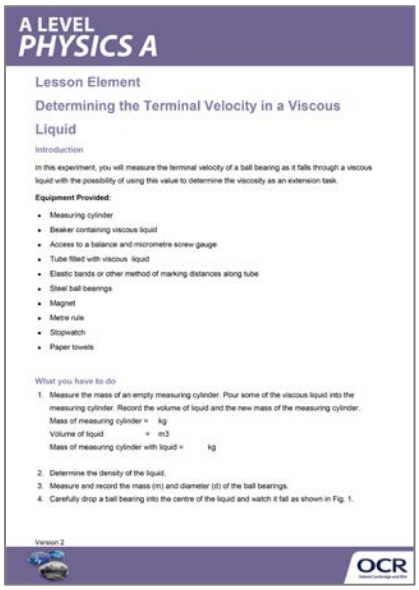
Lesson Element

Determining the Terminal Velocity in a Viscous Liquid

Instructions and answers for teachers

These instructions should accompany the OCR resource 'Determining the Terminal Velocity in a Viscous Liquid' activity *which supports OCR A Level Physics A.*


A LEVEL
PHYSICS A

Lesson Element

Determining the Terminal Velocity in a Viscous Liquid

Introduction

In this experiment, you will measure the terminal velocity of a ball bearing as it falls through a viscous liquid with the possibility of using this value to determine the viscosity as an extension task.

Equipment Provided:

- Measuring cylinder
- Beaker containing viscous liquid
- Access to a balance and micrometre screw gauge
- Tube filled with viscous liquid
- Elastic bands or other method of marking distances along tube
- Steel ball bearings
- Magnet
- Metre rule
- Stopwatch
- Paper towels

What you have to do

1. Measure the mass of an empty measuring cylinder. Pour some of the viscous liquid into the measuring cylinder. Record the volume of liquid and the new mass of the measuring cylinder.
   Mass of measuring cylinder = kg
   Volume of liquid = m3
   Mass of measuring cylinder with liquid = kg
2. Determine the density of the liquid.
3. Measure and record the mass (m) and diameter (d) of the ball bearings.
4. Carefully drop a ball bearing into the centre of the liquid and watch it fall as shown in Fig. 1.

Version 2

OCR

The Activity:

This resource comprises of 1 task.

This activity offers an opportunity for English skills development.

This activity offers an opportunity for maths skills development.

Associated materials:

Determining the Terminal Velocity in a Viscous Liquid Lesson Element learner activity sheet.

Introduction

Specification References:

Physics (A) 3.2.2 Non-linear motion:

(a) Drag as the frictional force experienced by an object travelling through a fluid

Physics (B) Space, Time & Motion:

4.2c (xi) modelling changes of displacement and velocity in small discrete time steps, using a computational model or graphical representation of displacement and velocity vectors

4.2b (ii) graphs of accelerated motion; slope of displacement-time and velocity-time graphs; area underneath the line of a velocity-time graph

Prior knowledge

Students may be familiar with the forces on a parachute falling through air.

Introductory demonstrations and discussion

Using two beakers show the behaviour of water and the viscous liquid as the beakers are tipped to the side. Discuss their behaviour, linking to what may happen when an object moves through these liquids. Drop a ball bearing through air and water.

