A Virtual Reality Adventure in Electrostatics

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Abstract

VR and Gamified activities can provide an opportunity for an entertaining exploration of challenging topics in introductory physics. The Virtual Reality Adventure in Electrostatics activity is being collaboratively developed in part as an honors project. This presentation will talk about the project development as a novel approaches to learning about electric fields and forces, and will also talk about some of the ultimate goals of the project as a learning vehicle for students in an introductory Electromagnetism course.

Student Honors Project Goals

Initial Objectives:

- Prototype an electric field "detector" to explore electric fields in a virtual space
- Design field configurations to allow "simple" exploration and characterization by student explorers
- Develop and refine virtual space and equipment esthetics

Long Term Goals

- Develop scenarios (with goals) for student exploration
- What is the detector detecting?
- What's in the box?
  - Training room for scaffolding
  - Randomized scenarios with tasks
- Multiple randomized scenarios (rooms) with tasks (an electrostatic Scavenger Hunt)

Virtual Physics

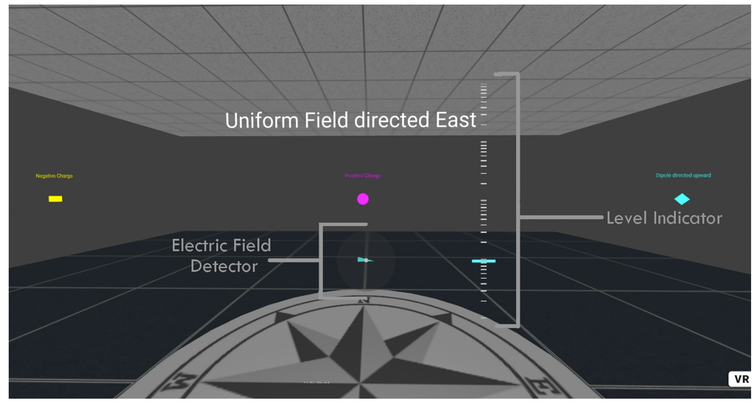
Electric Field Detector: Simple representation of Electric field at a field point

- "Hand Held"
- Electric field $\vec{E}$ direction indicated by pointer
- Electric field $|\vec{E}|$ magnitude
  - scale pointer size to reflect changes in magnitude (limited dynamic range)
  - Additional scale
  - All scales logarithmic
  - Additional color cues on magnitude changes

Electric Field Configurations

- Uniform Field E_0 in one of 6 cardinal directions
  - Sets scale for point sources
- Positive/Negative point charges
  - $\vec{E}(\vec{r}) = \frac{kq}{r^2}\hat{r}$
- Electric Dipoles
  - $\vec{E}(\vec{r}) = k\frac{3(\vec{p}\cdot\hat{r})\hat{r}-\vec{p}}{r^3}\hat{r}$
  - Oriented in one of 6 cardinal directions
- Threshold distance R
  - Transition from uniform field to point source
  - Sets scale for point sources
  - $E_0 = \frac{k|q|}{R^2} = \frac{k2|p|}{R^3}$
  - Always use same parameter magnitudes
  - E_0 set to be (slightly) more than barely detectable (detector can show if no uniform field is present)
  - Point sources are separated by more than R to avoid "cross talk"

The Virtual Space



Annotated snapshot of the detector in the "Training Room"

The training room:

- has a uniform field, a positive, a negative and a dipole source, all details
- Familiarizes prospective explorers with navigating the space and the detector's responsiveness

Random Room

- Three objects which may or may not contain a point source
- May or may not be a uniform field
- There will be at least two of: uniform field, positive charge, negative charge, dipole
- Explorer may go to a "circle of knowledge" to check their observations with the simulation

Essential Ingredients

Game180N: The Art and Science of Virtual Worlds

- PSU multidisciplinary general education course

A-Frame WebVR toolkit: https://aframe.io/

- A web framework for building 3D/AR/VR experiences

Penn State Schuylkill Campus Honors Program