Exercise walk-through

Resistive Forces ▪ 2.9

eXercise

You must be able to

- describe a **drag force** 阻力 that opposes motion and grows with speed
- explain **terminal velocity** 终极速度: reached when drag balances weight
- describe the acceleration as it falls from g to zero at terminal velocity
- reason about a velocity-time graph that levels off

Method — Drag opposes motion and grows with speed

A resistive (drag) force points opposite to the velocity and increases as the object speeds up. At low speed it is small; at high speed it can become large.

Method — Terminal velocity

A falling object speeds up, so drag grows, until drag equals weight. Then the net force is zero and the velocity stops changing:

$$\text{drag} = mg \quad \Rightarrow \quad \text{terminal velocity.}$$

Method — The acceleration fades

Just after release, drag is tiny, so $a \approx g$. As speed rises, drag grows and a falls, reaching zero at terminal velocity. The v-t graph curves and levels off.

Practice 2.1 ▪ 1 mark

State the direction of a drag force relative to the motion.

Solution 2.1

Method: Drag opposes motion and grows with speed

Worked steps

Opposite to the motion B1.

Practice 2.2 ▪ 1 mark

What condition is met at terminal velocity?

Solution 2.2

Worked steps

Drag equals weight (net force zero) B1.

Practice 2.3 ▪ 1 mark

State the acceleration of an object at its terminal velocity.

Solution 2.3

Worked steps

Zero B1.

Practice 2.4 ▪ 2 marks

Just after a skydiver jumps, what is their approximate acceleration, and why?

Solution 2.4

Method: The acceleration fades

Worked steps

About g (≈ 9.8 m s^{-2}) — the speed is still low, so drag is negligible M1 A1.

Exam-style 3.1 ▪ 1 mark

As a falling object speeds up, the drag force on it

A decreases

B increases

C stays constant

D becomes zero

Solution 3.1

Method: Terminal velocity

A decreases

B increases ✓

C stays constant

D becomes zero

Worked steps

B — drag increases with speed.

Exam-style 3.2 ▪ 1 mark

At terminal velocity, the net force on the object is

A equal to its weight

B zero

C upward

D increasing

Solution 3.2

Method: Terminal velocity

A equal to its weight

B zero ✓

C upward

D increasing

Worked steps

B — at terminal velocity the forces balance, so the net force is zero.

Exam-style 3.3 ▪ 2 marks

A raindrop falls and reaches terminal velocity.
(a) Explain, in terms of forces, why the velocity stops increasing.
(b) Sketch in words the shape of its velocity-time graph.

Solution 3.3

Method: The acceleration fades

Worked steps

(a) Drag grows with speed until it equals the weight; the net force becomes zero, so the velocity stops changing M1 A1. (b) It rises steeply, curves over, and levels off at a constant value B1.

Exam-style 3.4 ▪ 2 marks

A 70 kg skydiver reaches terminal velocity ($g = 10$ m s^{-2}).
(a) State the size of the drag force.
(b) State the acceleration at that instant.

Solution 3.4

Method: Terminal velocity

Worked steps

(a) drag $= mg = 70 \times 10 = 700$ N M1 A1. (b) Zero B1.