

An Apparatus for the Study of Electrostatic Forces Between Charged Parallel Plates

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Abstract:

We describe a simple apparatus to quantitatively demonstrate the forces produced by the electrostatic attraction of charged parallel plates. The apparatus is based on an inexpensive digital scale with a least count of 0.01 gram, sufficiently sensitive to measure the force produced on one of two circular parallel plates with a 5 cm radius, and an inexpensive digital caliper, which measures the plate separation with a least-count resolution of 10 μm . The apparatus demonstrates the dependence of the electrostatic force on the potential between the plates ($\propto V^2$) and the distance of separation between the plates ($\propto d^{-2}$). Students can derive the force acting on the plate as a function of the potential difference between the plates and the plate separation by using Gauss' Law to relate the plate surface charge density to the electric field between the plates and then applying the definitions of the electric field and electrostatic potential. By measuring the electrostatic force for a known potential difference and plate separation, ϵ_0 can be determined to within $\leq 5\%$ of the accepted value.

Description

This is a simple apparatus to construct. A small table is constructed from sheet plastic and cylindrical plastic support legs. Two banana binding posts are mounted to the side of this small support table. One plate rests on the pan of the digital scale supported by a lightweight foam pedestal. The second plate is supported by the movable jaw of the digital caliper which is mounted to the support table on a plastic support pylon. A mechanical stop attached to the caliper support

permits the top plate to rest with zero-gap and zero-load on the bottom plate. The inter-plate gap can then be set to a resolution of $10\ \mu\text{m}$ by sliding the caliper jaw vertically. A fine copper wire lead, attached with conductive copper tape, connects the bottom plate to the positive binding post. The upper plate is connected to the negative binding post with wire and a ring lug. A special low-current high-voltage power supply maintains a fixed potential (0-6 kV) between the plates. A photo of the apparatus appears below:

