Roll No: 21KL003

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Experiment Name and No.: Liquid Drops, EXPT-3

Part-A: Surface tension of water

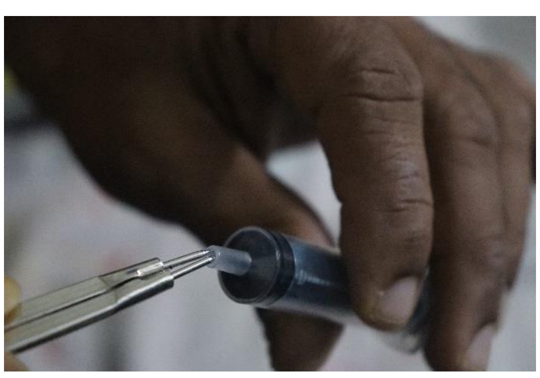
Aim: To find out the surface tension of water using a syringe.

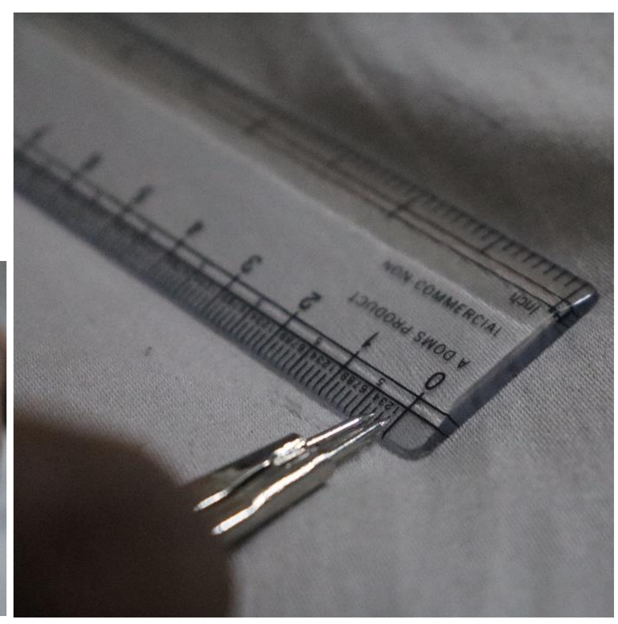
Setting up the experiment:

I used a 5ml syringe to form the drops and they were filled upto 1ml to check for the number of drops I got per ml of water in the syringe.

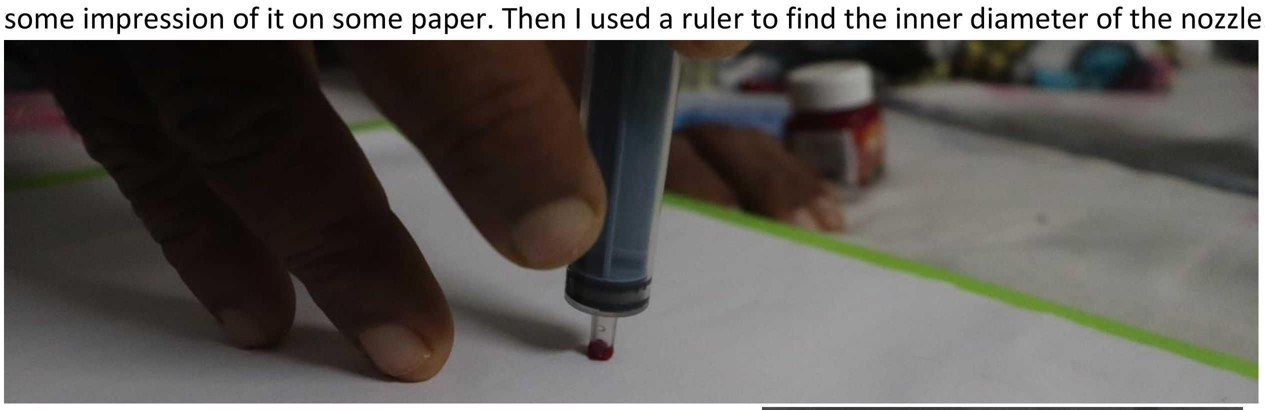
First I had to find the radius of the syringe. I used two methods:

