

## Introduction

As with most simple classification schemes, the boundary between “squidgy solids” and “sticky liquids” is not well defined. Liquids vary in their viscosity (resistance to flow), from highly mobile liquids such as water or ethanol through more viscous ones like syrup, to near solids such as molten lava or glass.

The emphasis in this mini-project is initially technological, devising and comparing different ways of measuring or comparing viscosities. However, results for different liquids can be linked to science ideas about the structure and arrangement of particles within the liquids studied.

## Running the activity

### The initial stimulus

The study may be introduced using “rain-drop races” in which liquids are dripped onto a window (or other sheet of glass) and the rate of flow down the slope is compared. This may be used to raise interest in why some liquids run freely, whilst others are very “thick” and slow moving.

These races lead directly into the first suggested technique **Slippery Slopes**, which has been used in several schools as the basis for an assessed coursework investigation.

This technique is comparative rather than absolute, and is best used where a series of liquids can be compared during a single session. Some of the other techniques suggested can be standardised and controlled to give results which can be compared across different working sessions. This provides an opportunity to discuss how control of conditions can lead to results which can be reliably duplicated.

### Possible lines of study

Suitable examples would be a series of alkanes e.g. hexane to decane, and liquid paraffin, or a series of alcohols. More obviously, commercial sets might include different grades or brands of motor vehicle lubricating oils, or the series skimmed milk, semi-skimmed milk, full-fat milk, single cream, double cream, or a series of sugar syrups of different concentration. Students could also study the effect of thickening agents such as starch.

The **Ball-Fall** technique, in particular, can be used to measure how viscosity is affected by temperature, opening up the possibility of other studies. For example, summer and winter grade oils and multi-grade oils could be tested over a range of temperatures, to see whether the multi-grades actually do maintain near ideal properties over a wider range.

### Practical techniques

Three basic types of technique are suggested:

**Slippery slopes** can be made on a small scale using microscope slides, or on a larger scale using white tiles. Surfaces of other (non-porous) materials e.g. plastics, painted or varnished wood, could also be used to investigate whether interaction with the surface has any effect. The upper end of the slope may be held in place with a clamp, or supported on wooden blocks. Care is needed to ensure that it does not slip, either by using blu-tack or sellotape to fix both ends, or by arranging the whole set-up on a soft cloth to reduce slipping. Droppers can be used to deliver the samples. Students may need to experiment to find the optimum number of drops to be dispensed. Facilities are needed for collecting liquid which has run down the slope.

This is not a very sensitive technique and is best for introductory work, where liquids of widely differing viscosity are being compared.

## Learning outcomes

- Revision and extension of ideas about the arrangement of particles in liquids, and about interactions between particles. Thickening effects can be related to tangling of long molecules (e.g. in lubricating oils) or strong interaction between solute and solvent molecules (e.g. sugar syrups) or both (e.g. starch suspensions).
- Ideas of control and fair testing in investigative work can be developed.

## Prior learning

- Arrangement of particles in solids, liquids and gases, properties of liquids.

## Where the activity fits in

### KS3:

- Sc3.1b
- Sc4.2c, d

### KS4:

- Sc1.2d, e, g, h, j, p, q
- Sc3.2 a, b

## Skills

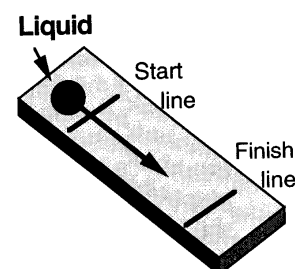
General manipulative skills will be developed by these exercises with basic laboratory apparatus.

Where investigations extend over more than one session, skills in planning and monitoring progress will be enhanced.

Where a class or group collaborate to share out tasks in order to give wider coverage of the chosen topic, skills of working with others will be demonstrated.

ICT skills may be developed by using spread-sheets to record and analyse data.

Communication skills are involved in locating information about the substances tested and in writing reports.



**Ball-fall** devices can be made using graduated test-tubes or measuring cylinders. The start and finish levels must be clearly defined. Students can explore the effect of end-errors if either mark is too near the top or bottom of the vessel. They can also explore the effect of varying the relative dimensions of the tube and the ball, and with using different falling objects, including stones of irregular shapes.

