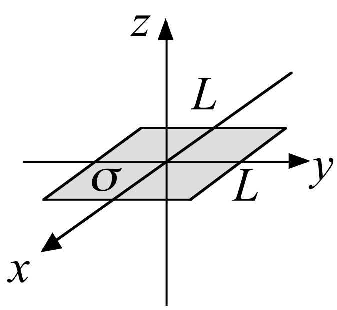
PHY 142 **EXAM 1** **Thursday, October 1, 2009**

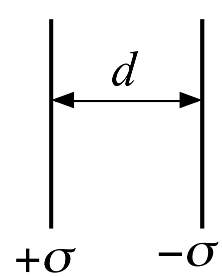
Please put a box around around your final answer. Cross off any work you do not want the grader to consider.

1) [20 points]
Consider a flat square plane of charge of side L and uniform surface charge density σ. The square lies centered about the origin in the xy plane at $z = 0$, with its sides parallel to the x and y axes, as shown in the figure below.

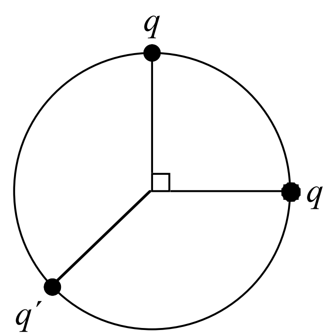


a) What is the approximate electric field for $|z| \gg L$ above and below the charged square?
b) What is the approximate electric field for $|z| \ll L$ just above and just below the center of the charged square?
c) Write down, in terms of explicit x, y, and z coordinates, the integral by which you would compute the electrostatic potential at a height z along the z-axis. You do not have to evaluate the integral.

2) [20 points]
Two infinite parallel planes are separated by a distance d. One plate carries a positive surface charge density σ. The other plate carries a negative surface charge density $-\sigma$. What is the work per unit area needed to move the two planes so the separation between them is $2d$? Express your answer in terms of σ and d.



3) [30 points]
Three positively charged particles are constrained to move on a fixed circular track of radius R. Two of the charges have equal magnitude q, while the third charge has magnitude q'. When the charges are in mechanical equilibrium, the angle between the two equal charges is 90°, as shown below. What is the ratio of the third charge to the other two, i.e. what is q'/q? Your answer should be a pure number.



4) [30 points]
A possible model of the helium atom is a sphere of positive charge (total charge $+2e$) of radius R with two electrons embedded symmetrically at radius r' with $r' < R$ as shown in the figure. Suppose, in this model, that the positive charge is distributed out to radius R with a charge density going as $\rho(r) = Cr$. Find r' in terms of R for the situation when the electrons are at equilibrium. Your final answer should be a pure number. We have discussed in lecture a general result that there can be no stable mechanical equilibrium in an electrostatic electric field; why does that not apply in this example?