# MILLIKAN'S OIL DROP EXPERIMENT

EXPERIMENTAL REPORT

## ABSTRACT

In this report is discussion of the results of Millikans Oil Drop Experiment, in which an electric field was used to apply a calculable force onto droplets of oil. This report aims to determine whether that force, and its attendant electric charge, falls into integer multiples of some common force, which would indicate a fundamental, indivisible charge; the electron.

The charge found in this report was not consistent with the common accepted value for the charge on an electron.

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# Introduction

The accepted model of the electron posits that the electron is an individual particle with a particular charge common to all electrons. If true, the charge on that electron should be determinable by determining the effect of a magnetic field on an ionized object, such as an oil droplet, regardless of the ability to detect a droplet with a single electron. Statistical methods should be sufficient to see the relevant patterns.

This report aims to use the result of an experiment called "Millikans Oil Drop Experiment" In which ionized droplets of oil are moved through a viscous air, to determine the force, and hence charge, on each droplet. The charge on an electron should be determinable by balancing the force due to the electric field with the force due to viscosity of air, using this formula, described further in the report.

$$q = \frac{4}{3}\pi\rho g \left[ \sqrt{\left(\frac{b}{2p}\right)^2 + \frac{9\eta v_f}{2g\rho} - \frac{b}{2p}} \right] \times \frac{(v_f + v_r)}{E v_f}$$

This reports hypothesis is that the charge on each oil droplet will be a integer multiple of some fundamental amount of charge, E.

# Materials and Methods

## Materials

This experiment included an apparatus designed for this experiment, called the *droplet viewing chamber*. This apparatus is designed to allow the undisturbed free-fall of oil droplets between two charged or uncharged plates, whilst also allowing viewing using a viewing scope, and exposure to an ionization source. Specialised equipment exists for this purpose.

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

### GROUP DATASET 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) | $7.86 \times 10^{-3}$ | $10^{-5}$ |
| Plate Voltage (Volts) | 502.9 | 0.005 |
| Temperature (Celsius) | 22 | 0.5 |
| Air Viscosity (Nsm$^{-2}$) | $1.832 \times 10^{-5}$ | 0.006 |
| Barometric Pressure (millibar) | 1008 | 0.5 |
| Oil Density | | |

Commented [KW1]: Oil density must yet be inserted, here

The electric field strength between the two capacitive plates is given by $E = \frac{V}{r} = \frac{502.9}{7.86 \times 10^{-3}} = 64.0 \times 10^3 \ NC^{-1}$ with an error given by $\Delta E = E\left(\frac{\Delta V}{V} + \frac{\Delta r}{r}\right) = 64.0 \times 10^3 \left(\frac{0.005}{502.9} + \frac{0.00001}{0.00786}\right) = 1.28 \ NC^{-1}$.

The value of electric field intensity, for all droplets of this experiment was E=64.0 $\times 10^3 \pm$ 1.28 NC$^{-1}$.

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

*Table 2 Collected data for droplet 1*

Travel Distance: 0.002 ± 0.000025 m

| Trial N | Time Fall (s) | Velocity (mm/sec) | Δ Velocity (mm/sec) | Time Rise (s) | Velocity (mm/sec) | Δ 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 | 0.1 |
| AVERAGE | 4.980 | 0.042 | 0.005 | 1.012 | 0.206 | 0.1 |

**Commented [KW2]:** This is all Tom's calculations, not sure if I pulled the right values. Check, anyway

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

*Equation 1 Equation to find charge, as a function of fall and rise times.*

$$q = \frac{4}{3}\pi\rho g \left[ \sqrt{\left(\frac{b}{2p}\right)^2 + \frac{9\eta v_f}{2g\rho} - \frac{b}{2p}} \right] \times \frac{(v_f + v_r)}{E v_f}$$

Where:
$q$ = charge carried by the droplet [C]
$d$ = separation of the plates in the droplet viewing chamber [m]
$\rho$ = density of oil [kg/m$^3$]
$g$ = acceleration due to gravity [m/s$^2$]
$\eta$ = viscosity of air [N.s/m$^2$]
$b$ = constant -= 8.20 x 10$^{-3}$ [Pa.m]
$p$ = barometric pressure [Pa}
$v_f$ = velocity of fall [m/s]
$v_r$ = velocity of rise [m/s]
$V$ = potential difference across the plates [V]

Using the average values for fall velocity and rising velocity for this droplet ($v_f$ and $v_r$) values presented in Table 2, this equation is now solvable for each droplet.

The error on q can be calculated by the equation in Equation 2, below.

*Equation 2 Error calculation on charge, q.*

$$dQ = Q(1.5\frac{\Delta V_f}{V_f} + \frac{\Delta V_f + \Delta V_r}{\Delta V_f + V_r} + \frac{\Delta V_f}{V_f})$$

For which the relative error is given by $\frac{\Delta q}{q}$. This process was done for all droplets in the dataset. The data for droplet three shows a dramatic, change in behavior after its 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 | $-1.103 \times 10^{-18}$ | -8.198E-19 | 0.743 |
| 2 | $-9.291 \times 10^{-19}$ | -6.682E-19 | 0.719 |
| 3 | -8.501E-19 | -5.665E-19 | 0.666 |
| 4 | $-5.277 \times 10^{-19}$ | -5.563E-19 | 1.054 |
| 5 | $-4.083 \times 10^{-19}$ | -2.047E-19 | 0.501 |
| 6 | $-2.468 \times 10^{-19}$ | -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 |

The table above was used to create Figure 1, below.
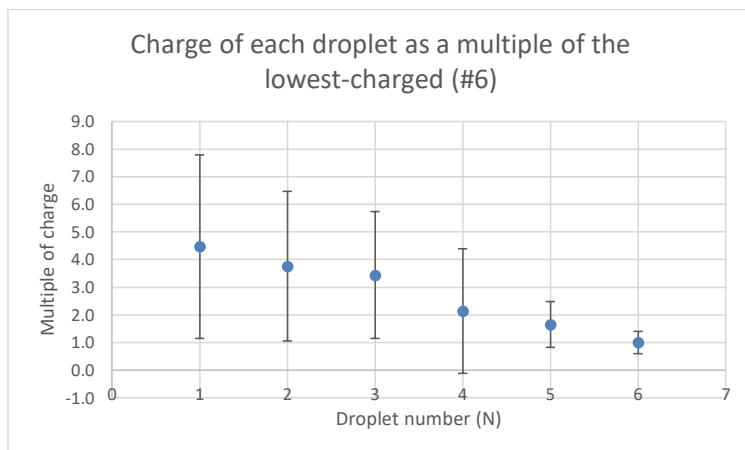
Figure 1 Charge as a multiple of the lowest charge

The same process was used as above, but comparing it to half of the lowest charge, to produce Table 5 Charge and error as a multiple of half the lowest chargeTable 5, below.

