

Exercise walk-through

2.9

Resistive Forces

AP Physics C: Mechanics

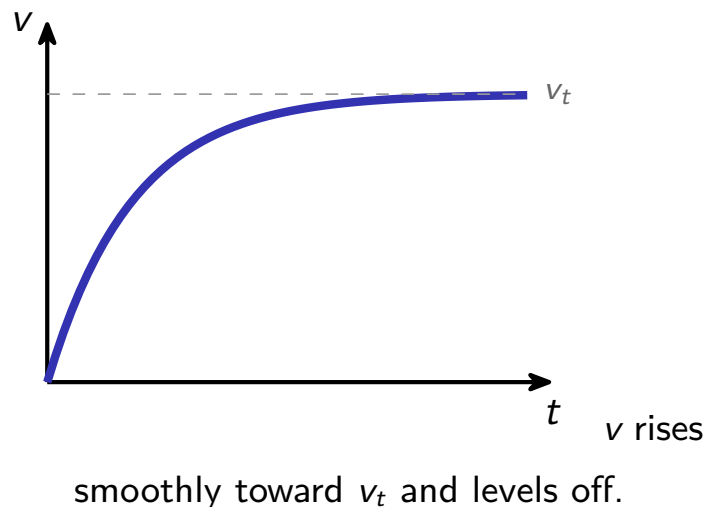
Resistive forces and terminal velocity

Drag grows with speed ($F = -bv$), so Newton's law becomes a **differential equation** :

Falling with drag

$$m \frac{dv}{dt} = mg - bv$$

At **terminal velocity** , $\frac{dv}{dt} = 0$, so $v_t = \frac{mg}{b}$.



Separating the variables, and why you must

the problem

with drag, $m \frac{dv}{dt} = mg - bv$ – the acceleration depends on v ,
so no SUVAT equation applies

separate the variables

$$\int_0^v \frac{dv'}{mg - bv'} = \int_0^t \frac{dt'}{m}$$

the result

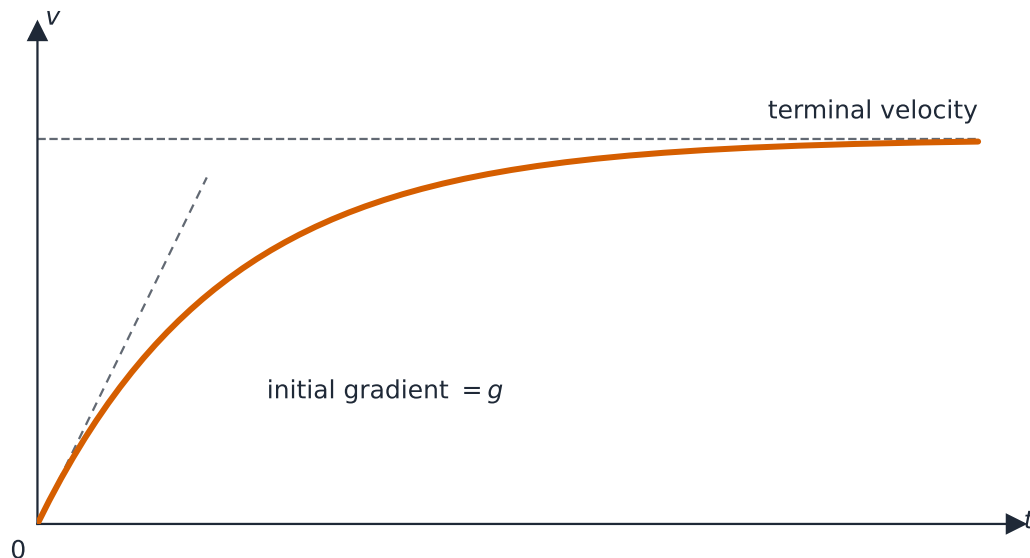
$$v(t) = \frac{mg}{b} (1 - e^{-bt/m})$$

terminal velocity

set $dv/dt = 0$: $v_T = \frac{mg}{b}$ – reachable without solving the equation at all

If a question asks only for the **terminal** value, set the acceleration to zero and stop. Integrate only when it asks for $v(t)$.

An object falling through a fluid speeds



An object falling through a fluid speeds up to a terminal velocity

Exercises 2.1-2.3

2.1 State the direction of a drag force relative to the motion. [1]

2.2 What condition is met at terminal velocity? [1]

2.3 State the acceleration of an object at its terminal velocity. [1]

Exercises 2.1-2.3

2.1 State the direction of a drag force relative to the motion. [1]

2.1

- Opposite to the motion
-

2.2 What condition is met at terminal velocity? [1]

2.2

- Drag equals weight (net force zero)
-

2.3 State the acceleration of an object at its terminal velocity. [1]

2.3

- Zero

Exercises 2.4·3.1

2.4 Just after a skydiver jumps, what is their approximate acceleration, and why? [2]

3.1 As a falling object speeds up, the drag force on it [1]

☐

A decreases

B increases

C stays constant

D becomes zero

Exercises 2.4·3.1

2.4 Just after a skydiver jumps, what is their approximate acceleration, and why? [2]

2.4

- About g ($\approx 9.8 \text{ m s}^{-2}$) – the speed is still low, so drag is negligible

3.1 As a falling object speeds up, the drag force on it [1]

☐

A decreases

B increases

C stays constant

D becomes zero

3.1 B

- drag increases with speed

Exercise 3.2

3.2 At terminal velocity, the net force on the object is

[1]

☐

A equal to its weight

B zero

C upward

D increasing

Exercise 3.2

3.2 At terminal velocity, the net force on the object is

[1]

☐

A equal to its weight

B zero

C upward

D increasing

3.2 B

- at terminal velocity the forces balance, so the net force is zero

Exercise 3.3 (a)

3.3 A raindrop falls and reaches terminal velocity.

(a) Explain, in terms of forces, why the velocity stops increasing.

[2]

Exercise 3.3 (a)

3.3 A raindrop falls and reaches terminal velocity.

(a) Explain, in terms of forces, why the velocity stops increasing. [2]

(a)

- Drag grows with speed until it equals the weight; the net force becomes zero, so the velocity stops changing

Exercise 3.3 (b)

3.3 A raindrop falls and reaches terminal velocity.

(b) Sketch in words the shape of its velocity-time graph.

[1]

Exercise 3.3 (b)

3.3 A raindrop falls and reaches terminal velocity.

(b) Sketch in words the shape of its velocity-time graph.

[1]

(b)

- It rises steeply, curves over, and levels off at a constant value

Exercise 3.4 (a)

3.4 A 70 kg skydiver reaches terminal velocity ($g = 10 \text{ m s}^{-2}$).

(a) State the size of the drag force.

[2]

Exercise 3.4 (a)

3.4 A 70 kg skydiver reaches terminal velocity ($g = 10 \text{ m s}^{-2}$).

(a) State the size of the drag force.

[2]

(a)

- drag = $mg = 70 \times 10 = 700 \text{ N}$

Exercise 3.4 (b)

3.4 A 70 kg skydiver reaches terminal velocity ($g = 10 \text{ m s}^{-2}$).

(b) State the acceleration at that instant.

[1]

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3.4 A 70 kg skydiver reaches terminal velocity ($g = 10 \text{ m s}^{-2}$).

(b) State the acceleration at that instant.

[1]

(b)

- Zero