

# COULOMB'S LAW

The Coulomb's Law Kit is designed to investigate the electrostatic force between charged pith balls in a protected environment inside a black box.

The pith balls can be charged using an electrophorus, a perspex rod or acetate strips.

The box contains a window for viewing the interactions, a scale for taking measurements and a mirror mounted to enable accurate readings to be taken.

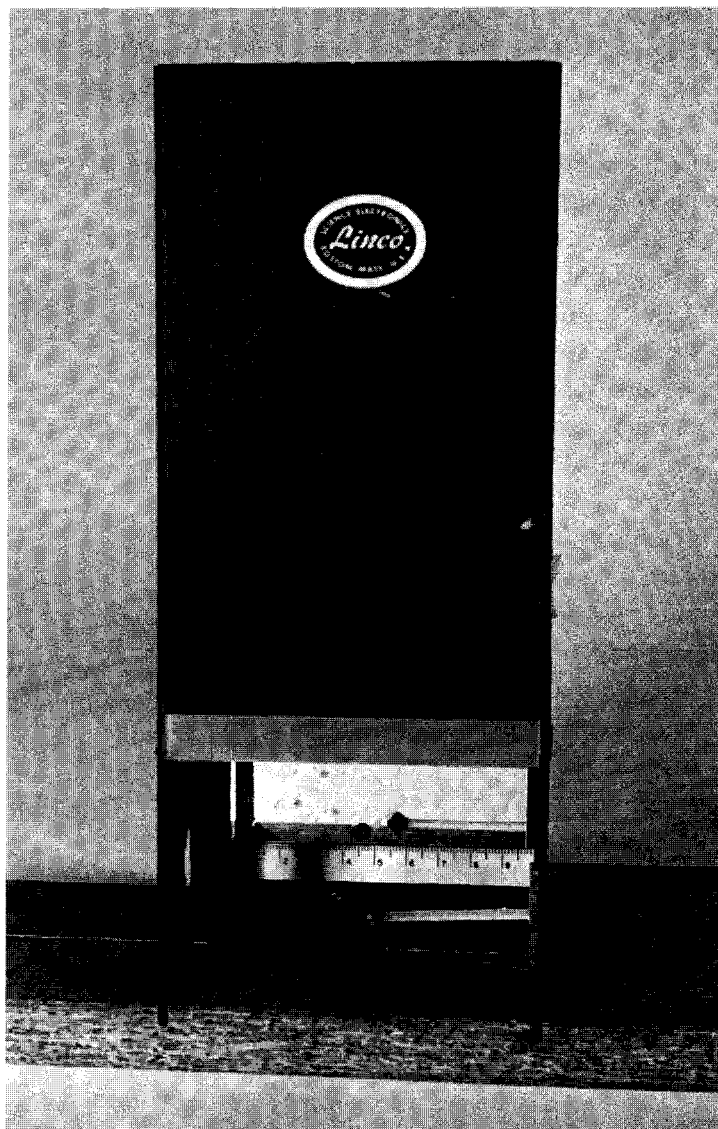
## SETTING UP AND USING COULOMB'S LAW KIT

**C** It is worth noting the following before setting up the equipment.

- *This equipment is heavily dependent on the weather conditions.* The electrostatic charge leaks away rapidly to water molecules and dust particles in the air. Hence the equipment works well on a dry windy day but poorly on a wet, humid day.
- Check that there are metallic-coated pith balls with the equipment.
- Check that a ball is stuck firmly to each of the plastic rods protruding from the sliding wooden stands.
- Keep all the charged objects (pith balls, electrophorus, rods) away from good conductors such as metals which will discharge them.

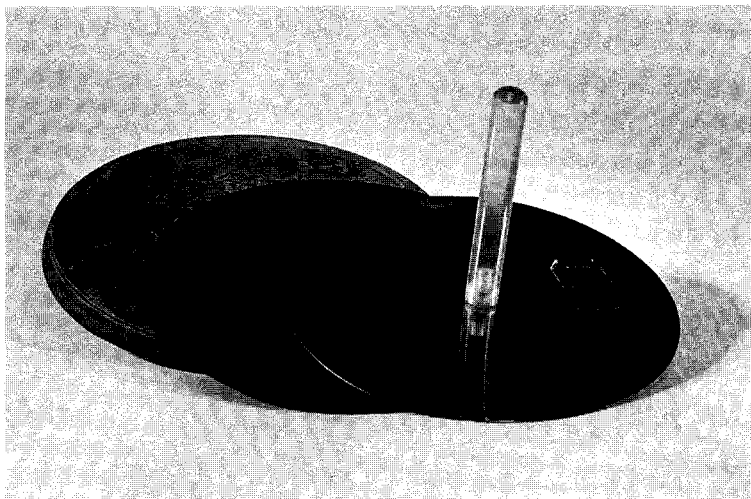
Extra equipment for the suggested learning experiences includes:

- electrophorus and flannel or . . .
- perspex rod and silk
- silk thread (less kinky than the nylon thread supplied)
- a scalpel to pierce the pith ball so that it can hang on the silk thread
- aluminium powder or graphite to coat the pith balls
- an overhead projector
- large sheets of paper to put on the wall
- an overhead transparency made from graph paper.