Table 5 Charge and error as a multiple of half the lowest charge

| Droplet # | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Multiple of charge | 8.93972 | 7.528783 | 6.88857 | 4.276034 | 3.308897 | 1 |
| error | 6.643104 | 5.415085 | 4.590192 | 4.50825 | 1.658879 | 0.40408323 |

That data is presented in Figure 2 , presented below.
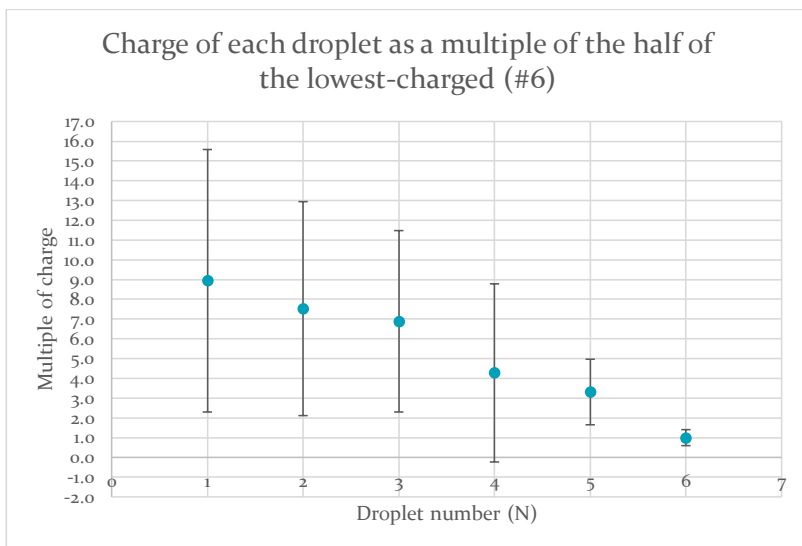
Figure 2 Charge as a multiple of the half of lowest charge

Figure 2 was further analysed by plotting how far from an integer multiple each droplet is. That data is presented below, in Figure 3



Figure 3 Each droplet's distance to an integer multiple

CLASS DATASET RESULTS

The class dataset was not performed under the same environmental test conditions (barometric pressure, temperature, etc), nor was the same voltage recorded across the capacitor plates, despite having the same intended voltage. Therefore, no single table can be given to show these conditions, however, that information is available in the full dataset, in Appendix 2 The full class dataset.
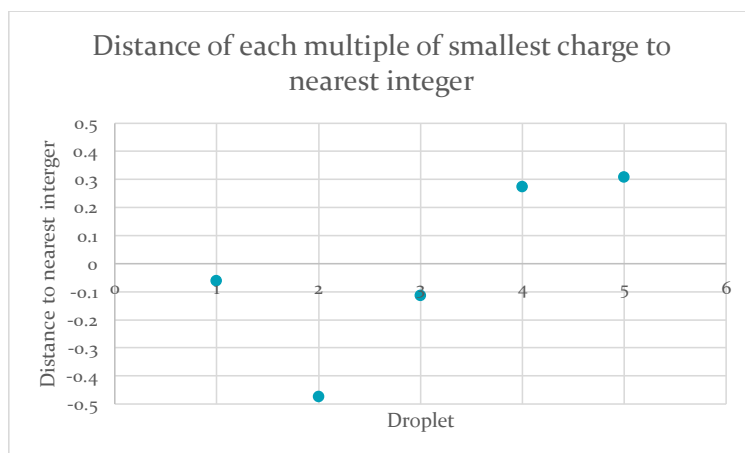
A sub-sample of the first 5 entries of the class dataset (N=182) is shown below in Table 6.

*Table 6 Sub-sample of the class dataset*

| Trial N | vf (mm/sec) | Δvf (mm/sec) | vr (mm/sec) | Δvr (mm/sec) | d (mm) | T (°C) | p [Pa] | V (Volt) |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.03863 | 0.01176 | 0.11325 | 0.03446 | 6.75 | 22.80 | 88900 | 500 |
| 2 | 0.07248 | 0.02206 | 0.27223 | 0.08284 | 6.75 | 22.80 | 88900 | 502 |
| 3 | 0.07174 | 0.02183 | 0.30102 | 0.09160 | 6.75 | 22.80 | 88900 | 499 |
| 4 | 0.03037 | 0.00924 | 0.81967 | 0.24943 | 6.75 | 22.80 | 88900 | 502 |
| 5 | 0.04864 | 0.01480 | 0.25907 | 0.07884 | 6.75 | 22.80 | 88900 | 502 |

The charge on the drops of oil was calculated from this data using Equation 1, and the error calculated using Equation 2, and a subset of the results are presented below in Table 7.

*Table 7 Subset of the results of the class calculations of charge on each oil droplet*

| Droplet number (n) | Charge, q (Coulombs) | Δq (Coulombs) |
|---|---|---|
| 1 | $-2.84 \times 10^{-19}$ | $-3 \times 10^{-19}$ |
| 2 | $-1.09 \times 10^{-18}$ | $-1.2 \times 10^{-18}$ |
| 3 | $-1.25 \times 10^{-18}$ | $-1.3 \times 10^{-18}$ |
| 4 | $-2.6 \times 10^{-18}$ | $-2.8 \times 10^{-18}$ |
| 5 | $-9.13 \times 10^{-19}$ | $-9.7 \times 10^{-19}$ |

The mean value of q was found to be $\bar{q} = 2.35 \times 10^{-19}$ with s standard deviation of $\sigma_q = 1.34 \times 10^{-16}$.

The class dataset was adapted such that all values were all positive, for reasons discussed in the discussion section of this report, and then sorted in order of their charge. There was an apparent discontinuity in the seven lowest values, and so data which was not within five orders of magnitude of the average was removed. This resulting data is presented below, on a log-linear graph (Logarithmic$_{10}$ Y-axis), in
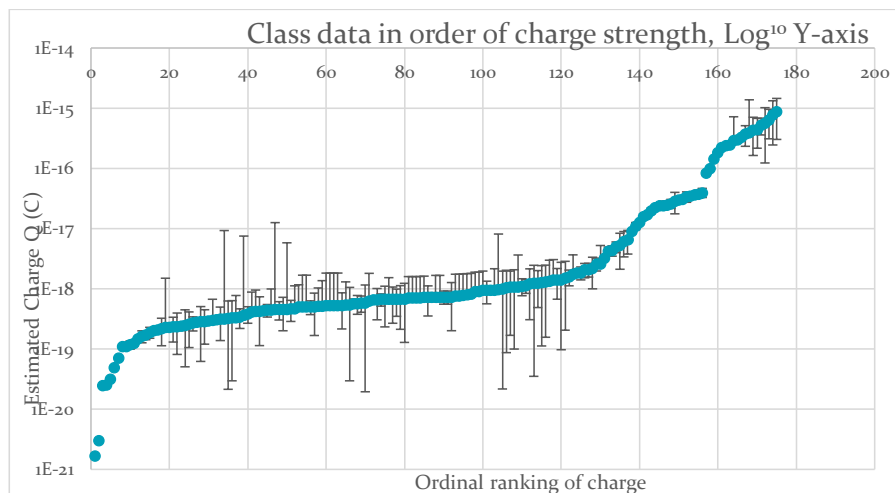
*Figure 4 Class data sorted in order of charge, with estimated charge plotted on a log10 scale*

