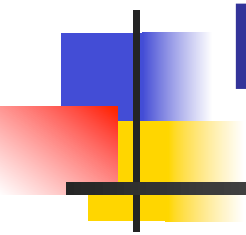


Electrostatics

Intro Video:

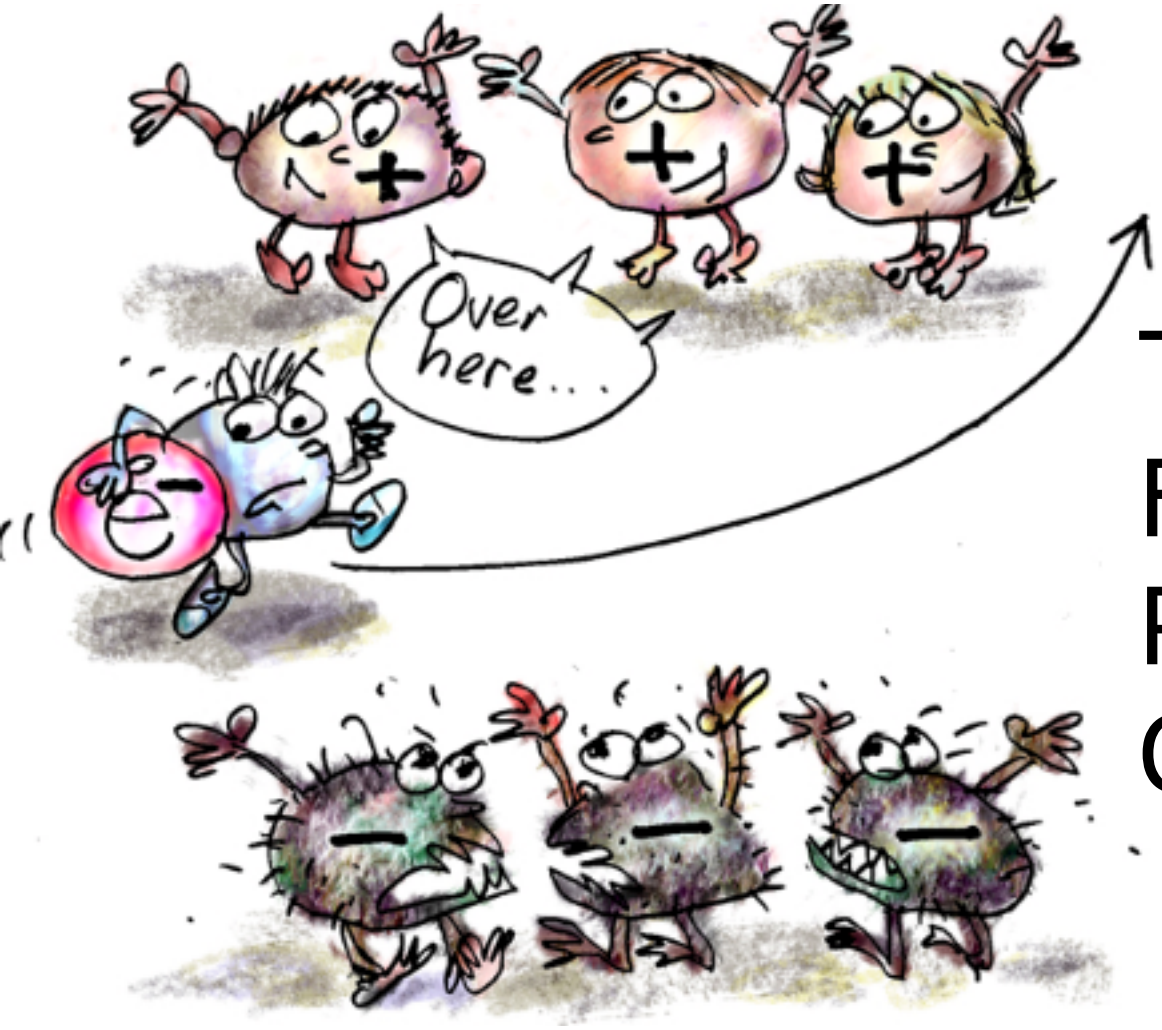
- What is charge?
- https://www.youtube.com/watch?v=DvlpAsDwXPY

What is electrostatics?

- Electrostatics or “electricity at rest”
- Involves electric charges , the forces between them and their behavior in materials

What is an electrical force?

- The attractive and repulsive force between all matter
- Like charges repel and opposites charges attract



The Fundamental Rule of Electric Charge.

Like charges repel and opposite charges attract.

Electrical forces arise from particles in atoms

Atomic Particles

Particle	***Charge***	***Location***
Proton	Positive charge +1	In nucleus
Electron	Negative charge -1	In orbit surrounding nucleus
Neutron	No charge 0	In nucleus

What is a neutral atom?

- When the number of electrons and protons is the same, so the atom has no net charge

What is an ion?

- When atoms of certain elements gain or lose charge (electrons)
- A positive ion has lost electrons, thus having more protons than electrons
- A negative ion has gained electrons, thus having more electrons than protons

The principle of *Conservation of Charge*

- Net electric charge is neither created nor destroyed but is transferrable from one material to another
- An object that is charged has an excess or a deficiency of some number of electrons

- The Law of Conservation of Charge states that the net charge of an isolated system remains constant.

Conductors vs. Insulators

- Whether a substance is classified as a conductor or an insulator depends on how tightly the atoms of the substance hold their electrons

Conductors vs. Insulators

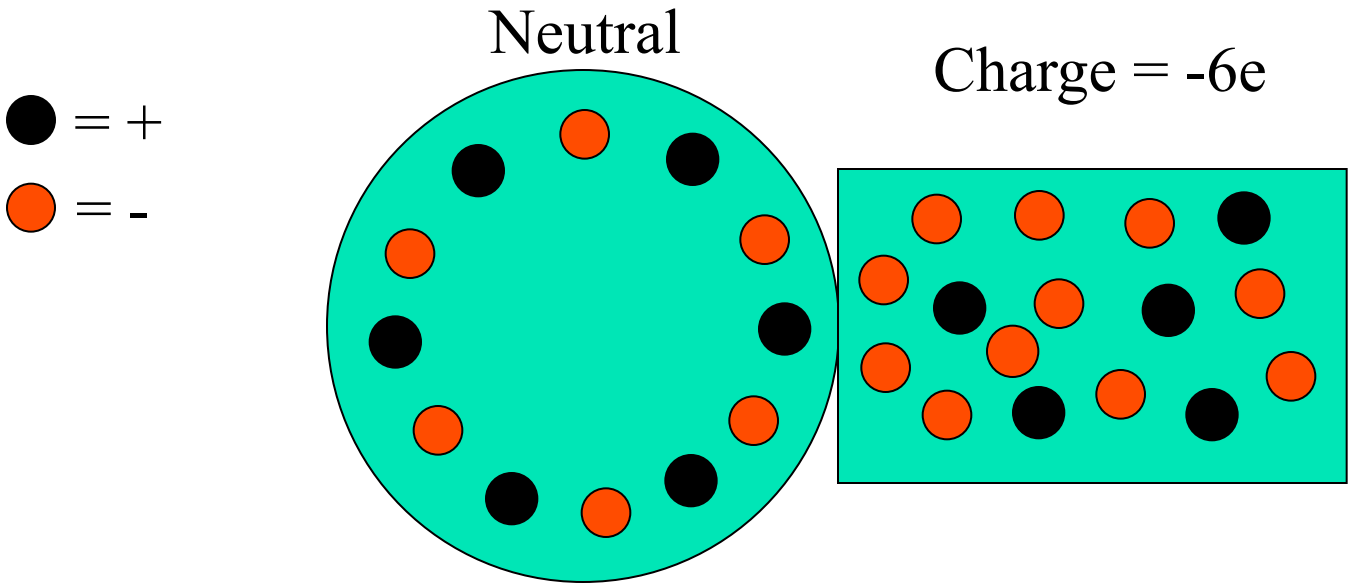
- Conductors = good flow of charge
  - In conductors, such as metals, the outermost electrons in the atoms are so loosely bound to their nuclei that they're free to travel around the material.
- Insulators = poor flow of charge
  - In insulators, such as rubber, distilled water, wood or plastic, the electrons are much more tightly bound to the atoms, and are not free to flow.

