

Millikan Oil Drop Experiment

Introduction

One of the classical experiments in Physics was Robert Millikan's famous Oil Drop Experiment where he determined the existence of a smallest charge and then determined the value of that charge.

Purpose

To determine if there is a smallest charge and if so, what that charge is.

Theory

A tiny oil droplet that has a charge can be suspended between parallel plates by balancing the downwards gravitational force on the droplet ($F_g = mg$ where m is the mass of the droplet in kg and g is the acceleration due to gravity equal to 9.8 m/s^2) and the upwards electrostatic force ($F_e = VQ/D$ where V is the voltage across the plates in volts, Q is the charge on the droplet in coulombs and D is the separation between the plates in metres). The mass of the droplet can be determined from its volume and density. For the volume, it can be assumed the droplet is a sphere so that $\text{vol} = 4/3 \pi r^3$. The density of oil is a constant at 851 kg/m^3 . Equating $F_g = F_e$ and solving for the charge leads to

$$Q = \frac{mgD}{V}.$$

Procedure

1. Start the program. Press the <PRGM> button and select the program "MILLIKAN". Press <Enter>. The line prgmMILLIKAN will appear on the screen. Press <Enter> again. An introduction screen appears. Press <Enter> again.
2. Select whether a new experiment is to be started or a previous experiment is to be continued. Usually, a new experiment is started; however, if during an experiment it is necessary to exit the program, the experiment can be continued without the stored data being lost by choosing to "Continue Old".
3. Select "New Droplet". The following screen appears:

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V(V) = 0	
VSTEP(V) = 100	
R(M) = 1.240E-6	
N = 0	

The droplet immediately begins to fall. Adjust the voltage until the forces are balanced and the droplet stops. The arrow to the right of the droplet indicates the direction of the net force. It will disappear when the net force is 0. If the droplet hits one of the plates, it will be lost and a new droplet will need to be generated.

The voltage is adjusted using the arrow keys on the calculator.

Up arrow – increases the voltage by the VSTEP amount.

Down arrow – decreases voltage by the VSTEP amount.

Left arrow – decreases VSTEP by a factor of 10. The minimum VSTEP is 1 V.

Right arrow – increases VSTEP by a factor of 10. The maximum VSTEP is 10000 V.

The voltage must be adjusted to the nearest 1 V to stop the droplet.

4. Once the droplet is stopped, press <Enter> to return to the Main menu. Press <2> to store the droplet data. The plate separation, droplet radius, voltage to stop the droplet and the resulting charge are stored.
5. Repeat steps 3 and 4 until 30 to 40 droplets are stored. A plot of the droplet charges can be viewed at any time by selecting <3> off the Main menu.
6. Once all the droplets have been collected, use the “View Data” option on the Main menu and copy the plate separation, droplet radius and voltages into a spread sheet on the computer. Use the spreadsheet to calculate the charge on each droplet. Plot a histogram of the charges (sorted from smallest charge to largest). The histogram should show the clear step-like character of a variable that has discrete values.
7. From the histogram and the data, determine the value of the smallest charge. Compare it to the accepted value of $e = 1.602 \times 10^{-19} \text{ C}$.
8. Exit the MILLIKAN program on the calculator by selecting “Exit” off the main menu. This will properly reset the calculator screen and other properties to their normal mode.

DO NOT USE <2ND><MEM> AND RESET TO RESET THE CALCULATOR. THIS WILL ERASE ALL THE PROGRAMS ON THE CALCULATOR INCLUDING THE MILLIKAN PROGRAM.