The class data was arranged in ascending order of charge strength, and the difference between each sequential charge was found (a "step-difference"). The data was re-arranged in ascending order of those differences. From Figure 4 a data point was chosen as a 'guess' for the value of E, the fundamental charge. The point chosen was based on which one seemed to be part of the main sequence of data, but yet which was extremely small. This is because it could be assumed that a single-electron droplet may have been measured at least several time, and yet would be one of the smallest. The initial estimate was datapoint n=101, q=$1.098 \times 10^{-19}$ Coulombs, Because of the position on the graph. For each data point, the estimate of charge was divided by this guess, and rounded down to a whole number. The associated step-difference, calculated earlier, was then divided by this integer. The average of that ratio was then found; this process yields a second 'guess', an estimated value for E. It was found to be equal to E= $1.10 \times 10^{-19}$ Coulombs, with a standard deviation of $8.349 \times 10^{-21}$.

## Discussion

### GROUP DATASET DISCUSSION

On the assumption that the charge on any given object is an integer multiple of some fundamental charge, and on the assumption that the amount of charge on the oil droplets is within a reasonable order of magnitude of that fundamental charge, the charge on each oil droplet was divided by the charge of the *least charged* oil droplet. The expectation is that the charges on the oil droplets would increase in steps of the size of some integer fraction of each other, or the least-charged droplet.

Figure 1 and Figure 2 show the results of this operation, and there is some apparent stratification involved, especially in Figure 2. This does not appear to hold up, as seen in Figure 3, where the data apparently has no tendency to be near an integer multiple, or any apparent trend as it approaches an integer multiple.

### Group dataset error discussion

Droplet Three showed a strong change in its rise and fall times which was strong and consistent, and so not suspected to be a random error. It was concluded that this droplet had in fact been struck by another droplet of unknown size or charge. In the sense of this experiment, the droplet had become a new droplet, and so that data is treated as such in this report. The new droplet was named 'droplet 4'.

In Table 3 Calculated charge on each droplet., the relative error on the calculation for q is quite significant, with error margins of between 40% and 110%, and these errors perpetuate and are revealed in Figure 1 Charge as a multiple of the lowest charge, when it is seen that the error of margin for every droplet includes the error of margin for the least-charged droplet. The implication is that all of these droplets could in fact be equally charged, and there is no clear evidence that the rank order they are presented in is in fact the true order.

## CLASS DATASET DISCUSSION

The class dataset was manipulated to have entirely positive values, because the experiment was performed in such a way as to disregard which sign (+/-) of charged plate the oil droplet was approaching in each measurement. This means that oil droplets of positive and negative charge are treated the same in the data, and there is in physics the general acceptance that an electron is equal and oppositely charged to a proton. Therefore, whether the ionization dislodged or added an electron is an immaterial difference, for this experiment.

The results of this experiment for the class dataset indicate an electron with a charge of $E= 1.10 \times 10^{-19}$ Coulombs, with a standard deviation of $8.349 \times 10^{-21}$ Coulombs. This value is comparable in magnitude to the accepted value of $1.60217662 \times 10^{-19}$. The standard deviation does not include the accepted value. This experiment comes close to the true value of charge of an electron, to within $0.4 \times 10^{-19}$ Coulombs. This represents a relative error from the true value of 69%.

### Class dataset error discussion

The data was gathered by a large collection of people in several dozen groups. The level of care taken in recording data is unknown, and may be reflected in some of the values in the dataset.

There are random errors involved in this experiment to do with the method of data gathering. The process of timing a droplet through a scope, crossing a hairline of comparable size to the droplet is a major source of error, perhaps the largest. A second source of error is the possibility that certain groups have mistaken their data, submitted

it, and not being able to recognize their mistake. When this data is analyzed, it can be hard to determine which is mistaken, although the original creators may have been able to identify it as such.

## Conclusions

This experiment was not able to confirm the accepted value for the charge on an electron, to within experimental error. This experiment had a large dataset, but was also plagued by that dataset coming from many different people, with attendant unknown errors.

Further experimentation, with a better controlled experimental environment and a review of the employed data analysis techniques may be necessary.

