Homework 2, PHYS 112 (General Physics II)
Fall 2020
Due via pdf upload to OAKS prior to Friday, September 4th at 10 AM

This will be the first "regular" homework assignment of the semester. For this, and all other homework assignments, please turn in your solutions with all supporting work; answers without supporting work will not earn credit.

You do not need to upload the sheet with the questions on it, but please clearly number your problems and circle or box your final answers.

I encourage you to collaborate with classmates to discuss how to approach a particular question, but the mathematical steps to generate your final answer on your submitted work should be your own. If I see the same simple mistake on multiple homework assignments, I will take off more points for that error than I normally would.

Please include *words* in your answers. When you get answer keys back from me, you'll see that there are explanations, ideas, commentary, and thought processes included – not just a set of equations one after another.

Finally, please ensure that all numerical answers have units. As always, if you have questions feel free to email me.

1. Find the total electric charge of:
   a) 2.5 kg of electrons
   b) 2.5 kg of protons
2. A container holds a gas consisting of 3 moles of oxygen molecules. One in a billion of these molecules has lost a single electron.
   a) What is the net charge of the gas?
   b) What fraction of the total mass of the gas has been removed by removing these electrons? (You might have to look up the mass of an oxygen molecule). [Your answer is small, but "approximately zero" isn't good enough. I want a number. Leave your answer in scientific notation. I only need a couple of sig figs here.]
3. The attractive electrostatic force between two point charges has a magnitude of 1.24 N when the separation between the charges is 1.47 m. One of the point charges is 8.44 μC. What is the sign and magnitude of the other charge?
4. A point charge $q = -0.42$ nC is fixed at the origin. Where must an electron be placed in order for the electric force acting on it to be exactly opposed by its weight. (In other words, where would an electron need to be placed so that it would have no net force on it?) (Let the y axis be vertical and the x axis be horizontal, assume that gravity acts in the $-y$ direction, and also assume we're near the surface of the Earth).

5. A system consists of two positive point charges, q_1 and q_2 ($q_2 > q_1$). The total charge of this system is $+73.0\ \mu$ C, and each charge experiences an electrostatic force of magnitude 113 N when the separation between them is 0.27 m. Find q_1 and q_2.

6. Two otherwise identical metal (conducting) spheres carry charges of $2Q$ and $-3Q$, respectively. The sphere centers are initially separated by distance d.

   a) What is the initial force between the spheres? (Let + indicate a repulsive force, and - indicate an attractive force). [I am looking for a symbolic answer here; your answer should be in terms of Q, d, fundamental constants of nature, and numbers (which are also fundamental constants of nature) only!]

   b) The two spheres are brought to touch. After touching, the total net charge is equally distributed over the two spheres. (This is true because the spheres are (i) conducting, and (ii) identical, implying that they are the same size). After touching, the spheres are returned to their initial positions separated by distance d. What is the final force between the spheres? (Again, let + indicate a repulsive force, and - indicate an attractive force). [Another symbolic question.]

   c) Let us assume each sphere has a radius $R = d/5$. How much work was done in initially taking the spheres (with their initial separation of d and charges of $+2Q$ and $-3Q$) and getting them to a position right before touching? (Recall: $W = \int_{\text{initial}}^{\text{final}} \vec{F} \cdot \mathrm{d}\vec{r}$). [Another symbolic question.]

   d) How much work is done in taking the spheres right after they touch and moving them back to their initial position? [Yet another symbolic question.]

   e) You should have found that the sign to your solution to parts (c) and (d) are the same. Yet, at the end, you have two charged spheres that are separated a distance d. Why isn't this work equal and opposite?