**Problem 4.3** Find the total charge contained in a cone defined by $R \leq 2$ m and $0 \leq \theta \leq \pi/4$, given that $\rho_v = 10R^2\cos^2\theta$ (mC/m$^3$).

**Problem 4.8** An electron beam shaped like a circular cylinder of radius $r_0$ carries a charge density given by

$$\rho_v = \left( -\frac{\rho_0}{1 + r^2} \right) \text{ (C/m}^3)$$

where $\rho_0$ is a positive constant and the beam’s axis is coincident with the $z$-axis.

(a) Determine the total charge contained in length $L$ of the beam.

(b) If the electrons are moving in the $+z$-direction with uniform speed $u$, determine the magnitude and direction of the current crossing the $z$-plane.

**Problem 4.14** A line of charge with uniform density $\rho_l = 8$ (μC/m) exists in air along the $z$-axis between $z = 0$ and $z = 5$ cm. Find $E$ at $(0,10\text{ cm},0)$.

**Problem 4.20** Three infinite lines of charge, $\rho_l = 3$ (nC/m), $\rho_l = -3$ (nC/m), and $\rho_l = 3$ (nC/m), are all parallel to the $z$-axis. They pass through the respective points $(0,-b)$, $(0,0)$, and $(0,b)$ in the $x$-$y$ plane, find the electric field at $(a,0,0)$. Evaluate your result for $a = 2$ cm and $b = 1$ cm.

**Problem 4.22** Given the electric flux density

$$\mathbf{D} = \mathbf{\hat{x}}2(x+y) + \mathbf{\hat{y}}(3x-2y) \text{ (C/m}^2)$$

determine

(a) $\rho_v$ by applying Eq. (4.26).

(b) The total charge $Q$ enclosed in a cube 2 m on a side, located in the first octant with three of its sides coincident with the $x$-, $y$-, and $z$-axes and one of its corners at the origin.

(c) The total charge $Q$ in the cube, obtained by applying Eq. (4.29).

**Problem 4.24** Charge $Q_1$ is uniformly distributed over a thin spherical shell of radius $a$, and charge $Q_2$ is uniformly distributed over a second spherical shell of radius $b$, with $b > a$. Apply Gauss’s law to find $E$ in the regions $R < a$, $a < R < b$, and $R > b$. 
**Problem 4.25** The electric flux density inside a dielectric sphere of radius $a$ centered at the origin is given by

$$\mathbf{D} = \hat{R} \rho_0 R \quad (\text{C/m}^2)$$

where $\rho_0$ is a constant. Find the total charge inside the sphere.

**Problem 4.27** An infinitely long cylindrical shell extending between $r = 1 \, \text{m}$ and $r = 3 \, \text{m}$ contains a uniform charge density $\rho_r$. Apply Gauss’s law to find $\mathbf{D}$ in all regions.