

eMATH

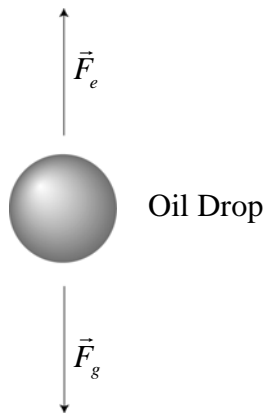
Millikan's Oil-drop Experiment

Purpose:

To gain insight into the methods Robert Millikan used to determine the fundamental unit of charge.

Background:

Robert Millikan is credited with being the first person to determine the charge of an electron. He did this using his "Oil-drop Apparatus." In this apparatus he balanced the electric and gravitational forces acting on a charged oil drop, causing it to be suspended in these fields (see figure 15.9 in your textbook for diagram of the apparatus).



If the two forces are balanced, then it is possible to write the equation as:

$$\vec{F}_{net} = \vec{F}_e + \vec{F}_g$$

Since these forces are equal and opposite, the net force is zero and the equation can be written as:

$$\vec{F}_e = \vec{F}_g$$

$$\vec{E}q = m\vec{g}, \quad \text{since } \vec{E} = \frac{V}{d}$$

$$\frac{V}{d}q = mg$$

$$q = \frac{mgd}{V}$$

Millikan knew the mass of each drop (m), the gravitational field strength (g), the distance between the plates (d), and the voltage across the plates (V), so he was able to determine the charge on each oil drop. Unfortunately, the charge on each oil drop could be the result of an excess or deficit of many electrons, not just one.

To determine the charge of an electron, he performed the experiment many times, each time determining the charge on each drop. Then he made a table where he arranged the charges from smallest to largest and looked for the lowest common factor between all the charges. He knew that this would be the charge of an electron, or the smallest possible charge in nature – the fundamental unit of charge.

The purpose of this eMATH is to replicate Millikan's experiment with a much smaller sample of data. You will follow the same procedure Millikan did to determine the fundamental unit of charge.

Instructions:

1. Download and open the accompanying Excel spreadsheet. Table 1 shows a sample of 10 oil drops with the charge found on each. Take the charges of the oil drops and copy them in ascending order into the first column of table 2. As you do this, the second column in table 2 computes the difference in charge between each successive drop and plots a bar graph of the differences in charge.

Analysis:

1. Look at the graph created after the charges were entered into table 2. Find the lowest difference in charge. What is this value?
2. Take this value and divide it into the other differences and oil-drop charges shown on the chart. Does it divide into these differences/charges evenly? If so, what can you say about this charge difference?
3. What limitations does this model have? (Hint: What might happen if more oil drops were used?)