Section 1: Aim.

- The aim of this experiment is to study the fluid resistance and *Stokes's law*. In particular, we will use three types of balls and drop them into the detergent one by one. And we will measure the distances and times of each ball, so that we can calculate the viscosity according to *Stokes's law*.

Section 2: Background.

- **Definitions.**
  - Fluid resistance:
    A force acted on a moving body through a liquid.
- **Equations.**
  - $f = kv$ (1)

    For a sphere, the resistance force on it is almost proportional to its velocity. The coefficient depends on the shape and size of the object.
  - $mg - kv - B = m\frac{dv}{dt}$ (2)

    From Newton's Law, we can get this equation when taking the buoyant force into consideration.
  - $v_T = \frac{mg}{k} - \frac{B}{k}$ (3)

    We can obtain the exact value of the constant with the terminal velocity.

Section3: Experimental Procedure.

A. Part One.

1) Fill the small beaker with some detergent. Put it on the electronic balance and then press the Tare button in order to clear the displaying number to zero.
2) Hold the string which suspends one of the beads, and slowly submerge the bead into the liquid. Record the number on the balance, R1.
3) Make the bead stand on the bottom. Record the number on the balance, R2.
4) Lift the bead until it stays in the same position as that in Condition 2. Record the number on the balance, R3.
5) Drop and lift the bead through the liquid. No touching the side is allowed. Record the number on the balance, R4.
6) Free the ball and make it drops through the liquid. Record the number on the balance, R5.

B. Part Two.

1) Build up the apparatus as the following figure. Prepare some beads in three different sizes. And weight the smallest one.

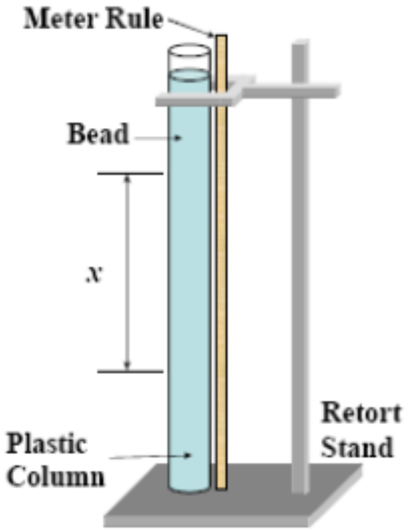


Figure 1: Apparatus setup.

2) Drop the bead in the center of the column, and then measure the positions of the bead at different times. Calculate the terminal velocity with these measurements.
3) Repeat step 2 with different-sized beads, and repeat more than five times.
4) Calculate the viscosity by using the aforementioned equations. Compare the result with the reference value, which is of 1410 centipoise.

Section 4: Results.

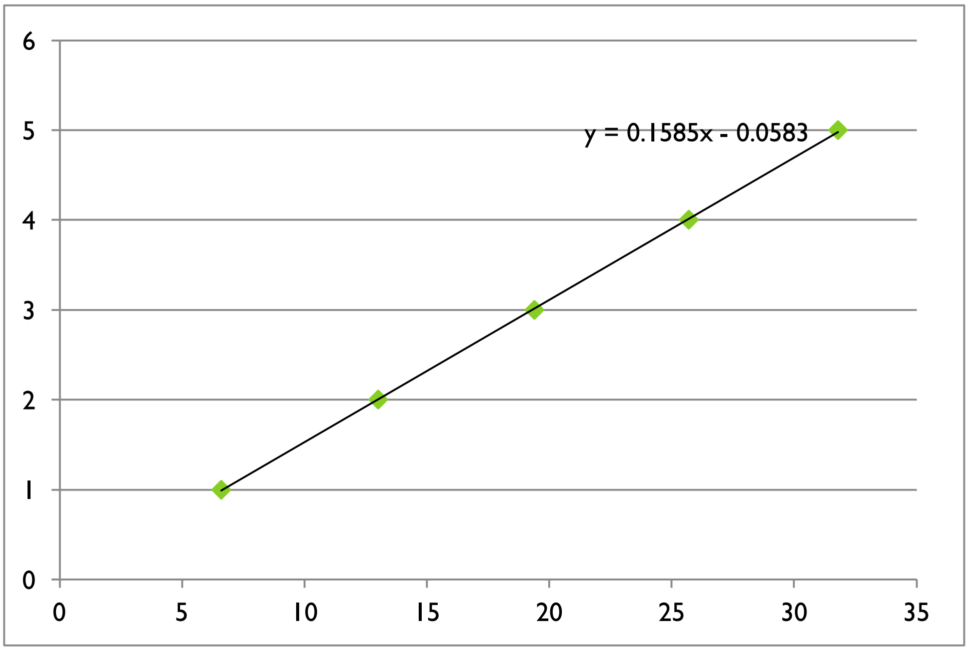
A. Part One.

