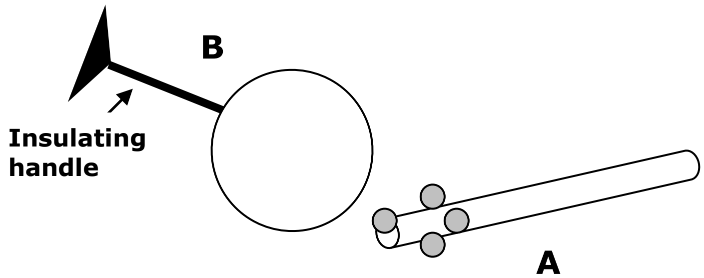
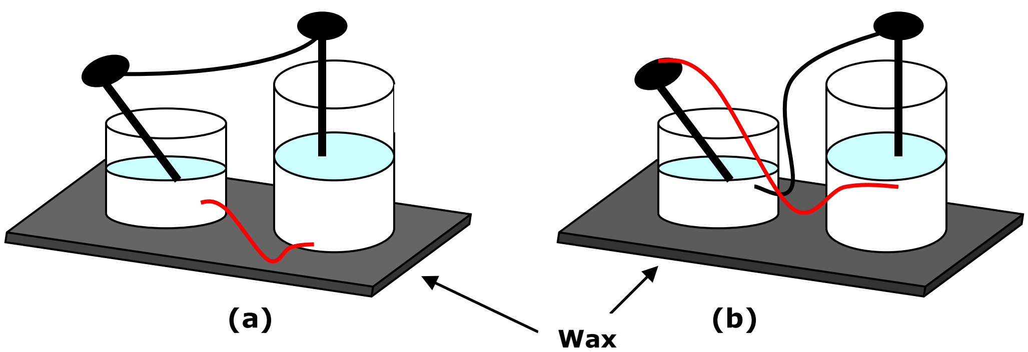
UNL2206, Nature's Threads: Tutorial 2

1) A glass rod A is charged, for example by rubbing it with a piece of fur, positively as illustrated below (where the excess positive charge is indicated by the grey circles). One end of the rod is then brought close to a neutral sphere B.



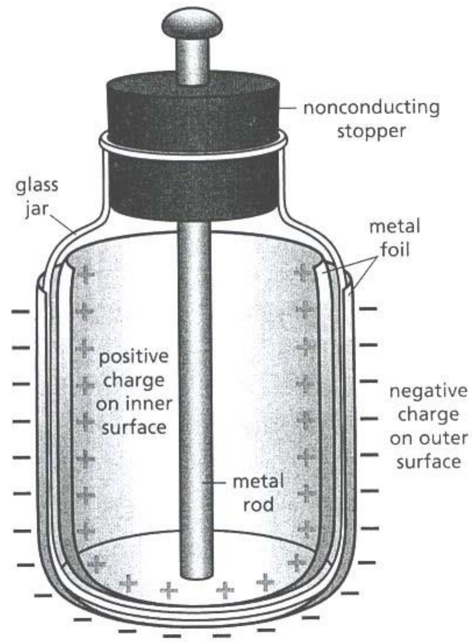
Sketch and explain the charge distribution that you expect to result on B for the cases where a) the sphere is made out of insulating material, and b) is a conductor. The end of A touches B – what is the charge distribution on B now? What happens if instead the opposite end of A is brought close to B?

2) Two Leiden jars carry +40 Coulombs and +10 Coulombs of electric charge on their outer surfaces respectively. When they are connected in series as illustrated in (a) below, the larger jar has a capacity to store 60% of the total charge. What is the charge that resides on each of the jars in (a)?



The jars in (a) are disconnected (without being discharged) and then re-connected as shown in (b): what is the final charge on each jar now?

3) A Leiden Jar is an old-fashioned capacitor or condenser as these are sometimes called (because they ‘condense’ or collect electric charge). One version is illustrated below.



The energy stored in a charged Leiden Jar is actually stored

a) on the metal foil inside the jar
b) on the metal foil outside the jar
c) in the glass between the inner and outer foil
d) inside the jar itself

4) If the average current in a bolt of lightning is 120,000 A, and it lasts for 2 x 10^{-4} s, how much charge does the lightning bolt transfer? Assume that, just before the strike, the potential difference between the storm clouds and the Earth’s surface is 2 million Volts. What would be the electrical power contained in this single lightning bolt?