# Appendix

*Appendix 1 Group dataset*

| Droplet 1 | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Trial N** | **Time Fall (s)** | **vf (mm/sec)** | **Dvf (mm/sec)** | **Time Rise (s)** | **vr (mm/sec)** | **Dvr (mm/sec)** | **d(mm)** |
| 1 | 3.57 | 0.056022409 | 0.007846276 | 1.41 | 0.141843972 | 0.050299281 | 7.86 |
| 2 | 5.49 | 0.036429872 | 0.003317839 | 1.26 | 0.158730159 | 0.062988158 | 7.86 |
| 3 | 5.99 | 0.033388982 | 0.00278706 | 1.02 | 0.196078431 | 0.096116878 | 7.86 |
| 4 | 6.92 | 0.028901734 | 0.002088276 | 0.92 | 0.217391304 | 0.118147448 | 7.86 |
| 5 | 5.14 | 0.038910506 | 0.003785069 | 1.32 | 0.151515152 | 0.057392103 | 7.86 |
| 6 | 4.18 | 0.04784689 | 0.005723312 | 0.92 | 0.217391304 | 0.118147448 | 7.86 |
| 7 | 4.42 | 0.045248869 | 0.00511865 | 0.79 | 0.253164557 | 0.160230732 | 7.86 |
| 8 | 6.4 | 0.03125 | 0.002441406 | 0.79 | 0.253164557 | 0.160230732 | 7.86 |
| 9 | 3.69 | 0.054200542 | 0.007344247 | 0.9 | 0.222222222 | 0.12345679 | 7.86 |
| 10 | 4 | 0.05 | 0.00625 | 0.79 | 0.253164557 | 0.160230732 | 7.86 |
| AVERAGE | 4.98 | 0.04221998 | 0.004670213 | 1.012 | 0.206466622 | 0.11072403 | 7.86 |
| Droplet 2 | | | | | | | |
| **Trial N** | **Time Fall (s)** | **vf (mm/sec)** | **Dvf (mm/sec)** | **Time Rise (S)** | **vr (mm/sec)** | **Dvr (mm/sec)** | **d(mm)** |
| 1 | 2.83 | 0.070671378 | 0.012486109 | 2 | 0.1 | 0.025 | 7.86 |
| 2 | 3.14 | 0.063694268 | 0.010142399 | 1.88 | 0.106382979 | 0.028293345 | 7.86 |
| 3 | 3.05 | 0.06557377 | 0.010749798 | 1.17 | 0.170940171 | 0.073051355 | 7.86 |
| 4 | 2.39 | 0.083682008 | 0.017506696 | 2.38 | 0.084033613 | 0.01765412 | 7.86 |
| 5 | 3.31 | 0.060422961 | 0.009127335 | 1.36 | 0.147058824 | 0.054065744 | 7.86 |
| 6 | 3.15 | 0.063492063 | 0.010078105 | 1.71 | 0.116959064 | 0.034198557 | 7.86 |
| 7 | 3.62 | 0.055248619 | 0.007631025 | 1.5 | 0.133333333 | 0.044444444 | 7.86 |
| 8 | 3.54 | 0.056497175 | 0.007979827 | 1.71 | 0.116959064 | 0.034198557 | 7.86 |
| 9 | 3.02 | 0.066225166 | 0.010964431 | 2.18 | 0.091743119 | 0.021042 | 7.86 |
| 10 | 3.49 | 0.05730659 | 0.008210113 | 1.71 | 0.116959064 | 0.034198557 | 7.86 |
| 11 | 3.43 | 0.058309038 | 0.00849986 | 1.63 | 0.122699387 | 0.037637849 | 7.86 |
| 12 | 3.22 | 0.062111801 | 0.00964469 | 1.55 | 0.129032258 | 0.041623309 | 7.86 |
| 13 | 3.51 | 0.056980057 | 0.008116817 | 1.86 | 0.107526882 | 0.028905076 | 7.86 |
| 14 | 3.23 | 0.061919505 | 0.009585063 | 1.56 | 0.128205128 | 0.041091387 | 7.86 |
| 15 | 3.05 | 0.06557377 | 0.010749798 | 1.65 | 0.121212121 | 0.036730946 | 7.86 |
| 16 | 2.53 | 0.079051383 | 0.015622803 | 1.66 | 0.120481928 | 0.036289737 | 7.86 |
| AVERAGE | 3.156875 | 0.064172472 | 0.010443429 | 1.719375 | 0.119595433 | 0.036776561 | 7.86 |
| Droplet 3 | | | | | | | |

| Trial N | Time Fall (s) | vf (mm/sec) | Δvf (mm/sec) | Time Rise (s) | vr (mm/sec) | Δvr (mm/sec) | d(mm) |
|---|---|---|---|---|---|---|---|
| 1 | 5.18 | 0.039 | 0.004 | 1.010 | 0.198 | 0.098 | 7.86 |
| 2 | 5.37 | 0.037 | 0.003 | 1.210 | 0.165 | 0.068 | 7.86 |
| 3 | 5.09 | 0.039 | 0.004 | 0.620 | 0.323 | 0.260 | 7.86 |
| 4 | 4.86 | 0.041 | 0.004 | 0.970 | 0.206 | 0.106 | 7.86 |
| 5 | 6.45 | 0.031 | 0.002 | 0.990 | 0.202 | 0.102 | 7.86 |
| 6 | 4.78 | 0.042 | 0.004 | 0.920 | 0.217 | 0.118 | 7.86 |
| 7 | 6.13 | 0.033 | 0.003 | 1.100 | 0.182 | 0.083 | 7.86 |
| 8 | 6.48 | 0.031 | 0.002 | 0.990 | 0.202 | 0.102 | 7.86 |
| 9 | 5.93 | 0.034 | 0.003 | 1.150 | 0.174 | 0.076 | 7.86 |
| 10 | 4.76 | 0.042 | 0.004 | 0.970 | 0.206 | 0.106 | 7.86 |
| 11 | 4.20 | 0.048 | 0.006 | 0.830 | 0.241 | 0.145 | 7.86 |
| 12 | 5.94 | 0.034 | 0.003 | 0.910 | 0.220 | 0.121 | 7.86 |
| AVERAGE | 5.430833333 | 0.037472589 | 0.003572638 | 0.9725 | 0.211347321 | 0.11545197 | 7.86 |
| Droplet 4 | | | | | | | |

| Trial N | Time Fall (s) | vf (mm/sec) | Δvf (mm/sec) | Time Rise (s) | vr (mm/sec) | Δvr (mm/sec) | d(mm) |
|---|---|---|---|---|---|---|---|
| 13 | 4.00 | 0.050 | 0.006 | 1.620 | 0.123 | 0.038 | 7.86 |
| 14 | 5.00 | 0.040 | 0.004 | 1.780 | 0.112 | 0.032 | 7.86 |
| 15 | 4.03 | 0.050 | 0.006 | 2.460 | 0.081 | 0.017 | 7.86 |
| 16 | 4.60 | 0.043 | 0.005 | 2.770 | 0.072 | 0.013 | 7.86 |
| AVERAGE | 4.34 | 0.047 | 0.005 | 1.953 | 0.106 | 0.029 | 7.86 |
| | | | | | | | |
| Droplet 5 | | | | | | | |

| Trial N | Time Fall (s) | vf (mm/sec) | Δvf (mm/sec) | Time Rise (s) | vr (mm/sec) | Δvr (mm/sec) | d(mm) |
|---|---|---|---|---|---|---|---|
| 1 | 5.77 | 0.035 | 0.003 | 1.740 | 0.115 | 0.033 | 7.86 |
| 2 | 6.27 | 0.032 | 0.003 | 1.940 | 0.103 | 0.027 | 7.86 |
| 3 | 7.09 | 0.028 | 0.002 | 2.150 | 0.093 | 0.022 | 7.86 |
| 4 | 6.31 | 0.032 | 0.003 | 2.240 | 0.089 | 0.020 | 7.86 |
| 5 | 7.12 | 0.028 | 0.002 | 2.170 | 0.092 | 0.021 | 7.86 |
| 6 | 6.59 | 0.030 | 0.002 | 2.010 | 0.100 | 0.025 | 7.86 |
| 7 | 6.13 | 0.033 | 0.003 | 2.340 | 0.085 | 0.018 | 7.86 |
| 8 | 5.65 | 0.035 | 0.003 | 1.870 | 0.107 | 0.029 | 7.86 |
| 9 | 7.43 | 0.027 | 0.002 | 1.860 | 0.108 | 0.029 | 7.86 |
| 10 | 7.51 | 0.027 | 0.002 | 2.330 | 0.086 | 0.018 | 7.86 |
| 11 | 5.95 | 0.034 | 0.003 | 2.190 | 0.091 | 0.021 | 7.86 |
| 12 | 5.99 | 0.033 | 0.003 | 2.030 | 0.099 | 0.024 | 7.86 |
| 13 | 5.71 | 0.035 | 0.003 | 1.830 | 0.109 | 0.030 | 7.86 |
| 14 | 6.47 | 0.031 | 0.002 | 2.140 | 0.093 | 0.022 | 7.86 |