R1 0.742
R2 0.934
R3 0.728
R4 decreasing
R5 increasing

B. Part Two.

1. Small
   a) m=0.071, d=0.455

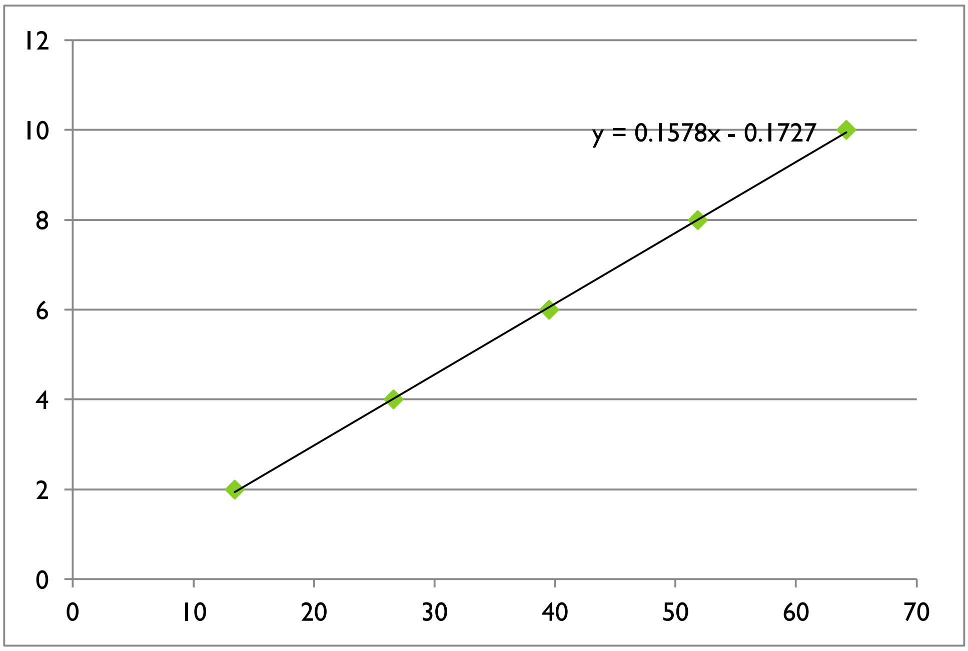
t	6.6	13	19.4	25.7	31.8
s	1	2	3	4	5



η =1654.88

b) m=0.068, d=0.452

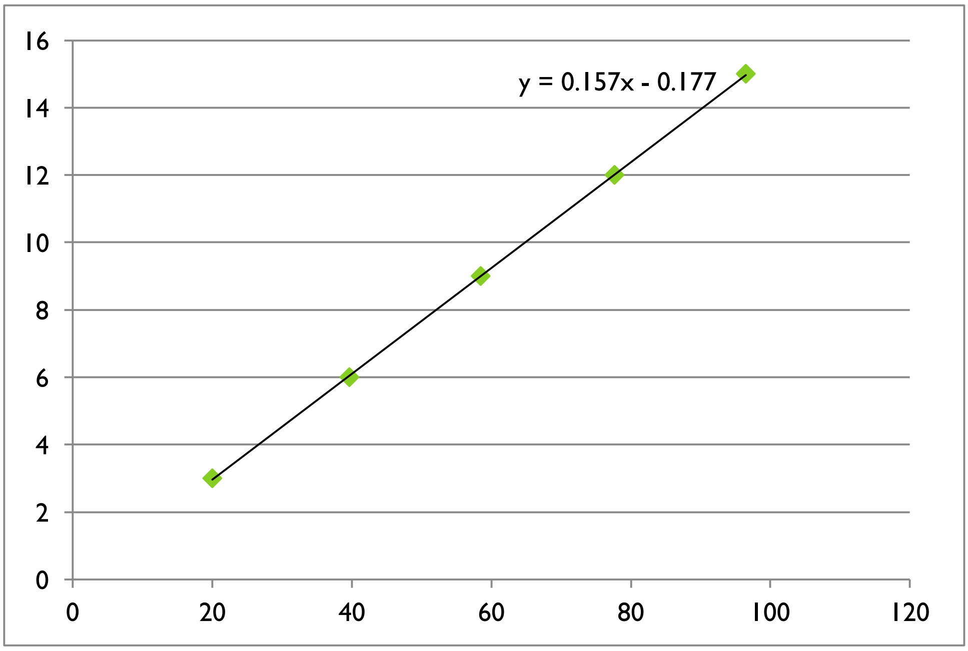
t	13.44	26.6	39.53	51.86	64.17
s	2	4	6	8	10



