PS 250: Lecture 3
Superposition and Electric Fields

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Today’s Class

- Electric Field
- Superposition of Electric Fields
- Example Problems
- Summary
A force \( \vec{F}_o \) is exerted on a test charge \( q_o \) by an electric field \( E \).

Given Coulomb's law, the Electric Field due to a Point Charge can be found:

\[
\vec{F}_o = q_o \vec{E} = q_o \frac{1}{4\pi \epsilon_o} \frac{q}{r^2} \hat{r}
\]

\[
\vec{E}_o = \frac{1}{4\pi \epsilon_o} \frac{q}{r^2} \hat{r}
\]
Electric field can be calculated for any charge distribution – However, Coulomb’s law (as was specified in 21.3) applies to point charges only.

... “F=qoE” only applies for test point charges “qo”, although “E” may be due to a charge distribution!

Electric fields exist without the presence of the test charges, such that:

\[
\vec{E} = \lim_{q \to 0} \frac{\vec{F}}{q}
\]
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Superposition of Fields/Forces

\[ \vec{F} = \vec{F}_1 + \vec{F}_2 + \vec{F}_3 \]

\[ \vec{F} = q_o \vec{E} = q_o \vec{E}_1 + q_o \vec{E}_2 + q_o \vec{E}_3 \]

\[ \vec{E} = \frac{\vec{F}}{q_o} = \vec{E}_1 + \vec{E}_2 + \vec{E}_3 \]
Superposition

- **Coulomb’s Law Superposition**: Sum of vector forces upon a test charge in the presence of other point charges can be calculated.

- **Electric Field Superposition**: The total vector electric field can be calculated from the sum of fields due to other charged bodies.

  ... Then, use “F=q_oE” to obtain force!
Charge Configurations

- **Line Charge:** 1D Charge Distribution $\lambda (\text{C/m})$
  \[ Q = \int dQ = \int_1 \lambda dl \]

- **Surface Charge:** 2D Charge Distribution $\sigma (\text{C/m}^2)$
  \[ Q = \int dQ = \int_s \sigma ds \]

- **Volume Charge:** 3D Charge Distribution $\rho (\text{C/m}^3)$
  \[ Q = \int dQ = \int_v \rho dv \]
Electric Field due to Charge Distribution

Consider infinitesimal E-field contributions (dE) due to each part of the distributed charge!

\[ E = \int dE = \frac{1}{4\pi\varepsilon_0} \int \frac{dQ}{r^2} \]

This will require examples!
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Summary / Next Class:

- **Read** Textbook Sections: 21.6–21.7 (and begin Chapter 22 if feeling ambitious!)
- **Work** on Homework for Wednesday.
- **Mastering Physics** for Monday.
- **Prepare** to discuss!