- One large protractor
- 5- measuring cylinders (2000mL, 1000mL, 500mL, 400mL, 100mL)
- Water
- Ruler
- Cello-tape

b) Take a large protractor and fix it onto a wall, which will be later used to find the angle of tilt of the measuring cylinder.

c) Then keep a 2000ml measuring cylinder on a fixed position parallel to the 90-degree mark of the protractor.

d) Gently push the top of the cylinder so that the cylinder begins to tilt and continued pushing it until the bottle completely topple to find the angle at which it toppled.

Figure 3

6.70	35	36.0	36.0	36.0	36.0
8.10	23	23.0	24.0	24.0	24.0
8.70	22	23.0	22.0	23.0	23.0
11.10	24	25.0	26.0	25.0	25.0
12.80	19.0	20.0	20.0	20.0	21.0

Choice of uncertainty:

diameter: least count/2:- 0.1cm/2= ±0.05cm

Tilt angle: least count/2:- 1˚ /2= ±0.5˚

Data Presentation and Analysis:

Processing:

The raw data collected in the data tables does not constitute the average tilt angle. The processed data is presented below in a tabulated form, which will be further plotted onto a graph.

Calculations:

I. Average tilt angle will be found by adding all the trials and dividing it by 5.

Average Tilt angle = (Trial 1 + Trial 2 + Trial 3 + Trial 4 + Trial 5)/5

II. Uncertainty in the readings of the Tilt angle can be calculated by finding the range of values for each volume and dividing it by 2 as shown below:

Uncertainty of Tilt angle (When volume of water added is 0 ml) = (Maximum [Trial 1, Trial 2, Trial 4, Trial 5] – Minimum [Trial 3])/2

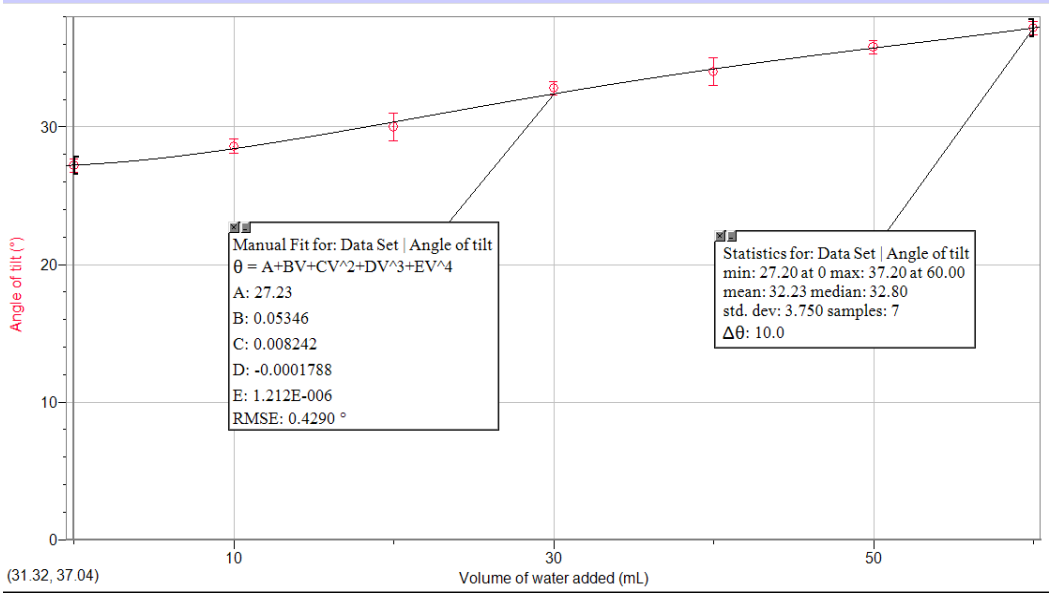
Processed Data for Case 3:

Case 3 processed data tables:

Table 1.1.1 (2000mL)		
Diameter: 12.8 cm; Mass: 410.2g (without any liquid added)		
Volume/ ± 10 ml	Tilt Angle/ **± 0.5 ˚ (Degree)**	
	Average Tilt angle	Uncertainty in the tilt angle
0	17.6	±0.5
50	20.0	±1.0
100	20.6	±0.5
150	24.6	±1.0
200	27.2	±0.75
250	28.0	±1.0
300	28.0	±0.5

Table 1.1.2 (1000mL)		
Diameter: 11.1 cm ; Mass: 236.00 g (without any liquid added)		
Volume/ ± 10 ml	Tilt Angle/ **± 0.5 ˚ (Degree)**	
	Average Tilt angle	Uncertainty in the tilt angle
0	23.8	±0.5
50	25.0	±1.0

Quartic model:



After reviewing the plotted graph, I have concluded that the cubic model is the best for modelling the graphs for the relationship between the volume of water added and the tilt angle of the measuring cylinder. This is because the RMSE (Root mean square) value is the lowest for the cubic model.