η =1406.25

c) m=0.069, d=0.455

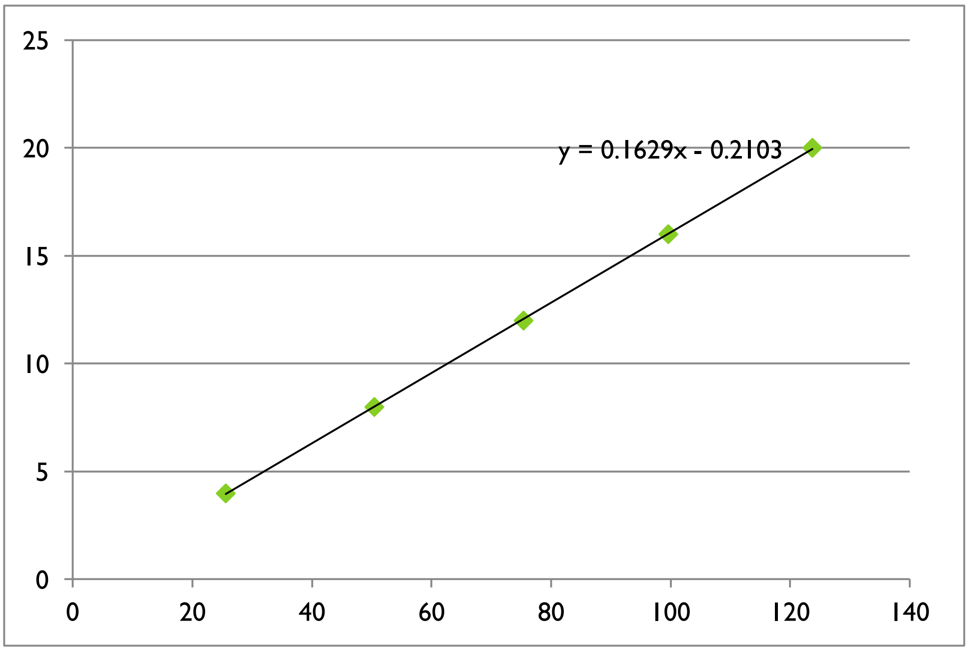
t	20	39.6	58.5	77.7	96.5
s	3	6	9	12	15



η =1379.36

d) m=0.070, d=0.457

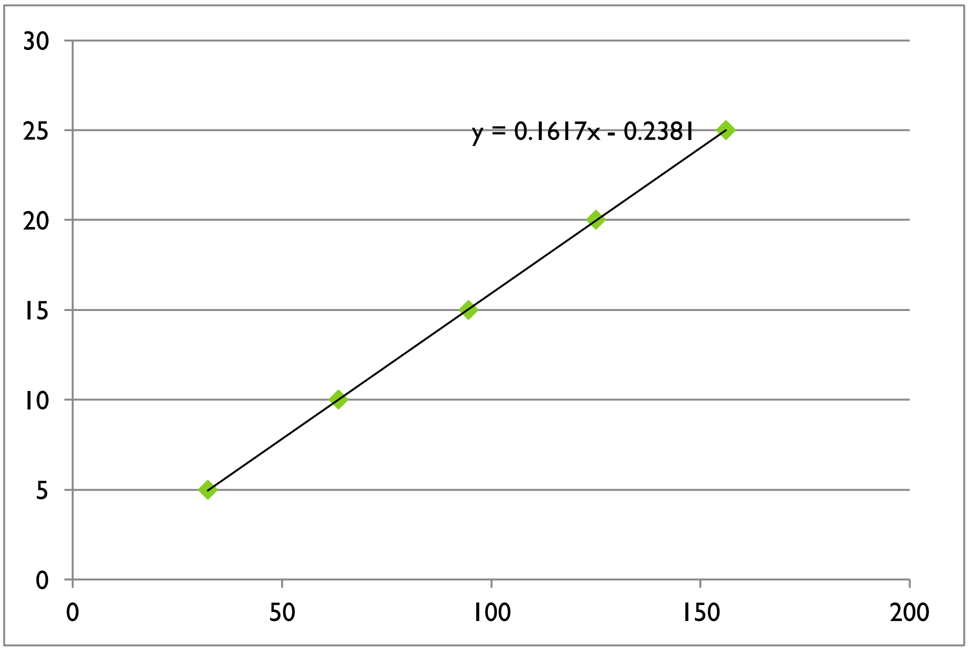
t	25.57	50.39	75.42	99.59	123.7
s	4	8	12	16	20



