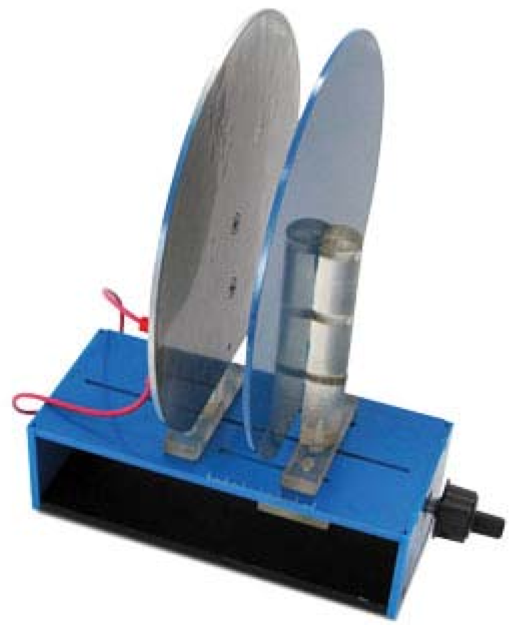
615-4125 (10-225) Variable Plate Capacitor



Introduction: Capacitance is an electrical phenomenon. It describes the ability of an object to hold an electric charge, as well as the amount of charged stored. A charge is stored when two objects are given opposite charges and separated from each other. This creates an electrical potential, which becomes current when the two charged objects are brought into contact. The symbol for the charges is +Q and –Q. Thus, the equation $C = \frac{Q}{V}$ describes capacitance, where

C= capacitance
Q= the level of charge
V= the voltage potential.

The SI unit for capacitance is the Farad, which is one volt per coulomb. Devices called *capacitors* use the property of capacitance to store electricity. Most operate at capacities below one Farad.

A capacitor is basically two conductors separated by a dielectric, i.e. a nonconductor. When electricity is applied to the device, the two plates charge, but cannot discharge because they are not grounded. An electrical field forms between them, occupying the same space as the dielectric. In fact, the electricity stored inside a capacitor is actually stored on the dielectric, not the conductors!

A capacitor functions best when it is composed of two smooth, large plates separated by a very small distance. Our variable plate capacitor operates on this principle.

Description: Our variable plate capacitor is so named because the two plates can be moved closer to or farther away from each other using the plastic hand crank. In general, the farther the plates are from each other, the less electricity can be stored. Consider the inverse square law: the strength of an electromagnetic field decreases as the square of the distance. This means that the field becomes exponentially weaker as you move away from it. For this reason, the plates of a capacitor should be as close together as possible to maximize storage.

Concepts Taught: Capacitance; Conductors; Dielectric Constants; Electric Fields; Electricity

Curriculum Fit: Electricity and Magnetism

Additional Materials Needed:

- 6V battery
- 100M charging probe
- 1 banana plug cable, black approximately 120 cm, with one alligator clip (for ground lead)
- 1banana plug cable, black, approximately 60 cm, with two alligator clips (for battery)
- Cable with BNC at one end, 2 alligator clips at other end (for electrometer)
- Electrometer
- Digital Multimeter, item 25-190

- 1 pair of Calipers

Experiment 1: Preparing the Variable Plate Capacitor

1. Measure the parallel plate area and record its value below.
   Plate area (A) =_____________________________________cm^2
2.
3. Use the hand-crank to separate the two plates by 1cm. Use calipers to verify the distance is 1 cm. Calculate capacitance by using the formula:

$$C=\frac{K\varepsilon_0 A}{d}$$

   K=dielectric constant of material between electrodes
   $_0$ = permittivity of space = 8.854×10^{-12}
   A = area of parallel metallic plate in m^2
   d= distance between plates in meters

   Note: Air has a K value of 1.00054

   C=____ (pF)

4. Connect your 6V battery as follows:
   a. One terminal is connected to the charging probe
   b. The other terminal is connected to a banana plug cable

5. Move the plates to the minimum separation, approximately 1mm apart.

6. Connect the banana plug cable from step 3 to one of the binding posts on the variable plate capacitor. To charge your electrode, touch one of the capacitor plates momentarily with the probe.

7. Adjust the electrometer so that it is on a 30 V scale.

8. Connect the output of the electrometer (two banana plugs) to the input of the multimeter (two more banana plugs). Choose the 20V DC scale on the multimeter. **note: because you are using 30V scale on the electrometer and a 20V scale on the multimeter, you will need to multiply your results by 10.

Experiment 2: Measure Potential Voltage versus Separation Distance

Theory: Calculate 1/V and 1/d for each of the values. Make a plot of 1/V versus 1/d. The plot should be a straight line. Note: a straight line indicated that C is proportional to 1/d for the capacitance of two parallel plates separated by a distance d.

1. Separate the plates at a distance of 5mm

2. Banana plug leads should be attached to the two binding posts of the capacitor. The other ends should be connected by means of a coaxial cable to the electrometer.

3. Apply a charge to an electrode using the two leads attached to the battery (one is a banana plug, the other is the probe).

4. After applying the charge, remove the leads from the binding posts.

5. Measure the potential indicated by the electrometer, by reading the value from the multimeter display. Record value in Table 1 below.
6. Repeat steps 1-5 for the following distances 5, 10, 15, 20, 25, 30, 25, 40, and 45mm. You will apply a fresh charge each time as per step 3 when the electrodes are positioned at 5mm, and then move the distance to 10-45mm as stated by the experiment.

Table 1.

Potential (V)	Distance (mm)
	5
	10
	15
	20
	25
	30
	35
	40
	45

Related Products:

615-3095 Faraday Cage- Demonstrate that charge cannot exist inside a conductor cage. Study the lightning rod effect. Includes: cage with stand and cover; mounted point, instructions. Interior dimensions are 10.5 inches high and 4.75 inches in diameter.

615-3085 Electrostatic Studies- Charge electroscopes, show electrostatic attraction, duplicate Faraday's ice pail experiment and more! This kit contains everything needed for home or school study of static electricity. Includes: 2 electroscopes with flasks; 2 ball and disc terminals; Faraday cage; 6 friction rods, labeled; electrophorus with charge plate and handle; neon lamp; ice pail; acetate and polyethylene cloth; charge transfer ball; conductive ball; pith balls; mounted point; instructions.

615-3090 Electrostatic Studies- Make electricity by friction; store and transfer it; learn about electrophorus and proof plane. Includes: electrophorus with charge plate and handle; 6 friction rods, labeled; acetate and polyethylene cloth; proof plane with transfer ball; neon lamp; conductive ball with hook; pith balls; instructions.

615-3205 Leyden's Jar- This dissectible Leyden Jar will hold a charge for hours. Prove that a charge is stored in the dielectric insulator, not metal surfaces. After charging, the conductors may be removed and the charge measured. Includes two aluminum cans, polystyrene dielectric, electrode and ball terminal, and instructions with labs. Use your Van de Graaff Generator to charge it up!

615-0330 Lenz' Law Hoops- This great demonstration teaches Faraday's Law of Induction as well as Lenz's Law. Show how passing a magnet through a complete loop causes the device to move. No movement at all occurs when using the split loop.

Warranty and Parts:
We replace all defective or missing parts free of charge. Additional replacement parts may be ordered toll-free. We accept MasterCard, Visa, checks and School P.O.s. All products warranted to be free from defect for 90 days. Does not apply to accident, misuse or normal wear and tear. Not designed for children under 13 years of age.