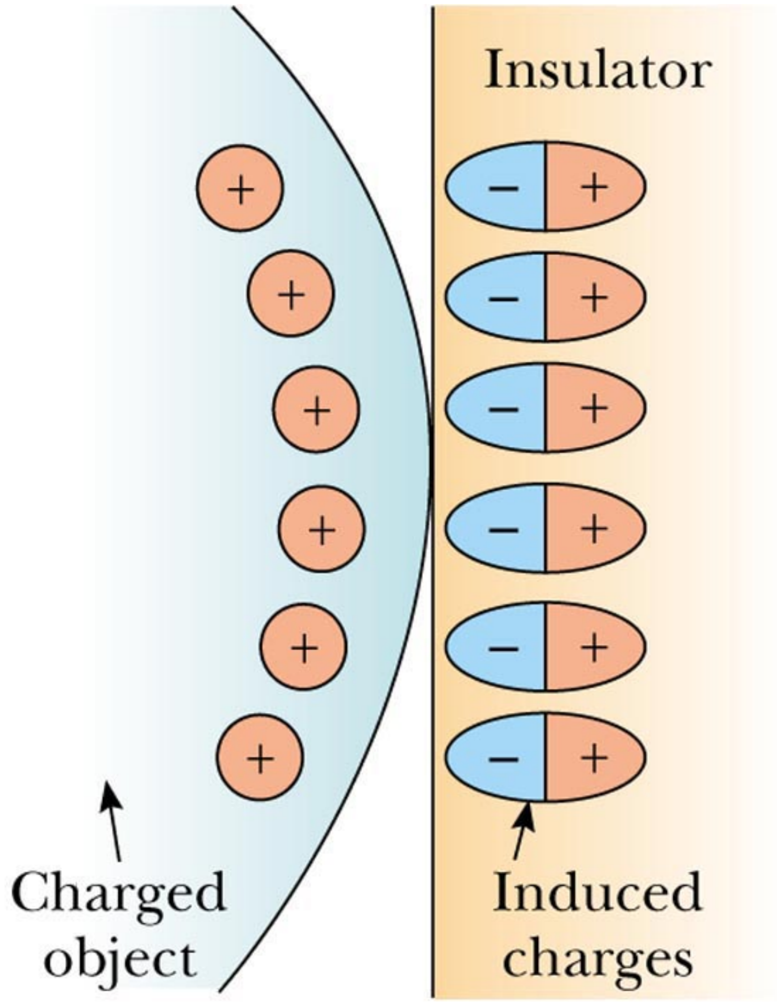
I can induce a dipole on an insulator by bringing a charge close.



# Electric dipoles

- The charged rod can attract an uncharged insulator if the insulator has electric dipoles inside it
- …or by inducing electric dipoles (separation of charges)



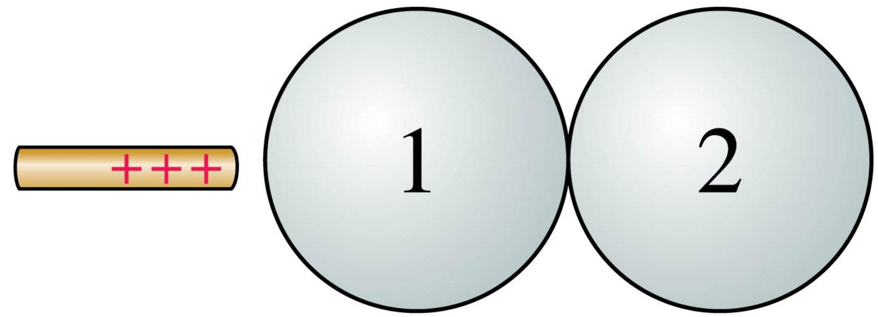
Metal spheres 1 and 2 are touching. Both are initially neutral.

a. The charged rod is brought near.

b. The charged rod is then removed.

c. The spheres are separated.

