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Lesson 3.4: Electric field

Figure 1 Electric charges on each strand of hair exert a repulsive force on the other strands, causing the hair to rise and spread out.

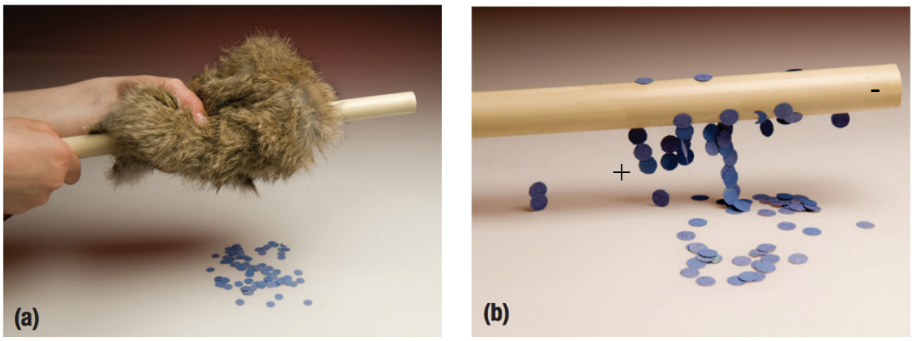
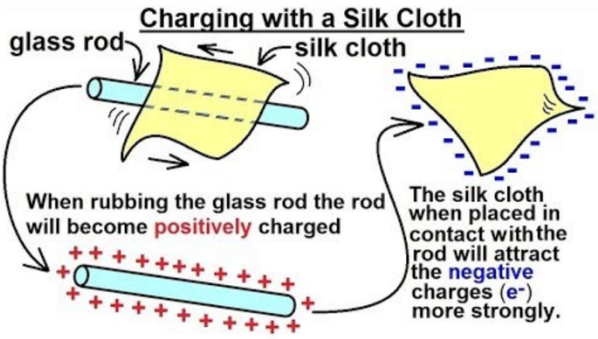


Figure 2 When a plastic rod is rubbed with fur (a), the rod acquires an electric charge. (b) The charged rod attracts small bits of paper and other objects.



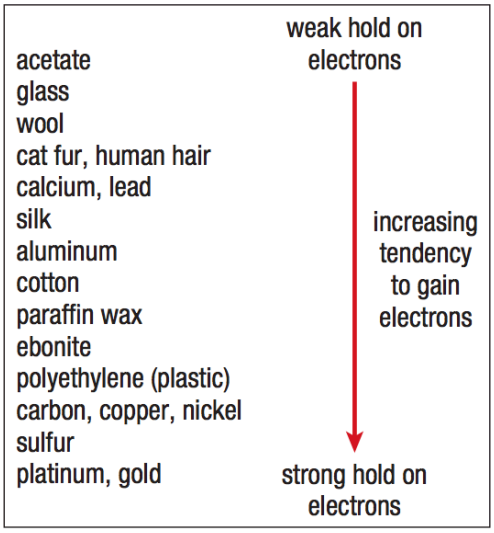


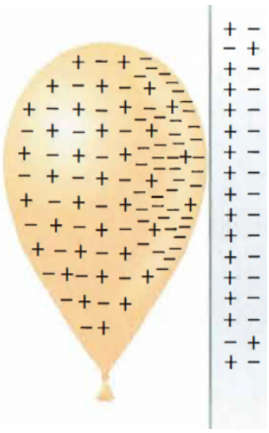
Figure 5 The electrostatic series

- **Charging an object by friction**

- **Charging an object by induced charge separation:** bring a charged object closer to a neutral object, ending up to be attractive. However, once charged object is moved away, the electrons in neutral object return to its original positions.

Figure 3.12 This diagram shows why a charged balloon sticks to an electrically neutral wall.

The negative charges in the wall are pushed away from the surface by the negative charges on the balloon. Then the positive ends of the molecules in the wall are attracted to the negative charges on the balloon. These forces of attraction are strong enough to hold the balloon to the wall.



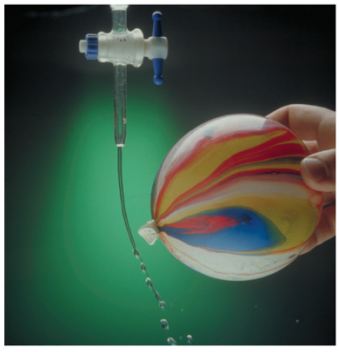


Figure 7 A stream of water is deflected by a nearby charged balloon.

