physicsUK
Smarter practice. Stronger understanding

WORKSHEETS
ATTEMPT | CHECK | CORRECT | IMPROVE

OCR A A Level Physics: Non-uniform acceleration

35–40 minutes independent practice + 15–20 minutes review

Specification points covered

- 3.2.1(a) Apply Newton's second law, F = ma.
- 3.2.1(c) Understand weight of an object, W = mg.
- 3.2.2(a) Define drag as a frictional force experienced by an object travelling through a fluid.
- 3.2.2(b) Explain factors which affect drag for an object travelling through air.
- 3.2.2(c) Describe the motion of falling objects in a uniform gravitational field in the presence of drag.
- 3.2.2(d) Define terminal velocity and use practical procedures to determine it in a fluid.

Main scenario

A coastal research team tests a 0.200 kg air-quality sensor pod released from a drone above a secure test range. The pod falls vertically; its streamlined casing experiences air drag but it has no parachute. A motion sensor records its downward velocity. Take g = 9.81 m s^{-2} throughout.

Use precise language

A quantity can increase, decrease or stay the same. Say that an object has an acceleration; do not say that its velocity 'accelerates'.

1. Sensor pod in air

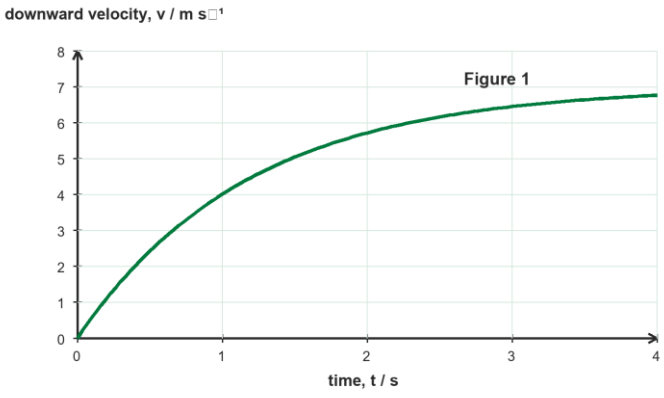


Figure 1

1. Define drag. **[1 mark]**

2. State the two vertical forces acting on the sensor pod just after it is released. Ignore any horizontal forces. **[2 marks]**

1. Sensor pod in air continued

3. Explain why the initial downward acceleration of the pod is approximately g. [1 mark]

4. Use Figure 1 to state the downward velocity of the pod at 1.0 s. [1 mark]

5. Draw a tangent to the curve at 0.50 s. Use it to determine the downward acceleration of the pod at this instant. [2 marks]

6. Calculate the weight of the sensor pod. [1 mark]

7. Use your answer to question 5 to calculate the resultant force acting on the pod at 0.50 s. State its direction. [2 marks]

8. Calculate the magnitude of the drag force acting on the pod at 0.50 s. [2 marks]

1. Sensor pod in air continued

9. Explain why the downward acceleration of the pod decreases as its downward velocity increases. [3 marks]

10. State what is meant by terminal velocity. Refer to the forces and the acceleration. [2 marks]

11. The pod is redesigned with larger side fins. At its original terminal velocity, the drag is now greater than its weight. State and explain how the pod's terminal velocity changes. [2 marks]

12. On the axes in Figure 2, sketch a velocity–time graph for the redesigned pod. It is released from rest in the same conditions. Label the terminal velocity. [2 marks]

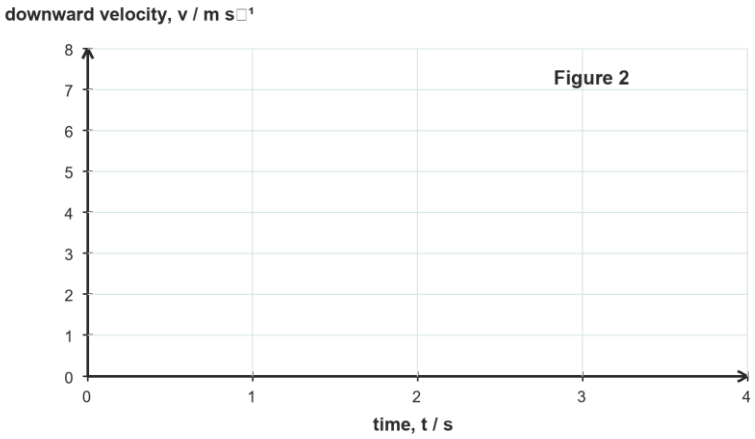


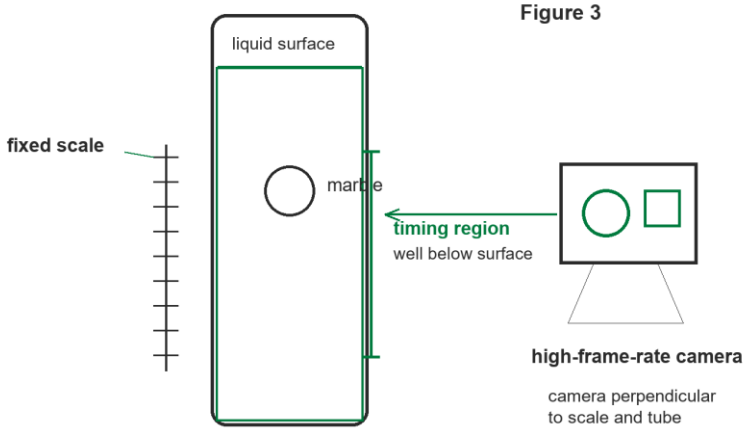
Figure 2

2. Marble in a viscous liquid

Investigation context

A materials engineer checks whether a marble reaches terminal velocity in a transparent viscous liquid. Figure 3 shows a suitable set-up using a high-frame-rate camera.

Figure 3



13. Explain why the timing region in Figure 3 begins well below the liquid surface. [1 mark]

14. Table 1 gives total distances measured from video frames. (a) Calculate the average speed during the first 0.10 s. (b) Calculate the average speed from 0.30 s to 0.50 s. (c) Use the data to state the terminal velocity and explain your choice. [3 marks]

Table 1: video-frame measurements

Time / s	0.00	0.10	0.20	0.30	0.40	0.50
Total distance travelled / m	0.000	0.040	0.140	0.260	0.380	0.500

15. Explain one advantage of using a high-frame-rate video camera instead of a hand-held stopwatch in this investigation. [2 marks]

16. State one practical precaution that improves the accuracy of the distance measurements in Figure 3. Explain how it helps. [2 marks]

3. Six-mark planning: verifying terminal velocity

Plan before you write

Use your answers from questions 13–16 to organise a connected method. Include: apparatus; a timing or video method; how to check terminal velocity; analysis; and one improvement, repeat or safety point.

17. A pupil wants to verify that a marble reaches a terminal velocity of 1.20 m s^{-1} as it falls through a transparent viscous liquid. Describe a suitable experiment using either a high-frame-rate camera or light gates. Explain how the measurements would show that the marble has reached terminal velocity. [6 marks]

Review and improve

- □ I can relate drag, resultant force and acceleration.
- □ I can use the gradient of a velocity–time graph to find acceleration.
- □ I can explain terminal velocity using balanced forces and zero acceleration.
- □ I use ‘increases’, ‘decreases’ and ‘stays the same’ accurately.