Afterward, the charges on the sphere are:




A. $Q_1$ is + and $Q_2$ is +.

B. $Q_1$ is + and $Q_2$ is –.

C. $Q_1$ is – and $Q_2$ is +.

D. $Q_1$ is – and $Q_2$ is –.

E. $Q_1$ is 0 and $Q_2$ is 0.

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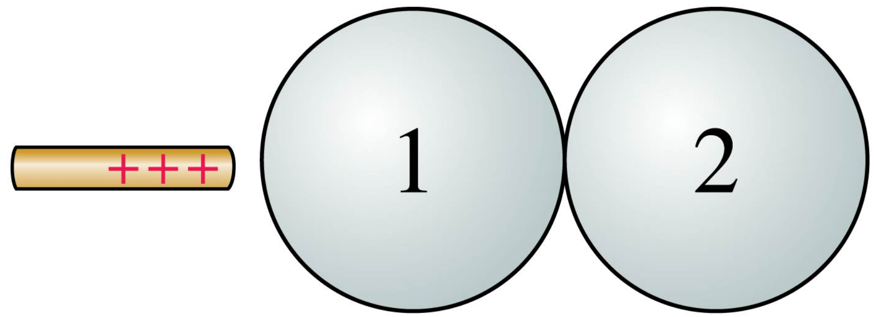


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✔ **E. $Q_1$ is 0 and $Q_2$ is 0.**

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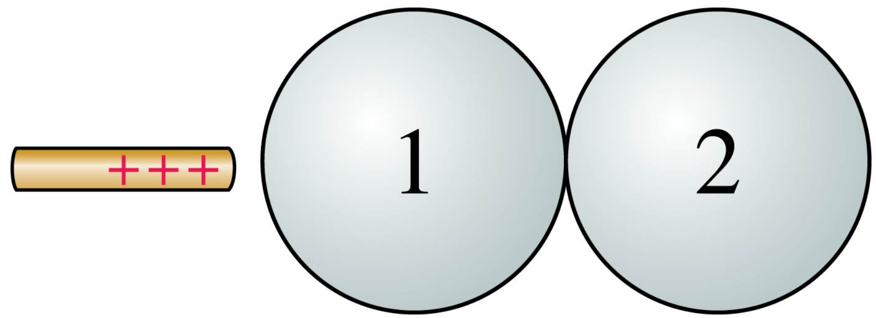


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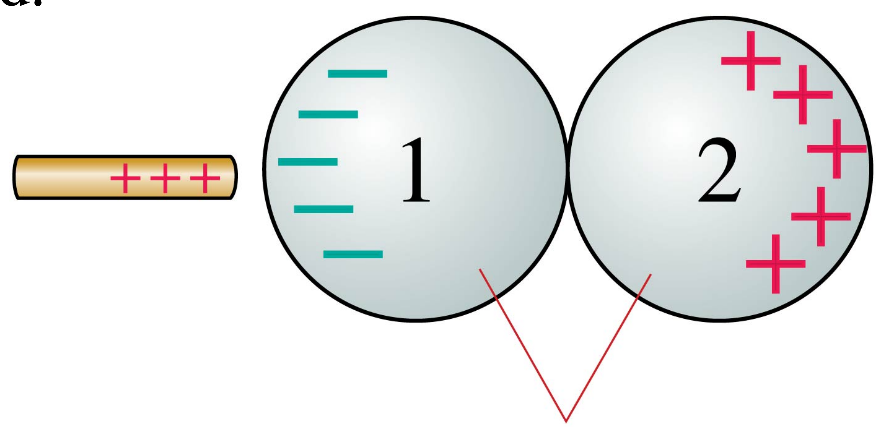



A. $Q_1$ is + and $Q_2$ is +.

B. $Q_1$ is + and $Q_2$ is –.

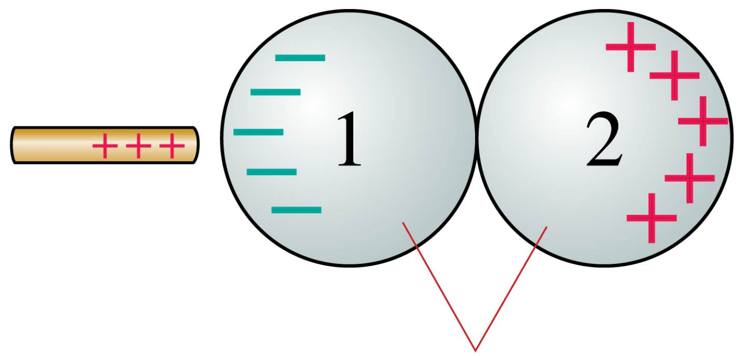
**C. $Q_1$ is – and $Q_2$ is +.**

D. $Q_1$ is – and $Q_2$ is –.

E. $Q_1$ is 0 and $Q_2$ is 0.

Net charge is obtained if contact is broken while the spheres are polarized. This is *charging by induction*.