Conduction vs Induction

- http://www.regentsprep.org/Regents/physics/phys03/aeleclab/induct.htm

Charging by Conduction

- To summarize: Charging by conduction involves contact between the charged object and the neutral object



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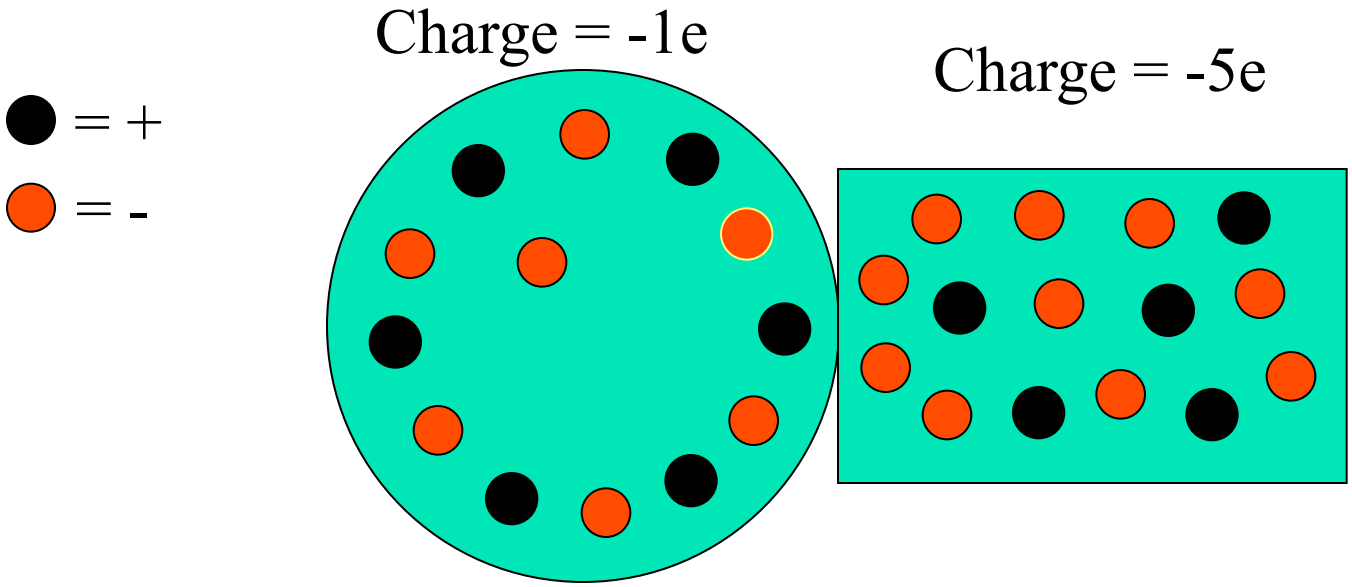

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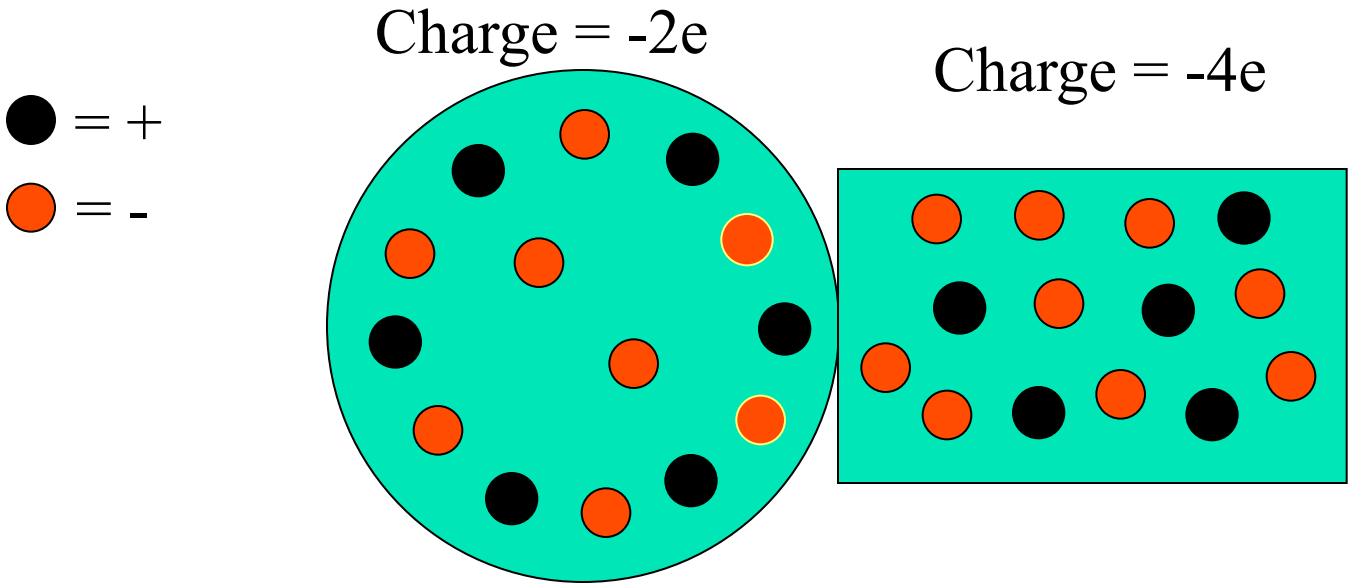
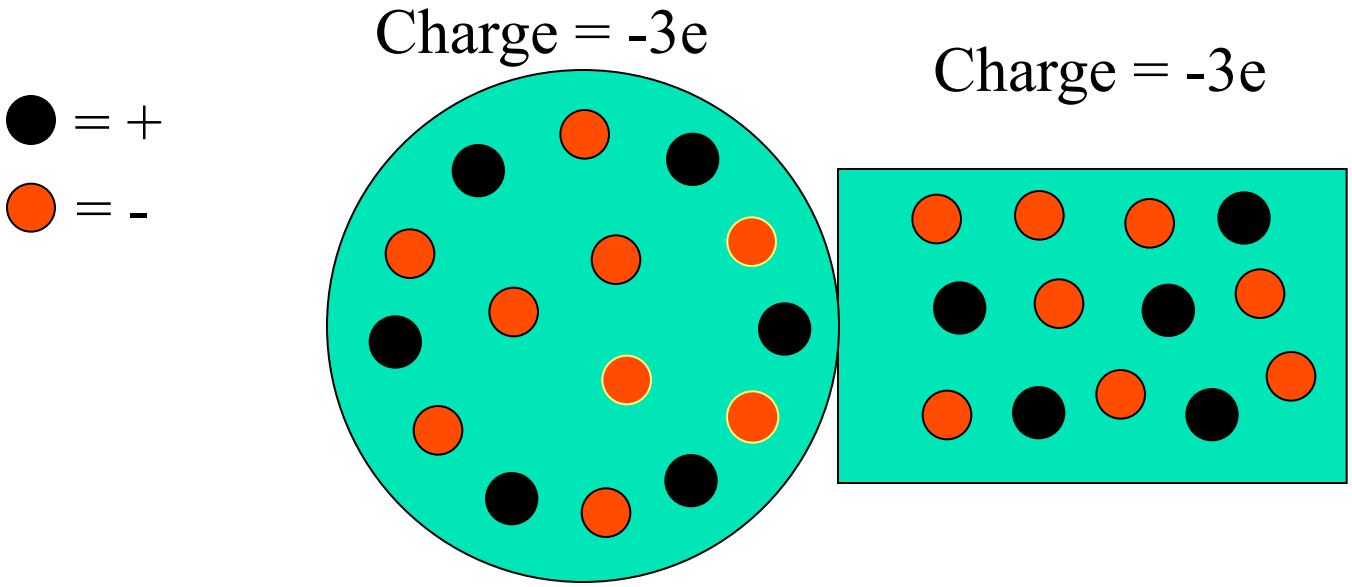


Charging by Conduction

To summarize: Charging by conduction involves contact between the charged object and the neutral object



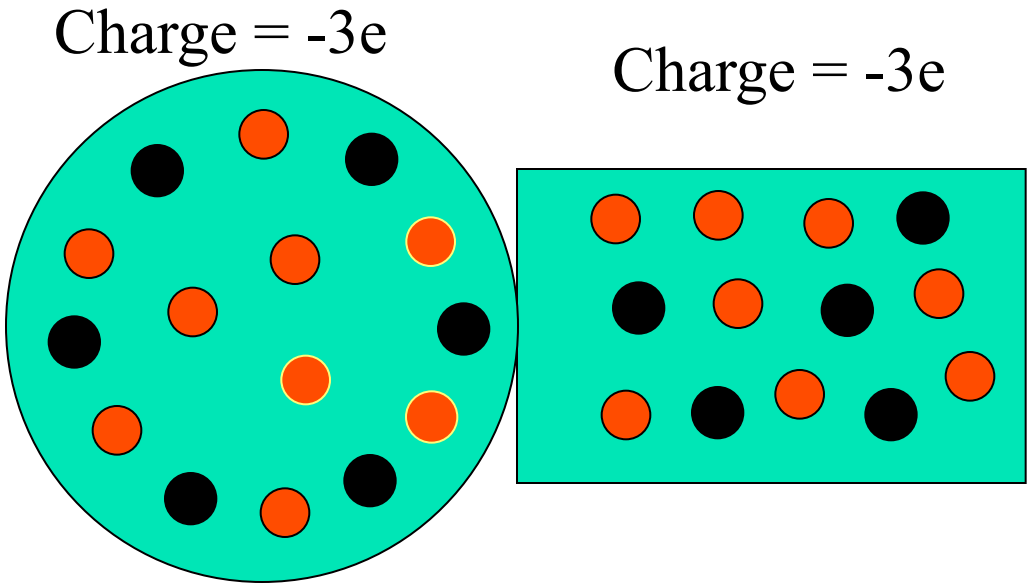
Charging by Conduction

Once the two objects have the same charge, no more charge is transferred!!!

