

Acceleration caused by gravity

AS Level

9702 AS Ch.2

Chapter 2: Accelerated motion

Lesson 2.11

Sections 2.11

Goal: Use $g = 9.81 \text{ m s}^{-2}$ in the suvat equations for objects falling, or thrown up, without air resistance.

01 The big picture

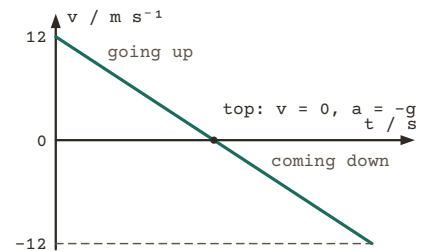
Near the Earth's surface, with no air resistance, every object falls with the same acceleration $g = 9.81 \text{ m s}^{-2}$, downwards, whatever its mass. This is free fall.

An object thrown upwards has the same downward acceleration all the way: it slows, stops for an instant at the top (where $v = 0$ but a is still g) and speeds up on the way down. Take up as positive and use $a = -9.81 \text{ m s}^{-2}$, or down as positive and $a = +9.81$.

Acceleration of free fall g [paraphrase]

The acceleration of a falling object with no air resistance: 9.81 m s^{-2} near the Earth.

Fig. 1 · v - t for a ball thrown up



One straight line with gradient $-g$ all the way, through $v = 0$ at the top.

02 Key equations

Dropped from rest: time

$$s = \frac{1}{2}gt^2$$

Dropped from rest: speed

$$v^2 = 2gs$$

Symbols and units

g acceleration of free fall, 9.81 m s^{-2} s distance fallen m

03 Sample problems with solutions

Sample 1 · A dropped stone

A stone is dropped from rest from a bridge 20 m above the water. Ignoring air resistance, calculate the time it takes to fall and its speed when it hits the water.

Step 1. Down positive, $u = 0$, $a = 9.81$:

$$t = \sqrt{\frac{2s}{g}} = \sqrt{\frac{2 \times 20}{9.81}} = 2.02 \text{ s}$$

Step 2. Speed:

$$v = \sqrt{2gs} = \sqrt{2 \times 9.81 \times 20} = 19.8 \text{ m s}^{-1}$$

Answer: 2.0 s; 20 m s⁻¹ (19.8 m s⁻¹)

Unit check: $\sqrt{\text{m s}^{-2} \times \text{m}} = \text{m s}^{-1} \checkmark$

04 Practice problems

P1 A ball is thrown up at 12 m s^{-1} . How long does it take to reach the top?

Answer: 1.2 s (1.22 s)

P2 How high does that ball rise?

Answer: 7.3 m

P3 A ball is dropped from rest. Find its speed and the distance fallen after 3.0 s.

Answer: 29 m s⁻¹ (29.4); 44 m (44.1)

P4 A hammer and a feather are dropped together on the Moon (no air). Which lands first?

Answer: Neither: they land together

05 Other useful information

Common mistakes

✗ **Wrong:** At the top of its flight the acceleration is zero.

✓ **Right:** Only v is zero; a is still 9.81 m s^{-2} downwards.

Exam tips

- Write your sign convention ("up +") at the top of the working.

What the syllabus asks

- 9702 topic 2: free fall without air resistance. Coursebook 2.11.

Explore: Practice questions for this lesson