η =1353.15

e) m=0.070, d=0.458

t	32.21	63.45	94.47	125.05	156.02
s	5	10	15	20	25

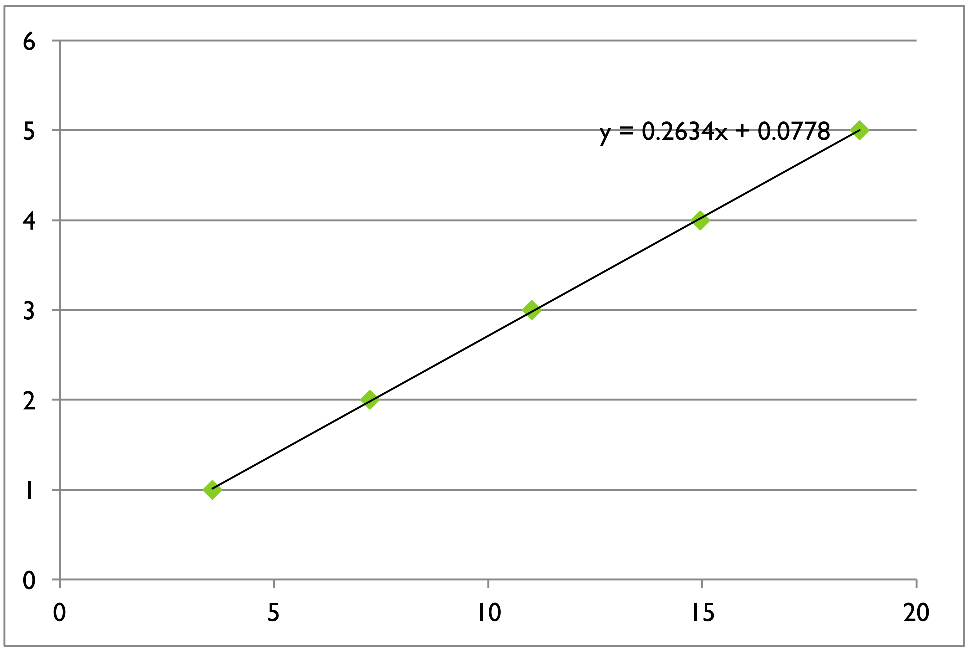


η =1304.46

2. Medium.

a) m=0.178, d=0.628

t	3.56	7.24	11.03	14.96	18.68
s	1	2	3	4	5

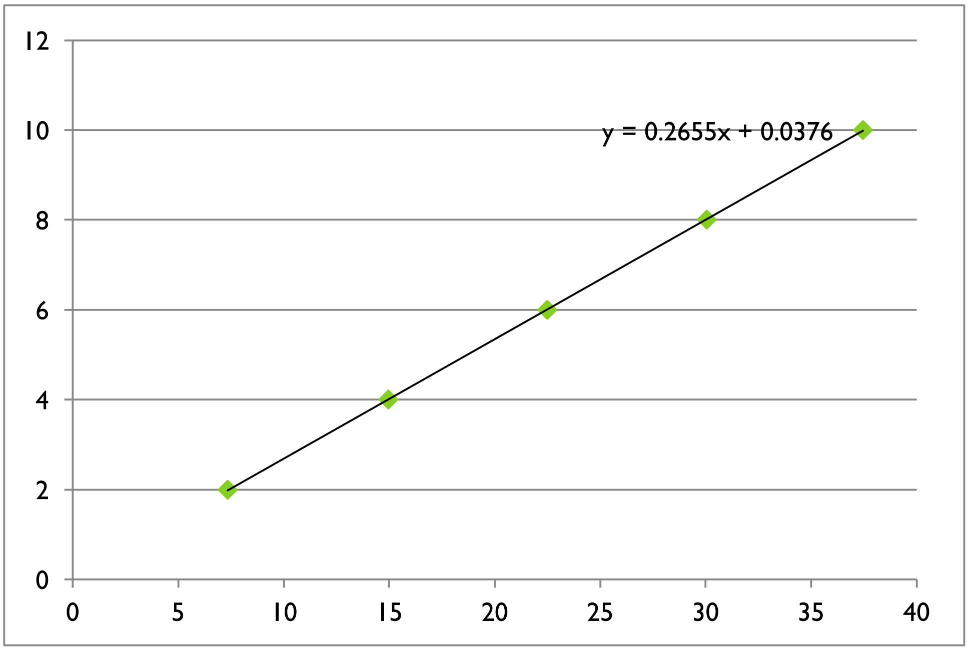