- The net charge overall is still -6e because electric charge is conserved

● = +

● = -



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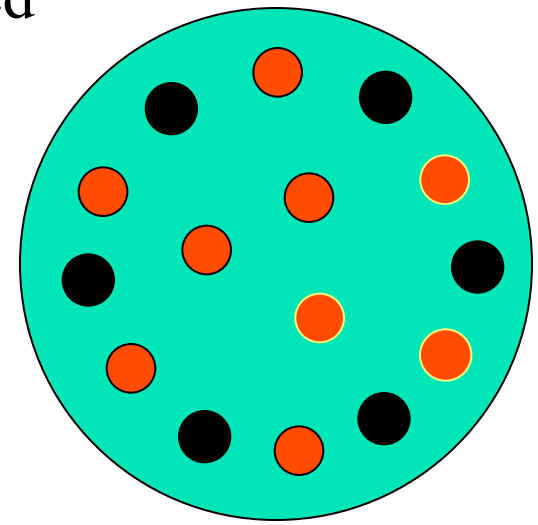


Charge = -3e

Charging by Induction

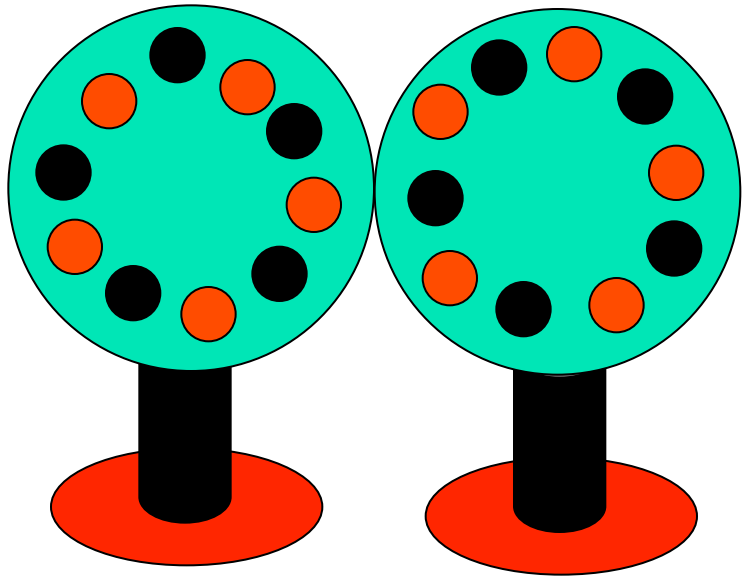
- The second way to charge an object is when there is no direct contact between the charged object and the neutral object
- Charges are influenced in the neutral object, but no transfer occurs with the charged object
- This method is called charging by *Induction*

Charging by Induction

- Here is how it works:
- Start with two neutral conductors (this won't work very well with insulators) that are in contact with each other but are <u>not</u> grounded

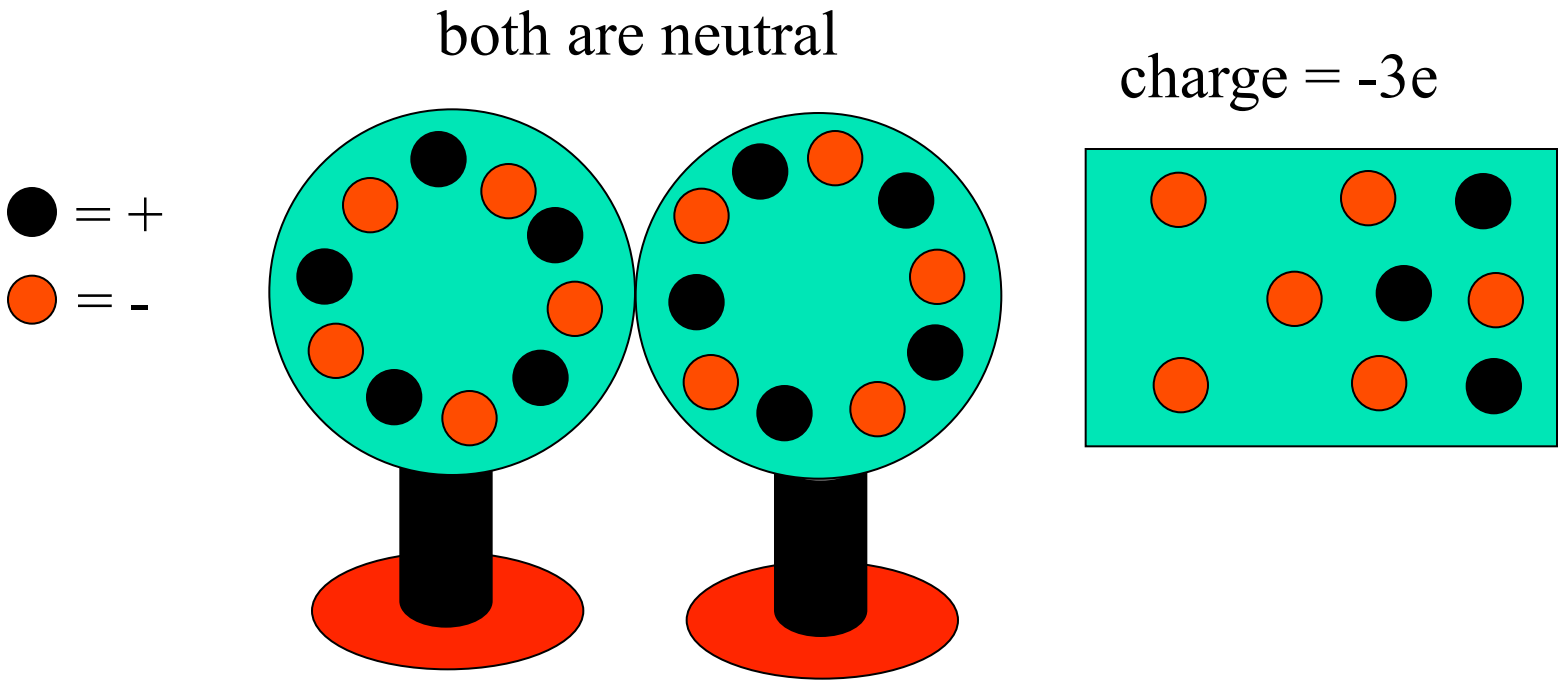
● = +

● = -



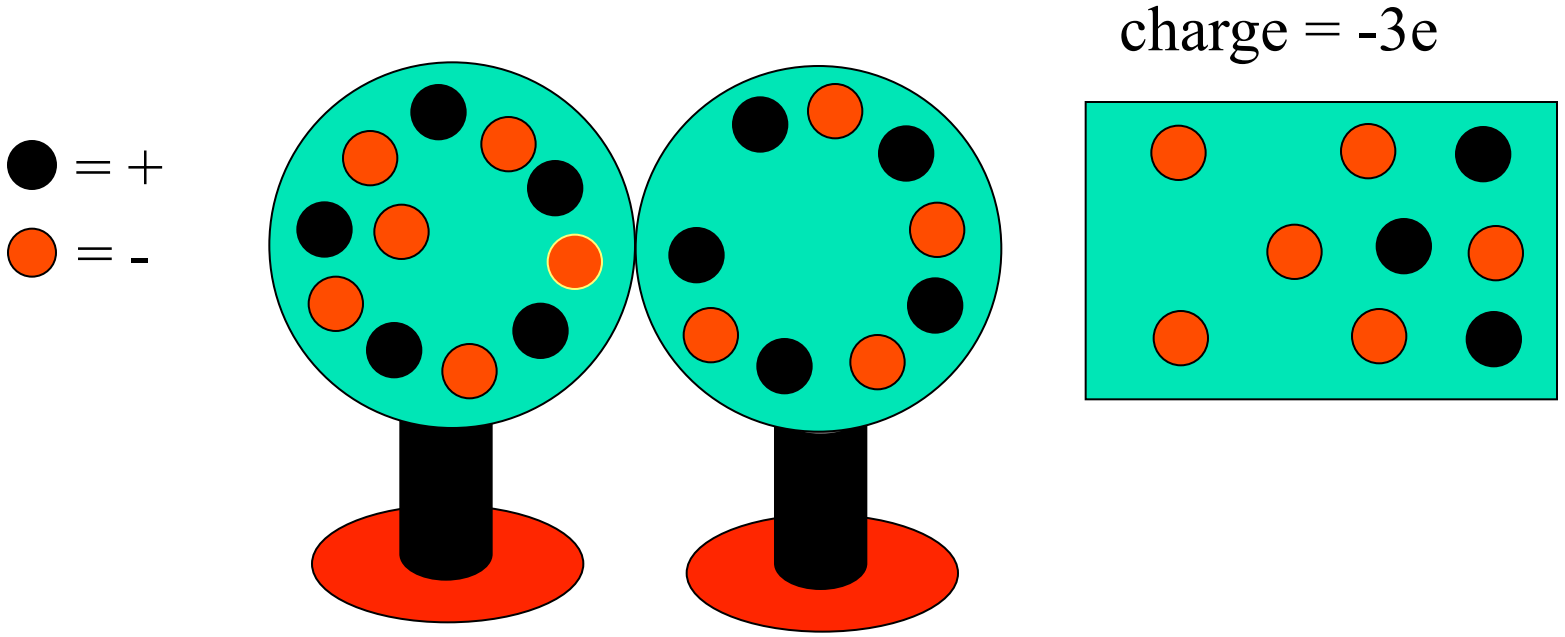
Charging by Induction

- Here is how it works:
  - I bring a charged object nearby the two conductors, but <u>it does not make contact with either conductor</u>



Charging by Induction

- Here is how it works:
  - The charged object pushes electrons from the right-hand sphere to the left-hand sphere