Therefore, from the above processed data tables, graphs can be plot for the average tilt angle versus the volume of water added. The uncertainty in each trial is showed with the help of the error bars in each graphs.

one single factor solely cannot determine the stability. Hence, even though the 2000mL cylinder is the tallest and 1000mL cylinder is relatively shorter the 2000mL is more stable. This because the rest of the factors such as diameter of the cylinder is dominating in this situation.

Moreover, we can determine the relation between variable capacity addition (x-axis) and the tilt angle (y-axis) of a fixed capacity-measuring cylinder. Hence, we tabulated a table using the table 1.1.1, 1.1.2, 1.1.3, 1.1.4, 1.1.5 that shows the relation of the volume vs tilt angle. Here I have taken data for four different capacities of cylinder and neglected 100ml because as mentioned above the 100mL measuring cylinder produces an anonymous state of readings, which cannot be collaborated with other sets of readings to determine the relationship.

In this table, the x-axis is the variable volume added to the cylinder and the y-axis is the average tilt angle approximated to an integer.

Evaluation:

Error analysis:

In this investigation, uncertainties were observed in each section of the experiment. These could have occurred because of one of the reasons of errors enlisted below.

The percentage uncertainties of the graph plotted for the five measuring cylinder with different capacities are as given below:

for 2000mL = 23.10%,

for 1000mL = 14.80%,

for 500mL = 9.93%,

for 400mL = 8.30%,

and for 100mL = 15.50%. (anonymous state reading)

The high uncertainty in the 2000mL cylinder is probably because of the multiple errors caused due to bad human handling. As we can see, there is a decrease in the trend of uncertainty, which proves the presence of a systematic error, which decreases with a decrease in the capacity/ volume of the cylinder. There is exception, which is to be marked as an anonymous state reading for the 100mL cylinder.

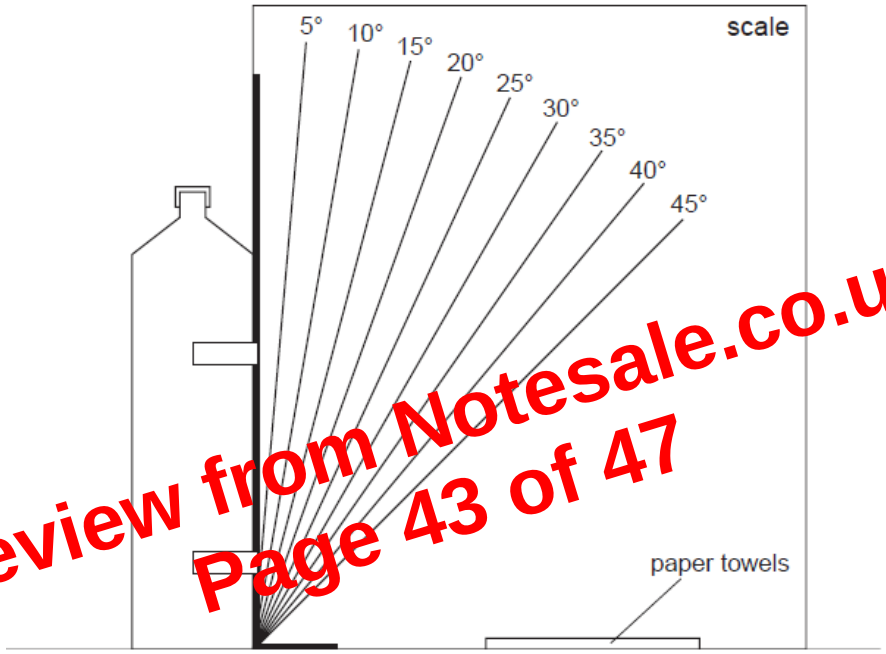
The errors that may have occurred in the Experiment are as follows:

1) While measuring the diameter of the measuring cylinder used in the experiment using a ruler there is a high probability for a parallax error to take place.

accuracy in measuring the diameter of the cylinder, the height of the cylinder and angle of tilt.

3) Get the eye level perpendicular to the protractor lines while measuring the tilt angle.

4) Make a protractor on a large sheet and stick it behind the apparatus as shown in the figure given below.



This will make the previous issue of keeping the head still while measuring the angle. This is because we do not need to strain our neck and keep our head still to measure the angle of tilt.

Methods already employed:

1) Used a wooden plank as a base instead of a fixed base, to elevate it from one of its side in order to improve the experiment by making the measurement of tilt angle more accurate.