- **Charging by contact (or charging by conduction):** happens when two objects touch, the charge on both objects will mostly balance.

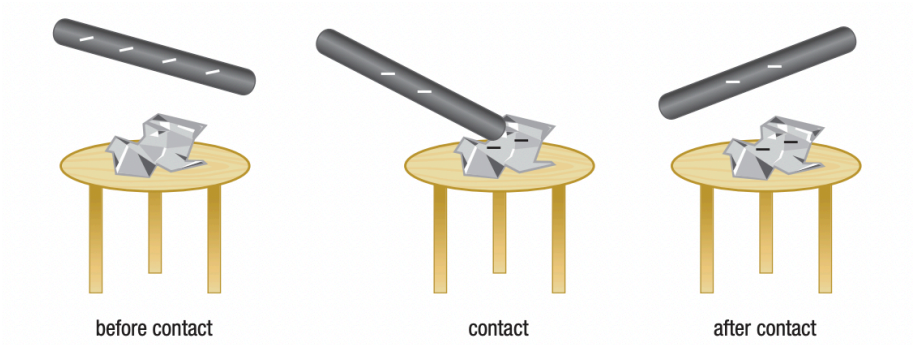


Figure 8 If one charged object touches a second object, the second object will usually acquire some of the excess charge. Hence, the second object is charged by contact. The stand in this illustration is an insulating stand.

- **Grounding:** Connect an object to the Earth. Earth is so large that it can absorb or supply enough charge to make any object neutral. For example, grounding wires direct excess charges away from users to protect them from electric shock.

- **Charging by induction**: Combination of induced charge separation and grounding.

  For example, first to bring a negative rod near a neutral metal, so negative electrons in the metal move away and then undergo grounding (i.e., electrons flow to the ground), once it is disconnected with ground, metal is left with excess positive charges.

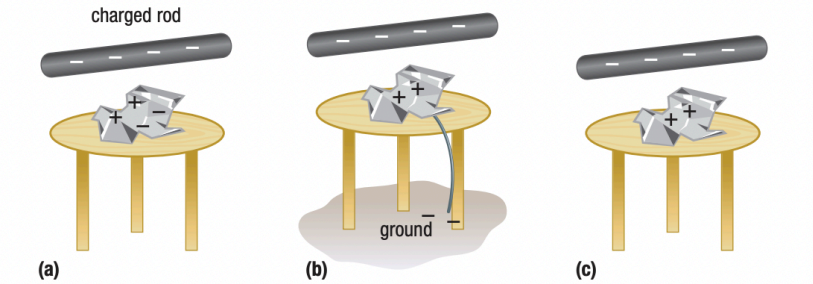


Figure 9 An object can be charged by the process of induction. (a) The object is first brought near a charged rod, separating the charges on the object. (b) The object is then connected to a ground; some electrons flow between it and the ground. (c) The object is left with an opposite excess charge when it is disconnected from the ground.

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Coulomb's Law (Chapter 7.2)

$F_E = k\frac{q_1 q_2}{r^2}$, $k = 8.99 \times 10^9 N \cdot m^2/C^2$ (Coulomb's constant)

- The electric force depends on both the amount of charges.
- Each electron, e^-, carries $-1.60 \times 10^{-19} C$; whereas each proton carries $+1.60 \times 10^{-19} C$.

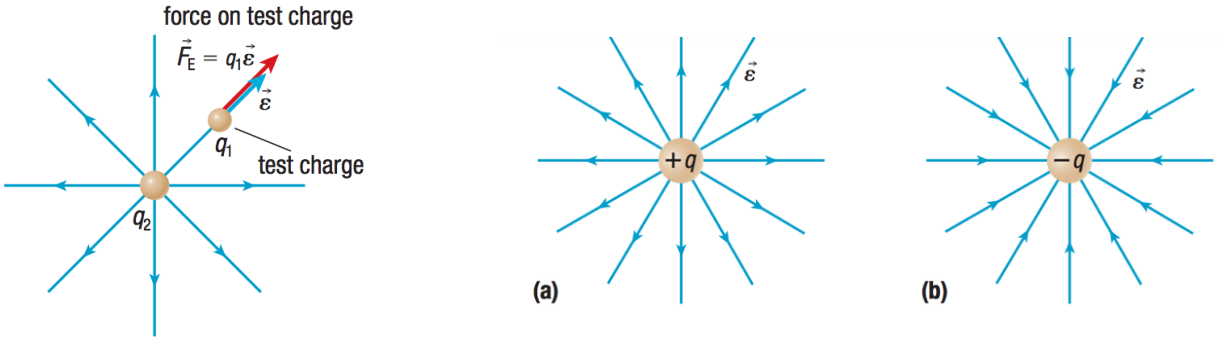
Example 1: Two charge, $q_1 = -2.00 \times 10^{-6} C$ and $q_2 = -1.80 \times 10^{-5} C$, are separated by a distance, L, 4.00 *m*. A third charge, $q_3 = +1.50 \times 10^{-6} C$, is placed somewhere between q_1 and q_2 where the net force exerted on q_3 by the other two charges is zero. Determine the location of q_3.