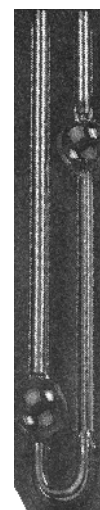
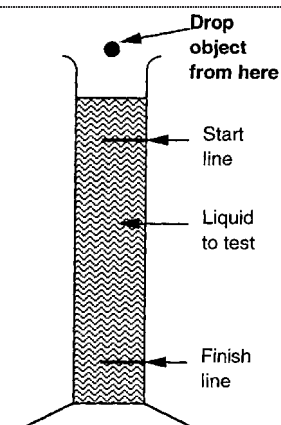
The vessel can be clamped in a water-bath (ideally a tank with a thermostat, but large beakers can be used) so that the effect of temperature can be studied. A range from just above freezing (ice and water) to about 40°C (to avoid burns or scalds) can be used. Do NOT allow this with volatile liquids such as low molecular mass alkanes or alcohols.

Much more reproducible results can be obtained with this technique, which is well suited to work with moderately viscous liquids. Further information and related theory may be found in some older advanced level physics texts.

**Run-out** devices can be made using glass tubing which has been drawn out at one end to form a jet. The larger size of Pasteur pipette is ideal for this purpose. The pipettes already have one gradation mark – a second must be added, and liquid is timed between these marks as it runs out of the pipette. Another alternative is to use a short length of rubber tubing to fix a short length of capillary tubing to the bottom of a section of wider glass tubing. Liquids may be drawn into the tubes by immersing the lower tip in the liquid and using a rubber bulb or pipette filler to draw liquid up beyond the upper mark. This avoids trapped bubbles. When ready, the bulb or filler is removed from the top of the tube to let the liquid run out under gravity.

Ostwald viscometers are available from school suppliers at prices around £18 - £20 and provide an example of how a standard device can be developed from a simple basic design by providing careful control of conditions.

This type of device is best suited to fairly mobile liquids.



## Safety

Eye protection should be worn at all times when any of this practical work is in progress.

In the “slippery slopes” experiments, where slopes are made from microscope slides, the edges should be covered with sellotape to reduce risk of cuts. Do not use larger sheets of glass unless the edges have been protected, and ensure great care to avoid stress which might crack or shatter glass sheets which are only supported at their ends.

The hazards associated with every liquid used in these tests must be checked. For example, liquid hydrocarbons and alcohols are flammable (and many are harmful). No flames should be allowed in the laboratory when any of these are in use. For studies of the effect of temperature, do not work with volatile liquids. Hot water for water baths may be obtained from kettles heated well away from any volatile liquids.

The Health and Safety at Work *etc* Act 1974<sup>1</sup> requires a risk assessment to be carried out before hazardous chemicals are used or made, or a hazardous procedure is carried out. Risk assessment is the responsibility of the employer. The task of assessing risk in particular situations may well be delegated by the employer to the Head of Science, who will be expected to operate within the employer’s guidelines. Most education employers have adopted various nationally available texts as the basis for their model risk assessments. Those commonly used include the following:

*Safeguards in the School Laboratory*, 10th edition, ASE<sup>2</sup>, 1996

*Topics in Safety*, 3RDd edition, ASE<sup>2</sup>, 2001

*Hazcards*, CLEAPSS<sup>3</sup>, 1998 (or 1995)

*Laboratory Handbook*, CLEAPSS<sup>3</sup>, 1997

*Safety in Science Education*, DfEE, HMSO, 1996

*Hazardous Chemicals Manual*, SSERC<sup>3</sup>, 1997.

If your employer has adopted one or more of these publications, you should follow the guidance given there, subject only to a need to check whether modification is required to deal with any special situation in your class/school. We have outlined safety considerations for the practical activities given on this CDROM. However, teachers must still verify that what is proposed conforms with any code of practice produced by their employer.

<sup>1</sup>The COSHH Regulations and the Management of Health and Safety at Work Regulations.

<sup>2</sup>ASE publications are available to order from ASE Headquarters, College Lane, Hatfield, Hertfordshire AL10 9AA Tel: 01707 283000

<sup>3</sup>CLEAPSS and SSERC publications are available only to members.

CLEAPSS School Science Service, Brunel University, Uxbridge UB8 3PH Tel: 01895 251496

SSERC, St. Mary’s Building, 23 Holyrood Road, Edinburgh EH8 8AE Tel: 0131 558 8180