

Millikan's Experiment

Objective:

To determine the elementary charge.

Procedure:

1. Measure the atmospheric pressure in pascals using Capstone and a pressure sensor.
2. Measure the distance between plates using a micrometer.
3. Connect the multimeter to the thermistor connectors and measure the resistance of the thermistor.
4. Spray the chamber with oil and charge the oil drops for a few seconds.
5. In the 'plates grounded' position select a drop that takes between 15 and 25 seconds to fall 0.5 mm (the distance between two major reticle lines)
6. Measure the **rise time** with top plate charged (+) and **fall time** plates 'not charged' about 3-6 times per drop. The rise time should be more than 3 seconds.

Repeat for a total of 6 drops. The resistance and atmospheric pressure should be noted for each drop.

Interpretation of results:

1. Refer to the Thermistor Resistance Table located on the platform (or on page 20 of the PASCO Millikan Oil Drop Experiment document) to find the temperature of the lower brass plate. In Excel plot a graph of Temperature vs. Resistance for values of temperature between 20°C and 30°C. The resistance can be expressed in units of megaohms ($M\Omega$). Do a power regression on the curve to obtain a function such as

$$T = \alpha R^\beta$$

2. Do a linear regression of the two endpoints of the viscosity versus temperature graph of the Pasco manual (p. 19) to obtain a function such as

$$\eta = mT + b$$

3. Combine the two functions to obtain the viscosity of the air function of measured resistance during the measurement of each of your drops. You should get something like

$$\eta = (m \alpha) R^\beta + b$$

FOR ALL OF YOUR DROPS:

4. Using the following Excel template as a guide,

| | A | B | C | D | E | F | G | H | I | J | K | L |
|----|-------------|----------|---------|-----------|-----------------|---------|-----|---------|-----|---------|---------|---------|
| 1 | g = | 9.785 | | | | | | | | | | |
| 2 | rho = | 886 | | | | | | | | | | |
| 3 | d = | | | | | | | | | | | |
| 4 | d ret = | 5.00E-04 | | | | | | | | | | |
| 5 | | | | | | | | | | | | |
| 6 | | | t1 | t2 | t3 | t4 | t5 | t6 | t7 | t8 | ave | e |
| 7 | gota1 | f | | | | | | | | | #DIV/0! | |
| 8 | | r | | | | | | | | | #DIV/0! | |
| 9 | V = | | vf = | #DIV/0! | vr = | #DIV/0! | | | | | | |
| 10 | patm = | | b = | 8.200E-03 | a = | #VALUE! | m = | #VALUE! | q = | #VALUE! | #VALUE! | #VALUE! |
| 11 | R (x10^6) = | | T (C) = | #VALUE! | visc (x10^-5) = | #VALUE! | | | | | | |
| 12 | | | | | | | | | | | | |

create an Excel sheet to calculate the radius of the oil drop using your parameters and parameters given on page 9 of the PASCO Millikan Oil Drop Experiment and

$$a = \sqrt{\left(\frac{b}{2p}\right)^2 + \frac{9\eta v_f}{2g\rho}} - \frac{b}{2p}$$

5. Calculate the mass of the oil droplet using

$$m = \frac{4}{3}\pi a^3 \rho$$

6. Determine the total charge of the oil droplet using

$$q = \frac{mg(v_f + v_r)}{Ev_f}$$

The electric field E is calculated using $E=V/d$ where d is the spacing between the plates and V is the plate voltage.

7. Divide each charge from interpretation 6 by $1.602 \times 10^{-19} \text{ C}$ (we are cheating a little here as technically we should not know the elementary charge, Millikan divided by the smallest difference found between two oil drops) and round the result to estimate the number of charges carriers on each oil drop.

8. Divide each total charge from interpretation 6 by the estimated number of charge carriers as given by interpretation 7 to estimate the elementary charge on each drop.

9. Give an example of each calculation and present your calculations in tabular form.

10. Average the elementary charges on all drops and find the percent error between your experimental and the accepted value of $1.602 \times 10^{-19} \text{ C}$.