

Physics 222

Quiz 3 – Electric Field of Distributed Charge,

Form: A

Name: _____

Date: _____

1. Sketch the electric field at each of three points along an axis through the centers of the plates: (1) between the capacitor plates; (2) on the left, outside the capacitor; (3) on the right outside the capacitor.

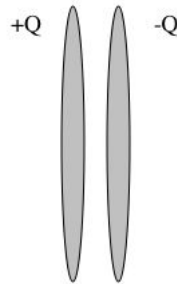


Figure 1:

2. A thin ring has a total charge $+Q$ distributed uniformly around the ring. The point P is at the center of the ring. Explain why the electric field at the center is zero without using any equations. Feel free to draw on the picture as needed, in order to clarify your explanation.

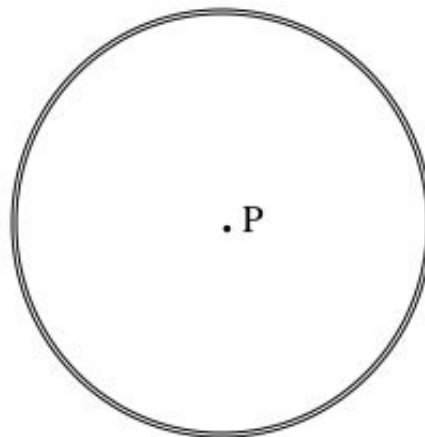


Figure 2:

3. An isolated metal sphere, far from any other charged objects or particles, has a uniform charge distribution of $-Q$ on its surface. What is the electric field at its center?

4. Now suppose that the same metal sphere is placed near a charged plastic sphere of charge $-Q$ as shown in the image below. Because it is a conductor, the net electric field inside the metal sphere is zero. Sketch the following 3 things: (1) the charge distribution on the metal sphere; (2) the electric field vector at the center of the metal sphere due to the charged plastic sphere; and (3) the electric field vector at the center of the metal sphere due to its own surface charge.

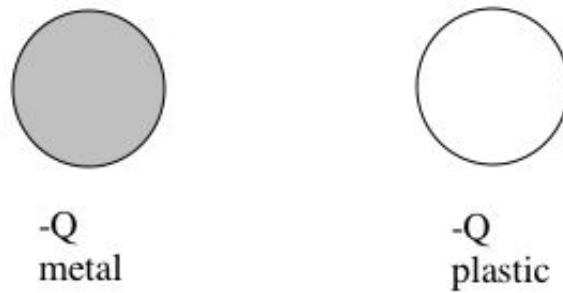


Figure 3:

5. What is the net electric field at the center of the plastic sphere? If it is zero, state so. If not, write it in vector form as an equation.

6. A very thin glass rod 4 meters long is rubbed all over with a silk cloth. It gains a uniformly distributed charge 1.6×10^{-6} C. Two small spherical rubber balloons of radius 1.2 cm are rubbed all over with wool. They each gain a uniformly distributed charge of -7×10^{-8} C. The balloons are near the midpoint of the glass rod, with their centers 3 cm from the rod. The balloons are 2 cm apart (so 4.4 cm between centers).

Find the net electric field at the location marked by the x, 0.6 cm to the right of the center of the left balloon.

Here are some things to think about: Which objects make nonzero contributions to \vec{E} at this location? What are the correct distances from sources to the observation location? What is the direction of \vec{E} due to the rod? (The drawing is not to scale. Read the problem statement carefully; for instance, what does it mean to be “near the midpoint of the rod”.)

