Lecture # 2

Electric Forces
Is it possible for a body to have an electric charge of \( 2.0 \times 10^{-19} \) C? 3.2 \times 10^{-19} C?

Checkup 22.4
For unlike charges, the attractive force of each lies along the line joining the charges.
Net force on \( \mathbf{a} \) is obtained by parastate diagram method.

Individual forces of \( \mathbf{F}_1 \) and \( \mathbf{F}_2 \) are added to find the total force.
What is magnitude of $F_1$ due to $\theta-\theta$ is attractive.

$+\theta$ is repulsive... and $F_1$ due to $\theta$ is attractive...

$F_2$ due to $-\theta$.
\[ |F_1| = \frac{kqQ}{r^2} = |F_2| \]

Component in \( y \)-direction is
\[ |F_1| \sin \theta = \frac{kqQ}{r^2} \sin \theta \]

Total force, add component from \( |F_2| \) that is of equal magnitude
\( \cos \theta = \frac{x}{r} \)
\[ |F_{\text{total}}| = 2 \frac{kqQ}{r^2} \sin \theta = 2 kqQ \frac{\theta}{2r^2} \]
\[ v^2 = x^2 + (d/2)^2 \]
\[ |F_{\text{total}}| = \frac{2 kqQ \theta}{2 \left( x^2 + \left( \frac{d}{2} \right)^2 \right)^{3/2}} \]

\( (5) \)
Is pushed outside the triangle
Is pushed toward the center of the triangle
Is in equilibrium and remains at rest

Vertex charges, the fourth charge
Three electric force contributions from the one side of the triangle. As a result of the point charge is placed at the midpoint of an equilateral triangular. A fourth, identical vertex.

Three identical point charges are at the vertices

Checkup 22.3
Find force on \( q \)

\[ b \]

\[ P \]

Not necessarily distributed

Total charge \( Q \)
\[
\frac{\Delta F}{\Delta l} = \frac{kq_0}{x} = \frac{dF}{dx}
\]

Integrate to infinitesimal limit

\[
\int_{x}^{x+\Delta x} \frac{kq_0}{x} \, dx = \left[ \frac{kq_0}{x} \right]_{x}^{x+\Delta x} = \frac{kq_0}{x} - \frac{kq_0}{x+\Delta x} \Delta x
\]

Force on \( \Delta q \) from \( \Delta q \)

\[
\frac{\Delta q}{\lambda} = \frac{1}{\lambda} \Delta x = \frac{\lambda}{L} \frac{1}{\lambda} = \frac{1}{L}
\]

\( \lambda = \frac{1}{L} \)

\( \lambda = \text{linear charge density} \)
where \( c \) is the side of the square.

**EXTRA:** Show that the magnitude of the electric force at \( P \) is \( F = \frac{4kQq}{c^2} \).

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
</table>

Assume the magnitudes of the charges at the corners have the same value \( q \).

What is the direction of the electric force at \( P \) on a negative charge \(-Q\)?

**Physics Quiz 22-4**
\[ \frac{2r}{c} = r \]

The center is \( r = \frac{2}{\sqrt{2}} \frac{2r}{c} \). The magnitude of the force can be written as \( F = 4kq_1q_2/c^2 \).

The resultant force at \( P \) is \( F = 2|kq_1q_2|/r \). Because the distance from corner to contributions of \( F \) from \( q_2 \) and \( q_1 \) cancel each other. Thus, the magnitude of the force from the sketch in the explanation, the force explanation—extra:

**Physical Quiz 22-4 Answer**
For an insulator, charge cannot move easily.

For a conductor, charge can move freely and find an equilibrium distribution.
\[ \sin \theta = \frac{L}{2} \]

Known variables are \( L \) and \( \theta \).

Find \( \theta \).

Equilibrium angle.

to make this

causings threads

...apart pushes balls

Electric force.
In equilibrium, vertical components of forces sum to zero, as do horizontal components.

\[ T \sin \theta = \frac{k q^2}{m g} \]

We resolve the tension into components.

\[ T \cos \theta = m g \]

Figure 22.5b Physics for Engineers and Scientists 3/e
© 2007 W.W. Norton & Company, Inc.

We eliminate both terms by dividing both sides by \( T \).
\[ \epsilon_0 = 8.85 \times 10^{-12} \text{ F/m} \]

\[ \frac{4\pi \epsilon_0}{1} = \frac{8.99 \times 10^9 \text{ N} \cdot \text{m}^2/\text{C}^2}{1} = \kappa \]

**Coulomb Constant**