21. Sinking Paper Clips

Reporter - Team Starry Night

Problem’s Task

In a well known physics demonstration, small metal objects (eg. paper clips, pins, or needles) stay afloat on water. If a small amount of soap is then added to water, some of the floating objects instantaneously sink. Investigate the critical conditions for sinking.

The Theoretical Part

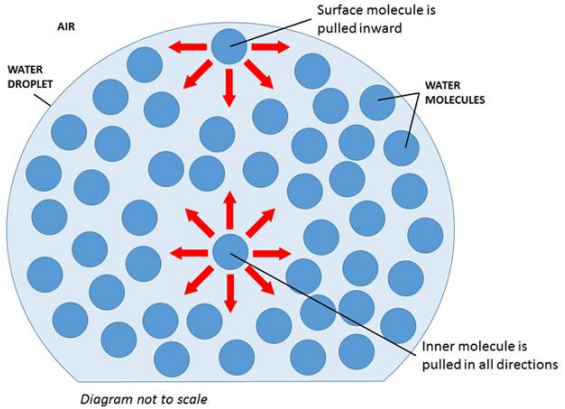
Water Structure - Surface Tension

Liquids have surface tension. This is the tendency for liquids to shrink so that they have the minimum surface area.

Surface tension happens because of the bonds between molecules.

As molecules pull on eachother, the molecules on the inside are equally pulled from each direction, while the ones on the outside (the surface) are pulled towards the inside.

In water, the bonds are especially strong, because of the strong hydrogen bonds, and the surface tension is powerful.



Paperclips

Because of the surface tension, objects that would usually sink because of their higher density, would float.

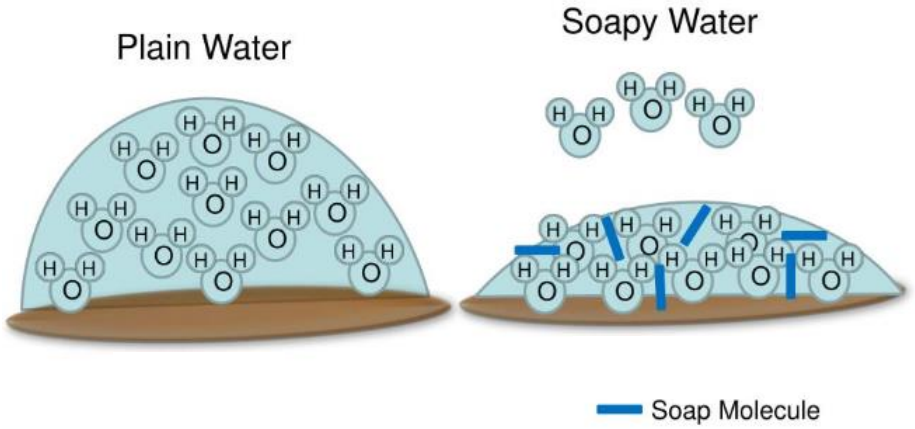
This however is directly influenced by the surface of the object that touches the water, and the weight of the objects.

That means that the overall shape of the object is irrelevant if the surface that touches the water is the same.

Surfactants - Soap

Surfactants are additives that decrease the strength of the surface tension.

Soap is a surfactant. This is because soap is made of a molecule that attaches to things like grease, and that is hydrophobic (does not like water). That means that soap molecules will stay afloat, to have less contact with water. This separates a part of the water molecules, breaking surface tension.



Hypothesis

We will measure the results in a qualitative way, but we will also make observations regarding sinking speed.

H1: The force which the paper clip plunges into the water (the height dropped) will affect the results.

H2: Volume of water should not make any difference. - This is for proving that only the surface has an impact.

H3: Soap should decrease the surface tension, making the paper clip fall.

H4: Bending the paperclip in such way that the surface is smaller (and the weight constant) should not influence the result.

H5: Carbonated liquids, due to the fact that they emit bubbles, will break the surface tension.

Parameters Varied

- Height of the drop
- Volume of the Water
- Different types of soap
- Paper clip surface that touches the water
- Carbonated drinks

Fun Experiment

We thought it would be fun to also try to see if surface tension could be broken in any other way. So we decided to also try to use a carbonated liquid.

We think that the carbonations bubbles will break the surface tension.