| Trial N | Time Fall (s) | vf (mm/sec) | Δvf (mm/sec) | Time Rise (s) | vr (mm/sec) | Δvr (mm/sec) | d(mm) |
|---|---|---|---|---|---|---|---|
| 15 | 6.21 | 0.032 | 0.003 | 2.200 | 0.091 | 0.021 | 7.86 |
| 16 | 5.77 | 0.035 | 0.003 | 2.250 | 0.089 | 0.020 | 7.86 |
| 17 | 7.21 | 0.028 | 0.002 | 2.090 | 0.096 | 0.023 | 7.86 |
| AVG | 6.42 | 0.031 | 0.002 | 2.081 | 0.097 | 0.024 | 7.86 |
| Droplet 6 | | | | | | | |
| Trial N | Time Fall (s) | vf (mm/sec) | Δvf (mm/sec) | Time Rise (s) | vr (mm/sec) | Δvr (mm/sec) | d(mm) |
| 1 | 15.90 | 0.013 | 0.000 | 1.400 | 0.143 | 0.051 | 7.86 |
| 2 | 14.68 | 0.014 | 0.000 | 0.840 | 0.238 | 0.142 | 7.86 |
| 3 | 10.03 | 0.020 | 0.001 | 0.770 | 0.260 | 0.169 | 7.86 |
| 4 | 13.74 | 0.015 | 0.001 | 0.510 | 0.392 | 0.384 | 7.86 |
| 5 | 11.19 | 0.018 | 0.001 | 0.570 | 0.351 | 0.308 | 7.86 |
| 6 | 15.79 | 0.013 | 0.000 | 0.860 | 0.233 | 0.135 | 7.86 |
| 7 | 11.35 | 0.018 | 0.001 | 0.800 | 0.250 | 0.156 | 7.86 |
| 8 | 13.94 | 0.014 | 0.001 | 0.800 | 0.250 | 0.156 | 7.86 |
| 9 | 18.42 | 0.011 | 0.000 | 0.700 | 0.286 | 0.204 | 7.86 |
| 10 | 13.71 | 0.015 | 0.001 | 0.460 | 0.435 | 0.473 | 7.86 |
| 11 | 2.00 | 0.100 | 0.025 | 0.520 | 0.385 | 0.370 | 7.86 |
| AVG | 12.80 | 0.023 | 0.003 | 0.748 | 0.293 | 0.232 | 7.86 |

*Appendix 2 The full class dataset*

| DROPLET N | vf (mm/sec) | Δvf (mm/sec) | vr (mm/sec) | Δvr (mm/sec) | d(mm) | T (°C) | p [Pa] | V (Volt) |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.03863 | 0.01176 | 0.11325 | 0.03446 | 6.75 | 22.80 | 88900 | 500 |
| 2 | 0.07248 | 0.02206 | 0.27223 | 0.08284 | 6.75 | 22.80 | 88900 | 502 |
| 3 | 0.07174 | 0.02183 | 0.30102 | 0.09160 | 6.75 | 22.80 | 88900 | 499 |
| 4 | 0.03037 | 0.00924 | 0.81967 | 0.24943 | 6.75 | 22.80 | 88900 | 502 |
| 5 | 0.04864 | 0.01480 | 0.25907 | 0.07884 | 6.75 | 22.80 | 88900 | 502 |
| 6 | 0.54120 | 0.87618 | 10.92001 | 2.72325 | 9.10 | 22.90 | 101000 | 500 |
| 7 | 1.21960 | 1.97447 | 20.34292 | 5.07316 | 9.10 | 22.90 | 101000 | 500 |
| 8 | 0.27544 | 0.44592 | 28.70264 | 7.15792 | 9.10 | 22.90 | 101000 | 500 |
| 9 | 3.73261 | 6.04292 | 2.30542 | 0.57493 | 9.10 | 22.90 | 101000 | 500 |
| 10 | 0.04127 | 0.01250 | 0.10305 | 0.01331 | 9.00 | 22.80 | 101100 | 500 |
| 11 | 0.06425 | 0.01365 | 0.24178 | 0.01104 | 9.00 | 22.80 | 101100 | 500 |
| 12 | 0.08228 | 0.01317 | 0.17947 | 0.01389 | 9.00 | 22.80 | 101100 | 500 |
| 13 | 0.18437 | 0.01629 | 0.15645 | 0.01236 | 9.00 | 22.80 | 101100 | 500 |
| 14 | 0.10500 | 0.01325 | 0.15281 | 0.01138 | 9.00 | 22.80 | 101100 | 500 |
| 15 | 0.11754 | 0.01357 | 0.12494 | 0.00991 | 9.00 | 22.80 | 101100 | 500 |
| 16 | 0.22104 | 0.01285 | 0.12189 | 0.01241 | 9.00 | 22.80 | 101100 | 500 |

