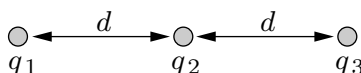
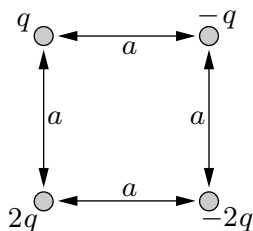


Problem Set 1
(due Friday, Aug. 28)

- (a) A positively charged glass rod attracts an object suspended from a nonconducting thread. Can you determine whether this object is charged? Please explain. (b) A positively charged glass rod repels a similarly suspended object. Can you determine whether this object is charged? Explain.
- Prepare two pieces of charged Scotch tape, as demonstrated in class. Estimate, *roughly*, how many coulombs of charge are on each piece. You will have to make a few assumptions and approximations, which you should state clearly. Be sure to describe fully the procedure you use to arrive at your estimate. (Hint: At what distance does the electrostatic attraction between the two pieces of tape balance the weight of one of them? A full spool of Scotch tape (3/4 inch by 36 yards) has a mass of about 45 grams.)
- In the figure below, three charged particles lie on a straight line and are separated by a distance d . Charges q_1 and q_2 are held fixed. Charge q_3 is free to move but happens to be in equilibrium (no net electrostatic force on it). Find q_1 in terms of q_2 .

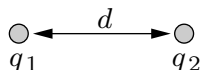


- In the figure below, $q = 1.0 \times 10^{-7}$ C and $a = 5.0$ cm. What are the horizontal and vertical components of the net electrostatic force on the charged particle in the lower-left corner of the square?

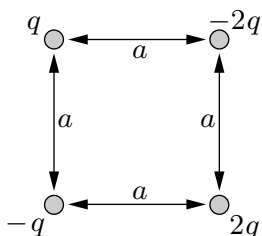


- Physicist Richard Feynman once said that if two persons stood at arm's length from each other and each person had 1% more electrons than protons, the force of repulsion between them would be enough to lift a "weight" equal to that of the entire earth. Check (approximately) whether this is true. You may assume that a person (like most forms of matter) is made up of roughly equal numbers of protons, neutrons, and electrons. The data you need is all inside the covers of your textbook.
- An electric field with an average magnitude of about 150 N/C points downward in the atmosphere near Earth's surface. Suppose you wish to "float" an object weighing 4.4 N in this field by putting a charge on the object. What charge (both sign and magnitude) would be needed? Why is this experiment impractical?

- Make a rough sketch of the electric field of a negative point charge. (Use arrows, not field lines.)
- In the illustration below, $q_1 = 1.0 \mu\text{C}$, $q_2 = 3.0 \mu\text{C}$, and $d = 10.0 \text{ cm}$. Calculate the electric field (magnitude and direction) at the point midway between the two charges. Then calculate the electric field at a point 5 cm above the midpoint. Be sure to treat the fields as vectors.



- In the figure below, $q = 10.0 \text{ nC}$ and $a = 5.0 \text{ cm}$. What are the magnitude and direction of the electric field at the center of the square?



- Thirteen identical positive point charges (each with charge q) lie on the vertices of an equilateral 13-sided polygon. The distance from the center of the polygon to any vertex is d . (a.) What is the electric field at the center of the polygon? Why? (b.) Suppose that one of the 13 charges is removed. Now what is the electric field at the center of the polygon? (Hint: There is an easy way to answer this question, without adding up the fields of the remaining twelve charges.)
- Use the EField applet (physics.weber.edu/schroeder/software/EField/EField.html) to make a field map of the electric field around a dipole (a positive and negative charge of equal strength, separated by a small distance). Print your field map. (Printing is straightforward with the Safari browser, at least on a Mac; with other browsers you'll need to do a screen capture and then print that.) Then pick two different field vectors on it and explain (with a sketch) how each of these was computed by the program.
- Use the EField applet to show that the electric field of a long, uniform line of charge falls off roughly in proportion to the distance from it (not the distance squared). Include a printout from the program, annotated with your explanation. (Use a line of point charges, not a single charge with the "Lines" option chosen.)
- Use the EField applet to explore the electric field inside and around a uniform cylindrical shell of charge. (Select the "Lines" option and then create a circle using the Patterns menu.) Attach a printout, annotated with your observations of the features of the electric field.

Study Guide for Quiz 1

You should understand the basic qualitative properties of electric charge, including the two types of charge, induced charges, charge conservation, conductors, and insulators.

Coulomb's law gives the strength of the electrostatic force between two pointlike charged objects:

$$|\vec{F}_e| = \frac{K|q_1q_2|}{r^2},$$

where q_1 and q_2 are the charges, r is the distance between them, and the constant K is $8.99 \times 10^9 \text{ N}\cdot\text{m}^2/\text{C}^2$. The SI unit of electric charge is the coulomb (C). The constant K is often written instead as

$$K = \frac{1}{4\pi\epsilon_0},$$

where ϵ_0 is another constant whose value you can figure out from this equation.

Electrostatic forces are vectors, and must be added as such (tip-to-tail, or in terms of components).

The electric field is a bunch of little arrows (vectors) that fill all of space. Each vector is the force per unit charge that *would* be exerted on a point charge q_0 if you were to put it there:

$$\vec{E} \equiv \frac{\vec{F}_{\text{on } q_0}}{q_0}.$$

The electric field created *by* a point charge q is strong near it and weak farther away; more precisely, according to Coulomb's law,

$$|\vec{E}_{\text{of } q}| = \frac{K|q|}{r^2}.$$

If q is positive, its electric field points away from it; if q is negative, its electric field points toward it.

To find the electric field created by a complicated arrangement of electric charge, you need to use the "superposition principle": find the field that would be created by each bit of charge separately, then add up all the separate field vectors to get the total field. You should be able to sketch arrows representing the electric field created by any reasonably simple arrangement of charges. You should also know how the electric field of a line or a plane of charge depends on the distance away from it: approximately proportional to $1/\text{distance}$ for a line and approximately constant for a plane, in the limit where the line or plane is very large compared to your distance from it.