The Methodology

Materials Used

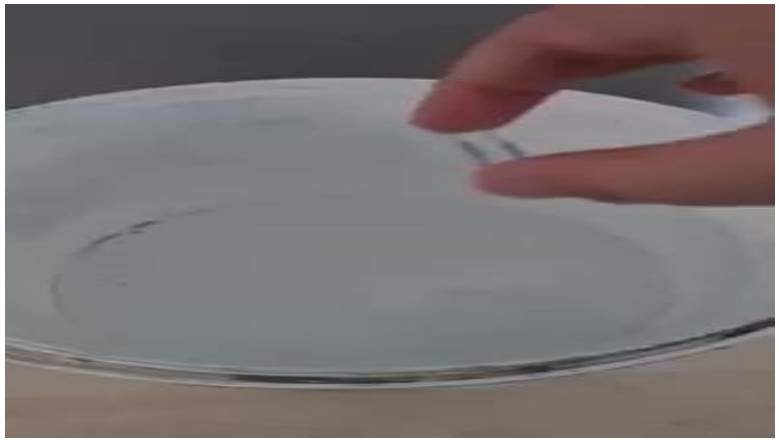
- Paper clips
- Plastic cups
- A bucket
- 2 types of dish soap
- Spoons for measuring the amount of soap and water (in an approximate but close enough manner)

The Experimental Part

Experiment 1 – Height Dropped

The height dropped should have an impact because the paper clip gains speed, thus being able to break the strength of the surface tension.

We can see in these videos that the impact speed does indeed have an effect. At the bigger height, the paperclip falls through the water, breaking the surface tension. Depth smaller than the height made the paperclip sink.

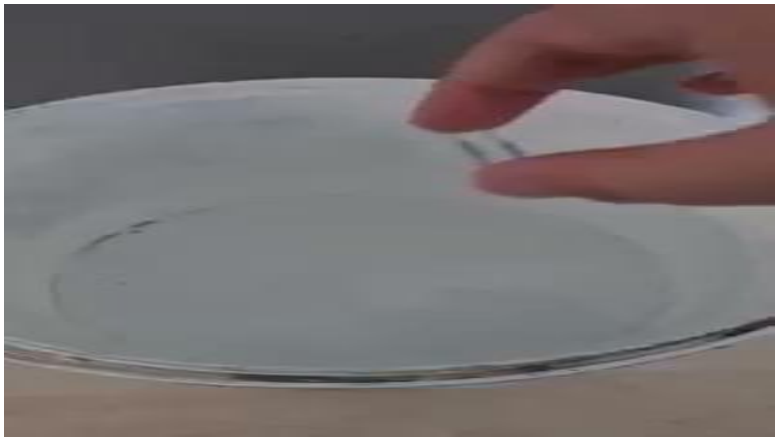


H1 Proven

Experiment 2 – Water Volume Variation

We used two different containers, with different sizes. This was so that we can have different depths of the water, while also seeing everything clearly.

We can see that the depth does not matter.



H2 Proven

Experiment 3 – Soap Variation

We used 2 types of soap. A red dish soap, and a green dish soap.

We did not notice any difference between the two dish soaps. The paperclips did indeed sink almost instantly.

You can see the paperclips at the bottom

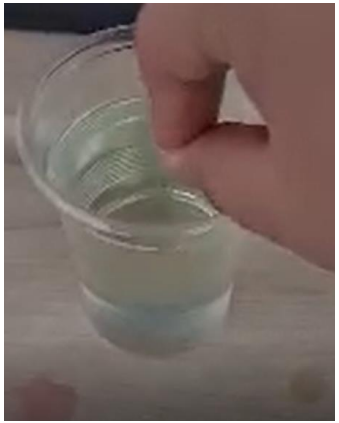
H3 Proven

Experiment 4 – Paper Clip Surface Variation

We bent the paperclips in half. This makes the surface area that touches the water smaller, while preserving the weight.

We can see that when the weight/surface ratio does indeed have an influence on the result

H4 False



Experiment 5 – Carbonated Drinks

We used carbonated drinks to test for H5. We expected the paperclip to instantly sink because of the carbonation bubbles breaking the surface tension. That was exactly what happened.

H5 Proven

Result Interpretation

H1: The force which the paper clip plunges into the water (the height dropped) will affect the results. – **True**

H2: Depth of water should not make any difference. - This is for proving that only the surface has an impact. – **True**

H3: Soap should decrease the surface tension, making the paper clip fall. – **True**

H4: Bending the paperclip in such way that the surface is smaller (and the weight constant) should not influence the result. – **False**

H5: Carbonated liquids, due to the fact that they emit bubbles, will break the surface tension. – **True**

Conclusions and possible errors

Conclusion

- Critical conditions for sinking were the presence of soap, the height from which the paper clip was dropped and the carbonation of the drink, the bubbles broke the surface tension.

Possible Errors

- The human error involved, a human can not drop the paper pin from the same height every time
- We did not use a graded cup to measure the amount of soap.

Purpose and Possible Improvements

We wanted to study the effects and characteristics of surface tension (what can break it or influence the effect), not so much the chemistry behind dish soap and such.

The study could be better if

- If quantities were accurately measured
- Use of other surfactants
- Use of other shapes of metal objects
- A more physics inclined explanation (the physics is complicated and thus not included)

Thank you for your attention!

Bibliography

https://www.britannica.com/science/soap

https://en.wikipedia.org/wiki/Surface_tension

https://en.wikipedia.org/wiki/Water