

Millikan’s Oil Drop Experiment

Experimental Report

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# Abstract

A concise summary (100-150 words) of the major aspects of the entire report. It should include the aim, (very) brief method and outcome

# Introduction

Establishes the context of the work being reported, typically by providing an overview of the theory and background information. The introduction should also state the aim of the study in the form of a hypothesis. This should also include the main equations used for analysis.

# Materials and Methods

### Materials

This experiment included an apparatus designed for this experiment, called the *droplet viewing chamber*. This apparatus consists of a *spacer; A* round disc, approximately 50 mm thick, of transparent plastic with a hollow region in the middle (like a torus), to act as a viewing area. This plastic piece is designed to allow light to be shone through the side into the viewing area, as well as allow clear sight in through the side, into the viewing area. It also includes an adjoining region which has been cut out to allow a radioactive ionization source, in this case Thorium-232, which allows the viewing area to be either shielded or exposed to ionization, and also opens a small hole through which air can pass. This adjustment is made with a lever with ionization positions ‘on’, ‘off’, and also ‘spray droplet’ which opens the hole.

This plastic spacer has a capacitor plate above and below it, with connector pins. The top plate has a small hole in the center (approximately 1-2 mm radius). This hole has a cover, to stop air from flowing in. This assembly is house within a hollow cylindrical housing which acts a shield from ambient light, but also allows a light source to be shone into the plastic spacer to the viewing area. The housing also has a hole through which viewing scope can be placed. This assembly is called the *Droplet viewing chamber*.

In addition to that apparatus, the material required are

* Voltage supply
* Switch capable of reversing polarity, and disconnecting the voltage supply
* Multimeter
* Thermometer
* Barometer
* Graph for conversion between temperature and air viscosity
* Mass scale
* Focusing wire
* Oil
* Oil atomiser
* Viewing scope with reticle (engraved hairline displacement scale)

# Method

## Part 1

The chamber is wiped clean on the interior with a paper towel and the separation of the capacitor plates is measured and recorded by measuring the thickness of the spacer, on the surface which the capacitor plates will be resting (Careful not to measure any lips or grooves).

A focusing wire is inserted into the hole of the upper capacitor plate. The brightness of the light source is adjusted such that there is maximum contrast when viewed through the scope. The scope is adjusted such that the reticle and also the wire are both in focus. The droplet hole cover and lid are both replaced.

## Part 2

The DC power supply is attached to the capacitor plates and adjusted to supply about 500 Volts. A multimeter is connected across the plates, and the true voltage potential is recorded.

The barometric pressure is recorded. The ambient temperature is recorded, and used with the suitable graph to estimate air viscosity. The density of the oil is recorded, and loaded into the atomiser.

## Part 3

The capacitor plates are disconnected from the voltage source. A sheet of paper is held near the atomiser nozzle, which is pumped rapidly until oil is coming out properly (no air occlusion which cause inconsistent oil flow). The ionization source lever is moved to ‘spray droplet’ position, the atomiser is placed at the hole in the lid of the viewing chamber, and an observer views through the eyepiece. The atomiser is squeezed until a sufficient spray enters the viewing area, at which point the ionization source lever is turned to ‘off’.

From the eyepiece, a drop is chosen which is falling at 0.2-0.5 mm per second, and the capacitor plates are charged to whatever voltage causes droplet to begin rising. If the droplet does not respond to the charge, a new droplet should be selected.

The droplet should be allowed to rise through a pre-determined distance, and the time it takes to do so is recorded, with the distance and direction of travel (up/down). The capacitor polarization is toggled and the time taken for the droplet to travel the same distance is recorded, along with the distance and direction, again. This process should be repeated 10-20 times. If the droplet stops reacting to the voltage, a new droplet should be selected, and the chamber re-ionized, or the viewing chamber wiped clean.

Part 3 should be repeated entirely again, for as many droplets as is required.

# Results

The measurements obtained from part 1 of this experiment is presented below in Table 1

Table 1 Measurements of experimental conditions

|  |  |  |
| --- | --- | --- |
| **Measurement** | **Recording** | **Error** |
| Plate separation (metres) | 7.86 × 10-3 | 10-5 |
| Plate Voltage (Volts) | 502.9 | 0.005 |
| Temperature (Celsius) | 22 | 0.5 |
| Air Viscosity (Nsm-2) | 1.832 × 10-5 | 0.006 |
| Barometric Pressure (millibar) | 1008 | 0.5 |
| Oil Density |  |  |

The electric field strength between the two capacitive plates is given by with an error given by .

