**Investigating Terminal Velocity**

**Introduction**

This experiment should be carried out when learners are familiar with the basic formula for acceleration and are able to identify resultant forces. An understanding of the suvat equations is useful, but not essential.

**Aim and skills covered**

* To time motion over short time periods
* Use of appropriate analogue apparatus to measure distance
* Use of a stopwatch for timing
* Use of calipers, Vernier calipers or micrometers to measure dimensions
* Use of methods to increase accuracy such as a set square or plumb line

**Intended class time**

* 60 to 120 minutes

**Links to Specifications**

**Physics A**

* 3.1.1 (a) displacement, instantaneous speed, average speed, velocity and acceleration
* 3.1.1 (b) graphical representations of displacement, speed, velocity and acceleration
* 3.1.1 (c) displacement-time graphs
* 3.2.2 (a) drag as the frictional force experienced by an object travelling through a fluid
* 3.2.2 (b) factors affecting drag for an object travelling through air
* 3.2.2 (c) motion of objects falling in a uniform gravitational field in the presence of drag
* 3.2.2 (d)(i) terminal velocity
* 3.2.2 (d)(ii) techniques and procedures used to determine terminal velocity in fluids.

**Physics B Advancing Physics**

* 4.2 a(vii) measurement of displacement, velocity and acceleration
* 4.2 b(ii) graphs of accelerated motion; slope of displacement–time and velocity–time graphs; area underneath the line of a velocity–time graph
* 4.2 c(iii) the kinematic equations for constant acceleration
* 4.2 d(iii) investigating terminal velocity with experiments such as dropping a ball-bearing in a viscous liquid or dropping paper cones in air.

**Practical Skills**

* 1.2.1(b) safely and correctly use a range of practical equipment and materials
* 1.2.1(c) follow written instructions
* 1.2.1(d) make and record observations/measurements
* 1.2.1(e) keep appropriate records of experimental activities
* 1.2.1(f) present information and data in a scientific way
* 1.2.1(j) use a wide range of experimental and practical instruments, equipment and techniques appropriate to the knowledge and understanding included in the specification
* 1.2.2 (a) use analogue apparatus to measure length
* 1.2.2(b) use of appropriate digital instruments to include time…
* 1.2.2(c) use methods to increase accuracy such as a plumb line
* 1.2.2(d) use of stopwatch for timing
* 1.2.2(e) use of calipers and micrometers for small distances, using digital or vernier scales

**CPAC** (section 5g Table 2)

1. Follows written procedures
2. Safely uses a range of practical equipment and materials

(4) Makes and records observations

**Mathematical skills**

* M0.1 Recognise and make use of appropriate units in calculations
* M0.2 Recognise and use expressions in standard form
* M0.3 Calculate percentage uncertainties
* M1.1 Use an appropriate number of significant figures
* M1.2 Find arithmetic means
* M2.3 Substitute numerical values into algebraic equations using appropriate units
* M2.4 Solve algebraic equations, including quadratic equations
* M3.1 Translate information between graphical, numerical and algebraic forms
* M3.2 Plot two variables from experimental or other data
* M3.6 Draw and use the slope of a tangent to a curve as a measure of rate of change
* M3.7 Distinguish between instantaneous and average rate of change

**Equipment**

**Method 1**

* 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

**Method 2**

* bun-case
* access to a balance
* vernier calipers or calipers
* metre rule x 2
* stopwatch

(It is possible to purchase small paper cases which will fit between the jaws of some light gates, allowing data logging rather than timing with a stopwatch.)

**Health & Safety**

Materials being dropped should not be likely to break or shatter. Care should also be taken to avoid possible injury from dropped materials.

If using wallpaper paste as the viscous liquid, use a non-fungicide version.

If using any soap or detergent product staff should determine that no student has an allergy to that product.

These experiments are referred to in the “Mainly Physics” section of the CLEAPSS Laboratory Handbook, section 12.4 Dynamics.

Before carrying out any experiment or demonstration based on this guidance, it is the responsibility of teachers to ensure that they have undertaken a risk assessment in accordance with their employer’s requirements, making use of up-to-date information and taking account of their own particular circumstances. Any local rules or restrictions issued by the employer must always be followed.

**Notes**

* These practical activities are not controlled assessments, should not be carried out in exam conditions and can be adapted by the centre. Students can collaborate during the activities which should take place as part of the normal teaching sequence. They are intended to be formative with students acquiring and practising skills throughout the course.
* To achieve a pass in the Practical Endorsement each student is required to demonstrate competence in all the skills, apparatus and techniques listed in section 1.2 of the specification and assessed against the Ofqual Common Practical Assessment Criteria (CPAC) at the end of the course.
* The skills, apparatus and techniques can be demonstrated during any practical work undertaken during the A Level course whether an OCR practical activity or not.
* OCR recommends that this experiment is trialled by the teacher in advance of giving it to the students to ensure familiarity with the data logging equipment and the suitability of the worksheet for the data loggers being used
* Value bath bubble liquid or similar such products are reported to give measurable outcomes.
* It is acknowledged that these activities are very difficult to complete with consistent outcomes. The Practical Endorsement is assessing the students’ competences and not the outcome of subsequent calculations.
* Learners may use mobile phones with freeze frame recording to generate timing data.

**Recording**

* Learners should not need to re-draft their work but rather keep all their notes as a continuing record of Practical Activity.
* As evidence for the Practical Endorsement learners should have the data collected from their group in a clear and logical format.
* Additionally to support their performance in the written examination they should estimate the terminal velocity from their graphs and explain how they determined their estimate.