Based on the last experiment, where two spheres were charged by induction, we can conclude that




A. Only the – charges move.

B. Only the + charges move.

C. Both the + and – charges move.

D. We can draw no conclusion about which charges move.

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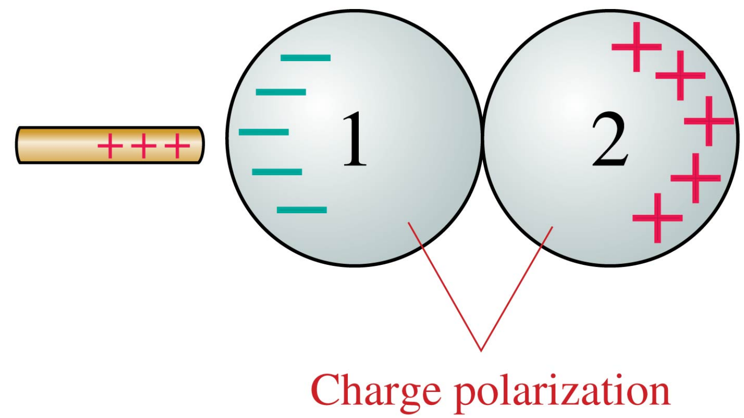



A. Only the – charges move.

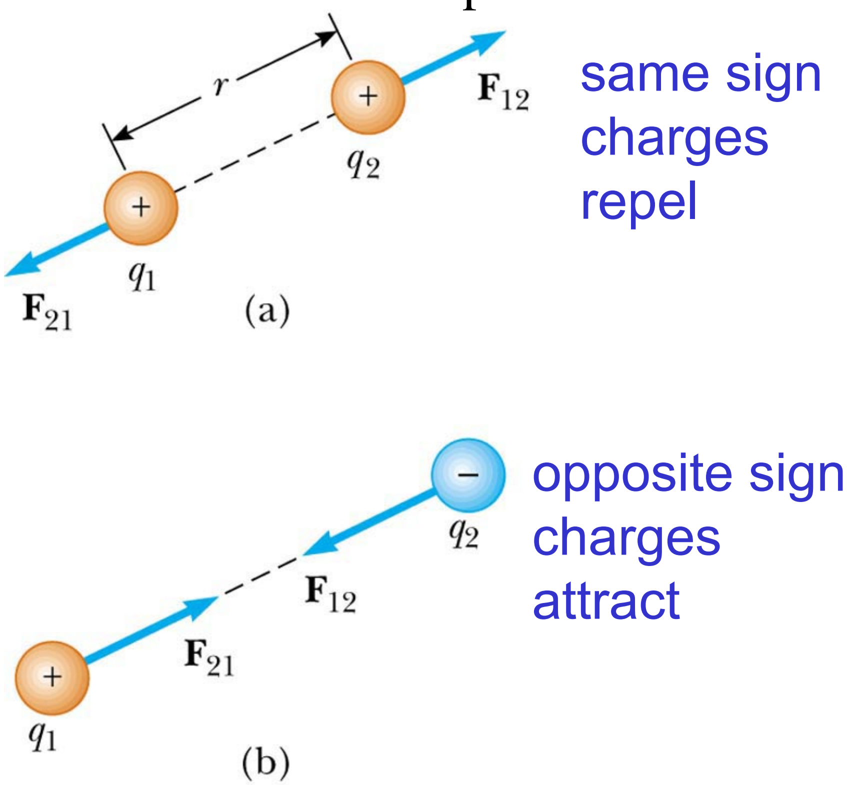
B. Only the + charges move.