η =1350.88

b) m=0.180, d=0.631

t	7.34	14.95	22.5	30.04	37.46

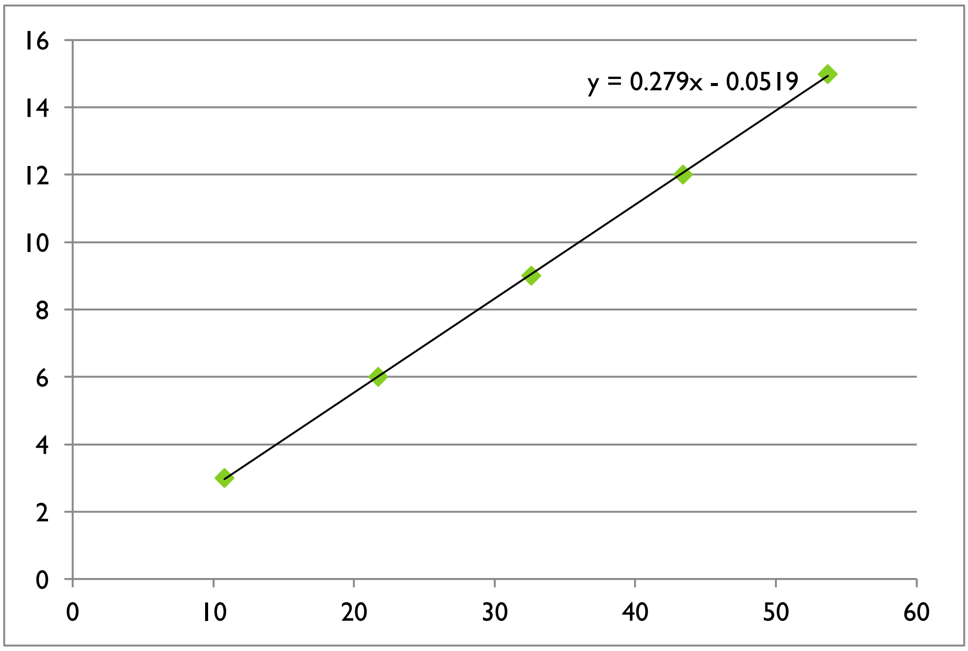
s	2	4	6	8	10



η =1318.05

c) m=0.185, d=0.631

t	10.8	21.7	32.6	43.4	53.7
s	3	6	9	12	15

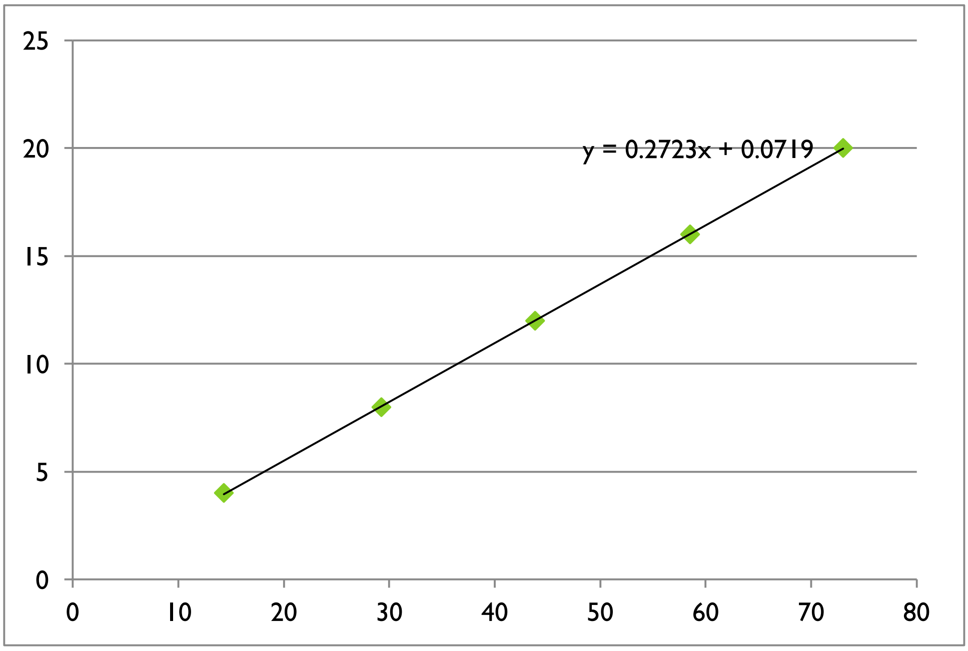


