Consider a thin spherical shell of radius 14.0 cm with a total charge of 32.0 μC distributed uniformly on its surface. Find the electric field (a) 10.0 cm and (b) 20.0 cm from the center of the charge distribution.

P24.31

(a) \( E = 0 \)

(b) \[
E = \frac{kQ}{r^2} = \frac{(8.99 \times 10^9)(32.0 \times 10^{-6})}{(0.200)^2} = 7.19 \text{ MN/C}
\]

E = 7.19 MN/C radially outward
36. An insulating sphere is 8.00 cm in diameter and carries a 5.70-μC charge uniformly distributed throughout its interior volume. Calculate the charge enclosed by a concentric spherical surface with radius (a) \( r = 2.00 \) cm and (b) \( r = 6.00 \) cm.

\[
\rho = \frac{Q}{\frac{4}{3} \pi a^3} = \frac{5.70 \times 10^{-6}}{\frac{4}{3} \pi (0.0400)^3} = 2.13 \times 10^{-2} \ \text{C/m}^3
\]

\[
q_{in} = \rho \left( \frac{4}{3} \pi r^3 \right) = (2.13 \times 10^{-2}) \left( \frac{4}{3} \pi \right) (0.0200)^3 = 7.13 \times 10^{-7} \ \text{C} = 713 \ \text{nC}
\]

(b) \[
q_{in} = \rho \left( \frac{4}{3} \pi r^3 \right) = (2.13 \times 10^{-2}) \left( \frac{4}{3} \pi \right) (0.0400)^3 = 5.70 \ \mu\text{C}
\]

Silly哥 said stupid.
A long, straight metal rod has a radius of 5.00 cm and a charge per unit length of 30.0 nC/m. Find the electric field (a) 3.00 cm, (b) 10.0 cm, and (c) 100 cm from the axis of the rod, where distances are measured perpendicular to the rod.

\[ E = \frac{q_{\text{in}}}{2\pi \varepsilon_0 r} \]

(a) \( r = 3.00 \text{ cm} \)

\[ E = \frac{30.0 \times 10^{-9}}{2\pi (8.85 \times 10^{-12})(0.03)} = 5400 \text{ N/C, outward} \]

(b) \( r = 10.0 \text{ cm} \)

\[ E = \frac{30.0 \times 10^{-9}}{2\pi (8.85 \times 10^{-12})(0.10)} = 540 \text{ N/C, outward} \]
44. A solid conducting sphere of radius 2.00 cm has a charge of 8.00 µC. A conducting spherical shell of inner radius 4.00 cm and outer radius 5.00 cm is concentric with the solid sphere and has a total charge of -4.00 µC. Find the electric field at (a) \( r = 1.00 \) cm, (b) \( r = 3.00 \) cm, (c) \( r = 4.50 \) cm, and (d) \( r = 7.00 \) cm from the center of this charge configuration.

P24.44  (a) \( E = 0 \)

(b) \[
E = \frac{kQ}{r^2} = \frac{(8.99 \times 10^9)(8.00 \times 10^{-8})}{(0.0300)^2} = 7.99 \times 10^7 \text{ N/C}
\]

(c) \( E = 0 \)

(d) \[
E = \frac{kQ}{r^2} = \frac{(8.99 \times 10^9)(4.00 \times 10^{-8})}{(0.0700)^2} = 7.34 \times 10^6 \text{ N/C}
\]

E = 79.9 MN/C radially outward

E = 7.34 MN/C radially outward
51. A hollow conducting sphere is surrounded by a larger concentric spherical conducting shell. The inner sphere has charge $-Q$, and the outer shell has net charge $+3Q$. The charges are in electrostatic equilibrium. Using Gauss's law, find the charges and the electric fields everywhere.

P24.51 Use Gauss's Law to evaluate the electric field in each region, recalling that the electric field is zero everywhere within conducting materials. The results are:

- $E = 0$ inside the sphere and within the material of the shell.
- $E = \kappa \frac{Q}{r^2}$ between the sphere and shell, directed radially inward.
- $E = \kappa \frac{2Q}{r^2}$ outside the shell, directed radially outward.

Charge $-Q$ is on the outer surface of the sphere.
Charge $+Q$ is on the inner surface of the shell.
and $+2Q$ is on the outer surface of the shell.
Two infinite, nonconducting sheets of charge are parallel to each other, as shown in Figure P24.62. The sheet on the left has a uniform surface charge density $\sigma$, and the one on the right has a uniform charge density $-\sigma$. Calculate the electric field at points (a) to the left of, (b) in between, and (c) to the right of the two sheets.

![Diagram showing electric fields](image)

**P24.62** Consider the field due to a single sheet and let $E_+$ and $E_-$ represent the fields due to the positive and negative sheets. The field at any distance from each sheet has a magnitude given by Equation 24.8:

$$|E_+| = |E_-| = \frac{\sigma}{2\varepsilon_0}.$$

(a) To the left of the positive sheet, $E_+$ is directed toward the left and $E_-$ toward the right and the net field over this region is $E = 0$.

(b) In the region between the sheets, $E_+$ and $E_-$ are both directed toward the right and the net field is

$$E = \frac{\sigma}{\varepsilon_0} \text{ to the right}.$$

(c) To the right of the negative sheet, $E_+$ and $E_-$ are again oppositely directed and $E = 0$.
What If? Repeat the calculations for Problem 62 when both sheets have positive uniform surface charge densities of value $\sigma$.

The magnitude of the field due to each sheet given by Equation 24.8 is

$$E = \frac{\sigma}{2 \varepsilon_0}$$
directed perpendicular to the sheet.

(a) In the region to the left of the pair of sheets, both fields are directed toward the left and the net field is

$$E = \frac{\sigma}{\varepsilon_0}$$
to the left.

(b) In the region between the sheets, the fields due to the individual sheets are oppositely directed and the net field is

$$E = 0$$

(c) In the region to the right of the pair of sheets, both are fields are directed toward the right and the net field is

$$E = \frac{\sigma}{\varepsilon_0}$$
to the right.