| 17 | 0.11666 | 0.01051 | 0.14045 | 0.01186 | 9.00 | 22.80 | 101100 | 500 |
|----|---------|---------|---------|---------|------|-------|--------|-----|
| 18 | 0.11671 | 0.01171 | 0.17253 | 0.01055 | 9.00 | 22.80 | 101100 | 500 |
| 19 | 0.12315 | 0.01019 | 0.16995 | 0.01086 | 9.00 | 22.80 | 101100 | 500 |
| 20 | 0.03700 | 0.16000 | 0.13200 | 0.13600 | 8.00 | 23.00 | 91900 | 495 |
| 21 | 0.04200 | 0.01900 | 0.24100 | 0.41600 | 8.00 | 23.00 | 91900 | 495 |
| 22 | 0.27675 | 0.05933 | 0.15773 | 0.04009 | 7.68 | 22.90 | 91000 | 500 |
| 23 | 0.14809 | 0.03184 | 0.14270 | 0.02992 | 7.68 | 22.90 | 91000 | 507 |
| 24 | 0.06900 | 0.01449 | 0.14346 | 0.03001 | 7.68 | 22.90 | 91000 | 487 |
| 26 | 11.41000 | 0.00022 | 1.92000 | 0.00022 | 8.00 | 22.50 | 100700 | 490 |
| 27 | 11.18000 | 0.00039 | 2.59000 | 0.00022 | 8.00 | 22.50 | 100700 | 490 |
| 28 | 4.42500 | 0.00305 | 3.89000 | 0.00022 | 8.00 | 22.50 | 100700 | 490 |
| 29 | 4.59000 | 0.00305 | 2.14000 | 0.00022 | 8.00 | 22.50 | 100700 | 490 |
| 30 | 7.77500 | 0.00305 | 1.91000 | 0.00022 | 8.00 | 22.50 | 100700 | 490 |
| 31 | 7.98667 | 0.00305 | 1.24000 | 0.00022 | 8.00 | 22.50 | 100700 | 490 |
| 32 | 0.02000 | 0.01000 | 0.24000 | 0.01000 | 8.50 | 23.00 | 101000 | 498 |
| 33 | 0.02000 | 0.01000 | 0.22000 | 0.01000 | 8.50 | 23.00 | 101000 | 498 |
| 34 | 0.01000 | 0.01000 | 0.24000 | 0.01000 | 8.50 | 23.00 | 101000 | 498 |
| 35 | 0.02000 | 0.01000 | 0.24000 | 0.01000 | 8.50 | 23.00 | 101000 | 498 |
| 36 | 0.02000 | 0.01000 | 0.25000 | 0.01000 | 8.50 | 23.00 | 101000 | 498 |
| 37 | 0.02000 | 0.01000 | 0.24000 | 0.01000 | 8.50 | 23.00 | 101000 | 498 |
| 38 | 0.02000 | 0.01000 | 0.22000 | 0.01000 | 8.50 | 23.00 | 101000 | 498 |
| 39 | 0.02000 | 0.01000 | 0.24000 | 0.01000 | 8.50 | 23.00 | 101000 | 498 |
| 40 | 0.02000 | 0.01000 | 0.22000 | 0.01000 | 8.50 | 23.00 | 101000 | 498 |
| 41 | 0.02000 | 0.01000 | 0.22000 | 0.01000 | 8.50 | 23.00 | 101000 | 498 |
| 42 | 0.02000 | 0.01000 | 0.24000 | 0.01000 | 8.50 | 23.00 | 101000 | 498 |
| 43 | 0.02000 | 0.01000 | 0.22000 | 0.01000 | 8.50 | 23.00 | 101000 | 498 |
| 44 | 0.01000 | 0.01000 | 0.24000 | 0.01000 | 8.50 | 23.00 | 101000 | 498 |
| 45 | 0.02000 | 0.01000 | 0.23000 | 0.01000 | 8.50 | 23.00 | 101000 | 498 |
| 46 | 0.01000 | 0.01000 | 0.22000 | 0.01000 | 8.50 | 23.00 | 101000 | 498 |
| 47 | 0.02000 | 0.01000 | 0.24000 | 0.01000 | 8.50 | 23.00 | 101000 | 498 |
| 48 | 0.02000 | 0.01000 | 0.23000 | 0.01000 | 8.50 | 23.00 | 101000 | 498 |
| 49 | 0.02000 | 0.01000 | 0.24000 | 0.01000 | 8.50 | 23.00 | 101000 | 498 |
| 50 | 0.01000 | 0.01000 | 0.24000 | 0.01000 | 8.50 | 23.00 | 101000 | 498 |
| 51 | 0.01000 | 0.01000 | 0.24000 | 0.01000 | 8.50 | 23.00 | 101000 | 498 |
| 52 | 0.01000 | 0.01000 | 0.22000 | 0.01000 | 8.50 | 23.00 | 101000 | 498 |
| 53 | 0.07453 | 0.00252 | 0.19726 | 0.02211 | 7.74 | 23.00 | 100800 | 500 |
| 54 | 0.05325 | 0.00122 | 0.39906 | 0.01455 | 7.74 | 23.00 | 100800 | 500 |
| 55 | 0.09741 | 0.00100 | 0.12795 | 0.01604 | 7.74 | 23.00 | 100800 | 500 |
| 56 | 0.08578 | 0.00223 | 0.16364 | 0.00508 | 7.74 | 23.00 | 100800 | 500 |
| 57 | 0.00015 | 0.00003 | 0.00003 | 0.00001 | 7.54 | 21.00 | 1007 | 500 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 58 | 0.00012 | 0.00003 | 0.00002 | 0.00000 | 7.54 | 26.00 | 920 | 500 |
| 59 | 0.00033 | 0.00009 | 0.00001 | 0.00000 | 7.54 | 26.00 | 912 | 500 |
| 60 | 0.00060 | 0.00019 | 0.00001 | 0.00000 | 7.54 | 28.00 | 912 | 500 |
| 61 | 0.00101 | 0.00043 | 0.00001 | 0.00000 | 7.54 | 26.00 | 906 | 500 |
| 62 | 0.00010 | 0.00002 | 0.00021 | 0.00005 | 7.54 | 26.00 | 911 | 500 |
| 63 | 0.00013 | 0.00003 | 0.00004 | 0.00001 | 7.54 | 26.00 | 911 | 500 |
| 64 | 0.03863 | 0.01176 | 0.11325 | 0.03446 | 6.75 | 22.80 | 88900 | 500 |
| 65 | 0.07248 | 0.02206 | 0.27223 | 0.08284 | 6.75 | 22.80 | 88900 | 502 |
| 66 | 0.07174 | 0.02183 | 0.30102 | 0.09160 | 6.75 | 22.80 | 88900 | 499 |
| 67 | 0.03037 | 0.00924 | 0.81967 | 0.24943 | 6.75 | 22.80 | 88900 | 502 |
| 68 | 0.04864 | 0.01480 | 0.25907 | 0.07884 | 6.75 | 22.80 | 88900 | 502 |
| 69 | 0.01364 | 0.00684 | 0.11644 | 0.02356 | 7.95 | 23.50 | 91800 | 497 |
| 70 | 0.01401 | 0.00703 | 0.14313 | 0.02883 | 7.95 | 23.40 | 91600 | 497 |
| 71 | 0.01348 | 0.00676 | 0.19810 | 0.03989 | 7.95 | 23.30 | 91600 | 497 |
| 72 | 0.01788 | 0.00897 | 0.22124 | 0.04462 | 7.95 | 23.30 | 91600 | 497 |
