Electric Potential

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1 Introduction

Today we will be talking about the electric potential, even though I am not present. You can email me at 2015akannan@tjhsst.edu or ask one of the other officers if you have questions.

2 Electric Potential

You may have noticed the many similarities between the gravitational force and the electric force. The gravitational field was the force per unit of mass exerted at each point in space, and the gravitational potential was the amount of energy needed per unit mass to bring an object to that point. The same thing is true for the electric field, except with charges. What makes all of this work is that the electric field will always be conservative ($\nabla \times E = 0$).

We therefore note that the electric potential depends on some reference value. For example, in gravity, we often set the ground to have zero potential. We will do the same with electric fields - this implies that we are generally interested in the difference between any two points in the field (also known as the potential difference). The definition of electric potential at an point $\vec{r}$ is:

$$V(\vec{r}) = -\int_O^{\vec{r}} \vec{E} \cdot d\vec{l}$$

Here O is the reference point. This means that the potential difference between any two points $\vec{a}$ and $\vec{b}$ is

$$\Delta V = V(\vec{b}) - V(\vec{a}) = -\int_{\vec{a}}^{\vec{b}} \vec{E} \cdot d\vec{l}$$

This potential difference is constant regardless of the reference point. This is usually why we study potential differences, like in a battery. From multivariable calculus, we can therefore state:

$$\vec{E} = -\nabla V$$

This relationship is analagous to that of force and potential energy.

There's one last important thing to know. Potential, which has a unit of a volt (joules per coloumb), obeys the superposition principle we talked about last time. This means that you can find the potential of various charge distributions using integrals.

3 Problems

1. Find the potential of a spherical shell of radius R and uniform charge (total charge q) at a point r away. Remember there are two cases. Let $r = \infty$ have zero potential.

2. Find the potential of an infinitely long wire of constant and uniform charge density λ a distance L above the wire.

4 Thanks to...

David Griffith's Introduction to Electrodynamics