7 Continuous charge distributions

$$\mathrm{d}\vec{F} = \frac{1}{4\pi\epsilon_0}\frac{q_0\,\mathrm{d}Q}{r^2}\hat{r} = q_0\mathrm{d}\vec{E} \qquad \mathrm{d}\vec{E} = \frac{1}{4\pi\epsilon_0}\frac{\mathrm{d}Q}{r^2}\hat{r} \qquad \mathrm{d}Q = \lambda\,\mathrm{d}l = \sigma\,\mathrm{d}A = \rho\,\mathrm{d}V$$

$$\vec{E} = \int \mathrm{d}E \qquad E_x^{line} = \frac{1}{4\pi\epsilon_0}\frac{\lambda L}{x\sqrt{x^2 + L^2/4}} \qquad E_z^{ring} = \frac{\lambda}{2\epsilon_0}\frac{Rz}{(z^2+R^2)^{3/2}}$$

7.a RHK Exercises

25-17 Consider the rod with total charge Q, and the point charge q_0 in Fig. 25-11. Where can you place a second point charge Q (same charge as the rod), so that q_0 is in equilibrium? Solve this problem assuming that *(a)* q is positive and *(b)* q is negative

25-19 Assume the rod in Fig. 25-11 instead has a charge density λ on the top half of the rod and a uniform charge density $-\lambda$ on the bottom half of the rod. Find the force on q_0.

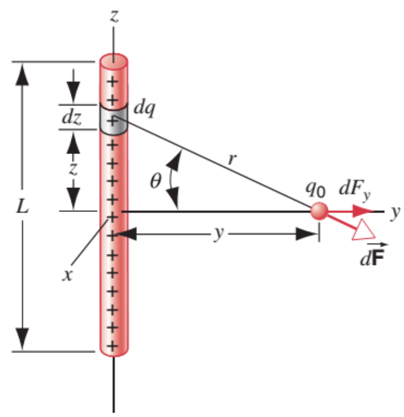

FIGURE 25-11. A uniformly charged rod.

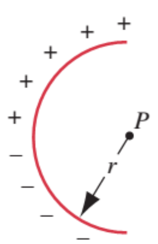

FIGURE 26-28. Exercise 16.

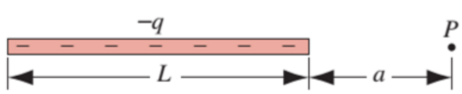

FIGURE 26-29. Exercise 18.

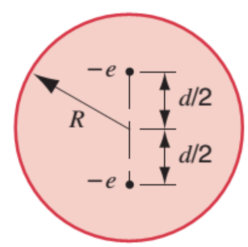

FIGURE 26-36. Exercise 40.

26-XX A circular disk of radius R has a uniform area charge density σ. Determine the electric field along the axis of the disk as a function of the distance z from the disk.

26-28 A thin glass rod is bent into a semicircle of radius r. A charge $+q$ is uniformly distributed along the upper half and a charge $-q$ is uniformly distributed along the lower half, as shown in Fig. 26-28. Find the electric field $2\vec{E}$ at P, the center of the semicircle.

26-29 An insulating rod of length L has charge q uniformly distributed along its length, as shown in Fig. 26-29. *(a)* What is the linear charge density of the rod? *(b)* Find the electric field at point P a distance a from the end of the rod. *(c)* If P were very far from the rod compared to L, the rod would look like a point charge. Show that your answer to *(b)* reduces to the electric field of a point charge for $a \gg L$.

26-40 Figure 26-36 shows a Thomson atom model of helium ($Z = 2$). Two electrons, at rest, are embedded inside a uniform sphere of positive charge $2e$ with a fixed radius R. Find the distance d between the electrons so that the configuration of the electrons is in static equilibrium.

7.b RHK Problems

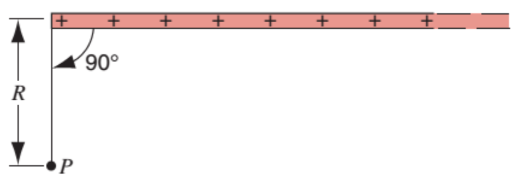

FIGURE 26-39. Problem 6.

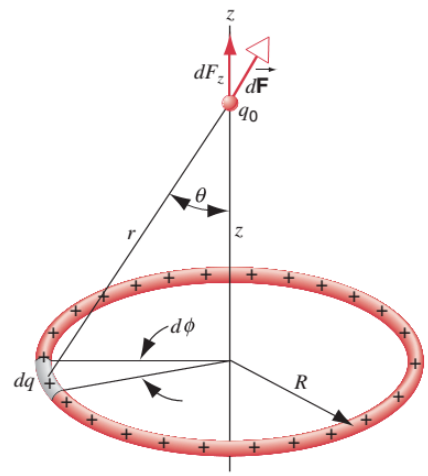

FIGURE 25-12. A uniformly charged ring. To find the force on a point charge q_0, we consider the ring to consist of many individual charge elements such as dq.

25-3 Consider the ring of charge in Fig. 25-12. Suppose that the charge q is not distributed uniformly over the ring but that charge q_1 is distributed uniformly over half the circumference and charge q_2 is distributed uniformly over the other half. Let $q_1 + q_2 = q$. *(a)* Find the component of the electric field at any point on the axis directed along the axis and compare with the uniform case. *(b)* Find the component of the electric field at any point on the axis perpendicular to the axis and compare with the uniform case.

25-6 A "semi-infinite" insulating rod (Fig. 26-39) carries a constant charge per unit length of λ. Show that the electric field at the point P makes an angle of 45° with the rod and that this result is independent of the distance R.

25-7 A thin nonconducting rod of finite length L carries a uniform linear charge density $+\lambda$ on the top half and a uniform charge density $-\lambda$ on the bottom half; compare to Fig. 25-11. *(a)* Use a symmetry argument to determine the direction of the electric field at P (the location of q_0 in Fig. 25-11) due to the rod. *(b)* Find $\vec{E}$ at P. *(c)* Take the limit of this expression for large y. How does it depend on y? What does it remind you of?

25-8 A nonconducting hemispherical cup of inner radius R has a total charge q spread uniformly over its inner surface. Find the electric field at the center of curvature. *(Hint: Consider the cup as a stack of rings.)*
'

25-12 An electron is constrained to move along the axis of the ring of charge discussed in Fig. 25-12. Show that the electron can perform small oscillations, through the center of the ring, with a frequency given by

$$\omega = \sqrt{\frac{eq}{4\pi\epsilon_0 m R^3}} \tag{7.1}$$