Exercise walk-through

Motion ▪ 1.2

eXercise

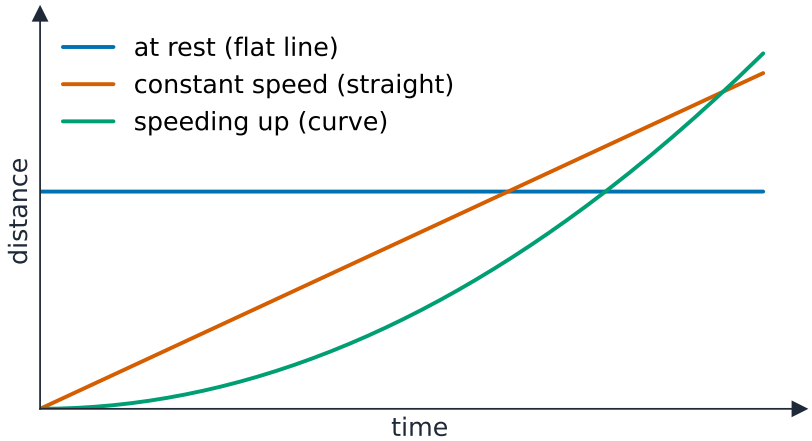
You must be able to

- use $v = \frac{s}{t}$ and $a = \frac{\Delta v}{\Delta t}$
- read distance–time and speed–time graphs (gradient and area)
- describe falling objects and terminal velocity

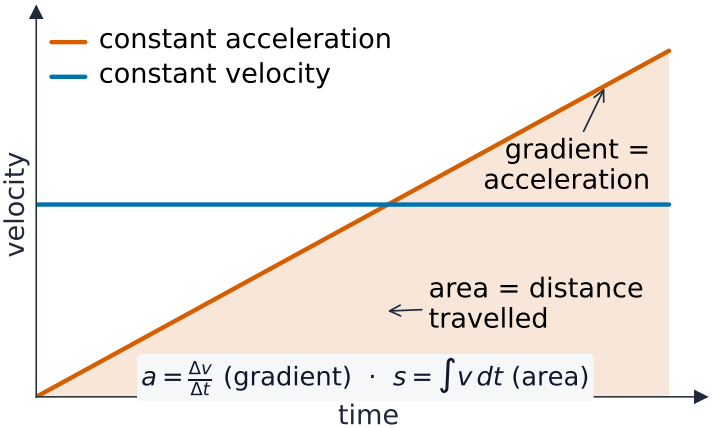
Method — Graphs and acceleration

Car $8 \to 20$ **m/s in** 4.0 **s:** $a = \dfrac{20 - 8}{4.0} = 3.0\ \text{m/s}^2$.

Method — Graphs and acceleration



Method — Graphs and acceleration



A velocity–time graph: gradient is acceleration, area is distance

Method — Reading a speed-time graph, and deceleration

Describe each straight section of a speed–time graph by name: a horizontal line is **constant speed**; a line sloping up is **constant (uniform) acceleration**; a line sloping down is **constant deceleration**. A **deceleration 减速** is a negative acceleration, so put a minus sign in the arithmetic: slowing from 12 m/s to 4 m/s in 4.0 s gives $a = \dfrac{4 - 12}{4.0} = -2.0$ m/s^2, a deceleration of 2.0 m/s^2.

The **area under a speed-time line** is the distance travelled. Split the area into rectangles and triangles: a rectangle is speed $\times$ time; a triangle is $\frac{1}{2} \times$ base $\times$ height.

Worked example (show that). A bus is at 10 m/s for 120 s, then decelerates uniformly to rest in 40 s. Show that it travels about 1400 m. Rectangle: $10 \times 120 = 1200$ m. Triangle: $\frac{1}{2} \times 40 \times 10 = 200$ m. Total 1400 m. In a "show that" question, always finish with the number the question quotes.

Method — Reading a speed-time graph, and deceleration

Near the Earth all objects fall with the same **acceleration of free fall** $g \approx 9.8\ \mathrm{m/s^2}$ while air resistance is small. As speed rises, air resistance grows until it equals the weight; the resultant force is then zero and the object falls at a steady **terminal velocity 收尾速度**.

