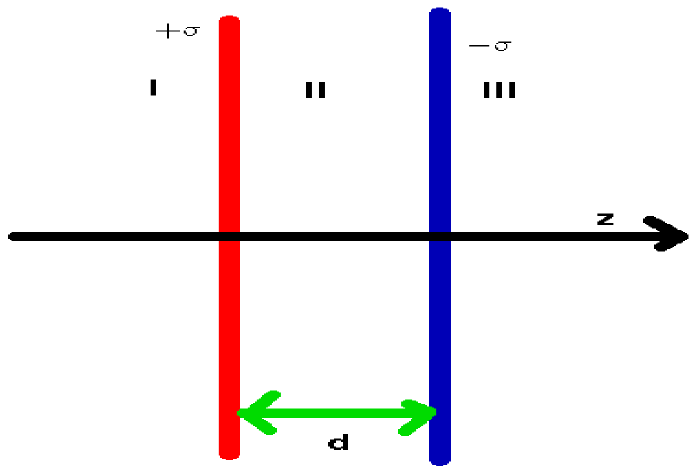
Instructions: You have a total of 50 minutes to complete this test. Answer each question completely. In order to obtain full credit for the problems, **you must** supply sketches, words, and details (including all assumptions) showing clearly how you obtained your answer. Correct SI units must be provided for numerical answers where required.

Time Start______________ Time finish ____________pledged ________________

Constants: $k = 8.987 \times 10^{9} \frac{Nm^2}{C^2} : \epsilon_0 = 8.854 \times 10^{-12} \frac{C^2}{Nm^2}$

[1] An ideal parallel plate capacitor is in the x-y plane a shown. The capacitor is charged with a surface charge density +σ on the plate located at z=0 and -σ on the plate located at z=d.



[1:a] Make a sketch of the electric field, including electric field directions on the diagram below. You will need to use several lines here to correctly show this. In each of the 3 regions, **use a single line arrow to represent fields from +σ** and **use a double line arrow to represent the field from -σ**.

[1:b] Find the **vector electric field** , $\vec{E}$ between the plates of the capacitor (in region 2). You must show details and assumptions here (and a sketch).

[1:c] If $\sigma = 1.0 \times 10^{-12} \frac{C}{m^2}$. Find a numerical result for the **vector electric field** in region 2 with correct SI units.

[2:a] A point charge Q_i =1μC is located at the origin (x=0, y=0). Find, with proper SI units, the value of the **vector** electric field at (x=1m, y=0 m).

[2:b] A second charge Q_p =-1μC is located at (x=1m, y=0) from the charge in [a]. Find, with proper SI units, the value of the **vector** electric force on Q_p.

[2:c] A point charge Q_1 =1μC is located at the origin (x=0, y=0). Find, with proper SI units, the value of the electric potential at (x=1, y=0).

[2:d] A second charge Q_2 =-1μC is located at (x=1, y=0) in the presence of the charge [c]. Find, with proper SI units, the work required to assemble this charge distribution.

[3] Two charges have the following coordinates: #1: +q(x=0,y=+a) and #2: -q(x=0,y=-a).

[3:a] Find the **vector electric field** , $\vec{E}$ along the +x axis has coordinates (x_p ,0) in terms of k,q, x_p and a. Note that the constant a is assumed to be positive here.

[3:b] If a charge q_p is placed at the coordinate (x_p,0) , what is the **vector electric force** on this charge in terms of k,q,q_p, x_p and a?

[3:c] Provide a numerical result for the **vector electric force** with correct SI units on this charge for the case x_p =1, a=1m, and with q given by 1 μC.

[4] In order to obtain full credit for this problem, **you must** supply sketches, words, and details (including all assumptions) showing clearly how you obtained your answer.

A sphere of radius a has a volume charge density per unit volume given by $\rho(r)=\frac{Q}{\pi a^3}\left(\frac{r}{a}\right)$ and the total charge on the sphere is Q.

[4:a] Find the **vector electric field** , $\vec{E}$ **outside** the sphere of charge.

[4:b] Find the **vector electric field** , $\vec{E}$ **inside** the sphere of charge.

[4:c] Show that the two solutions are the same at the surface of the sphere of charge.