Charging by Induction and Conduction

TA's signature allowing you to take the quiz or leave _____

Your Name _____

Partners' Names _____

_____

Obtained reasonable experimental results?	yes ☐
Answered questions?	yes ☐
Cleaned your table?	yes ☐

Introduction

Electric charges have positive and negative ones. Between the charges, electric forces are created. Unlike charges, namely a positive and a negative charge, acquire a attractive force, but like charges repel one another. This is a different property from the gravitational force because gravity has only attractive forces.

As a universal principle, the net charge of a closed system is always conserved. In a word, the total charge must be constant any time. Charges are induced or conducted by the other charges. Induction of charges is to attain the opposite charge by bringing a positively / negatively charged object near to it. Conduction of charges is to contact a charged object to the other object to transfer or neutralize the charges. Magnitude of the elementary charge is:

$$|e| = 1.602 \times 10^{-19}\ \text{C}$$

The unit of charge is called the coulomb (C). One electron and one proton have -1.602×10^{-19} C and $+1.602 \times 10^{-19}$ C, respectively. There is so called alpha particle which is the nucleus of a helium. It contains two protons and two neutrons. The neutron has no charge; therefore, the charge of alpha particle is $+2 \times 1.602 \times 10^{-19}$ C.

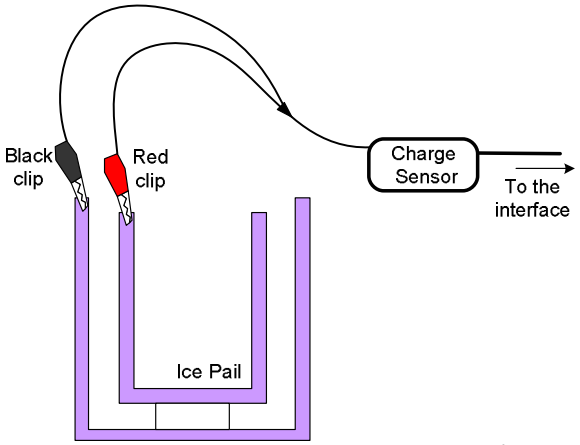
We now understand what the properties of charges are, but how do we create charges in the first place? Charge creators called wands are electrically neutral initially. By rubbing their surfaces, the certain charges are transferred to the other. This process is known as triboelectric charging. Some materials can be charged more positively. For example, rabbit fur tends to obtain more positive charges and Teflon likely obtain more negative charges by this process. In nature, the process to have thunder can be associated with this process.

One of the famous applications of static charges is laser printers and copiers. They utilize the charges to control toner particles.

Objectives:

- To understand the properties of charges, such as attraction between unlike charges
- To see how charges are induced and conducted by the charge creators (wands)

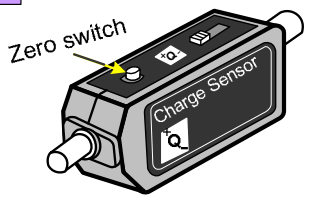
1. Inducing charges on a metal surface:



Procedure

① Start up DataStudio; click "Create Experiment"; make sure the charge sensor is plugged in the analog channel; and click the correspondent connection to select the charge sensor. Display "Digits" and "Graph."

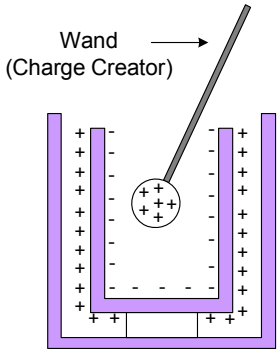
② Set up the experimentation as follows:



③ Press the zero switch of the charge sensor to reset. Click on the start button in DataStudio to make sure that the initial data is 0.

④ Pick up two charge creators called wands. By rubbing both surfaces, the electrons are ripped off and transferred into the other.

⑤ After that, one of the wands will be put inside the ice pail. Then, it induces the other charges as shown.



Conceptual Question:

What is inducing charges? Explain it more in detail by looking at the figure.

What will happen if the wand is charged negatively?

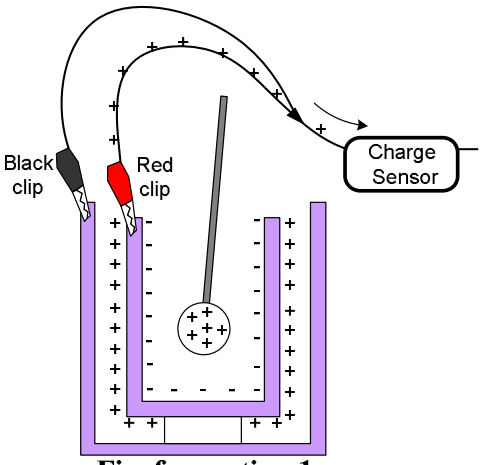


Fig. for section 1

⑥ The black clip of the charge sensor is ground, and the red clip measures the not-induced charges. In the above figure, you will find positive charges in DataStudio.

The experimental data: (ⓘ Do not delete the data run. You have to print out the graph.)

