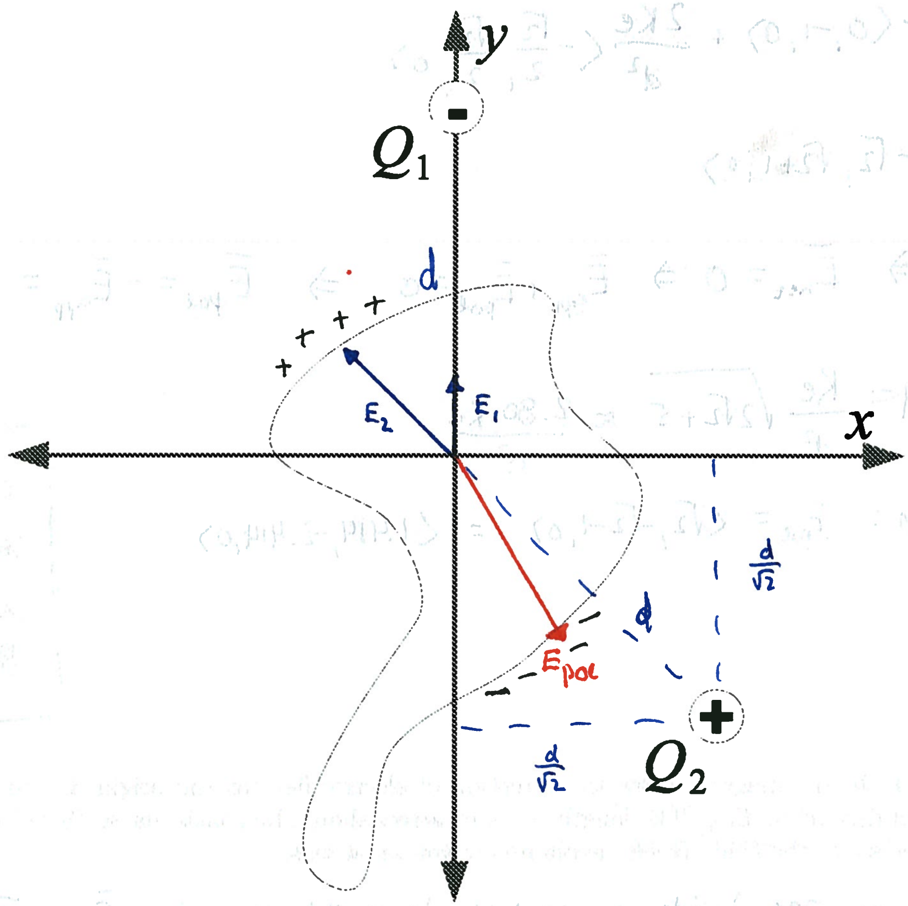
Physics 2212 Fall 2014 Lab Quiz #1

Name: Key Section NPQ

Play-Doh is a modeling compound used by young children for art and craft projects at home and in school. The large salt content of Play-Doh means that it is also a conductor. A **neutral** yellow blob of Play-Doh is placed near a negative charge $Q_1 = -e$ and a positive charge $Q_2 = 2e$ as indicated in the figure below. The negative charge Q_1 is located at $\vec{r}_1 =< 0, d, 0 >$ and the positive charge Q_2 is located at $\vec{r}_2 =< d/\sqrt{2}, -d/\sqrt{2}, 0 >$.



1. (*20 points*) On the diagram draw the direction of electric field at the origin for both Q_1 and Q_2. Label these arrows E_1 and E_2. The lengths of your arrows should be consistent so that they correspond to the relative strength of each field.

→ 10pts each: $\vec{E}_1$, $\vec{E}_2$, $\vec{E}_{pol}$

→ $\vec{E}_2$ arrow should be twice as long as E_1 arrow } −5pts

→ $\vec{E}_{pol} = -(\vec{E}_1 + \vec{E}_2)$ } −10pts

2. (*50 points*) Once the Play-Doh is in equilibrium, determine the magnitude and direction of the electric field at the origin due to the charge induced on the surface of the polarized Play-Doh.

$\bar{r} = \bar{r}_{obs} - \bar{r}_{src}$

$$\bar{E}_{app} = \bar{E}_1 + \bar{E}_2$$

$$= \frac{KQ_1}{d^2}\hat{r} + \frac{KQ_2}{d^2}\hat{r}$$

$$\frac{1}{d}\left[\langle 0,0,0\rangle - \langle 0,d,0\rangle\right] = \langle 0,-1,0\rangle$$

$$\frac{1}{d}\left[\langle 0,0,0\rangle - \langle \tfrac{d}{\sqrt{2}}, -\tfrac{d}{\sqrt{2}}, 0\rangle\right] = \langle -\tfrac{1}{\sqrt{2}}, \tfrac{1}{\sqrt{2}}, 0\rangle = \langle -\tfrac{\sqrt{2}}{2}, \tfrac{\sqrt{2}}{2}, 0\rangle$$

$$= -\frac{Ke}{d^2}\langle 0,-1,0\rangle + \frac{2Ke}{d^2}\langle -\tfrac{\sqrt{2}}{2}, \tfrac{\sqrt{2}}{2}, 0\rangle$$

$$= \frac{Ke}{d^2}\langle -\sqrt{2}, \sqrt{2}+1, 0\rangle$$

Equilibrium $\Rightarrow \bar{E}_{net} = 0 \Rightarrow \bar{E}_{app} + \bar{E}_{pol} = 0 \Rightarrow \bar{E}_{pol} = -\bar{E}_{app} = \frac{Ke}{d^2}\langle \sqrt{2}, -\sqrt{2}-1, 0\rangle$

$\therefore \quad |\bar{E}_{pol}| = \frac{Ke}{d^2}\sqrt{2\sqrt{2}+5} \approx \frac{2.80\,Ke}{d^2}$

direction: $\hat{r}_{pol} = \langle \sqrt{2}, -\sqrt{2}-1, 0\rangle = \langle 1.414, -2.414, 0\rangle$

CE	−2.5
Minor	−7.5
Major	−15
BTN	−40

3. (*20 points*) On the diagram draw the direction of electric field at the origin due to the polarized Play-Doh. Label this arrow E_{pol}. The lengths of your arrow should be consistent so that it correspond to the relative strength of the field. Briefly explain how you know this.

10 pts $\Bigg\{$ E_{net} must be zero inside a conductor in equilibrium. i.e. $\bar{E}_{net} = \bar{E}_{app} + \bar{E}_{pol} = 0$. The applied field is the superposition of both E_1 and E_2 @ the origin. Therefore, the polarized field must have a magnitude and direction such that it cancels the applied field due to Q_1 & Q_2.

4. (*10 points*) On the diagram indicate how the neutral Play-Doh is polarized. Briefly explain how you know this.

5 pts $\Big\{$ We know the direction of $\bar{E}_{pol}$, therefore we can infer the position of the charges on the play-doh.

5 pts → equal # of "+" & "−" on surface