C. Both the + and – charges move.

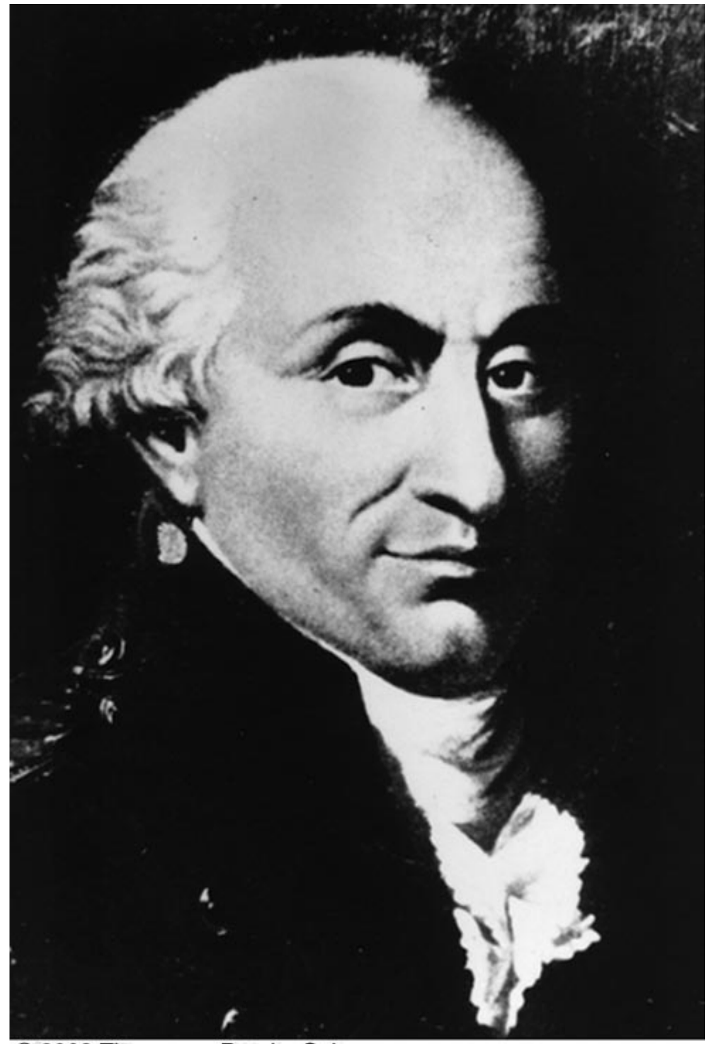
✔ **D. We can draw no conclusion about which charges move.**

# Coulomb's Law

There is a force between 2 charges along the line joining them (a central force).
The size of the force drops as $1/r^2$