## Setting up the Coulomb's law Kit

- Position the black box and lid on the overhead projector and leave for approximately half an hour before doing the experiments as the heat from the projector helps to dry out the air, improving the results.
- Use a scalpel to cut a slit in one of the pith balls and thread it on to a piece of silk thread. Remove any kinks from the thread so that the movement of the suspended ball, as far as possible, is restricted to one dimension.
- Dip the metallic-coated pith balls in aluminium powder or graphite to enhance the amount of charge they can sustain.
- Suspend this thread by attaching it through the small slits cut into opposite sides of the top of the box to form a V-shape.
- Adjust the pith ball so that it hangs in the middle of the viewing area in front of the mirror approximately centred on the scale markings and level with the fixed ball attached to the wooden block.
- *Charge the pith balls using one of the following methods*
  1. **On a good day (low humidity)** it is easier to use a *perspex rod and silk cloth* to charge the pith balls. Vigorously rub the perspex rod with silk and touch the pith balls by inserting the rod through the side of the box.



The Electrophorus

2. **For a larger charge or for use on a humid day, try the *electrophorus*.** Induce a charge on the upper metal disc of the electrophorus in the following way:
  - Use a flannel cloth to rub vigorously the ebonite disc of the electrophorus.
  - Place the metal disc on top and earth it by touching the top of it with your finger.
  - Remove your finger first and then the metal disc, being careful to keep it exactly horizontal as you lift it off the ebonite. The induced charge will remain on the disc of the electrophorus for longer than that on the perspex rod.
  - Lift the suspended pith ball out of the box to touch it with the metal disc.
  - Ensure that the pith ball does not touch the sides of the box after it has been charged.

## HANDY HINTS

- Position the whole apparatus at eye-level for taking measurements.
- Readings must be taken within 30 seconds to ensure the minimum charge leakage.
- Test the amount of leakage by returning the balls to the initial separation and record the deviation once again. The difference between these readings will give a measure of the amount of charge which has leaked into the air (use this for error calculations).
- Charge both pith balls with the same charge as it is easier to manage the repulsive force between like charges than it is to control the attractive force between oppositely charged objects.
- When taking measurements, cover the box with the perspex lid and one side of the box with cardboard to prevent any currents of air from blowing the suspended ball.
- When taking measurements using the ruler and mirror, line up the pith ball with its image in the mirror to prevent parallax error.
- The experiences can all be performed on the overhead projector and consecutive positions marked on the image which has been projected onto the blackboard or large pieces of paper taped to the wall.

## SUGGESTED LEARNING EXPERIENCES

### TOPIC: Electrostatics

- 1. Discover the mathematical dependence of the electrostatic force ( $F_E$ ) between two charged objects and the distance ( $r$ ) separating them. [ $F_E \propto 1/r^2$ ]** This experiment is written up in many texts, including the PSSC Laboratory Manual, page 63.

This is a quantitative experiment involving the measurement of two distances. The distance  $r$  is between the pith balls and  $d$  is the distance the suspended pith ball moves from its equilibrium position. This second distance is shown in figure 1 to be a measure of the electrostatic force when both pith balls are charged.

As the fixed ball is moved closer to the suspended ball, pairs of measurements are quickly taken. To avoid too much error from the leakage of charge to the air, each set of measurements should be taken in a 30 second period. Graphs of  $F_E(d)$  against  $r$ ,  $r^2$  and  $1/r^2$  can be obtained from the results.

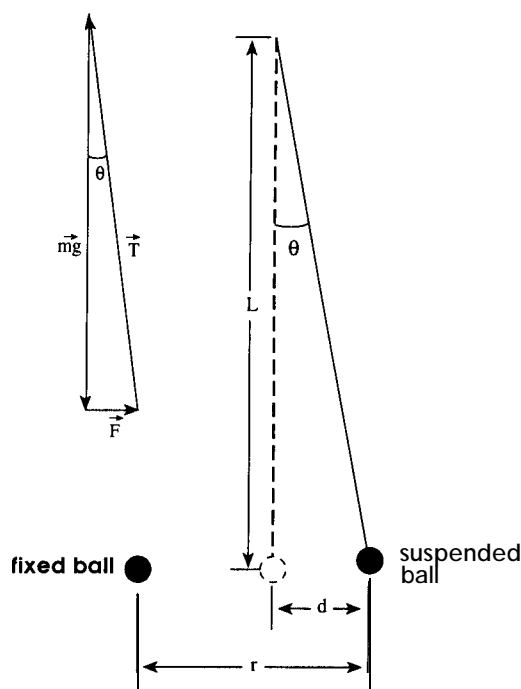


figure 1

- 2. Investigate the relationship between the electrostatic force on two charged objects and the charge on each of them. [ $F_E \propto q_1 q_2$ ]**

This is a quantitative experiment involving the measurement of the deflection of the suspended pith ball at a fixed distance from another charged ball (a measure of the electrostatic force) while varying the charge on one of the balls.

  - Note the equilibrium position of the suspended ball.
  - Charge both balls with the same charged rod or electrophorus.
  - Select a position for the fixed ball which produces a strong deflection in the suspended ball.
  - Halve the charge on the suspended ball by touching it with an identical, neutrally charged ball.
  - Note the new position of the suspended ball.
  - Repeat the procedure, halving the charge of the suspended ball again, though all measurements for a particular original charging should be taken within a 30 second period to avoid charge leakage into the air.
  - The whole experiment can be repeated several times.
  - As an extension to this experiment, halve the charge on both the pith balls and record the effect on the electrostatic force between them.

- 3. Demonstrate the vector addition of electrostatic forces on a charged object.**

**See page 67 of the PSSC Laboratory Manual for details of the procedure.**

This is a quantitative experiment involving the measurement of the deflection of the suspended ball when two similarly charged balls are placed close to it.

In order to measure the direction of the deflection the pith ball must be suspended by one single thread from the centre of the perspex lid of the box.

This experiment is easier to see if the whole thing is done on the overhead projector. Make an overhead transparency of the graph paper supplied and place it underneath the box. Measurements can be made on a piece of paper taped to the wall on to which the experimental grid has been projected.