| 73 | 0.01523 | 0.00764 | 0.32723 | 0.06594 | 7.95 | 23.20 | 91600 | 497 |
| 74 | 0.01257 | 0.00630 | 0.17253 | 0.03472 | 7.95 | 23.20 | 91600 | 497 |
| 75 | 0.02251 | 0.01131 | 0.36127 | 0.07307 | 7.95 | 23.20 | 91300 | 497 |
| 76 | 0.01315 | 0.00659 | 0.20408 | 0.04108 | 7.95 | 23.10 | 91300 | 497 |
| 77 | 0.01739 | 0.00872 | 0.19984 | 0.04032 | 7.95 | 23.10 | 91300 | 497 |
| 78 | 0.01489 | 0.00747 | 0.52854 | 0.10650 | 7.95 | 23.10 | 91300 | 497 |
| 79 | 0.05869 | 0.02969 | 0.36075 | 0.07427 | 7.95 | 23.10 | 91300 | 497 |
| 80 | 0.01225 | 0.00614 | 0.14384 | 0.02894 | 7.95 | 23.10 | 91200 | 497 |
| 81 | 0.01893 | 0.00950 | 0.39936 | 0.08063 | 7.95 | 23.00 | 91200 | 497 |
| 82 | 0.11400 | | 0.75900 | | 7.80 | 22.00 | 90600 | 500 |
| 83 | 1.56700 | | 2.32400 | | 7.80 | 23.00 | 90600 | 500 |
| 84 | 0.21600 | | 0.78700 | | 7.80 | 23.00 | 90600 | 500 |
| 85 | 0.20200 | | 0.59300 | | 7.80 | 23.00 | 90600 | 500 |
| 86 | 0.40500 | | 1.96500 | | 7.80 | 23.00 | 90600 | 500 |
| 87 | 0.66500 | | 1.62800 | | 7.80 | 23.00 | 90600 | 500 |
| 88 | 0.15700 | | 0.49000 | | 7.80 | 23.00 | 90600 | 500 |
| 89 | 0.45600 | | 2.45600 | | 7.80 | 23.00 | 90600 | 500 |
| 90 | 0.43000 | | 1.78500 | | 7.80 | 23.00 | 90600 | 500 |
| 91 | 0.59100 | | 2.62900 | | 7.80 | 23.00 | 90600 | 500 |
| 92 | 0.02621 | 0.00132 | 0.40078 | 0.08238 | 8.20 | 23.00 | 100000 | 505 |
| 93 | 0.03248 | 0.00184 | 0.20080 | 0.02502 | 8.20 | 22.70 | 100000 | 511 |
| 94 | 0.03128 | 0.00173 | 0.20441 | 0.02596 | 8.20 | 22.40 | 100000 | 511 |
| 95 | 0.04949 | 0.00365 | 0.39927 | 0.08864 | 8.20 | 22.50 | 100000 | 512 |
| 96 | 0.04005 | 0.00257 | 0.24690 | 0.03650 | 8.20 | 22.50 | 100000 | 512 |
| 97 | 0.04347 | 0.00294 | 0.16050 | 0.01680 | 8.20 | 22.60 | 100000 | 513 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 98 | 0.02345 | 0.00235 | 0.14011 | 0.01421 | 0.50 | 23.00 | 107000 | 499 |
| 99 | 0.03603 | 0.00362 | 0.14909 | 0.01533 | 0.50 | 23.10 | 107000 | 499 |
| 101 | 0.03365 | 0.00338 | 0.44301 | 0.04626 | 0.50 | 23.40 | 107000 | 500 |
| 102 | 0.02794 | 0.02794 | 0.04063 | 0.04063 | 0.50 | 23.30 | 107000 | 500 |
| 103 | 0.03365 | 0.02744 | 0.03987 | 0.03987 | 0.50 | 23.30 | 107000 | 500 |
| 104 | 0.01135 | 0.00227 | 0.11364 | 0.02299 | 7.76 | 23.00 | 101200 | 502 |
| 105 | 0.05139 | 0.01085 | 0.04669 | 0.01027 | 7.76 | 23.00 | 101200 | 502 |
| 106 | 0.02319 | 0.00561 | 0.06068 | 0.01451 | 7.76 | 23.00 | 101200 | 499 |
| 107 | 0.01737 | 0.00419 | 0.08532 | 0.01899 | 7.76 | 23.00 | 101200 | 500 |
| 108 | 0.01718 | 0.00477 | 0.37594 | 0.08616 | 7.76 | 23.00 | 101200 | 501 |
| 109 | 0.03237 | 0.23428 | 0.10883 | 0.48310 | 7.80 | 23.00 | 101000 | 503 |
| 110 | 0.02542 | 0.26945 | 0.10602 | 0.41908 | 7.80 | 23.00 | 101000 | 503 |
| 111 | 0.08319 | 0.22524 | 0.20377 | 0.31261 | 7.80 | 23.00 | 101000 | 503 |
| 112 | 0.02022 | 0.23050 | 0.14626 | 0.25290 | 7.80 | 23.00 | 101000 | 503 |
| 113 | 0.01258 | 0.00040 | 0.14286 | 0.05102 | 7.86 | 23.00 | 100700 | 504 |
| 114 | 0.01362 | 0.00046 | 0.23810 | 0.14172 | 7.86 | 23.00 | 100700 | 504 |
| 115 | 0.01994 | 0.00099 | 0.25974 | 0.16866 | 7.86 | 23.00 | 100700 | 504 |
| 116 | 0.01456 | 0.00053 | 0.39216 | 0.38447 | 7.86 | 23.00 | 100700 | 504 |
| 117 | 0.01787 | 0.00080 | 0.35088 | 0.30779 | 7.86 | 23.00 | 100700 | 504 |
| 118 | 0.01267 | 0.00040 | 0.23256 | 0.13521 | 7.86 | 23.00 | 100700 | 504 |
| 119 | 0.01762 | 0.00078 | 0.25000 | 0.15625 | 7.86 | 23.00 | 100700 | 504 |
| 120 | 0.01435 | 0.00051 | 0.25000 | 0.15625 | 7.86 | 23.00 | 100700 | 504 |
| 121 | 0.01086 | 0.00029 | 0.28571 | 0.20408 | 7.86 | 23.00 | 100700 | 504 |
| 122 | 0.01459 | 0.00053 | 0.43478 | 0.47259 | 7.86 | 23.00 | 100700 | 504 |
| 123 | 0.10000 | 0.02500 | 0.38462 | 0.36982 | 7.86 | 23.00 | 100700 | 504 |
| 124 | 0.01661 | 0.01291 | 0.21920 | 0.04908 | 7.54 | 23.00 | 101200 | 499 |
| 125 | 0.01705 | 0.00400 | 0.21587 | 0.10708 | 7.54 | 23.00 | 101200 | 499 |
| 126 | 0.01507 | 0.00392 | 0.22422 | 0.07556 | 7.54 | 23.00 | 101200 | 499 |
| 127 | 0.02461 | 0.00587 | 0.08728 | 0.03314 | 7.54 | 23.00 | 101200 | 499 |
| 128 | 0.01516 | 0.00403 | 0.10852 | 0.03146 | 7.54 | 23.00 | 101200 | 499 |
| 129 | 0.03998 | 0.00939 | 0.18823 | 0.04811 | 7.54 | 23.00 | 101200 | 499 |
| 130 | 0.01943 | 0.00489 | 0.07022 | 0.70885 | 7.54 | 23.00 | 101200 | 499 |
