A Low Tech Look At Electrostatic Interactions

Introduction
Throughout the 17th, 18th, and 19th centuries, significant experimental and theoretical understanding of electricity and magnetism developed through the endless toil of a host of scientists. This culminated in the work of James Clerk Maxwell, who synthesized the previous work, unified the electric and magnetic field into the electromagnetic field, and discovered the nature of light. However, much of the work through these centuries (particularly the earlier ones) concerned static fields. That is, a magnetic or electric field was created and then was not changed as its properties were explored. (The significance of time varying fields was understood only later in the period). So considerable time, trouble, money and expense were employed constructing great machines to separate charge and create the fields needed for study. So great were these devices that Benjamin Franklin was able to [deliberately] electrocute and knock down six men, each holding the hand of the next; and to kill turkeys and chickens, claiming that birds killed in this way were uncommonly tender. Our intentions are more modest (and, hopefully, less deadly).

Tasks:
1) Learn to charge and discharge an insulator, and explore the interaction of the charged object with an uncharged object.
2) Explore the interaction between two similarly charged objects.
3) Learn to imbue two insulators with opposite charge and explore the interaction between them.
4) Quantify (as best we can) the dependence of the interaction on separation distance.
5) Roughly estimate the amount of charge (and the number of uncompensated fundamental charges) deposited on our insulator.

Task 1)
Our insulator will consist of a short (~5-10") length of cellophane tape. Fold a little bit of one end over on itself to create a non-stick handle. Then affix this tape to a nearby horizontal surface (like, for example, a desk or table). Make another one just like it, and tape the second directly to the first. See the drawing and your instructor for more information. Now you’re all ready to separate some charge. Grasp the handle of the upper tape, hold down the handle of the lower tape, and pull the upper tape sharply upward. It should be hard to handle, because it will now have gobs of charge on it and will stick to everything it gets close to. Hold the tape at arm’s length and see what happens as you approach it with your free hand. Try holding various other objects composed of other materials and see how the tape reacts to each one. Make notes of whatever observations you make for each material. Finally, find some way to discharge the tape. That is, treat it so that it no longer acts like a charged tape.

Task 2)
Make two charged tapes in the same way that you made one in the previous task. See how they react when they approach each other and compare this with the way they react when approached by the various items
you investigated in task 1). Discharge one of the tapes partially and see how this affects the interaction. Partially discharge the other. See what happens. Fully discharge one and see how they interact. Finally, discharge both fully and see how the interaction is modified. Make notes on your observations.

**Task 3)**

Set up the over-and-under tape on the desk like you did in the first task. Before you lift the upper tape, however, tape a third tape to the second. Now, grab both upper handles, hold down the bottom handle, and sharply lift the other two. They should come up together. Ensure that the tape combination that came up is charged. Then discharge it. When it is fully discharged, sharply pull the two stuck together tapes apart (keep track of which one was on top). Check to see that they are charged. Determine how each interacts with the objects you considered in the first task. In what ways are the interactions the same or different? Investigate the interactions between the two charged tapes. How are they the same as previous observations? How are they different? Make another charged tape just like you did in the first task, and explore its interactions with each of the first two charged tapes. What can you conclude? Are we forced into the assumption that charge comes in two types?

**Task 4)**

Make a charged tape like you did in the first task. Then make another one. Estimate the magnitude of the force of interaction (how?) as you vary the distance between the two charged tapes. Herkemer Coulomb asserted that the variation should be as $r^{-2}$. How could you plot your results in order to check his assertion? Do so. What are your conclusions regarding the assumption of the $r^{-2}$ law? Attempt to reconcile any disagreements.

**Task 5)**

Figure out a way to calculate the amount of charge present on one of the charged tapes (hint: consider the orientation of the tape and any other forces acting on it). Discuss the assumptions you make and how they may affect your result. Use your method to calculate the amount of charge on each tape. You may be able to use the data you collected in task 4). Express the amount of charge in Coulombs and in number of elementary charges.

**Conclusion**

Prepare a report on your activities in the lab. It should include any plots of data made and a discussion of them. Also, address (in a coherent fashion) the various questions raised in these notes, as well as any others that may have arisen as you worked and talked amongst yourselves. Interpret your results in the context of Coulomb’s law of electrostatic force. Tell me how much charge was on your tape. Cure cancer.