⑦ (**Reset the charge sensor.**) Click start and insert a wand into the inner cage. After a while, take out the wand and stop the measurement.

⑧ **Print it out** and label on which wand you used (blue or white).

⑨ Justify which wand gets positive or negative polarity by considering the above figure and data from the graph.

	Blue Wand	White Wand
Which polarity?		
How do you justify with the theory and experimental data?		

Question: Why does the charge become zero after you take the wand out?

2. Conducting charges on a metal surface:

① Keep the same set up. Insert one of the wands into the inner cage. After inducing the opposite charges, contact the wand with the metal cage and rub it a couple of times. Then, take the wand out. (See the figure.)

② The induced charges are neutralized by conducting the charges on the wand.

③ After taking the wand out, the net remainder charge will be positive.

④ The charge will remain.

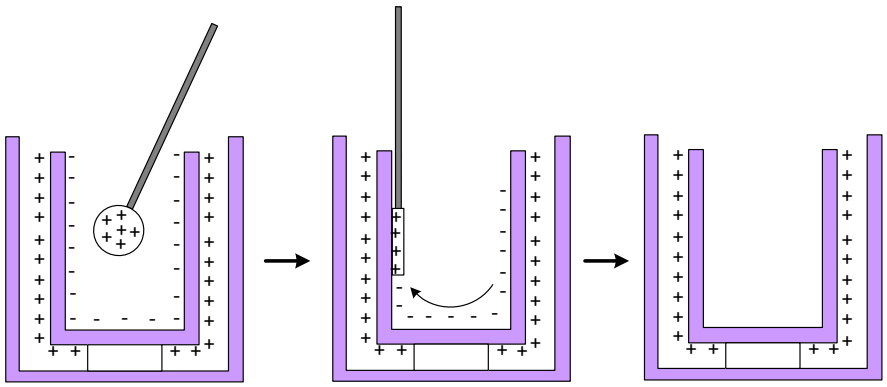


Fig. for section 2

Conceptual Question:

What is the process of conducting charges? What will happen if the wand is charged negatively?

The experimental data:

⑤ (**Reset the charge sensor.**) Click start and insert a wand into the inner cage. After 4 or 5 seconds, let the wand contact the cage. Then, take out the wand and stop the measurement.

⑥ Print it out and label on which wand you used (blue or white).

⑦ Justify which wand gets positive or negative polarity by considering the above figure and data from the graph.

	Blue Wand	White Wand
Which polarity?		
How do you justify with the theory and experimental data?		

Question: Why does not the charge become zero after you take the wand out in

3. Releasing charges by grounding

① With the same setup, a wand is inserted in the ice pail.

② Keep inducing the charges. By touching the cage, the charges not held by the wand will escape through the finger, which is grounding.

③ Keeping the wand inside, you remove your finger.

④ Take the wand out. The remaining charges will be recorded with the sensor.

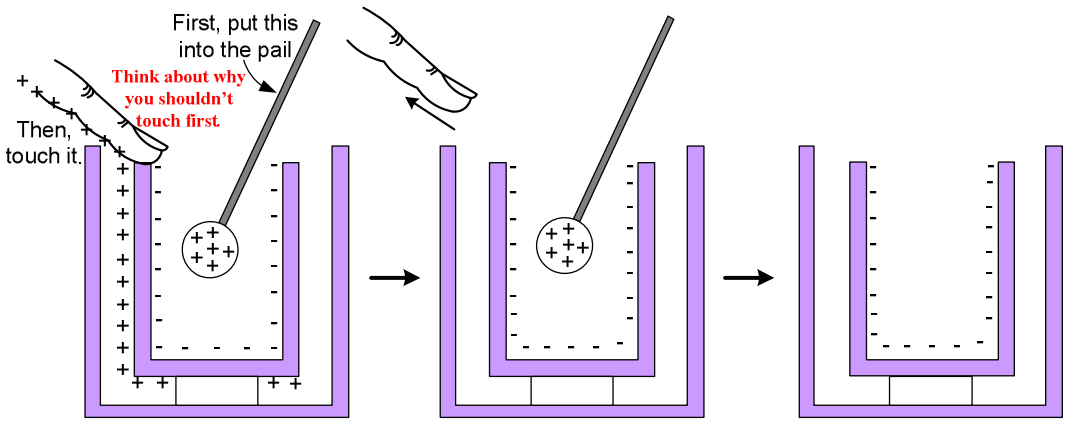


Fig. for section 3

Conceptual Question:

What is grounding charges? What will happen if the wand is charged negatively?

The experimental data:

⑤ (**<u>Reset the charge sensor.</u>** Push the zero switch.) Click start and insert a wand into the inner cage. After a few seconds, put your finger on the inner cage in a few seconds. Then, remove your finger.

⑥ After that, take the wand out of the ice pail.

⑦ Print it out and label on which wand you used (blue or white).

⑧ Justify which wand gets positive or negative polarity by considering the above figure and data from the graph.

	Blue Wand	White Wand
Which polarity?		
How do you justify with the theory and experimental data?		

Question: Why does the charge not become zero after you take the wand out in this case?