Point Charge in Uniform E field (corrected)

\[ \vec{F} = m\vec{a} = q\vec{E} \]

\[ \vec{a} = \frac{q}{m} \vec{E} \]

\[ v_x = v_0 \quad x = v_0 t \]

\[ y = \frac{1}{2} a_y t^2 = \frac{1}{2} \frac{q}{m} E \frac{x^2}{v_0^2} \]
Gauss’ Law

*relates the electric fields at points on a closed Gaussian surface and the net charge enclosed by that surface.

\[ \oint_S E_n \, dA = \frac{1}{\varepsilon_0} Q_{\text{inside}} \]
Concept of Flux

Air stream with uniform velocity, $v$, flows through a loop of area $A$ can define a flux:

$$\Phi = \frac{\text{volume}}{\text{time}}$$
Flux of an Electric Field

Gaussian surface of arbitrary shape immersed in a non-uniform electric field
Example: Flux through a Cube

Consider a uniform electric field oriented parallel to the x-direction. Find the net flux through the surface of a cube of edge L oriented as shown.
Gauss’ Law

*Relates net flux, $\Phi$, of an electric field through a closed surface to the net charge that is enclosed by the surface.

$$\varepsilon_o \Phi = \varepsilon_o \oint E \cdot d\vec{A} = q_{enc}$$
Gauss’ Law

\[ \varepsilon_o \oint \vec{E} \cdot d\vec{A} = q_{enc} \]
Gauss’ Law and Coulomb’s Law

Are equivalent and we can derive one from the other.

Gaussian Surface
Gauss’ Law: Spherical Symmetry

Shell Theorems

• A shell of uniform charge attracts or repels a charged particle that is outside the shell as if all the shell’s charge were concentrated at the center of the shell.

• A shell of uniform charge exerts no electrostatic force on a charged particle that is located inside the shell.
Gauss’ Law: Spherical Symmetry

Prove:

• A shell of uniform charge attracts or repels a charged particle that is outside the shell as if all the shell’s charge were concentrated at the center of the shell
Gauss’ Law: Spherical Symmetry

Prove

• A shell of uniform charge exerts no electrostatic force on a charged particle that is located inside the shell.
Gauss’ Law: Spherical Symmetry
Electric Field inside and outside a shell of uniform charge distribution

\[ E_r = \frac{1}{4\pi \varepsilon_0} \frac{Q}{r^2} \]

Demo: 5A-13 No Internal Field
Gauss’ Law: Spherical Symmetry

Spherically Symmetric Charge Distribution

Outside

Inside
Gauss’ Law: Spherical Symmetry

Spherically Symmetric Charge Distribution
Infinite Line of charge density $\lambda$

- From Symmetry: $E$-field only depends on distance $r$ from line
- Therefore, select the Gaussian surface to be a cylinder of radius $r$ and length $h$ aligned with the $x$-axis.

- Apply Gauss’ Law and assume uniform charge density $\lambda$: 
Example: Gauss’ Law: Cylindrical Symmetry

Two long, charged concentric cylinders have a radii of 3.0 cm and 6.0 cm. The charge per unit length is $5.0 \times 10^{-6}$ C/m on the inner cylinder and $-7.0 \times 10^{-6}$ C/m on the outer cylinder. Find the electric field at (a) $r = 4.0$ cm and (b) $r = 8.0$ cm, where $r$ is the radial distance from the common axis.