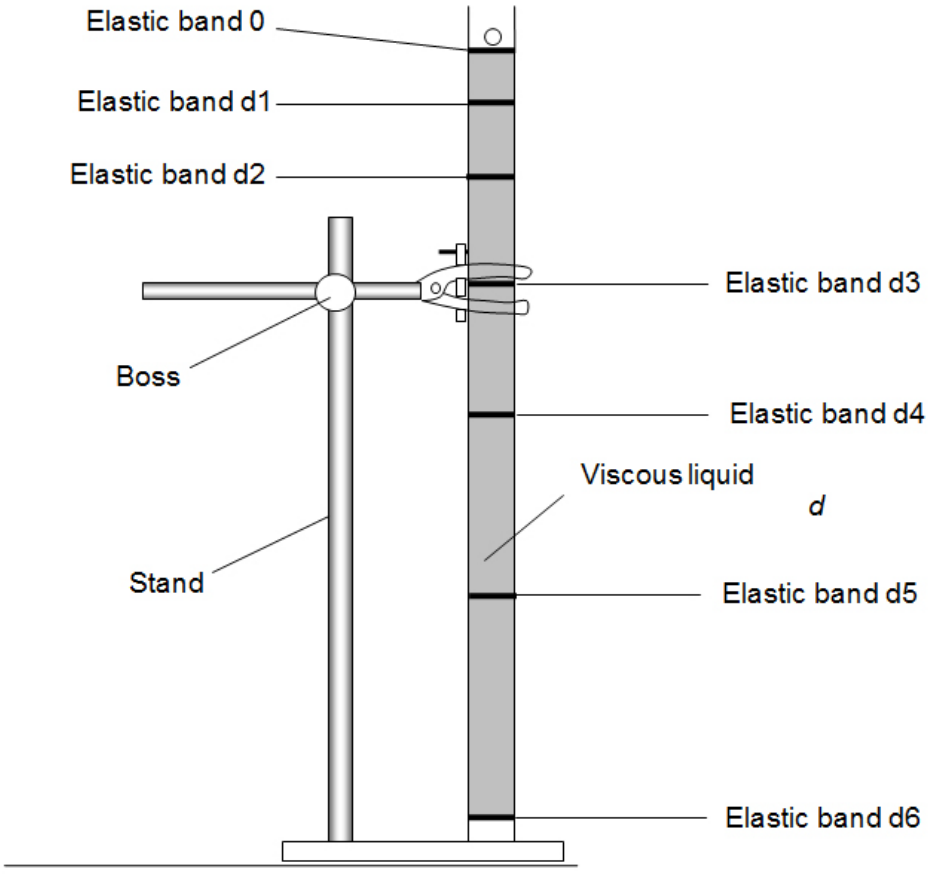


Fig. 1

Repeat for the ball bearing falling through the viscous liquid (Fig. 1) asking students to click fingers/tap when the ball reaches a band.

Discuss and compare the motion using technical terms eg viscous liquid, viscosity, force, acceleration, frictional, weight, gravity, upthrust, drag, air resistance and terminal velocity. Discuss the idea that the ball bearing takes some distance to reach terminal velocity. In the Practical Activity the ball bearing must reach terminal velocity for accurate measurements to be taken.

Aims To enable students to:

- recognise and understand the terms viscous liquid, viscosity, force, acceleration, frictional, weight, gravity, upthrust, drag, air resistance and terminal velocity;
- understand that at terminal velocity the forces on the ball bearing are balanced and the net force is zero;
- determine a value for the viscosity of a liquid as an extension.

Practical Skills used in performing this task successfully:

- Skills 1, 3, 4 and 5.
- make and record observations (from 5b)
- keep appropriate records of experimental activities (from 5b)

Teachers will need to ensure students are familiar with the apparatus in order to demonstrate these Practical Skills.

Apparatus requirements (per candidate):

- Beaker containing viscous liquid;
- Measuring cylinder;
- Large gas jar (500 ml) or a litre measuring cylinder filled with a viscous liquid eg Glycerol or wallpaper paste;
- Stand, clamp and boss;
- Elastic bands. (or masking tape & marker pen; or marker pen for glass);
- Metre rule reading to the nearest millimetre;
- Steel ball bearings in a container;
- Strong Magnet;

- Stopwatch reading to 0.1 s or better;

- Paper towels;
- Access to a balance and a micrometre screw gauge.

Recording

- Students should not need to re-draft their work but keep all their notes as a continuing record of Practical Activity.
- These notes may be requested for moderation.

Theory

- Frictional force acting upwards = (weight - upthrust)
- Average speed = distance travelled / time taken

For the extension activity the formula for viscosity is obtained by re-arranging and substituting values into:

$$6\pi\eta rv = (mg - \frac{4}{3} r^3 g\rho)$$

$$\eta = \frac{(mg - \frac{4}{3} r^3 g\rho)}{6\pi rv}$$

Health and Safety

Please consult the Practical Skills Handbook, section 8