

Chapter 2: Permittivity of Free Space

Overview:

Every charged particle creates a distribution of electric field. At any point in space, the magnitude of the electric field depends not only on the charge and its position, but on the permittivity of the space around the charge and your chosen point. This is true for electric fields in vacuum (“free space”) as well as for those in various materials. We will use the concept of capacitance to attempt to measure the permittivity of air. As a check, we will combine our resulting permittivity with the known magnetic permeability to determine the speed of light.

Suggested Reading Assignment:

Chapters titled “Capacitance” and “Electromagnetic Waves” in Halliday and Resnick.
e.g., Chapters 26 and 34 of Halliday, Resnick, and Walker, 6th edition.

Pre-lab Questions:

1. What is the relationship between the speed of light, the permittivity, and the magnetic permeability? What are the accepted values of these constants in vacuum? What is the uncertainty of each of these three values?
2. How much do these three constants differ for air as compared to vacuum?
3. What is the force between the capacitor plates of a parallel plate capacitor? (see problem 26-33P in Halliday, Resnick and Walker, 6th edition). Express this force as a function of ϵ_0 , A , the area of the plates, V , the voltage between the two plates, and r , the distance between the plates.
4. In the figure below, an upper plate, having weight m_0g , is made to hang from a spring having constant k . Use free-body analysis to obtain an equation for V as a function of r . Your final answer may include r_0 , but neither r_s nor m_0 . Plot this function. Where is the maximum of this function located?

