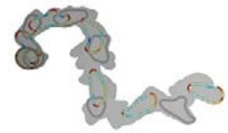
Physics 131- Fundamentals of Physics for Biologists I



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Electrical forces

Movie: Volcanoe lighning

Outline

- Polarization
- Coulomb's law
- Electric Fields

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Model: Charge
A hidden property of matter

- Matter is made up of two kinds of electrical matter (positive and negative) that have equal magnitude and that cancel when they are together and hide matter's electrical nature.
- Matter with an equal balance is called <u>neutral</u>.
- Like charges repel, unlike charges attract.
- The algebraic sum of postive and negative charges is a constant (i.e, $N_{+}- N_{-}$ = const.)

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Conductors and Insulators

- Insulators
  - In some matter, the charges they contain are bound and cannot move around freely.
  - Excess charge put onto this kind of matter tends to just sit there.
- Conductors
  - In some matter, charges in it can move around throughout the object.
  - Excess charge put onto this kind of matter redistributes itself or flows off (if there is a conducting path to ground).
- Unbalanced charges attract neutral matter (polarization)

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Example of charging in Insulators: Volcano lightning

- Watch movie
- Explain lightning

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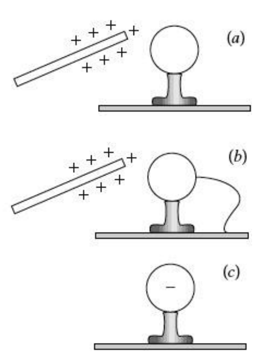
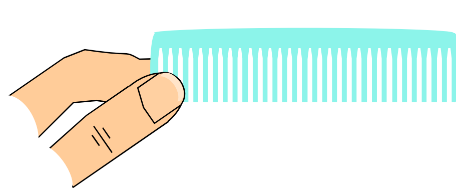
<u>Example of Charging in a conductor:</u>
A + charged object is placed near a conductor attached to an insulating pedestal (see Fig a). After the opposite side of the conductor is grounded for a short time (Fig b), the conductor becomes negatively charged (Fig c). Based on this information, we can conclude that within the conductor

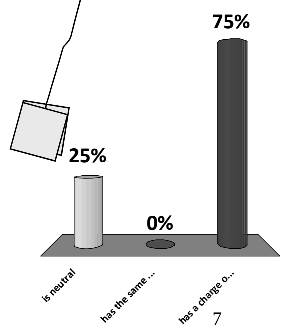


1. both + and - charges move freely
2. only - charges move freely
3. only + charges move freely
4. We can't really conclude anything

A student suspends a small piece of aluminum foil by a light insulating thread, holds the foil between her fingers for a moment, then releases it. The aluminum foil is then attracted towards a charged comb. Before it actually touches the comb, the foil most likely__________.

1. is neutral
2. has the same charge as the comb
3. has a charge opposite to the comb's





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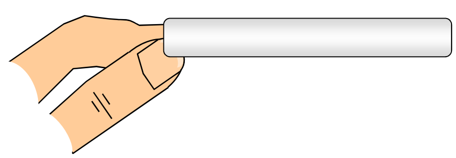
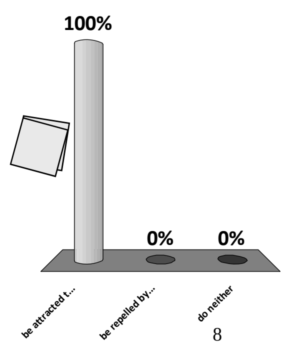
A small piece of aluminum foil suspended by a light insulating thread is attracted towards a charged comb. Suppose that instead of the comb you used a glass rod, which is charged oppositely to the comb. In this case, the aluminum foil would ____________ .

1. be attracted towards the glass rod
2. be repelled by the glass rod
3. do neither





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Question: "If neutral objects are composed of equal parts positive and negative charges, why isn't it possible for neutral objects to repel charges? Or, why can't nothing happen?"

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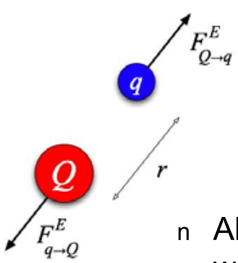

Foothold idea: Coulomb's Law

- All objects attract each other with a force whose magnitude is given by

$$\vec{F}_{q\to Q} = \frac{k_C qQ}{r_{qQ}^2}\hat{r}_{q\to Q}$$

- k_C is put in to make the units come out right.

$$k_C = 9\times 10^9 \text{ N-m}^2/\text{C}^2$$

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What’ s this?

- Hint: It’ s an animal.
- Hint: It’ s not oriented right.

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How about this way?

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Making sense

- Does this help?

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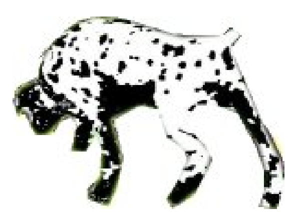
Making sense

- Our equations don't just provide a way of calculating something: They express relationships about the physical world.
- We have to "see the dog" in our equations.



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Making Sense of Coulomb's Law

- Changing the test charge
- **Changing the source charge**
- **Changing the distance**
- **Specifying the direction**
- **Use Subscripts!**

$$\vec{F}_{Q\to q} = \frac{k_C qQ}{R^2}\hat{r}_{Q\to q}$$

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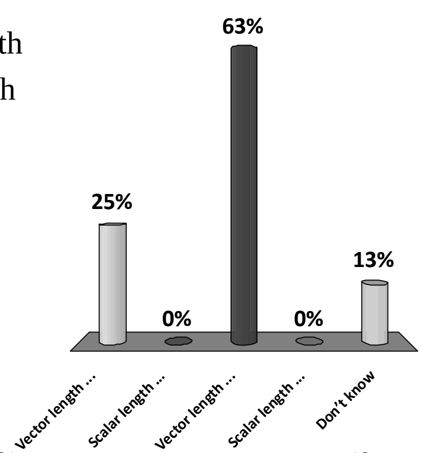
What does $\hat{r}$ mean?

1. Vector length 1, dimension length
2. Scalar length 1, dimension length
3. Vector length 1, dimensionless
4. Scalar length 1, dimensionless
5. Don't know



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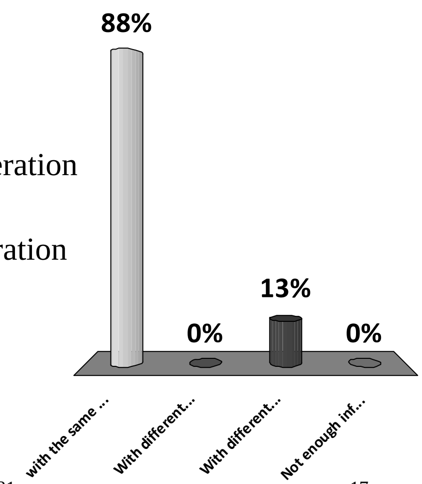
Questions: When two objects with the same sign of charge but different magnitudes are put together, they accelerate _____?

1. with the same acceleration
2. With different acceleration - Larger charge has higher acceleration
3. With different acceleration – Smaller charge = higher acceleration
4. Not enough information



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