| 131 | 0.01787 | 0.00436 | 0.18570 | 0.09904 | 7.54 | 23.00 | 101200 | 499 |
| 132 | 0.01480 | 0.00764 | 0.20400 | 0.10531 | 7.54 | 23.00 | 101200 | 499 |
| 133 | 0.02882 | 0.01347 | 0.11761 | 0.05495 | 7.54 | 23.00 | 101200 | 502 |
| 134 | 0.01636 | 0.00083 | 0.09293 | 0.00508 | 7.76 | 23.20 | 100700 | 502 |
| 135 | 0.07733 | 0.00417 | 0.15821 | 0.00916 | 7.76 | 23.00 | 100700 | 503 |
| 136 | 0.03009 | 0.00155 | 0.11713 | 0.00654 | 7.76 | 23.00 | 100700 | 503 |
| 137 | 0.01750 | 0.00089 | 0.26184 | 0.01653 | 7.76 | 22.80 | 100700 | 503 |
| 138 | 0.00870 | 0.00088 | 0.23606 | 0.02930 | 7.76 | 22.70 | 100700 | 501 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 139 | 0.04494 | 0.00470 | 0.33857 | 0.04549 | 7.76 | 22.80 | 100700 | 503 |
| 140 | 0.02579 | 0.00265 | 0.17788 | 0.02096 | 7.76 | 22.80 | 100700 | 503 |
| 141 | 0.01830 | 0.00311 | 0.16595 | 0.03228 | 7.76 | 22.90 | 100700 | 503 |
| 142 | 0.05545 | 0.00585 | 0.34621 | 0.04703 | 7.76 | 23.00 | 100600 | 503 |
| 143 | 0.04866 | 0.00510 | 0.45930 | 0.06723 | 7.76 | 23.20 | 100600 | 503 |
| 144 | 0.00781 | 0.00100 | 0.16949 | 0.05998 | 7.70 | 22.00 | 101500 | 501 |
| 145 | 0.00910 | 0.00100 | 0.13824 | 0.05998 | 7.70 | 22.00 | 101500 | 501 |
| 146 | 0.00676 | 0.00100 | 0.41667 | 0.05998 | 7.70 | 22.00 | 101500 | 501 |
| 147 | 0.00893 | 0.00100 | 0.70423 | 0.05998 | 7.70 | 22.00 | 101500 | 501 |
| 148 | 0.06341 | 0.00740 | 0.17833 | 0.05998 | 7.70 | 22.00 | 101500 | 503 |
| 149 | 0.05387 | 0.00740 | 0.45002 | 0.05998 | 7.70 | 22.00 | 101500 | 503 |
| 150 | 0.03696 | 0.00740 | 0.28617 | 0.05998 | 7.70 | 22.00 | 101500 | 504 |
| 151 | 0.24000 | 0.00700 | 0.22000 | 0.00600 | 7.50 | 22.00 | 101400 | 490 |
| 152 | 0.14600 | 0.00700 | 0.11700 | 0.00500 | 7.50 | 20.00 | 101400 | 504 |
| 153 | 0.17700 | 0.00900 | 0.16500 | 0.00700 | 7.50 | 18.00 | 101500 | 509 |
| 154 | 0.18800 | 0.00900 | 0.17700 | 0.00700 | 7.50 | 18.00 | 101500 | 510 |
| 155 | 0.24700 | 0.00800 | 0.23300 | 0.01600 | 7.50 | 18.00 | 101500 | 510 |
| 156 | 3.09200 | 0.31920 | 5.51300 | 0.56130 | 7.00 | 23.00 | 101400 | 500 |
| 157 | 3.07300 | 0.23150 | 2.48400 | 0.25840 | 7.00 | 23.00 | 101400 | 500 |
| 158 | 3.00900 | 0.32570 | 2.73500 | 0.28350 | 7.00 | 23.00 | 101400 | 500 |
| 159 | 2.91600 | 0.17020 | 2.26000 | 0.23600 | 7.00 | 23.00 | 101400 | 500 |
| 160 | 2.83200 | 0.34210 | 3.75700 | 0.38570 | 7.00 | 23.00 | 101400 | 500 |
| 161 | 2.78200 | 0.33300 | 3.75400 | 0.38540 | 7.00 | 23.00 | 101400 | 500 |
| 162 | 2.64500 | 0.16980 | 1.85400 | 0.19540 | 7.00 | 23.00 | 101400 | 500 |
| 163 | 2.53800 | 0.14440 | 1.59200 | 0.16920 | 7.00 | 23.00 | 101400 | 500 |
| 164 | 2.40600 | 0.19860 | 2.15700 | 0.22570 | 7.00 | 23.00 | 101400 | 500 |
| 165 | 2.33100 | 0.14720 | 1.52000 | 0.16200 | 7.00 | 23.00 | 101400 | 500 |
| 166 | 2.21500 | 0.16910 | 1.75833 | 0.18583 | 7.00 | 23.00 | 101400 | 500 |
| 167 | 2.16100 | 0.16020 | 1.79100 | 0.18910 | 7.00 | 23.00 | 101400 | 500 |
| 168 | 2.12200 | 0.21590 | 2.30400 | 0.24040 | 7.00 | 23.00 | 101400 | 500 |
| 169 | 0.07439 | 0.01291 | 0.05398 | 0.00937 | 10.00 | 21.00 | 101500 | 500 |
| 170 | 0.03263 | 0.00339 | 0.21701 | 0.02253 | 10.00 | 21.00 | 101500 | 500 |
| 171 | 0.09918 | 0.01082 | 0.24656 | 0.02689 | 10.00 | 20.00 | 101500 | 504 |
| 172 | 0.05944 | 0.00621 | 0.74266 | 0.07762 | 10.00 | 20.00 | 101500 | 504 |
| 173 | 0.06476 | 0.00688 | 0.10611 | 0.01127 | 10.00 | 20.00 | 101500 | 502 |
| 174 | 0.07322 | 0.00760 | 0.58524 | 0.06076 | 10.00 | 20.00 | 101500 | 502 |
| 175 | 0.89000 | 0.50000 | 15.15000 | 0.50000 | 9.00 | 21.00 | 101960 | 507 |
| 176 | 1.96000 | 0.50000 | 6.45000 | 0.50000 | 9.00 | 21.00 | 101960 | 508 |
| 177 | 0.89000 | 0.50000 | 11.92000 | 0.50000 | 9.00 | 20.00 | 101960 | 509 |
| 178 | 2.66000 | 0.50000 | 8.72000 | 0.50000 | 9.00 | 22.00 | 101960 | 509 |

| 179 | 1.21000 | 0.50000 | 8.67000 | 0.50000 | 9.00 | 23.00 | 101960 | 509 |
|-----|---------|---------|----------|---------|------|-------|--------|-----|
| 180 | 1.41000 | 0.50000 | 11.06000 | 0.50000 | 9.00 | 22.00 | 101960 | 509 |
| 181 | 0.90000 | 0.50000 | 14.42000 | 0.50000 | 9.00 | 22.00 | 101960 | 509 |
| 182 | 1.09000 | 0.50000 | 19.87000 | 0.50000 | 9.00 | 22.00 | 101960 | 509 |
| 183 | 2.75000 | 0.50000 | 2.40000 | 0.50000 | 9.00 | 22.00 | 101960 | 503 |
| 184 | 1.48000 | 0.50000 | 8.34000 | 0.50000 | 9.00 | 22.00 | 101960 | 509 |