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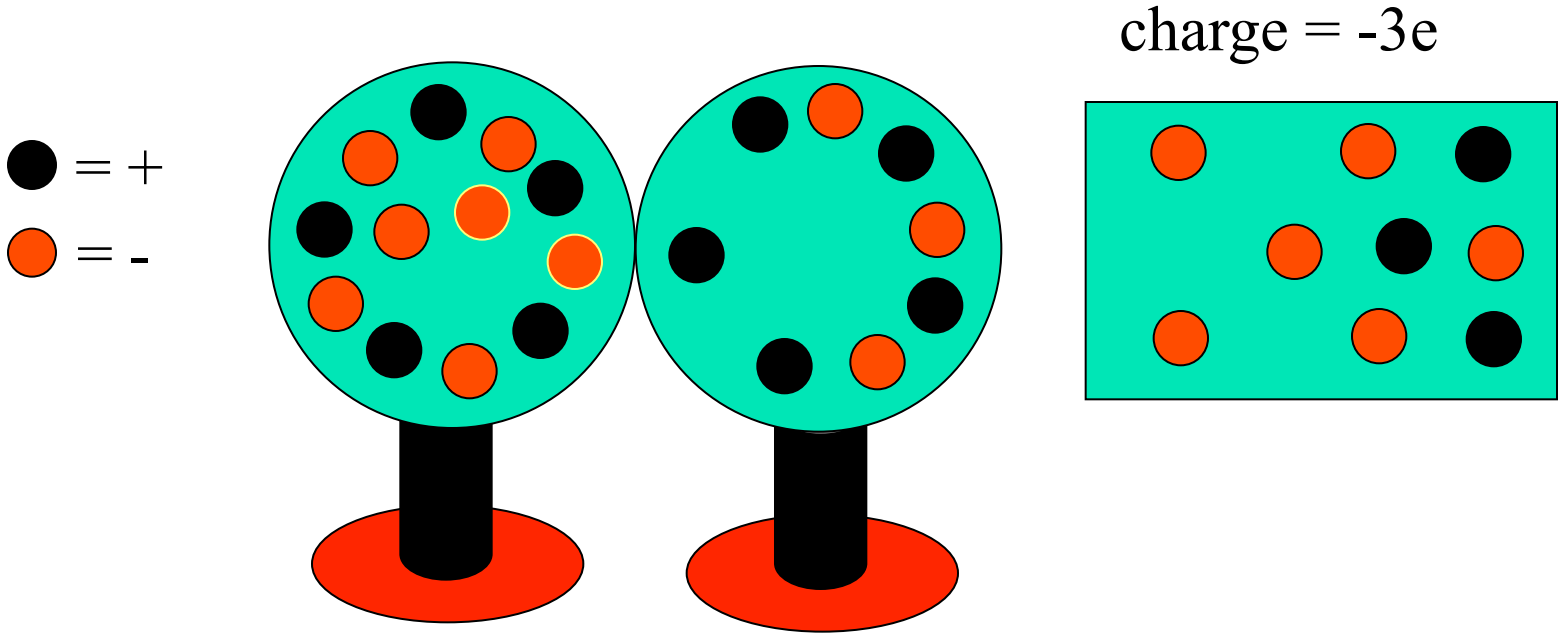

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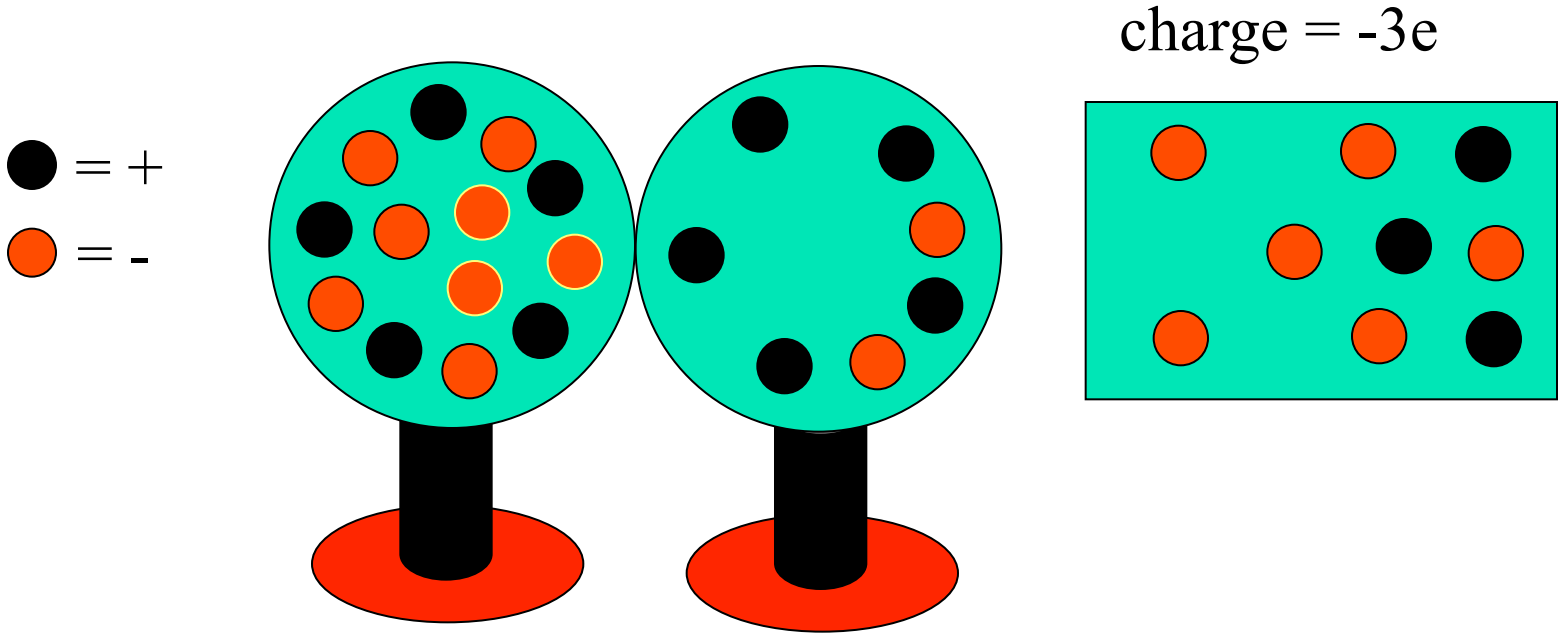
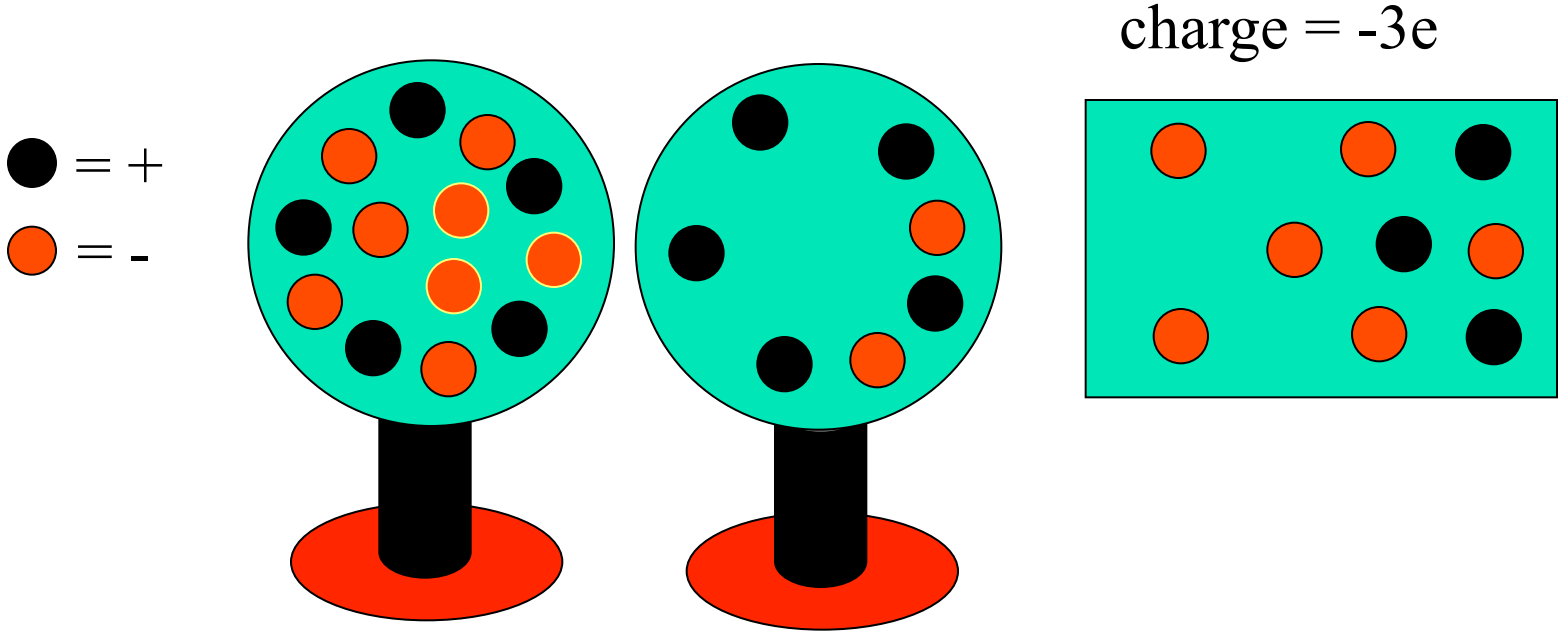