Read sample problem 3 on Textbook pg331, then practice pg333. #6, 7, 9

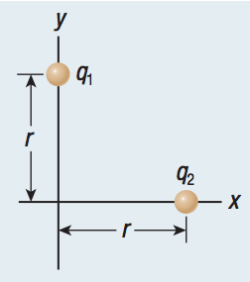
Electric Field on a Single Charge (Chapter 7.3)

$\vec{\varepsilon} = \frac{F_E}{q_1}$ (Unit: N/C) and $\vec{\varepsilon} = \frac{kq_2}{r^2}$.

- Electric field is a region in which a force is exerted on an electric charge, similar to gravitational field.
- If q_2 is the charge who creates electric field and q_1 is the positive test charge where you can place it anywhere, then the magnitude of electric field only depends on the amount of point charge q_2 and distance of the field from the charge.
- If the point charge is positive, the electric field lines are directed outward.
- If the point charge is negative, the electric filed lines are directed inward, toward the charge.

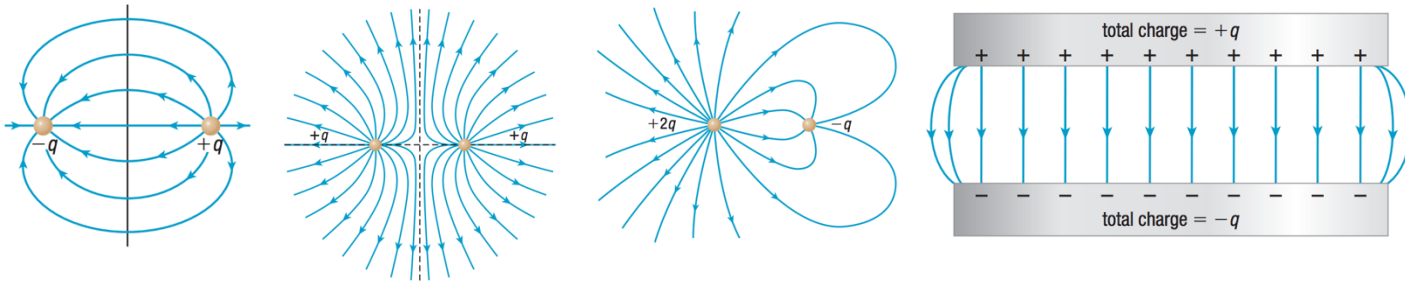


Example 2: Two point charges are arranged as shown. $q_1 = 4.0 \times 10^{-6}C, q_2 = -2.00 \times 10^{-6}C$ and $r = 3.0cm$. Calculate the magnitude of the electric field at the origin.



Electric Field line (Chapter 7.3): Continuous lines that show the direction and strength of electric force in a field.

The following pictures show the way of drawing electric filed between **two point charges** or **parallel conducting plates**.



Picture 1: A **electric dipole** that contains a pair of equal and opposite electric charges with centres separated by a small distance. Along the vertical axis midway between the two charges where two fields merge, the electric field is <u>parallel</u> to the line connecting the two charges.

Picture 2: Showing an electric dipole with two equal charges, the line repel instead of merging. Electric field is <u>zero</u> along the line that bisects the line connecting the charges. Also, at a large distance from the two charges makes it look like a field radiating from a single point charge.

Picture 3: Showing an electric dipole with different charges. Since the number of field lines for each charge is proportional to the magnitude of that charge. So Half of these lines converge on negative charge, while the other half radiate outward.

So the strength of the electric field varies with the number of charges, their placement, and the distance from the charges.

Picture 4: Two parallel plates, one contains evenly distributed positive charges, one contains all negative charge, then inside the plane, the electric filed extends straight from the +ve plane of charge to the -ve plane and is uniform. The magnitude of this special type of electric filed depends only on the amount of charge, the area of the plates, and the material between the plates.

Practice: Textbook pg345. #1, 2, 3, 4, 5, <u>6, 7</u>