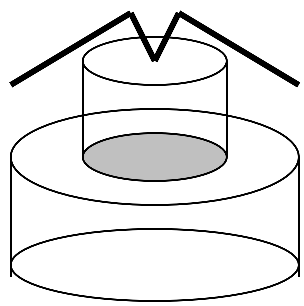
5) Why do storm clouds often cause static on phone lines, sometimes great enough to “blow” poorly protected and sensitive electrical equipment (modems for example) connected to phone lines?

6) A voltaic cell is rated at 2 V. A slow discharge through a resistor involves a nearly constant current of 0.1 A, which suddenly stops after 80 minutes. Find: (a) the resistance of the resistor; (b) the rate of energy dissipation; (c) the total energy dissipated; and (d) the “charge” on the voltaic cell.

7) Describe the response of the other charge carriers to the insertion of a single charge carrier within (a) a glass beaker containing salt solution and (b) a piece of copper wire sitting on an insulating surface.

For the following, form groups of 3-4 students. Each group should assemble the home-made devices outlined, perform the corresponding 'experiments' described below (and any further ones they can think of) noting carefully the various outcomes. Bring your working devices to class; groups will be expected to report on their collective results to the tutorial class.

8) Constructing a simple version of Gilbert's ***versorium***.
Obtain a 'twister' (as used to keep bread or fruit and vegetables in plastic bags) and bend it into a W–shape with long arms as indicated. Place the twister on top of a small glass bottle or other insulating object so that it is well balanced (this will require minor adjustments of the shape of the twister; if the bottle top is not smooth, place a piece of sticky tape on it). If this arrangement does not appear work well, you could instead try using a narrow strip of aluminum foil that is attached to an eraser by means of a pin and is free to pivot about the pin. Can you think of other possibilities?



A Simple *VERSORIUM*

a) Bring a rubbed comb near to one end of the *versorium* and observe its response. Repeat for the other end. Next, try rubbing a piece of styrofoam against your clothing and bring it up to the *versorium.* Take a piece of sticky tape and stick one side to a tablecloth; then quickly pull it off the table cloth and determine the response of both ends of the *versorium* to the tape.

b) Place a piece of writing paper between the *versorium* and a distant charged comb. Bring the comb nearer and observe how the *versorium* responds. Remove the paper and observe how the *versorium* responds now. Repeat using a paper napkin or toilet paper instead of writing paper. Repeat with a double thickness. Repeat with wet paper. Repeat with a piece of aluminum foil, and with a plastic bag. At least one of these materials should <u>not</u> screen.
(In fact, use of the term screening is somewhat misleading: in response to the charge on the comb, a redistribution of charge occurs on the screening material (for a conductor, by electrostatic induction; for an insulator, by polarization). This tends to cancel the effect of the charge on the comb.)

c) Cut a 5 cm piece of sticky tape, touching it as little as possible (to minimize charging). Ensure that it is uncharged by waiting a few minutes, or by moistening it and then gently blowing on it to speed up the drying. Test it for no charge with the *versorium*. Then stick the tape to one side of a small coin (the smaller the coin the better so as to have the tape cover its edges). Rest the tape side of the tape-coin combination on an insulating surface. With one hand, hold the edges of the tape in place (don't touch the coin). With your other hand, rub the coin with a piece of styrofoam, plastic, or bubble packaging. Lift up the tape-coin combination, and test the coin for charge with the *versorium*. Note that if you touch the coin, you draw off its charge, and the effect is not seen.

10) Rub your comb, and then wrap a string around a few of its teeth and tape them together. (Or just use a comb and sticky tape to secure the string.) Suspend the string from a door frame, so the comb can move horizontally. Determine the response of the comb when you bring your finger up to it.

11) Cut two 15 cm long strips of sticky tape (label them T1 and B1), and place the sticky side of T1 on top of the non-sticky side of B1. Pull them apart. Do they attract or repel? Is each attracted to your finger? (This is explained by electrostatic induction of your finger, if each tape is charged.) Stick the tape ends to the edge of a table.

Prepare another set, labeled T2 and B2. Record how the six combinations of pairs of tapes interact (attraction or repulsion). Stick the ends of the tape to the edge of a table, a few inches apart. Rub a comb through your hair, and determine how the comb interacts with each tape. Rub the side of a piece of styrofoam against your clothes and determine how it interacts with each tape. Determine the sign of T1, and so on under the assumption that the comb is "resinous" or negatively charged.