Charging by Induction

- Here is how it works:
- Now, I move the left-hand sphere away from the right-hand sphere, while the charged object is still nearby



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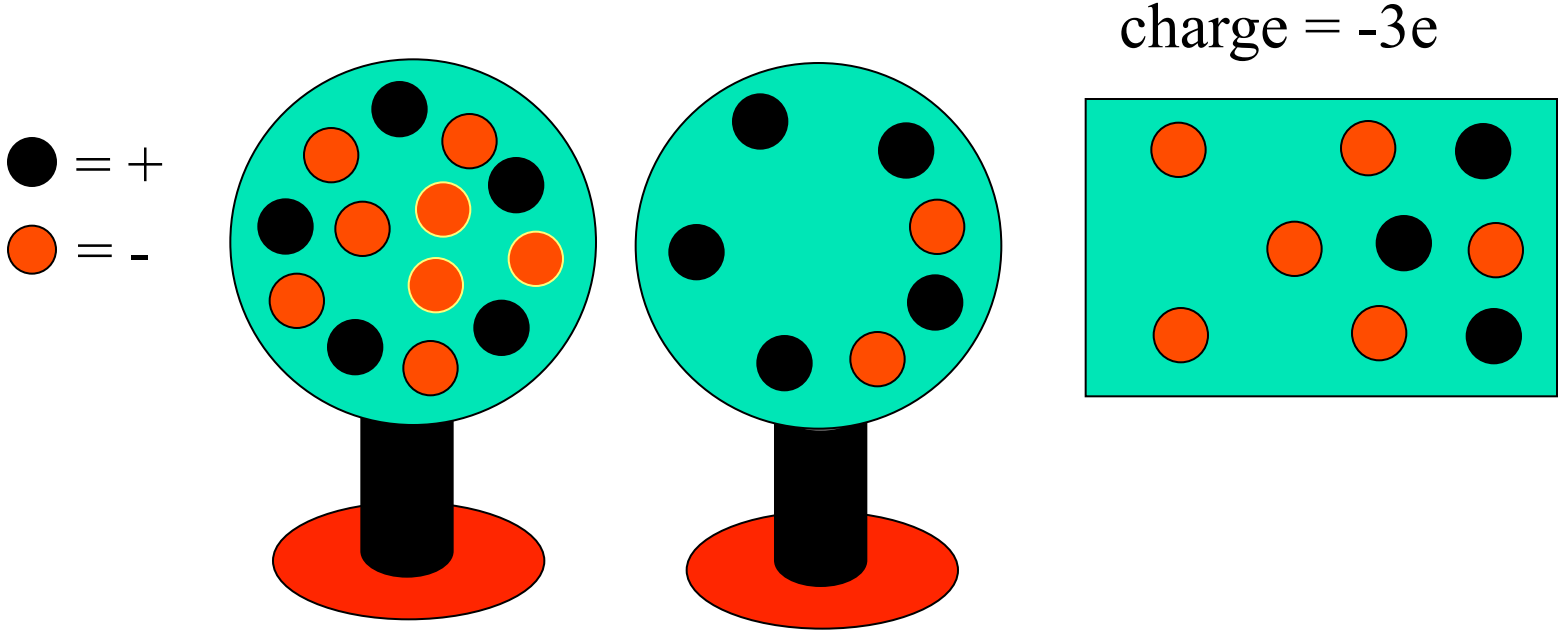
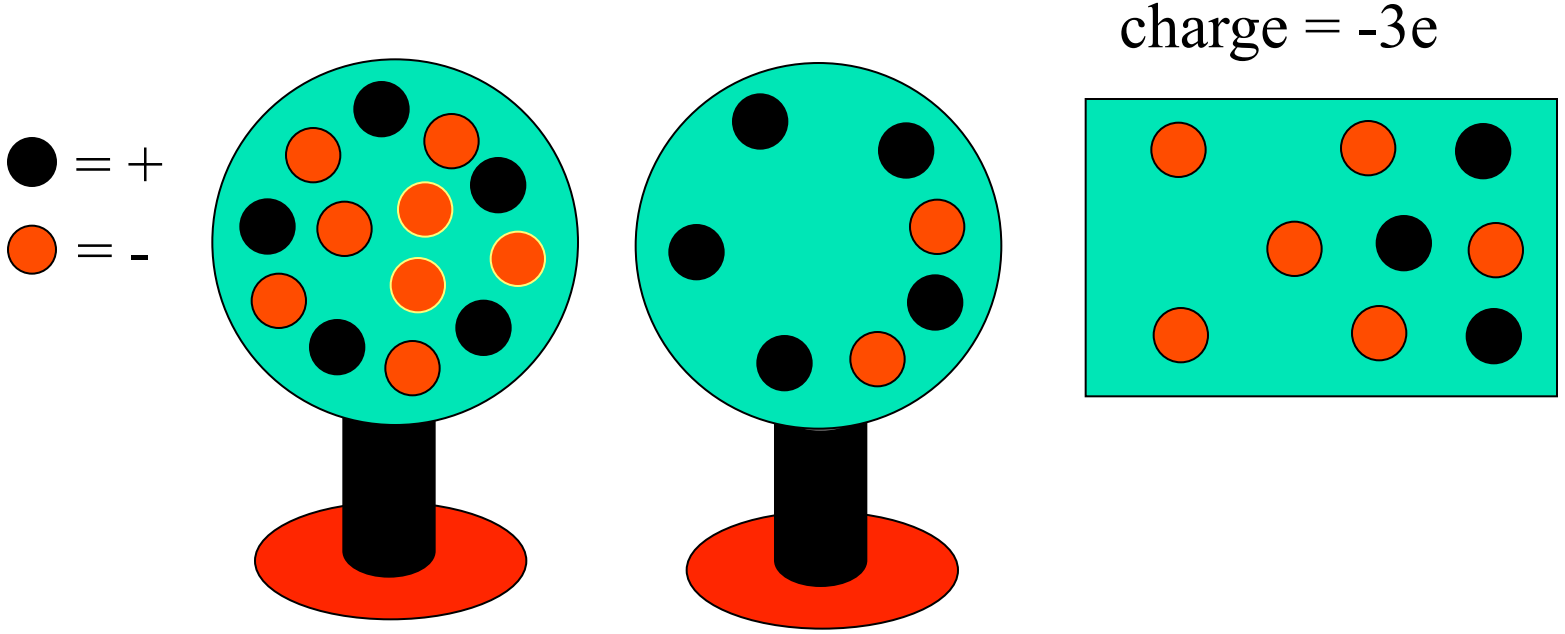


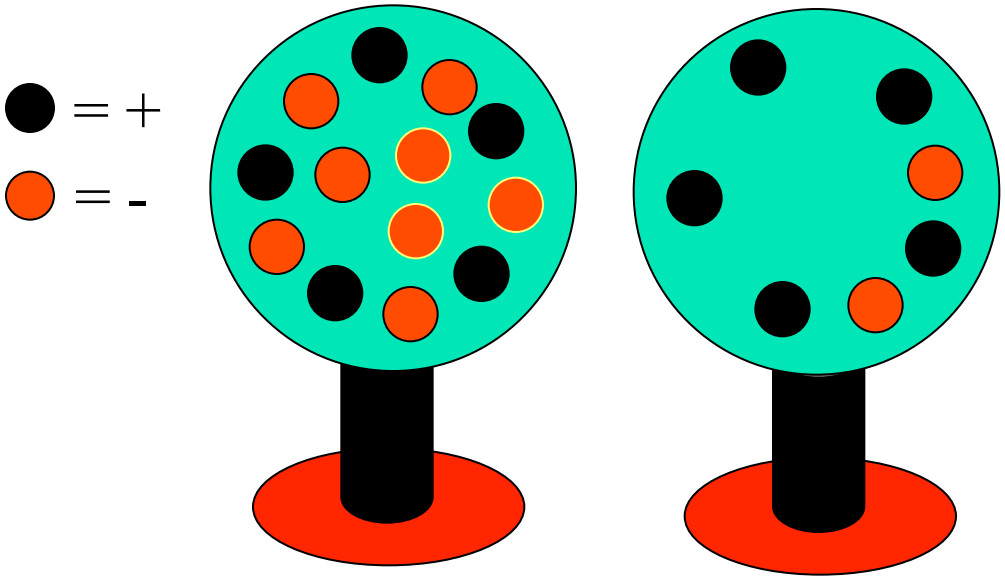
Charging by Induction

- Here is how it works:
- Now, I move the left-hand sphere away from the right-hand sphere, while the charged object is still nearby