Practice 2.1 ▪ 2 marks

A runner covers 100 m in 12.5 s. Find the average speed.

Solution 2.1

Method: Graphs and acceleration

Worked steps

$v = \dfrac{100}{12.5} = 8.0$ m/s M1 A1.

Practice 2.2 ▪ 1 mark

State what the area under a speed–time graph represents.

Solution 2.2

Method: Graphs and acceleration

Worked steps

the distance travelled B1.

Practice 2.3 ▪ 3 marks

A car slows from 18 m/s to 6.0 m/s in 4.0 s. Calculate its acceleration and state what the sign means.

Solution 2.3

Worked steps

$a = \dfrac{6.0 - 18}{4.0}$ M1 $= -3.0\ \text{m/s}^2$ A1; the minus sign means the car is decelerating, so the acceleration is opposite to the motion B1.

Practice 2.4 ▪ 1 mark

State how you find the distance travelled from a speed-time graph.

Solution 2.4

Worked steps

Find the area under the line (between the line and the time axis) B1.

Exam-style 3.1 ▪ 1 mark

On a distance–time graph, a horizontal (flat) line means the object is:

A accelerating

B at rest

C at constant speed

D decelerating

Solution 3.1

A accelerating

B at rest ✓

C at constant speed

D decelerating

Worked steps

B. A flat line on a distance–time graph means the distance is not changing — at rest.

Exam-style 3.2 ▪ 2 marks

A car accelerates uniformly from rest to 24 m/s in 8.0 s.
(a) Find the acceleration.
(b) Find the distance travelled (area under the speed–time graph).

Solution 3.2

Method: Reading a speed-time graph, and deceleration

Worked steps

(a) $a = \dfrac{24 - 0}{8.0} = 3.0\ \text{m/s}^2$ M1 A1.

(b) distance = area $= \frac{1}{2} \times 8.0 \times 24 = 96\ \text{m}$ M1 A1.

Exam-style 3.3 ▪ 3 marks

A skydiver falls and reaches terminal velocity. Explain, in terms of forces, why the speed becomes steady.

Solution 3.3

Method: Reading a speed-time graph, and deceleration

Worked steps

(a) Between 2.9 and 3.5 min: constant speed **B1**. Between 3.5 and 4.5 min: constant (uniform) deceleration to rest **B1**.

(b) Time $= (2.9 - 0.90) \times 60 = 120$ s **B1**; $a = \dfrac{7.5 - 0}{120}$ **M1** $= 0.063$ m/s^2 **A1**.

(c) Distance = area of the triangle $= \frac{1}{2} \times 120 \times 7.5$ **M1** $= 450$ m... use the correct base: the speeding-up section lasts 120 s, so $\frac{1}{2} \times 120 \times 7.5 = 450$ m; for the first 72 s of it the area is 270 m **M1** **A1** *for showing the working reaches the quoted value.*

(d) Time $= 60$ s; $a = \dfrac{0 - 7.5}{60}$ **M1** $= -0.13$ m/s^2 **A1**; the minus sign means the bus

Solution 3.3

is slowing down, so the resultant force is opposite to the motion B1.
(e) At first the acceleration is g, because only the weight acts B1; as the stone speeds up, air resistance grows and the resultant force falls, so the acceleration decreases B1; when air resistance equals the weight the resultant force and the acceleration are zero and the speed is constant B1.

Exam-style 3.3 ▪ 2 marks

Fig. 3.1 describes the first five minutes of a bus journey. The bus is at rest until $t = 0.90$ min, speeds up uniformly to 7.5 m/s at $t = 2.9$ min, holds that speed until $t = 3.5$ min, then slows uniformly to rest at $t = 4.5$ min.

(a) Describe the motion of the bus between $t = 2.9$ min and $t = 3.5$ min, and between $t = 3.5$ min and $t = 4.5$ min.

(b) Calculate the acceleration of the bus between $t = 0.90$ min and $t = 2.9$ min.

(c) Show that the bus travels about 270 m while it is speeding up.

(d) Calculate the deceleration of the bus in the last minute, and state what the sign of your answer means.

(e) A stone is dropped from a tall building. Describe how its acceleration changes from the moment it is released until it reaches terminal velocity, and explain why.

Solution 3.3

Method: Reading a speed-time graph, and deceleration

Worked steps

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