The value of electric field intensity, for all droplets of this experiment was E=64.0 × 103 ± 1.28 NC-1.

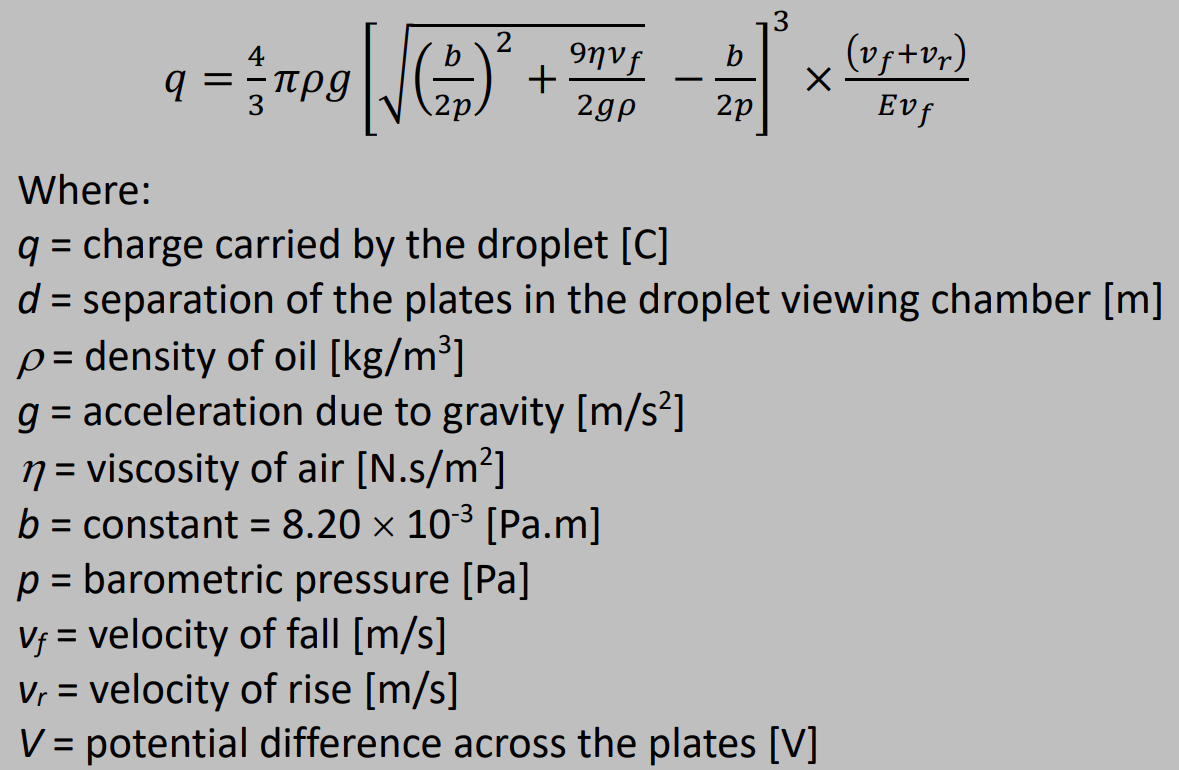
The data gathered for droplet #1 is presented in Table 2, as an example of the full dataset