η =1549.80

d) m=0.182, d=0.627

t	14.29	29.24	43.84	58.55	73.07

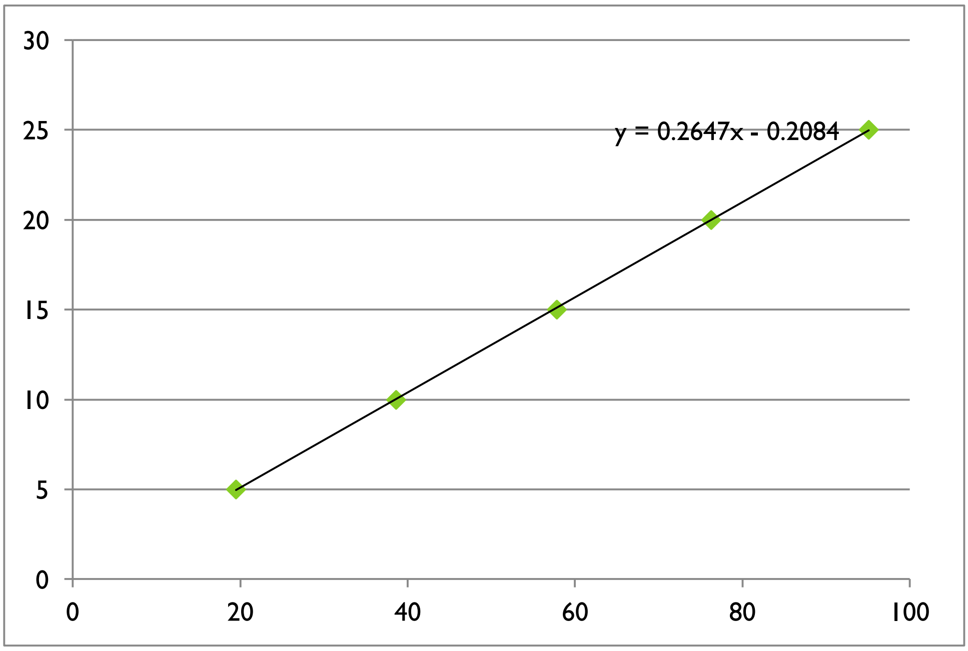
s	4	8	12	16	20



η =1598.09

e) m=0.178, d=0.630

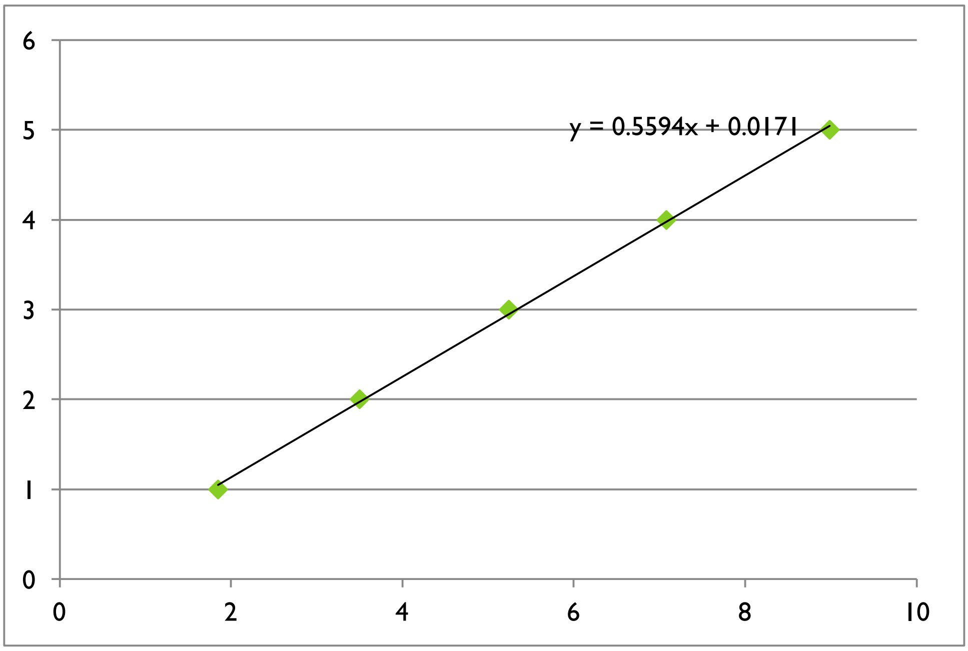
t	19.5	38.6	57.8	76.3	95.1
s	5	10	15	20	25