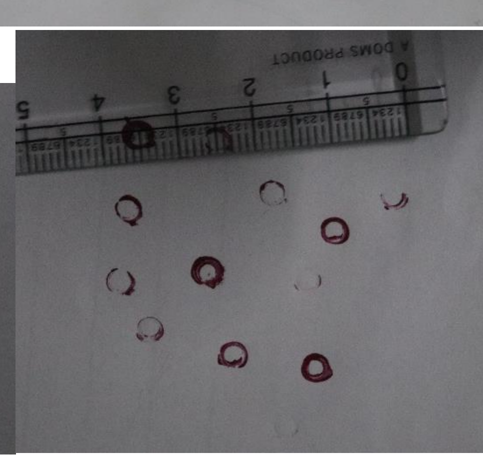
1. I used a divider to find the inner diameter of the syringe and then used a ruler to find the distance between the two legs of the diameter.





2. Considering that the previous measurement could be wrong, I dipped the nozzle of the syringe in some paint and then made some impression of it on some paper. Then I used a ruler to find the inner diameter of the nozzle.





The values I found in both the cases were the same. The diameter of the inner nozzle = 2mm. Therefore, the radius = 1mm = $10^{-3}m$.

Then I used the syringe to find the number of drops which were formed.

This is the video: Video1

I got the number of drops as 23 drops/ml.

This meant that the volume of 1 drop was 1/23 millilitres. As 1ml = 1 cubic centimetre. The volume was 1/23 cm^3. Then I checked online for the approximate density of tap water but I did not get a correct estimate. So I just took it as 1g/cm^3 . This meant that the mass of 1 drop was 1/23 grams. According to the formula given:

$$W = 2\pi r \times T$$

Therefore.

$$T = mg/(2\pi r)$$

$$T = \frac{(\frac{1}{23} \times 10^{-3}kg \ \times 9.81\frac{m}{s^2})}{(2 \times 3.14 \times 1 \times 10^{-3}m)}$$

$$T = 0.0679 \ N/m$$

Then I checked online for the actual surface tension of water-air interface and found it to be approximately 0.073 N/m. I got worried and tried the experiment again but still got the same result. Then I checked that 0.073N/m was the value at 25 degree Celsius. However, here in Trivandrum the temperature was considerably high about 29-30 degree Celsius. Also, the place where I lived was near the coast and therefore humidity was high. So I concluded that the increased temperature and humidity reduced the value that I got.

PART B – Surface tension of soap solution

Aim: To study the surface tension of soap solution at various concentrations.

I first took 100ml of water and 100ml of liquid soap (from a packet). Then I mixed them evenly. Then I diluted them further to get more values: After doing that I got the following values:

Solution	Concentration(v/v)	No of drops/ml
100ml only liquid soap	100%	36
100ml soap + 100ml water	50%	44
100ml soap + 300ml water	25%	54
100ml soap + 500ml water	16.667%	55
100ml soap + 700ml water	12.5%	43
100ml soap + 900ml water	10%	38

The density of the liquid soap was approximately found to be 1.1 g/ml. I found out the density of the water-soap solution and then found the surface tension as follows:

Volume of soap(ml)	Volume of water(ml)	mass of soap(g)	mass of water(g)	density of mixture(
100	0	110	0	
100	100	110	100	
100	300	110	300	
100	500	110	500	1.016
100	700	110	700	
100	900	110	900	

No of drops/ml	Volume of 1 drop(ml)	Density(g/ml)	Weight(N)	Length(2pir)
36	0.027777778	1.1	0.000299444	0
44	0.022727273	1.05	0.000233864	0
54	0.018518519	1.025	0.000186019	0
55	0.018181818	1.016666667	0.000181152	0
43	0.023255814	1.0125	0.000230756	0
38	0.026315789	1.01	0.000260474	0

This was the graph I obtained: Graph

I found something wrong with the values because I knew that soap was supposed to reduce the surface tension of water. This I observed as the concentration increased from 10% to 16.667%. However after this the value just increased.

I noticed that as it was liquid soap and as the concentration was above 16.67% and the density of the soap itself was 1.1 g/ml as the concentration of soap decreased the amount of soap due to the increased viscosity of the soap and therefore the surface tension increased.