Table 2 Collected data for droplet 1

Travel Distance: 0.002 ± 0.000025 m

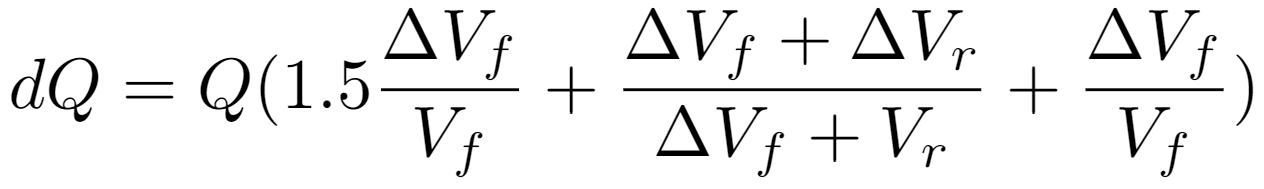
|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Trial N | Time Fall (s) | Velocity (mm/sec) |  Velocity (mm/sec) | Time Rise (s) | Velocity (mm/sec) |  Velocity (mm/sec) |
| 1 | 3.570 | 0.056 | 0.008 | 1.410 | 0.142 | 0.050 |
| 2 | 5.490 | 0.036 | 0.003 | 1.260 | 0.159 | 0.063 |
| 3 | 5.990 | 0.033 | 0.003 | 1.020 | 0.196 | 0.096 |
| 4 | 6.920 | 0.029 | 0.002 | 0.920 | 0.217 | 0.118 |
| 5 | 5.140 | 0.039 | 0.004 | 1.320 | 0.152 | 0.057 |
| 6 | 4.180 | 0.048 | 0.006 | 0.920 | 0.217 | 0.118 |
| 7 | 4.420 | 0.045 | 0.005 | 0.790 | 0.253 | 0.160 |
| 8 | 6.400 | 0.031 | 0.002 | 0.790 | 0.253 | 0.160 |
| 9 | 3.690 | 0.054 | 0.007 | 0.900 | 0.222 | 0.123 |
| 10 | 4.000 | 0.050 | 0.006 | 0.790 | 0.253 | 0.160 |
| AVERAGE | 4.980 | 0.042 | 0.005 | 1.012 | 0.206 | 0.111 |

From the equations provided in the experimental instructions the charge on a drop of oil can be calculated by:



Using the average values for fall velocity and rising velocity for this droplet (vf and vr) values presented in Table 2, this equation is now solvable, for this droplet:

The error on q can be calculated by:



This process was done for all droplets in the dataset. The data for droplet three shows a dramatic, change in behavior after it’s 12th change in direction. For reasons mentioned in the discussion of this report, that data is presented below as belonging to two different drops, number 3 and 4.

The results are presented below, in Table 3.

Table 3 Calculated charge on each droplet.

|  |  |  |  |
| --- | --- | --- | --- |
| Droplet Number (n) | Charge (Coulombs) | Absolute Error | Relative error |
| 1 | -1.103×10-18 | -8.198E-19 | 0.743 |
| 2 | -9.291×10-19 | -6.682E-19 | 0.719 |
|  | -8.501E-19 | -5.665E-19 | 0.666 |
| 3 | -5.277×10-19 | -5.563E-19 | 1.054 |
| 4 | -4.083×10-19 | -2.047E-19 | 0.501 |
| 5 | -2.468×10-19 | -9.973E-20 | 0.404 |

Droplet number 6, being the smallest, was then treated as being the fundamental charge which the others were multiples of. The charge on each droplet, and the error of charge on each droplet, was divided by the charge on droplet 6, to give the table below.

Table 4 Charge and error as a multiple of the lowest charge

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Droplet # | 1 | 2 | 3 | 4 | 5 | 6 |
| Multiple of charge | 4.46986 | 3.764392 | 3.444285 | 2.138017 | 1.654449 | 1 |
| error | 3.321552 | 2.707543 | 2.295096 | 2.254125 | 0.829439 | 0.404083 |

Figure 1 Charge as a multiple of the lowest charge

A description of your observations without interpretation or speculation. Data can be presented objectively in both text and illustrative examples such as summary tables and graphs. Full tables of results should only be included as appendix. All data must be accompanied by the experimental error.

# Discussion

Provides a forum to interpret the experimental data in light of the pre-existing knowledge. This is where you should compare your experimental results to expected values. Experimental error: You should include a discussion about the sources of error in the experiment – and how they impacted your results. A full calculation of the error propagation is also required. The length of this section will depend on your results and the experiment. Other issues that may be covered in a discussion include questions raised by the study that require further analysis or inconsistencies between the current study and other relevant publications.

# Conclusions

A brief summary of your findings, with comments on the key points and suggestions on future work if required.

# References

Include appropriate references to the original papers or books reporting the theory and the results of similar experiments or findings. In physics journals, references are typically progressively numbered. For more info on how to number references see <http://www.citewrite.qut.edu.au/cite/qutcite.jsp#numbered-journal-print>

# Figures

Graphs needs to be clearly labelled, with axes and scales properly marked. Prefer the sans serif, more simple fonts (Arial, Calibri, Helvetica, etc) which are more clearly readable. Data points need to be clearly visible. Indicate the error with suitable error bars, and the fitting/theory with a continuous or dashed line. In the schematics of the apparatus the parts need to be clearly described by appropriate labels. Photos can be inserted, but only if they are important to the discussion. Every figure need to be accompanied by a figure caption, with progressive numbers.