η =1246.36

3. Large.
   a) m=0.974, d=1.096

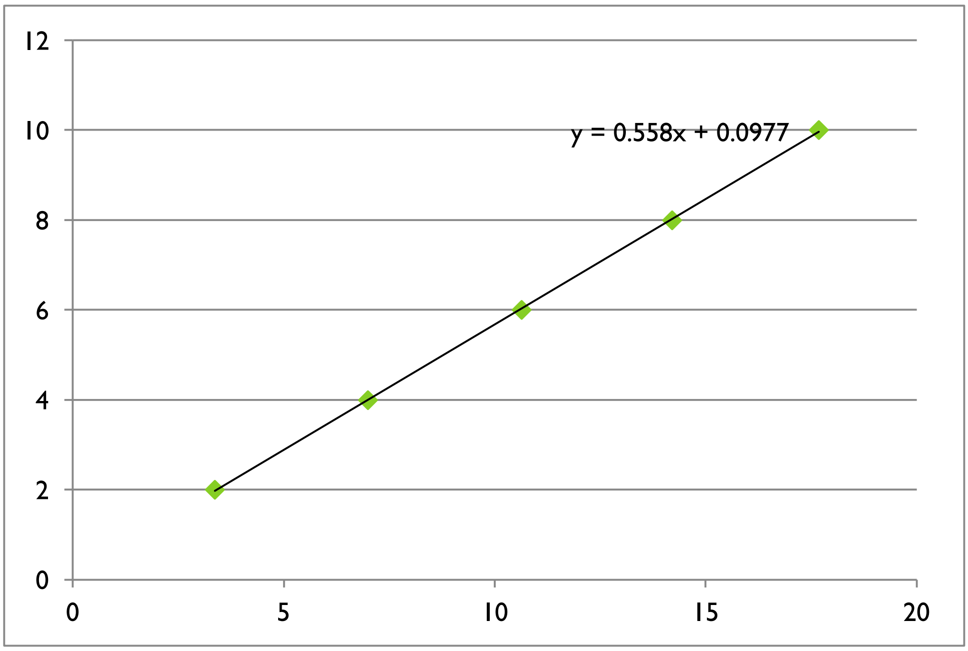
t	1.85	3.5	5.24	7.08	8.99
s	1	2	3	4	5



η =2409.56

b) m=0.941, d=1.096

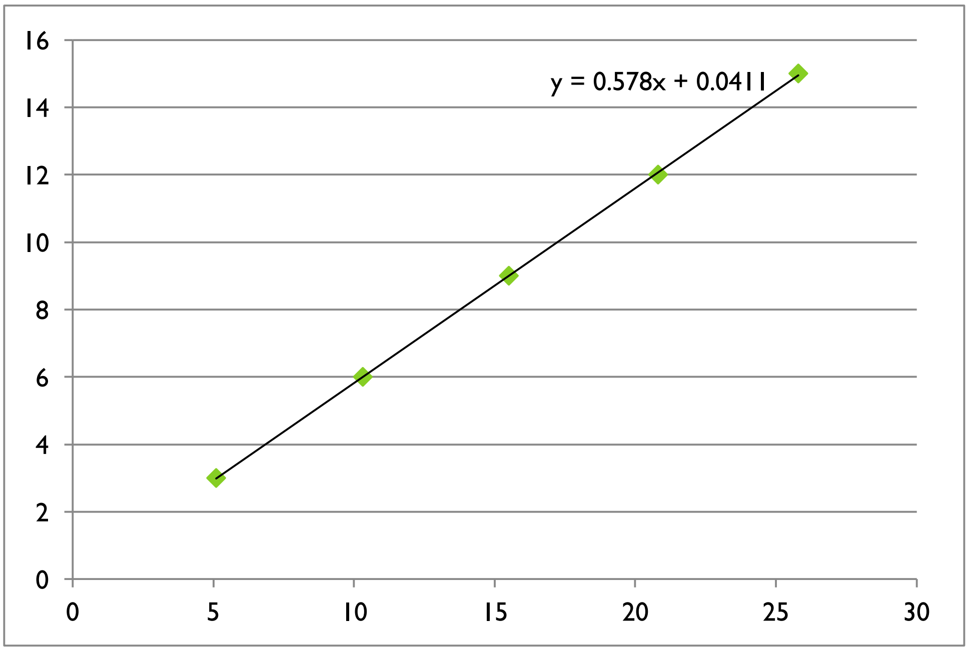
t	3.37	6.99	10.64	14.21	17.68
s	2	4	6	8	10