PART C – Surface tension of water-oil interface

For this I knew the density of the oil from part D as 0.83329 g/ml. I knew that here the force was not just weight but there was also buoyancy acting on the drops.

This was the formation of oil drops: Video4

The number of drops = 6 drops/ml

Therefore volume of one drop = 1/6 ml

The mass of one drop = 1/6 g

Weight = 1/6g x 0.001 x 9.8 = 1.63333 x 10^{-3}N

Buoyancy = 1/6ml x 0.83329 x 0.001 x 9.8 = 1.361040333 x 10^{-3}N

So here net force = $W - F_B = 0.272289666 \times 10^{-3} N$

Therefore Surface Tension = $\frac{F}{2\pi r} = \frac{0.272289666 \times 10^{-3} N}{2 \times 3.14 \times 0.001} = 0.043358\ N/kg$

PART D – Finding the density of oil

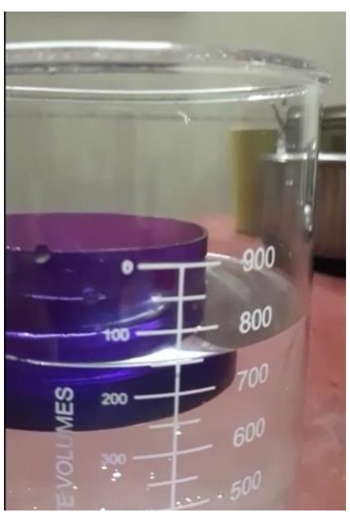
Aim: To find the density of the oil that is required in Part B.

I used a measuring cylinder here to find the density of the oil. This was because I had no transparent(plastic or glass utensil at home) and the ones which were had other markings and were more translucent than transparent. So I had to buy one from the nearby store.

The oil I used was some coconut hair oil.

I used a bottle cap as the container for the oil – as it floated and also it had a wide base such that it would not topple when I poured the oil into it.

This is the set up with the measurements visible:



I used scale for the smaller values. I noticed that 6mm in the scale was 50ml increase in volume in the cylinder and using this relation I calculated the finer increase in height of water.

These are the two videos for the measurement: Video2 and Video3

The values I got were

Volume of oil (ml)	Increase in height(mm)	Increase in volume of water(ml)
40 ml	4mm	4*50/6 = 33.33 ml
60 ml	6mm	6*50/6 = 50 ml

According to Archimedes Principle, a floating body displace amount of water that is equivalent to its own weight.

Which meant that the density of oil in each case:

Volume of oil (ml)	Mass of water displaced	Weight of Water = Weight of Oil	Mass of Oil	Density
40 ml	33.33 g	33.33 x 9.80 x 0.001 N	33.33 g	33.33/40 = 0.83325 g/cm^3
60 ml	50g	50 x 9.80 x 0.001 N	50g	50/60 = 0.83333 g/cm^3

Taking the mean of both: (0.83325 + 0.83333)/2 = 0.83329 g/cm^3. This is the value of density of oil I got.

Extra Exploration:

1. I also tried for oil in air. Here I got 36 drops from 1ml. Which meant that the volume of 1 drop = 1/36 ml. The density which we got from Part D was 0.83329g/cm^3 or g/ml. Therefore mass of 1 drop = $\frac{1}{36} \times 0.083329\ g$. Therefore the weight of 1 drop = $\frac{1}{36} \times 0.083329 \times 0.001 \times 9.8\ N$. Therefore, surface tension of oil in air = $\frac{\frac{1}{36} \times 0.083329 \times 0.001 \times 9.8\ N}{(2 \times 3.14 \times 1 \times 10^{-3} m)} = 0.03612\ N/m$.
   Earlier we got surface tension of water in air = 0.0679 N/m and surface tension of water-oil interface = 0.043358 N/m. This means that the highest value was for water-air, then for oil-air and finally water-oil.
2. Then I tried finding the number of drops of oil formed at the bottom of a container of water. This was not happening as drop were not being formed properly. Due to the low density of the oil as soon as some amount of

the oil came out they immediately rise up before they could even form a possible bubble. Also here pressing the piston was also hard as compared to other cases.

Acknowledgements

I would like to thank my younger sister and my parents who helped me in filming and in organising the equipment. I would like to thank NAEST for giving me the opportunity to do the experiment.