**Collaborators:**

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**HRK P28.10 Solo**   A total amount of positive charge $Q$ is spread onto a nonconducting, flat, circular annulus of inner radius $a$ and outer radius $b$. The charge is distributed so that the charge density (charge per unit area) is given by $\sigma = k/r^3$ where $r$ is the distance from the center of the annulus to any point on it. Show that (with $V = 0$ at infinity) the potential at the center of the annulus is given by;

$$V = \frac{Q}{8\pi\epsilon_0}\left(\frac{a+b}{ab}\right)$$

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**HRK 28.13** On a thin rod of length $l$ lying along the $x$ axis with one end at the origin $x = 0$, as in Fig. 28-46, there is distributed a charge per unit length given by $\lambda = kr$, where $k$ is a constant $r$ is the distance from the origin. ($a$) Taking the electrostatic potential at infinity to be zero, find $V$ at the point $P$ on the $y$ axis. ($b$) Determine the vertical component $E_y$ of the electric field at $P$ from the result of part ($a$) and also by direct calculation. ($c$) Why cannot $E_x$, the horizontal component of the electric field at $P$, be found using the result of part ($a$)? ($d$) At what distance from the rod along the $y$ axis is the potential equal to one half the value at the left end of the rod?
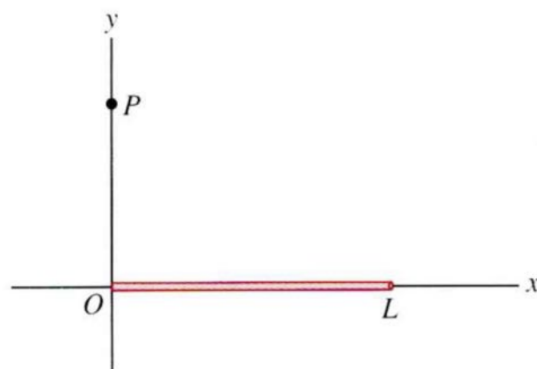


**FIGURE 28-46.** Problem 13.

**3. Need Thursday Lecture**   In lecture, we calculated the amount of electrostatic energy contained in the *interior* electric field of a uniform sphere of radius $R$ and charge density $\rho$. The result was

$$U = \frac{2\pi\rho^2}{45\epsilon_0}R^5$$

For this problem, complete the calculation by calculating the energy stored in the *exterior* electric field, and verify that the *total* stored energy matched the work done to assemble the sphere.

**4.** Consider an infinitely long line of charge with linear charge density $\lambda$. The line of charge is parallel to and a distance $d$ above the infinite grounded conducting plane. Sketch the resulting electric field lines in the half-space above the plane,including any surface charges.Then using the concepts discussed in lecture, determine the electric field $E(x)$ at the surface of the plane as a function of the horizontal distance $x$ from the from the perpendicular between the plane and line.

**5.** Consider a hollow conducting sphere that carries a net positive charge $Q$. Next, a second initially uncharged concentric conducting sphere is brought into proximity with the first (without touching it). In scenario (a), the second sphere is placed outside the first and left *ungrounded*. In scenario (b), the second sphere is outside the first and grounded. In scenario c the second sphere is *inside* the first and also grounded.

(a)     (b)     (c)
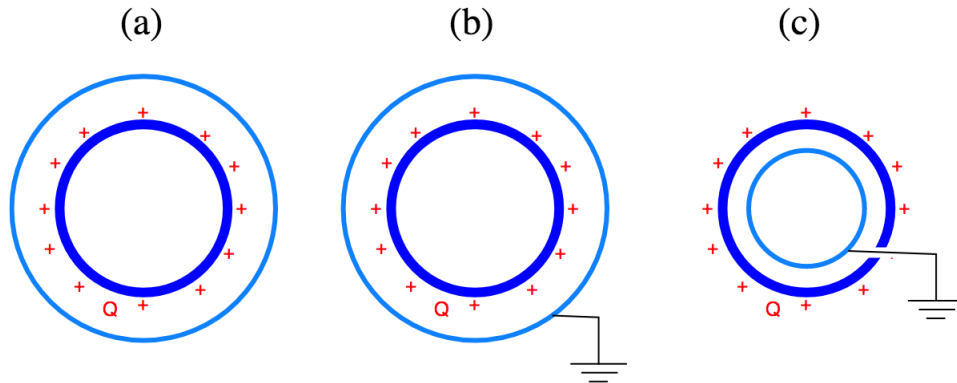


For all three scenarios, describe the final arrangement of charge on the second sphere and the electric field (if any) outside the second sphere.

**6. Need Thursday Lecture**  A cylindrical capacitor is made from two long thing concentric metal cylinders of length $L$ and radii $a$ and $b$ ($L >> a$ and $a > b$)

(a) Using the definition of capacitance $C = Q/V$, calculate the capacitance per unit length $C/L$ of this configuration.

(b) Repeat the capacitance calculation, this time using the stored energy $U = \frac{1}{2}\frac{Q^2}{C}$.

■