Charging by Induction

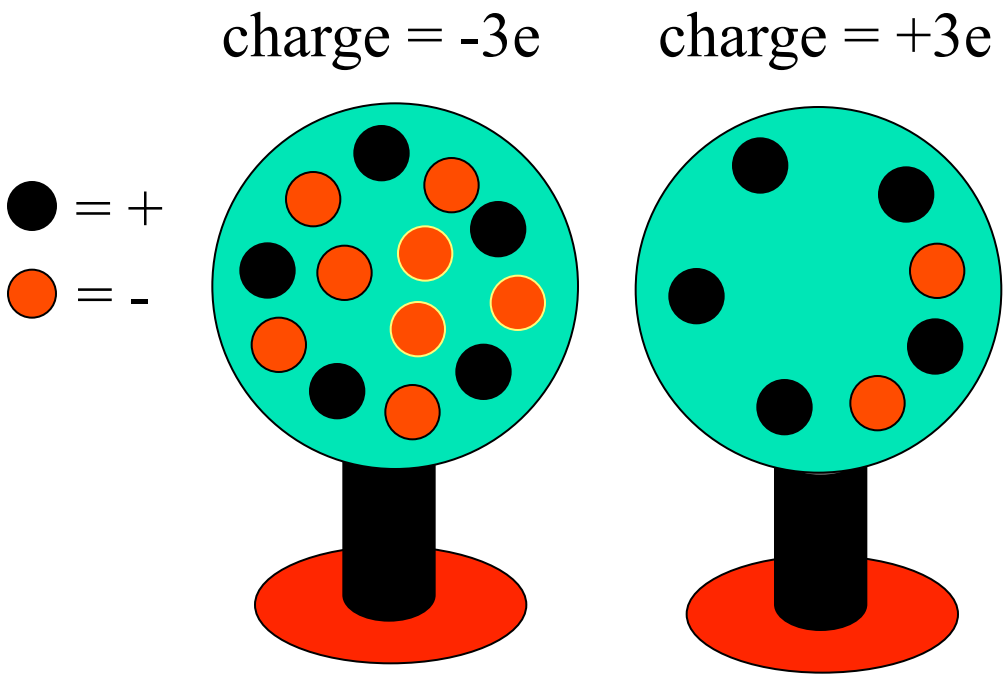
- Now I can take the charged object away
- Notice what happens - - -



- The left-hand sphere has three extra electrons (charge = -3e)
- The right-hand sphere has lost three electrons (charge = +3e)

Charging by Induction

- Both objects are now charged!!!
- Without either one making contact with the charged object

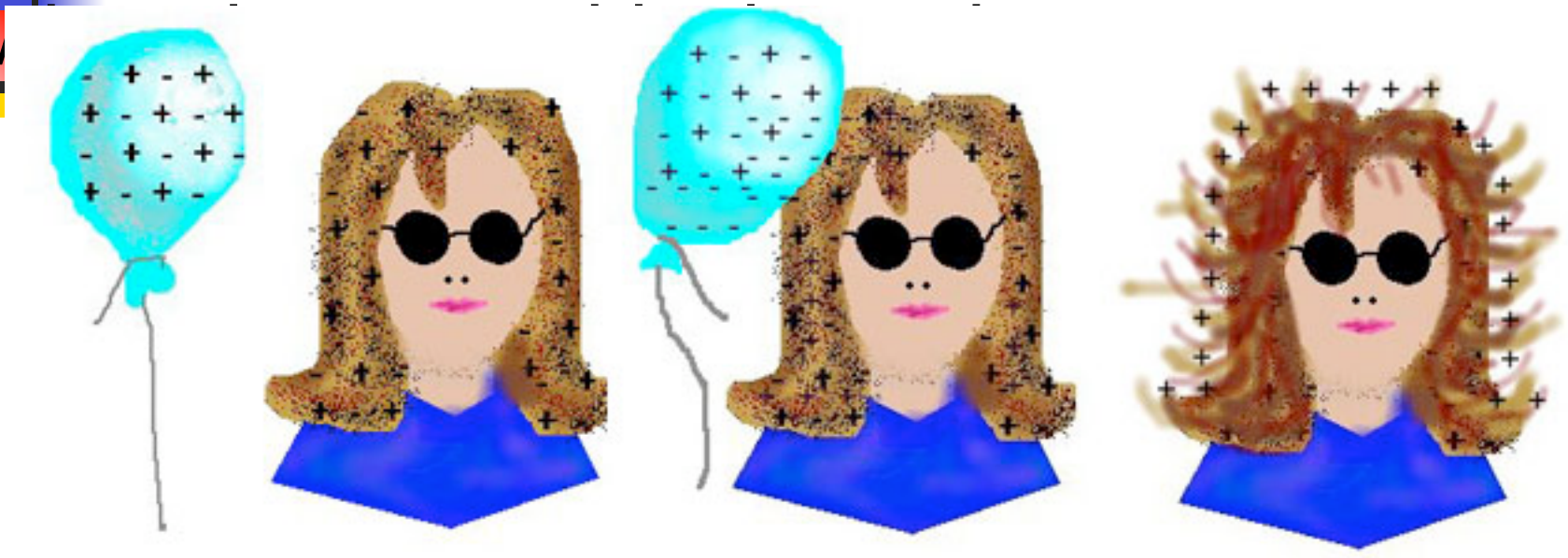


- The net charge between the two is still 0
- This is because electric charge is conserved - all charge gained by one is lost by the other!

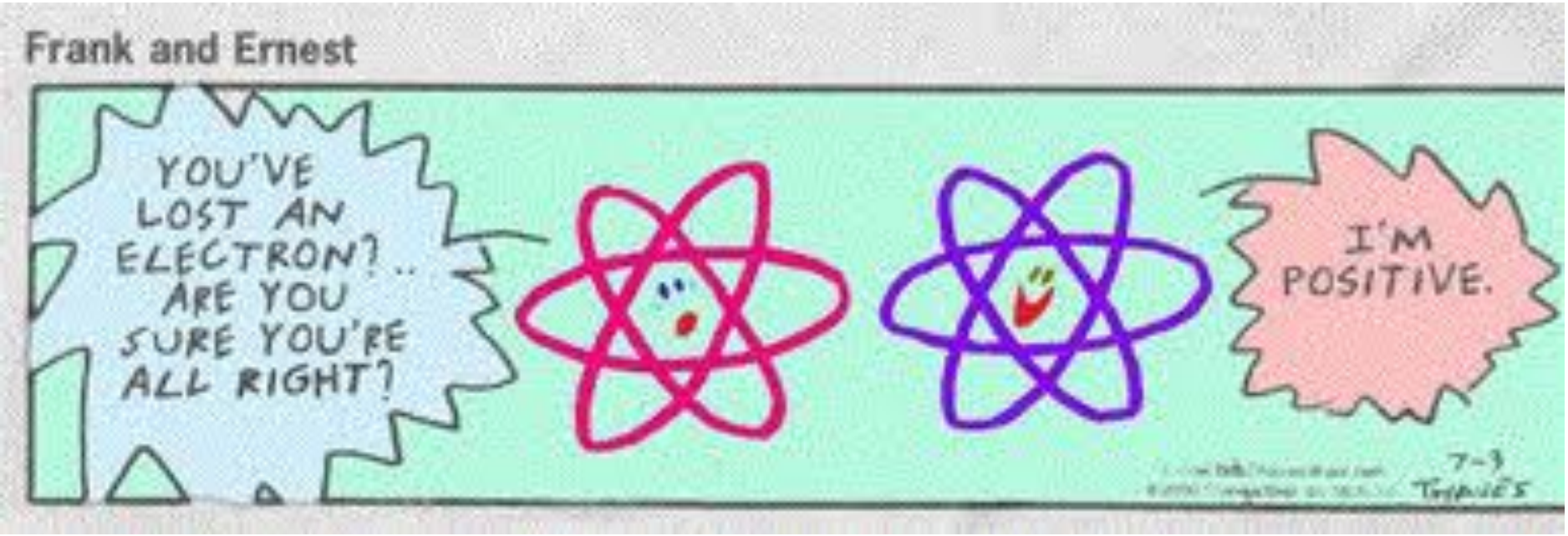
Late at night, and without permission, Reuben would often enter the nursery and conduct experiments in static electricity.

Charging by Contact – Friction

Charging by Friction: the transfer of electrons between two different neutral objects

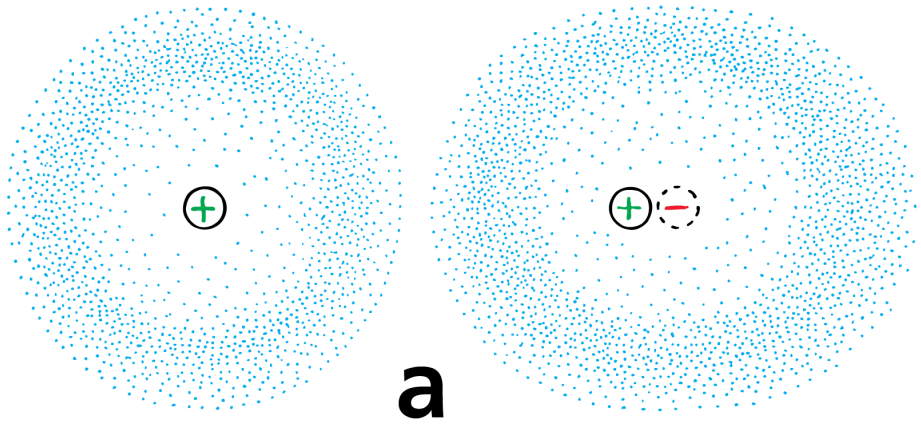


charging by friction video


Frank and Ernest
YOU'VE LOST AN ELECTRON? .. ARE YOU SURE YOU'RE ALL RIGHT?
I'M POSITIVE.