η =1854.13

c) m=0.943, d=1.095

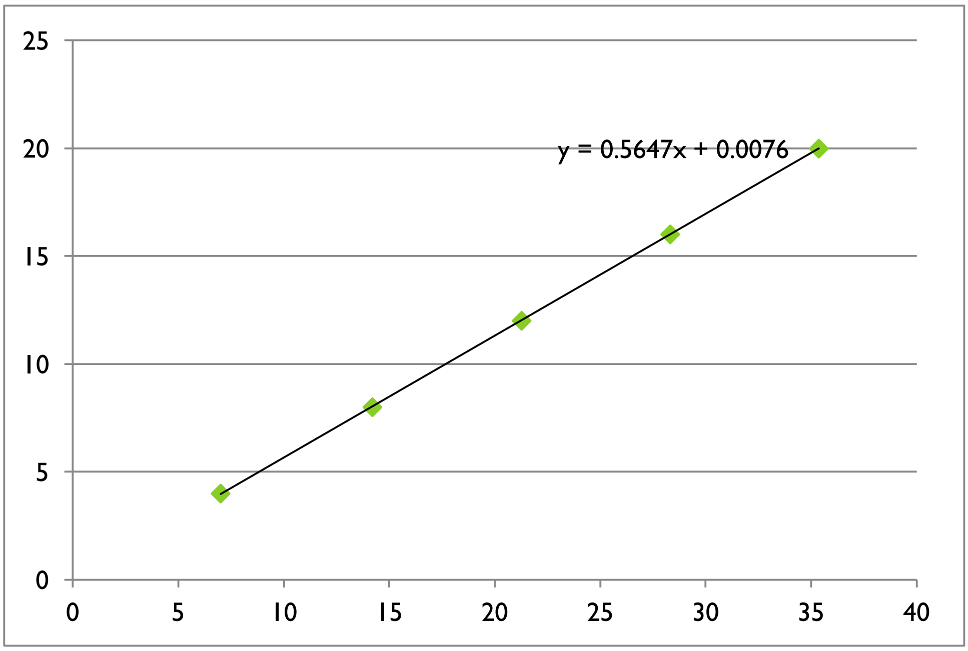
t	5.1	10.3	15.5	20.8	25.8
s	3	6	9	12	15



η =1861.89

d) m=0.942, d=1.095

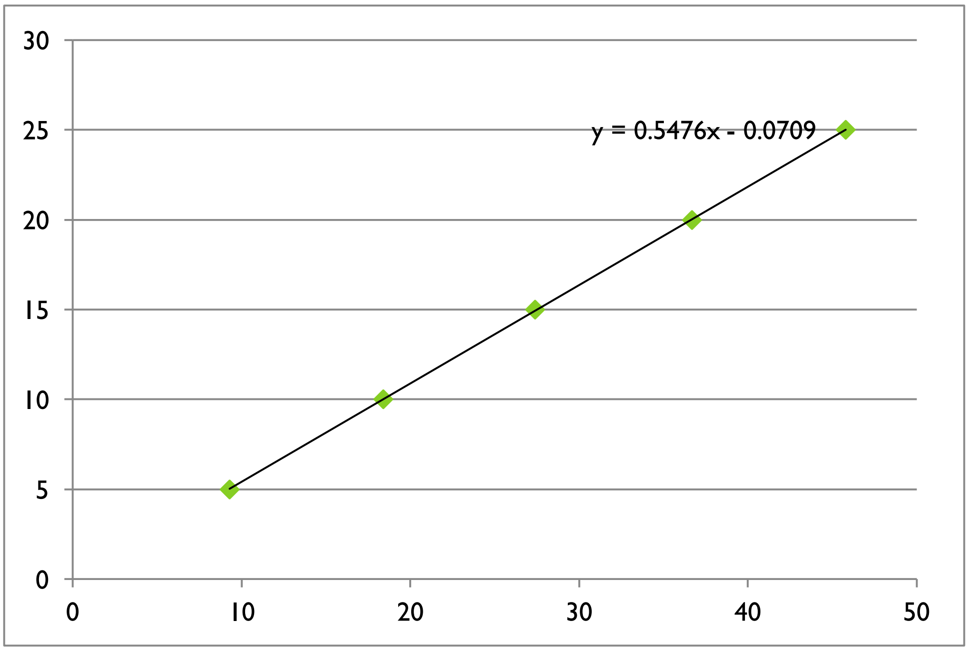
t	7	14.21	21.29	28.32	35.36
s	4	8	12	16	20



η =1888.92

e) m=0.943, d=1.095

t	9.3	18.4	27.4	36.7	45.8
s	5	10	15	20	25



η =1965.26

Section 5: Discussions.

A. Part One.

This part of experiment is easier than the second one. We can get the precise results as long as we are careful enough. The errors have been controlled strictly.

B. Part Two.

1. The theorem can be only applied when both the base area and the height of the column are infinite. But the fact is that we cannot find such a column. When the base area is small enough, we will get a larger value of the viscosity.
2. The viscosities of a same liquid are different in different temperatures. The viscosity tends to decrease when the temperature rises.
3. Sometimes there are some bubbles around the bead, which can also affect the results of the experiment.
4. Touching the column wall means increasing the friction force applied on the bead, from which we can also get a larger value of the viscosity.

Section 6: Conclusions.

1. This experiment requires measuring the times covering the same distance, while we measured some different ones. Next time we need to read the manual carefully.
2. In this experiment, all the values require measuring precisely. Any kind of carelessness can make a big difference to the results.