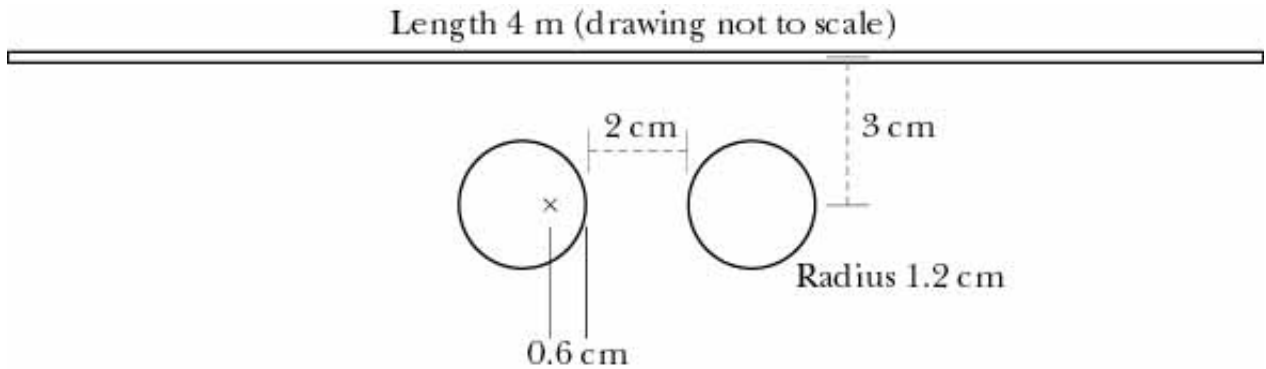


Figure 4:

A cut-out view in between a capacitor along an axis between the plates is shown below.

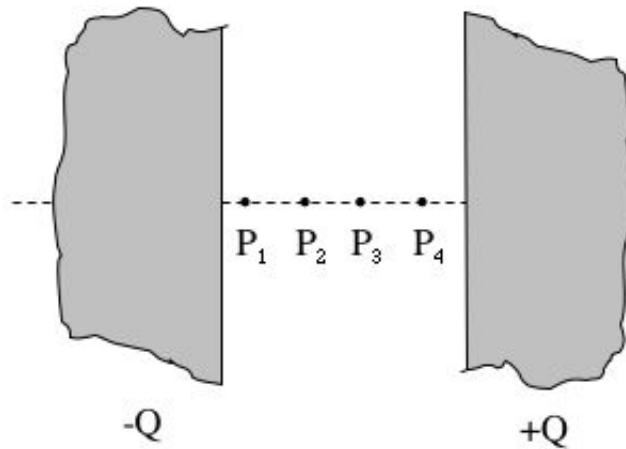


Figure 5:

7. At which point is the electric field the greatest?
- (a) P_1
 - (b) P_2
 - (c) P_3
 - (d) P_4
 - (e) It is the same at all points.
8. Suppose the electric field between capacitor plates is E . If you double the distance s between the plates, what is the electric field?
- (a) $4E$
 - (b) $2E$
 - (c) $(1/2)E$
 - (d) $(1/4)E$
 - (e) E

Answer Key for Exam A

1. \vec{E}_1 is to the right. \vec{E}_2 is to the left. \vec{E}_3 is to the left.
2. For each piece of the ring that creates a field $\Delta\vec{E}$ at the center, there is another piece on the opposite side of the ring that creates a field $-\Delta\vec{E}$, in the opposite direction. Thus the net electric field is zero.
3. It is zero everywhere inside the metal sphere because it is a conductor. For a conductor, the excess surface charge will distribute themselves on the surfaces so that the net electric field within the sphere is zero.
4. The electric field due to the plastic sphere, at the location of the center of the metal sphere, is to the right. Since the net electric field within a metal sphere is zero, the surface charge on the metal sphere distribute themselves on the surface (sphere must polarize) in such a way that they produce an electric field to the left that is equal in magnitude to the electric field due to the plastic sphere. There must be more negative charge on the left side of the metal sphere.
5. \vec{E} at the center of the plastic sphere is solely due to the electric field produced by the charged metal sphere since the charge on the plastic sphere is uniformly distributed and therefore produces zero electric field at the center. The electric field due to the metal sphere is

$$\vec{E}_{\text{due to metal sphere}} = \frac{1}{4\pi\epsilon_0} \frac{Q_{\text{metal}}}{r^2} \langle -1, 0, 0 \rangle$$

6. $\vec{E}_{\text{net}} = \langle 4.36 \times 10^5, -2.4 \times 10^5, 0 \rangle \text{ N/C}$

7. (e)

8. (e)