2018 EXPERIMENTAL PROJECT

(STUDENTS MAY WORK SINGLY OR IN TWO's OR THREE's)

SOAP FILM SURFACES AND BUBBLES

A. Introduction

Practical work is about technique and ideas. It is a skill that needs to be developed. You need to know where you are heading; real practical work is not about following instructions line by line, but about endeavouring to make things work. That is what this Experimental Project is concerned with.

Soap films as seen in the sink when washing up show a remarkably wide range of physics phenomena; from the range of colours which swirl around in the film when viewed in white light, we can suggest the thickness of the soap film. The simple shapes formed (spheres enclosing a bubble of air) tell us that the surface is under a tension trying to form the minimum area, which increases the pressure on the air contained within it. The effect of air drag as they fall are all interesting phenomena, but this experimental project is to examine instead the shapes and angles between surfaces and the recording of these for particular soap film surfaces.

B. Experimental Arrangement

Prepare the bowl of soap solution by almost filling the bowl with cold water. Add a few squirts of liquid detergent and stir thoroughly. Avoid producing bubbles on the surface and remove any bubbles from the surface of the solution.

Construct, using a Kubic Bubble kit (or similar), the four frameworks; tetrahedron, cube, octahedron and triangular prism. Note that there is an extra arm, for each framework, to act as a handle. Ensure that each framework can be totally immersed in the solution with the handle protruding from the surface.

Kubic Bubble kits are available for purchase online (e.g. Amazon, Cochranes of Oxford, etc.) for around £10 inc. P&P. The kit also includes an instruction booklet.

Similar kits are available, or you could potentially make your own kit if you wished.

C. First Experiment

(a) Dip each framework, completely submerged, into the solution and withdraw the framework. Ensure that no bubbles have been captured by the framework. The soap film surface, formed inside the framework, is the minimum area surface contained by the framework. Photograph this surface after selecting a suitable background coloured surface for the photograph, in order to maximize the contrast, so that the soap film surfaces and lines are clear.

(b) Obtain the minimum surface for each framework again, then partially dip each framework in order to capture a single bubble centrally in the framework. Then withdraw the frame from the solution. Photograph the framework with the centrally trapped bubble, using a suitable background.

D. Second Experiment

It is a general property of these soap films that:

(i) the angle, α, at which two curved lines of soap film meet is a constant for all lines
(ii) the angle, β, at which two curved soap film surfaces meet, along a line of soap film, is a constant for all points along the line, and for all lines.

This experiment is concerned with the measurement of α and β using the tetrahedral and cubic frameworks.

(a) Photograph the minimum surface inside the cubic and tetrahedral frameworks, at appropriate camera angles, to enable a measurement of α to be made from the printed version of the photographs in each case. Draw on the printed sheet the lines required to enable a protractor measurement of the angle.

Draw a diagram, in each case, indicating the camera angle, relative to the soap film surface/s used, together with any necessary explanation. Also give an **indication** of the error in your measurements and overall experimental accuracy.

(b) Again, using the minimum surfaces inside the cubic and tetrahedral frameworks, produce an appropriate printed photograph in order to measure β at a convenient point along one of the soap film lines, in both cases, by drawing in lines necessary to measure β.
As in (a), draw a diagram, in each case, indicating the camera angle, etc., with an explanation. Give an **indication** of the uncertainty in your measurements and overall experimental accuracy.

(c) Experimental Report

The report should describe the experimental work and include data, tables, diagrams and photographs, plus a discussion of measurement uncertainty and experimental accuracy.

This report should contain:

(i) A concise description of the experimental procedure, including diagrams and photographs.

(ii) A brief description of what you observe happening.

(iii) An outline of any experimental techniques used to improve accuracy or reduce uncertainty, and modifications to the procedure from any trial experiments.

(iv) Precautions taken to consider safety.

(v) Uncertainty and accuracy estimates (as in the instructions) and brief comments about them.

(d) Report Guidelines

There is no single correct way to write up a report. It depends on how you conducted the investigation. One critical feature is that it must be detailed and concise. If overlong, then it is too much to read through whilst trying to remember the detail; if too short then reader cannot grasp the essence of the investigation.

The page limit for your report is 12 pages including photographs.

Keep a log book; an A4 notebook from which pages cannot be ripped out, so that you can write and paste in comments and ideas, along with a record of your photographs and your progress. Learn to be organised. It helps you keep track of your progress and keeps the information in one place. You can refer to it and it makes writing up so much easier. All experimental physicists (and theoreticians) keep such a notebook.

You should give a full but concise description of the experimental procedure. Highlight any particular ideas you had to make the results more reliable, with results, tables, units, uncertainties, graphs, diagrams and images. This is elaborated below.

We do not want you to write a long report (12 pages maximum), but one which describes your progress and results in a way that would explain clearly to the reader what happens in the experiment, what you did, and what your results were, in such a clear way that they are persuaded that you knew pretty much what you were doing. Keep it simple and **BRIEF**. You are trying to remove elements of doubt in the reader's mind that you might just be making random measurements.

- Put **a title on the front, the date, your own name and school name and your Year Group**, and ensure your name is on **every page** by putting it in the footer, along with **page numbers**. It then appears automatically on each page. If you don't do this the projects get muddled.

- Write-ups can be by hand, in Word, or in Latex if you have someone to help you get started. Hand written reports often score well as such a report tends to be brief and to the point, although a word-processed report would score equally well if suitably concise.

- You should comment briefly on precautions you took and good ideas you had about reducing the uncertainties of your measurements and what were the difficult measurements to make and why. Do not write an essay but just a short comment about each good idea.

- If you feel that the results are not right, then don't scribble them out or delete them; keep them and just point out what might be wrong with them or why you have no confidence in them. The purpose is to show that **you have investigated the apparatus** and given it a good try out so that you can convince the reader that **you know and understand the science behind the investigation**. Things can go wrong and you need to show how you can overcome setbacks. If you delete everything that does not seem right to you, the reader might see a nice final table of results, but they do not know how much investigative effort you have put in to get that set of results. The reader might indeed wonder whether they are that good. Do **not** write an essay, just a few bullet point comments.

Good luck with the experiment!

The BPhO Team

(PTO: Checklist and submission details)

CHECKLIST

☑

1. Is your name and school on each page of the report, and year group? ☐
2. Is the reported dated? ☐
3. Are the pages numbered? ☐
4. Short introduction to your report, including key findings. ☐
5. Discussion of any relevant safety hazards, with measures to reduce risks. ☐
6. Outline of experimental procedure, including any problems and adjustments. ☐
7. Qualitative description of key observations from experiment. ☐
8. Uncertainties considered in some form, either discussed, calculated or both. ☐
9. Evaluation of project, considering validity of conclusions and improvements. ☐

The cover page must contain the school information.

A hard copy of the written report describing the experiments should be submitted by post together with all the printed photographs, from both experiments. In addition, an emailed version should also be sent with the scanned printed photographs, with markings, from (a) and (b).

NB - POSTED AND EMAILED REQUIRED

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