# Electricty and Magnetism

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Last modified: 2017/07/09, at 23:14:42

**Dedication:**

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# 1 Preface

This document is (with some fairly minor changes) essentailly a glorified write-up of the work I completed for my high school's AP Physics C course. The course focused on inquiry-based learning, and much of the educational value derived from it depended on that fact. As such, I would highly advise that any student reading this document follow along with a pencil and paper, and attempt to work out the solutions before looking at the solution method. I'll give my answer at the end of the section, and my overall solution method at some point later in the document.

One piece of advice before we launch into it: **don't be intimidated by algebra.** Algebra is not where learning happens.(TOfinish)

# 2 Electrostaics: Forces, Fields, and Gauss' Law

## 2.1 Electricity and Magnetism

Electricity and Magnetism (commonly referred to simply as 'E&M') is a phenomenally cool subject. Oftentimes, students are divided into two main 'camps' when it comes to feelings with respect to E&M: about half tend to find E&M very challenging, as the systems are more abstract (it is in some sense 'harder' to imagine the minutia of interactions between electrons than it is, say, to imagine a ball rolling down a ramp). The other half tend to find E&M to be far *simpler* than mechanics, as the systems we typically analyze are far more constrained, and generally 'cleaner' than those we encounter in mechanics.

The goal of this text is to move all its readers from the former camp to the latter.

## 2.2 Coulomb's Law

We'll begin our discussion of E&M by talking about interactions between **charges**. The following is (very lightly) paraphrased directly from my high school packets.

In 1747, Benjamin Franklin became the first person to hypothesize that electric forces were due to a property of matter called *electric charge*, which exists in two varieties: positive and negative. Opposite charges attract each other, and like charges repel, with a force described by **Coulomb's Law**. Coulomb's Law is only valid if we are dealing with 'point charges'—i.e., charges that don't have any dimension to them (meaning they are infinitely small, and therefore have no width, height, or depth, existing only as a singular point in space). This should raise some eyebrows—how can a physical object have no length, width, or depth? Well, in terms of real, physical systems, we won't see anything of that sort in this text. But, we will interact with a lot of objects that we can *show* (with some clever math) can be *treated* as point charges, without 'losing' any descriptive information about our system. As such, understanding how to deal with systems involving the interactions between point charges is important to being able to describe more complex systems.

If $q_1$ and $q_2$ are two point charges and $r$ is the distance between them, then they attract or repel (according to their signs) with a force

$$\|\vec{F}\| = \frac{k\,|q_1|\,|q_2|}{r^2}$$

where $k$ is a constant, with value

$$k = 9 \times 10^9 \frac{\mathrm{N} \cdot \mathrm{m}^2}{\mathrm{C}}$$

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