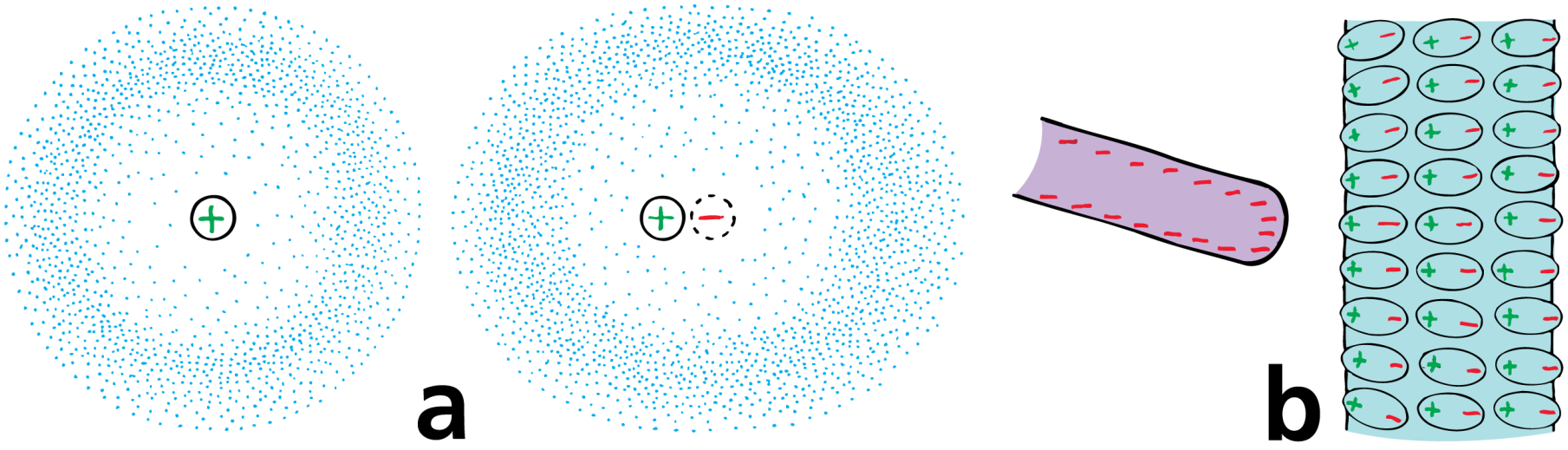
Charge Polarization

a. When an external negative charge is brought closer from the left, the charges within a neutral atom or molecule rearrange.



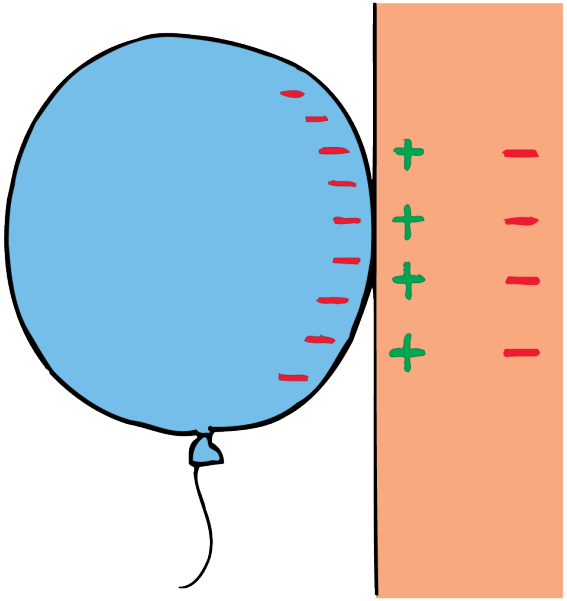
Charge Polarization

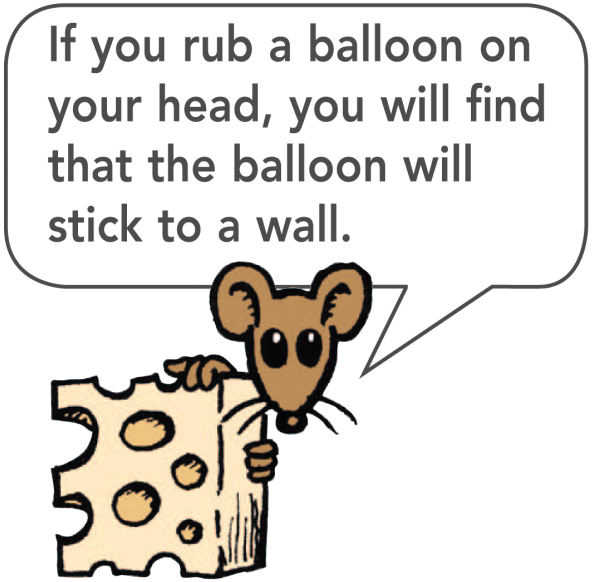
a. When an external negative charge is brought closer, the charges within a neutral atom or molecule rearrange.
b. All the atoms or molecules near the surface of the insulator become electrically polarized.



Charge Polarization

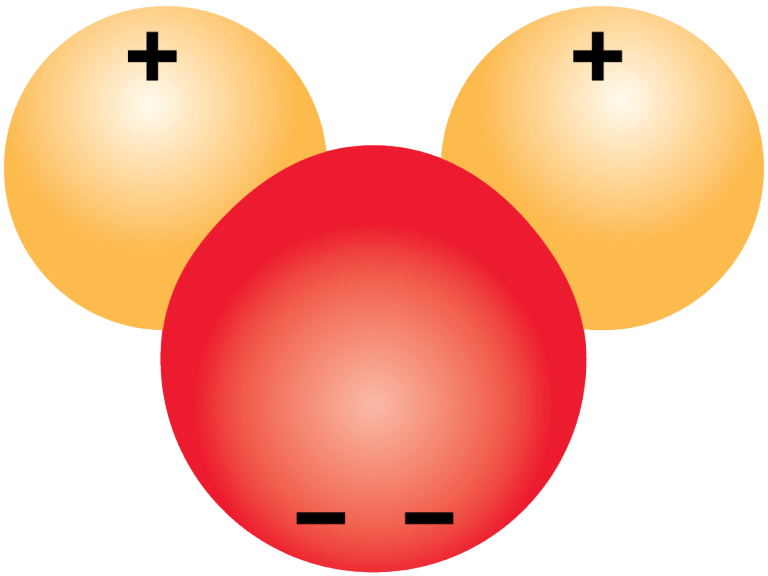
Rub an inflated balloon on your hair and it becomes charged.
Place the balloon against the wall and it sticks.
The charge on the balloon induces an opposite surface charge on the wall. The charge on the balloon is slightly closer to the opposite induced charge than to the charge of the same sign.





Charge Polarization

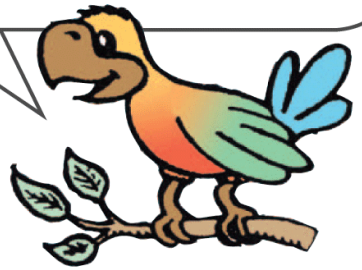
Electric Dipoles



Many molecules—H_2O, for example—are electrically polarized in their normal states. The distribution of electric charge is not perfectly even. There is a little more negative charge on one side of the molecule than on the other. Such molecules are said to be *electric dipoles.*

Charge Polarization

Be glad that water is an electric dipole. If its opposite ends didn't attract different ions, almost all the chemistry that occurs in aqueous solutions would be impossible. Three cheers for the electric dipole nature of the water molecule!



Grounding

- Grounding (verb) = the process of removing the excess charge on an object by means of the transfer of electrons between it and another object of substantial size

- Ground (noun) = an object which serves as a seemingly infinite reservoir of electrons

- When a charged object is grounded, the excess charge is balanced by the transfer of electrons between the charged object and the ground

Coulomb

- Unit of electric charge
- Named for Charles Coulomb, a French physicist
- Abbreviated “C”
- 1C = the charge of 6.25 billion billion (6.25×10^{18}) electrons

Coulomb's Law

- For charged particles or objects that are small compared to the distance between them , the force between the charges vary directly as the product of the charges and inversely as the square of the distance between them.
- The electric force between charges may be calculated using Coulomb's law.

F= the electrical force between any two objects

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

d=distance between the charged particles

q_1= quantity of charge in one particle (measured in coulombs)

q_2=quantity of charge in another particle

k= electrostatic proportionality constant

($k=9.0 \times 10^9\ Nm^2/C^2$)

Understanding what Coulomb's Law means:

- The interaction between charged objects is a non-contact force which acts over some distance of separation.

Question 1

- Doubling the distance between two charges results in a force ___ as big.
  a) 1/2
  b) 1/3
  c) 1/4

Question 1

- Doubling the distance between two charges results in a force ___ as big.
  a) 1/2
  b) 1/3
  c) *1/4*

Question 2

- Tripling the distance between two charges results in a force ___ as big.
  a) 1/3
  b) 1/6
  c) 1/9

Question 2

- Tripling the distance between two charges results in a force ___ as big.
  a) 1/3
  b) 1/6
  c) *1/9*

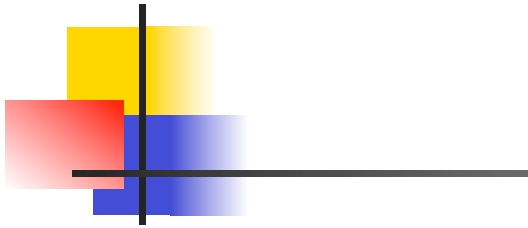

No. I said
electric fields
not fences!