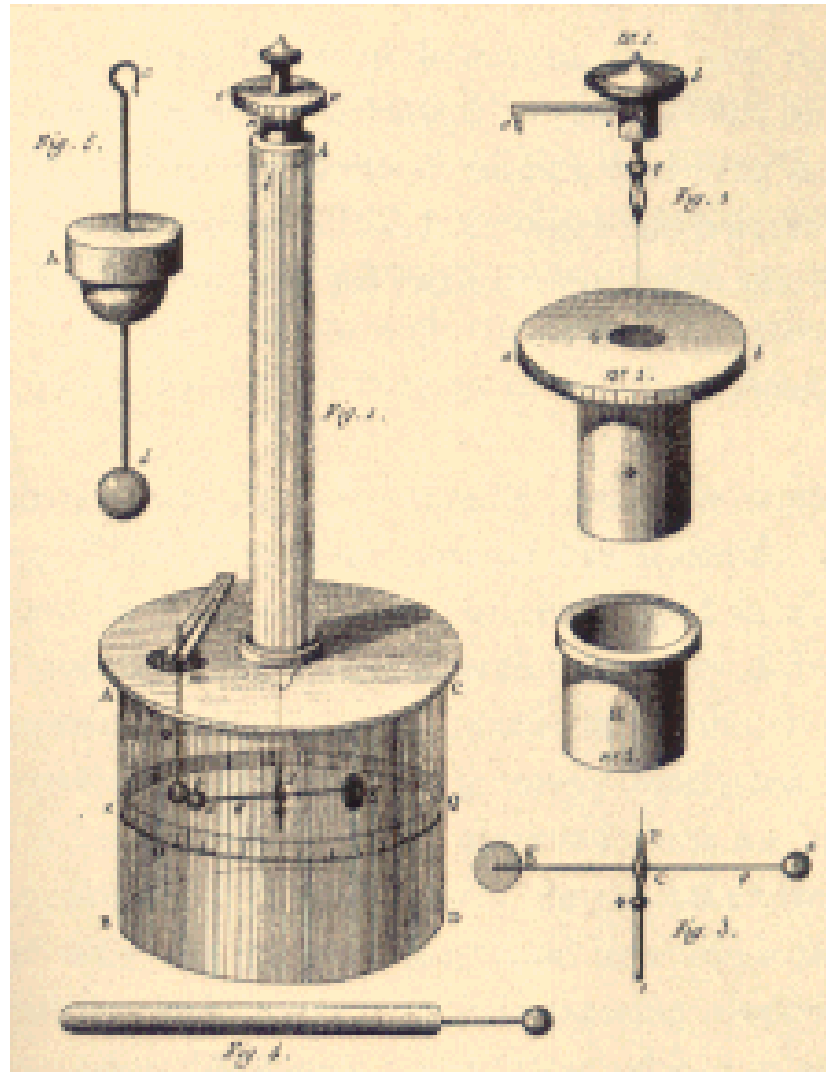
Where have we seen this before?

# Gravity

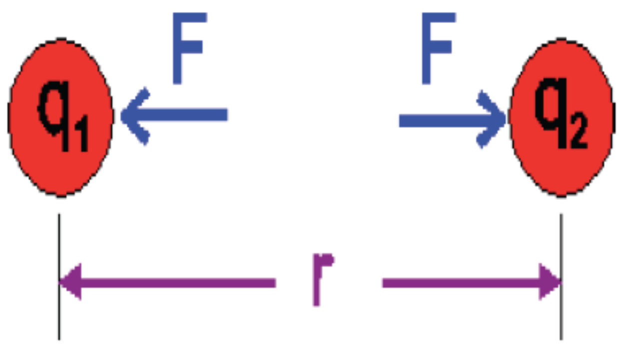
- Both gravity and this electrostatic force we've been discussing are
  - central
    - this means we can define a type of function called a potential (later)
  - vary as $1/r^2$
- But the electrostatic force is incredibly stronger than gravity

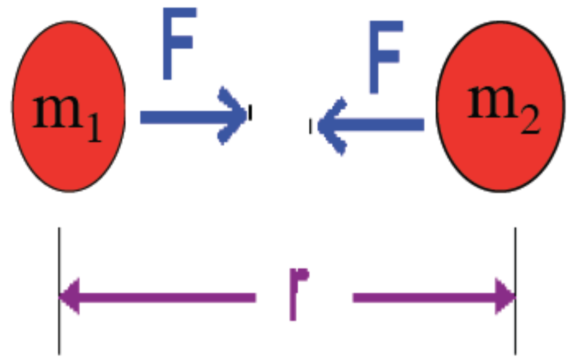
# Torsion balance

- In fact Coulomb derived his law using the same sort of torsion balance that Cavendish used to measure the gravitational constant G
- But Cavendish had an easier time of it since mass does not tend to leak away as charge does
- Did Coulomb's data decisively determine a $1/r^2$ force law, or did he jump to that conclusion in order to match Newton?
- In any case, the force law does go as $1/r^2$
  - but if there are extra dimensions on a large scale, then one signature would be deviations from the $1/r^2$ law for gravity at small distances → tests down to ~100 microns



# Comparison




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

$k = 9 \text{ X } 10^9 \text{ N·m}^2/\text{C}^2$

Force can be attractive or repulsive

$$F_G = \frac{Gm_1m_2}{r^2}$$

$G = 6.67 \text{ X } 10^{-11} \text{ N·m}^2/\text{kg}^2$

Force is always attractive

Consider the hydrogen atom ⟶ calculation