Due monday, February 8th.

This is the first problem set. Please present clean drawings/sketches wherever relevant, and show all calculations up to reasonable detail.

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1. (a) **[1+1 pts.]** Look up and report the values of the *permittivity of free space*, ϵ_0, and the *permeability of free space*, μ_0, in SI units. Include the units of each quanitity.

   (b) **[2 pts.]** Look up and report Coulomb's law in SI units and in CGS units.

2. We will ignore the z direction for this problem. Consider the following points on the x-y plane: the point A with coordinates $(0, a)$, the point B with coordinates $(0, -a)$, and the point P with coordinates $(r, 0)$.

   (a) **[5 pts.]** A particle at point P feels two forces, both of equal magnitude F_0. One force points in the direction from A towards P (along the direction AP), and the other acts towards B (along the direction PB). Find the total force acting on the particle.

   Reminder: Finding a vector means finding both its magnitude and its direction!!

   (b) **[5 pts.]** Imagine two vectors, each having the same magnitude E_0, acting on point P. One points from P towards A (along the direction PA), and the other points from P towards B (along the direction PB). Find the result of adding the two vectors.

3. **[8 pts.]** A thin glass rod lies along the x-axis, with one end at the origin and one end at the point $(L, 0, 0)$. The rod is charged non-uniformly. The linear charge density is $\lambda = 4\gamma x^3$. What is the total charge on the rod?

   Note: the linear charge density is the charge per unit length. Here γ is a constant.

   You will have to divide the rod into infinitesimally small pieces, and 'add up' the charge on each of these pieces. Adding up will mean performing an integration.

4. **[9 pts.]** A flat square plate lies parallel to the x-y plane and is charged with a variable surface charge density, $\sigma = 2\gamma(xy + x^2)$. (Here γ is a constant.) The four corners of the square plate are at the points $(0, 0, z_0)$, $(L, 0, z_0)$, $(0, L, z_0)$, (L, L, z_0). What is the total charge on the plate?

   Note: the surface charge density is the charge per unit area. In this case a two-dimensional integration will be required.

5. **[4 pts.]** The electric field in some region is given by

$$\mathbf{E} = \frac{V_0}{d}\left(5xy\hat{\imath} + 2z^2\hat{\jmath}\right)$$

   where $\hat{\imath}$ and $\hat{\jmath}$ are unit vectors in the x and y directions, and V_0 and d are positive constants. Find the force experienced by a charge q that is placed at the point $(x, y.z) = (d, -d, d)$.

6. **[7 pts.]** The closed curve C lies in the x-y plane and encloses area α. Using Stokes' theorem, calculate the line integral of the vector field

$$\mathbf{T} = -2y\hat{\imath} + 2x\hat{\jmath}$$

   around the curve C.

7. Here L and d are positive distances, with $d > L$. Also, Q and q are positive charges.

   (a) **[5 pts.]** Five point charges are placed on the x-axis, at the points with $x-$coordinates $L/5$, $2L/5$, $3L/5$, $4L/5$ and L. Each of these carry the charge $Q/5$.

   A point charge q is placed, also on the x-axis, at the point $(d, 0, 0)$. Find the total force experienced by the charge q.

   (b) **[3 pts.]** Consider the limit $d \gg L$. Simplify your expression for this limit, and explain your result physically.