IGCSE PHYSICS • EXERCISE SHEET

1.2 Motion

Name: _____ Class: _____ Date: _____ **Total: 28 marks**

KEY WORDS speed–time graph 速度-时间图 • acceleration 加速度 • terminal velocity 终极速度 • deceleration 减速 • uniform 均匀

Objective

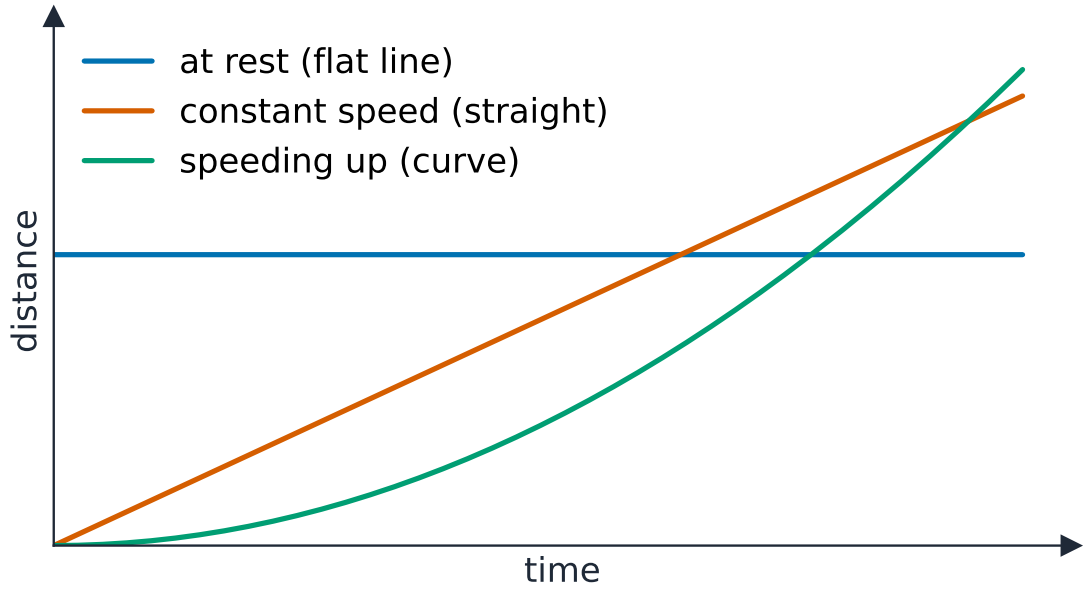
Build the skills to answer exam questions on **motion** 运动 — speed, velocity, **acceleration** 加速度, motion graphs, and **terminal velocity** 终极速度.

You must be able to:

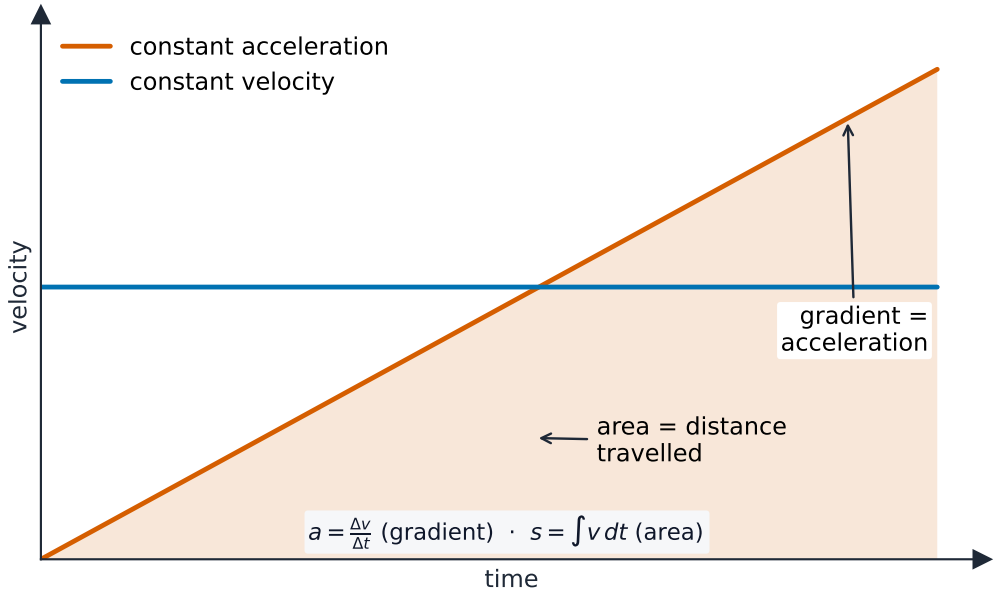
- use $v = \dfrac{s}{t}$ and $a = \dfrac{\Delta v}{\Delta t}$
- read distance–time and speed–time graphs (gradient and area)
- describe falling objects and terminal velocity

