22 •• A ring of radius a has a charge distribution on it that varies as $\lambda(\theta) = \lambda_0 \sin\theta$, as shown in Figure 22-39. (*a*) What is the direction of the electric field at the center of the ring? (*b*) What is the magnitude of the field at the center of the ring?

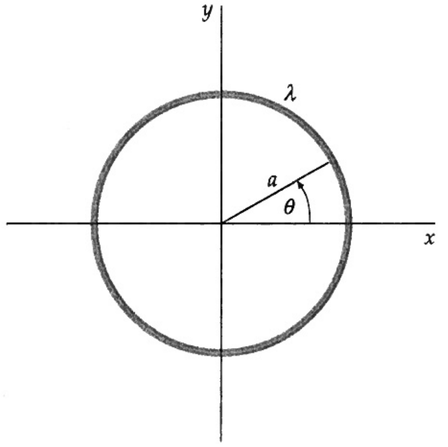

FIGURE 22-39 Problem 22

23 •• A line of charge that has uniform linear charge density λ lies on the x axis from $x = 0$ to $x = a$. Show that the y component of the electric field at a point on the y axis is given by $E_y = \frac{k\lambda}{y}\frac{a}{\sqrt{y^2 + a^2}}, y \neq 0.$

24 ••• Calculate the electric field a distance z from a uniformly charged infinite flat nonconducting sheet by modeling the sheet as a continuum of infinite straight lines of charge.

25 •• Calculate the electric field a distance z from a uniformly charged infinite flat nonconducting sheet by modeling the sheet as a continuum of infinite circular rings of charge. SSM

26 ••• A thin hemispherical shell of radius R has a uniform surface charge σ. Find the electric field at the center of the base of the hemispherical shell.

GAUSS'S LAW

27 • A square that has 10-cm-long edges is centered on the x axis in a region where there exists a uniform electric field given by $\vec{E} = (2.00\text{ kN/C})\hat{i}$. (*a*) What is the electric flux of this electric field through the surface of a square if the normal to the surface is in the $+x$ direction? (*b*) What is the electric flux through the same square surface if the normal to the surface makes a 60° angle with the y axis and an angle of 90° with the z axis?

28 • A single point charge ($q = +2.00\ \mu C$) is fixed at the origin. An imaginary spherical surface of radius 3.00 m is centered on the x axis at $x = 5.00$ m. (*a*) Sketch electric field lines for this charge (in two dimensions) assuming twelve equally spaced field lines in the xy plane leave the charge location, with one of the lines in the $+x$ direction. Do any lines enter the spherical surface? If so, how many? (*b*) Do any lines leave the spherical surface? If so, how many? (*c*) Counting the lines that enter as negative and the ones that leave as positive, what is the net number of field lines that penetrate the spherical surface? (*d*) What is the net electric flux through this spherical surface?

29 • An electric field is given by $\vec{E} = \text{sign}(x)\cdot(300\text{ N/C})\hat{i}$, where sign (x) equals -1 if $x < 0$, 0 if $x = 0$, and $+1$ if $x > 0$. A cylinder of length 20 cm and radius 4.0 cm has its center at the origin and its axis along the x axis such that one end is at $x = +10$ cm and the other is at $x = -10$ cm. (*a*) What is the electric flux through each end? (*b*) What is the electric flux through the curved surface of the cylinder? (*c*) What is the electric flux through the entire closed surface? (*d*) What is the net charge inside the cylinder? SSM

30 • Careful measurement of the electric field at the surface of a black box indicates that the net outward electric flux through the surface of the box is 6.0 kN · m²/C. (*a*) What is the net charge inside the box? (*b*) If the net outward electric flux through the surface of the box were zero, could you conclude that there were no charges inside the box? Explain your answer.

31 • A point charge ($q = +2.00\ \mu C$) is at the center of an imaginary sphere that has a radius equal to 0.500 m. (*a*) Find the surface area of the sphere. (*b*) Find the magnitude of the electric field at all points on the surface of the sphere. (*c*) What is the flux of the electric field through the surface of the sphere? (*d*) Would your answer to Part (*c*) change if the point charge were moved so that it was inside the sphere but not at its center? (*e*) What is the flux of the electric field through the surface of an imaginary cube that has 1.00-m-long edges and encloses the sphere?

32 • What is the electric flux through one side of a cube that has a single point charge of $-3.00\ \mu C$ placed at its center? *Hint: You do not need to integrate any equations to get the answer.*

33 • A single point charge is placed at the center of an imaginary cube that has 20-cm-long edges. The electric flux out of one of the cube's sides is -1.50 kN · m²/C. How much charge is at the center? SSM

34 •• Because the formulas for Newton's law of gravity and for Coulomb's law have the same inverse-square dependence on distance, a formula analogous to the formula for Gauss's law can be found for gravity. The gravitational field $\vec{g}$ at a location is the force per unit mass on a test mass m_0 placed at that location. (Then, for a point mass m at the origin, the gravitational field g at some position $\vec{r}$ is $\vec{g} = -(Gm/r^2)\hat{r}$.) Compute the flux of the gravitational field through a spherical surface of radius R centered at the origin, and verify that the gravitational analog of Gauss's law is $\phi_{net} = -4\pi G m_{inside}$.

35 •• An imaginary right circular cone (Figure 22-40) that has a base angle θ and a base radius R is in charge free region that has a uniform electric field $\vec{E}$ (field lines are vertical and parallel to the cone's axis). What is the ratio of the number of field lines per unit area penetrating the base to the number of field lines per unit area penetrating the conical surface of the cone? Use Gauss's law in your answer. (The field lines in the figure are only a representative sample.)

36 •• In the atmosphere and at an altitude of 250 m, you measure the electric field to be 150 N/C directed downward, and you measure the electric field to be 170 N/C directed downward at an altitude of 400 m. Calculate the volume charge density of the atmosphere in the region between altitudes of 250 m and 400 m, assuming it to be uniform. (You may neglet the curvature of Earth. Why?)

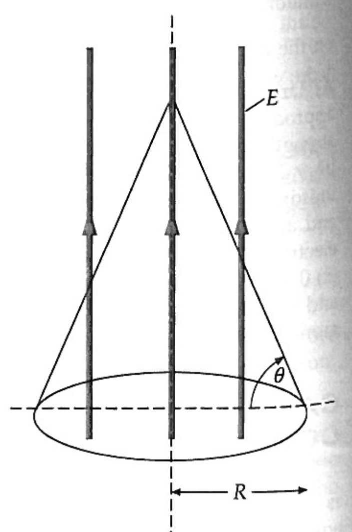

FIGURE 22-40 Problem 35