E field magnitude

- The magnitude or strength of an electric field in the space surrounding a source charge is related directly to the quantity of charge on the source charge and inversely to the distance from the source charge.

E fields (electric field)

- A region around a charged particle or object within which a force would be exerted on other charged particles or objects.
- the electric force per unit charge
- Units: N/C



$$\textbf{E-field} = \frac{\textbf{Force (e-field)}}{\textit{quantity of charge}}$$

For electricity, this becomes …

$$\mathbf{E} = \frac{\mathbf{F}_e}{q}$$

E field Direction

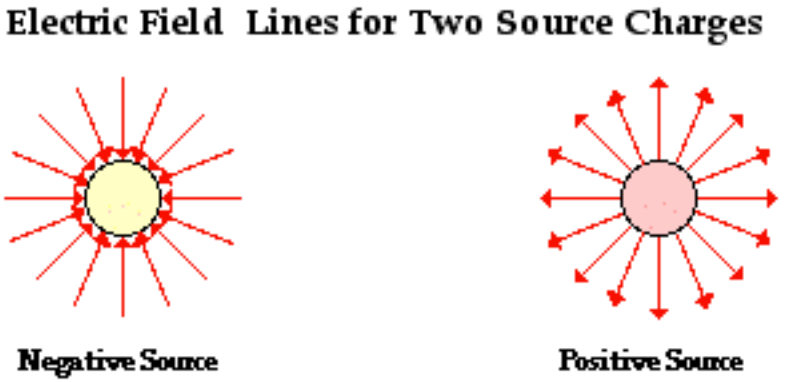
- The direction of the electric field is always directed in the direction that a positive test charge would be pushed or pulled if placed in the space surrounding the source charge

Electric Fields Are vector Qty

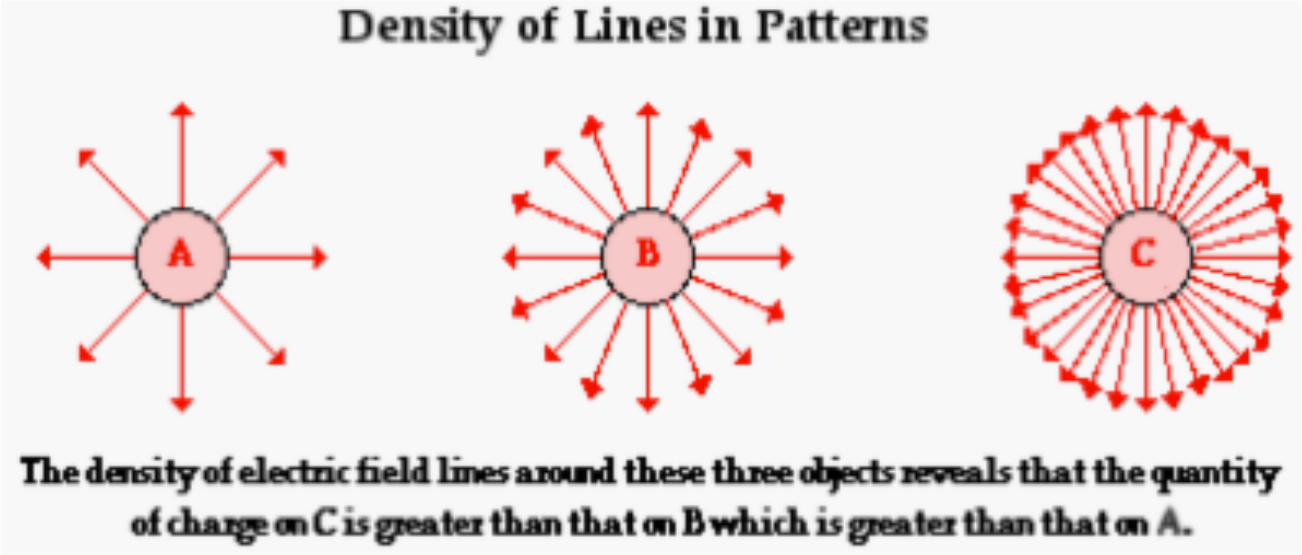
- electric field is a vector quantity, thus, represented by a vector arrow.
- the arrows point in the direction of the electric field and their length is proportional to the strength of the electric field at that location.
- the lengths of the arrows are longer when closer to the source charge and shorter when further from the source charge.

Direction of E-field

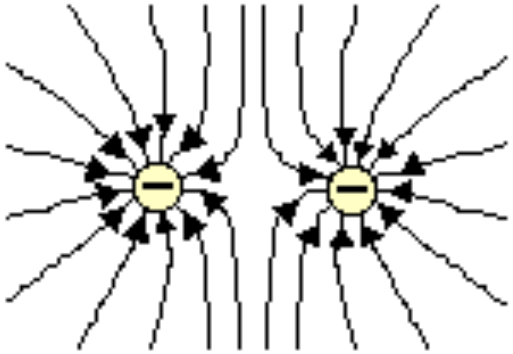
- **electric field lines**, point in the direction that a positive test charge would accelerate if placed upon the line



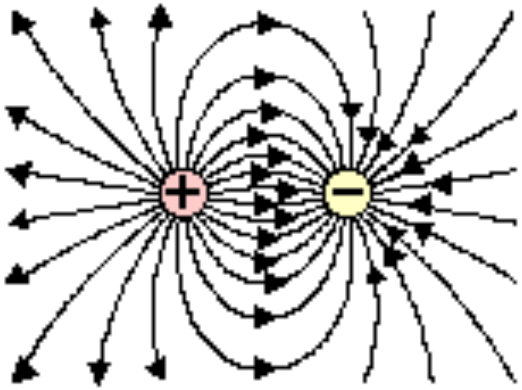
How do I illustrate different amount of charge on a particle?



Ho do I illustrate attraction and repulsion?

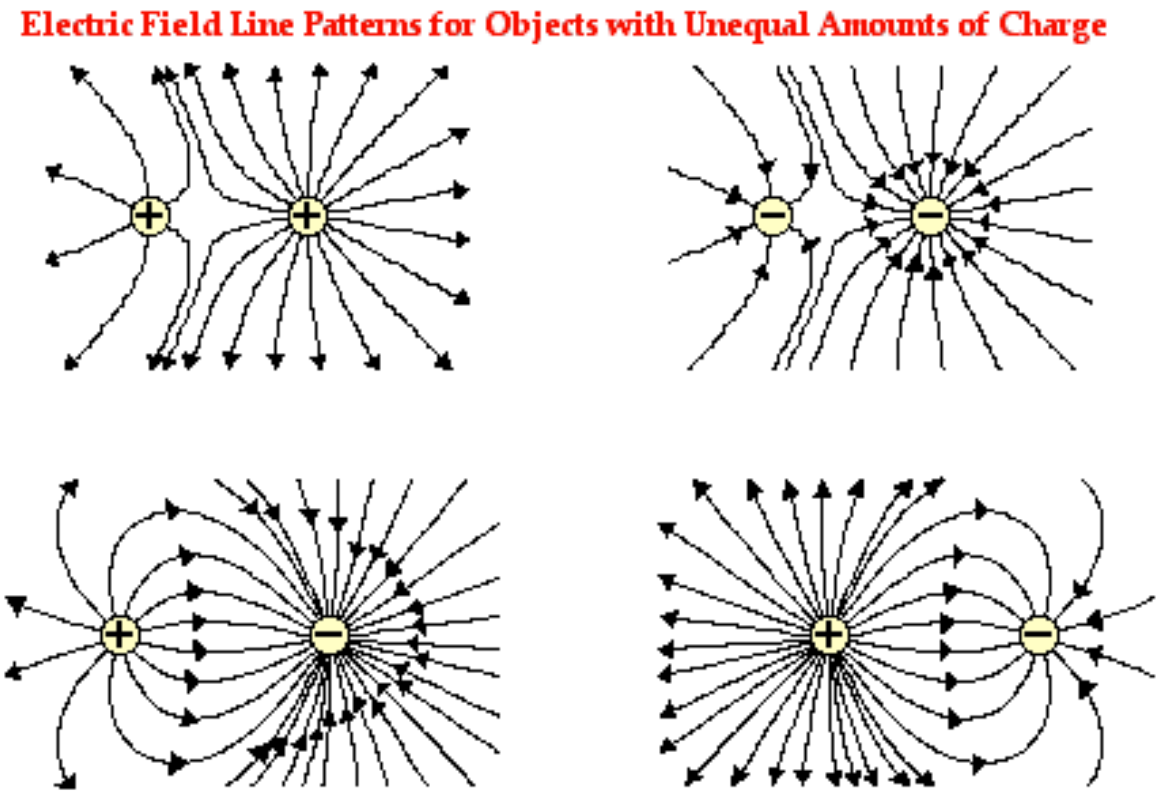


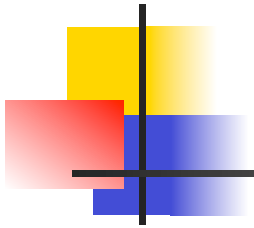
Two Negatively Charged Objects



A Positively and a Negatively Charged Object

How do I illustrate different quantities of charge?





- Read p 563- 565
- P 565 # 1-5