1 Worked examples

Graphs and acceleration



Distance–time: flat = at rest, straight slope = constant speed, rising curve = speeding up



Velocity–time: gradient = acceleration, area under the line = distance

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

■ 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 $a = \dfrac{4 - 12}{4.0} = -2.0\ \text{m/s}^2$, 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 × time; a triangle is $\frac{1}{2}$ × base × 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.

Near the Earth all objects fall with the same **acceleration of free fall** $g \approx 9.8\ \text{m/s}^2$ 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.

2 Practice

2.1 A runner covers 100 m in 12.5 s. Find the average speed. [2]

2.2 State what the area under a speed–time graph represents. [1]

2.3 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. [3]

2.4 State how you find the distance travelled from a speed-time graph. [1]

3 Exam-style questions

3.1 On a distance–time graph, a horizontal (flat) line means the object is: [1]

- **A** accelerating
- **B** at rest
- **C** at constant speed
- **D** decelerating

3.2 A car accelerates uniformly from rest to 24 m/s in 8.0 s.

(a) Find the acceleration. [2]

(b) Find the distance travelled (area under the speed–time graph). [2]

3.3 A skydiver falls and reaches terminal velocity. Explain, in terms of forces, why the speed becomes steady. [3]

3.3 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. [2]

(b) Calculate the acceleration of the bus between $t = 0.90$ min and $t = 2.9$ min. [3]

(c) Show that the bus travels about 270 m while it is speeding up. [2]

(d) Calculate the deceleration of the bus in the last minute, and state what the sign of your answer means. [3]

(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. [3]

Solutions

2.1 $v = \dfrac{100}{12.5} = 8.0$ m/s.

2.2 the distance travelled.

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

3.2 (a) $a = \dfrac{24 - 0}{8.0} = 3.0$ m/s^2.
(b) distance = area = $\frac{1}{2} \times 8.0 \times 24 = 96$ m.

3.3 as the diver speeds up, air resistance increases; when air resistance equals the weight, the resultant force is zero; so there is no acceleration and the speed stays constant (terminal velocity).

2.3 $a = \dfrac{6.0 - 18}{4.0} = -3.0$ m/s^2; the minus sign means the car is decelerating, so the acceleration is opposite to the motion.

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

3.3 (a) Between 2.9 and 3.5 min: constant speed. Between 3.5 and 4.5 min: constant (uniform) deceleration to rest.
(b) Time = $(2.9 - 0.90) \times 60 = 120$ s; $a = \dfrac{7.5 - 0}{120} = 0.063$ m/s^2.
(c) Distance = area of the triangle = $\frac{1}{2} \times 120 \times 7.5 = 450$ 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.
(d) Time = 60 s; $a = \dfrac{0 - 7.5}{60} = -0.13$ m/s^2; the minus sign means the bus is slowing down, so the resultant force is opposite to the motion.
(e) At first the acceleration is g, because only the weight acts; as the stone speeds up, air resistance grows and the resultant force falls, so the acceleration decreases; when air resistance equals the weight the resultant force and the acceleration are zero and the speed is constant.