Vertical Motion Under Gravity 1

Specification: AQA 7357: R3, Q3, OT3 · Edexcel 9MA0: 8.3, 7.3, OT3

INDEPENDENT

You do

A · Dropped and thrown down Down positive: a = +9.8.

1 A stone is dropped from rest from the top of a building 40 m high. Find the time it takes to reach the ground.

2 A coin is dropped from rest from a bridge and hits the water 1.5 s later. Find
(a) the height of the bridge above the water
(b) the speed of the coin when it hits the water.

3 A ball is thrown vertically downwards with speed 6 m s^{-1} from a window 15 m above the ground. Find the speed with which it hits the ground.

4 A stone is thrown vertically downwards with speed 2 m s^{-1} from the top of a cliff. It hits the sea 3 s later. Find the height of the cliff.

B · Thrown up Up positive: a = −9.8 all the way. At the top v = 0.

5 A ball is projected vertically upwards with speed 7 m s^{-1}. Find
(a) the greatest height above the point of projection
(b) the time taken to reach it.

6 A ball is projected vertically upwards from ground level with speed 17.5 m s^{-1}. Find
(a) the greatest height
(b) the time of flight.

7 A ball is projected vertically upwards. Two seconds later it is moving downwards with speed 5.6 m s^{-1}. Find
(a) the speed of projection
(b) the greatest height above the point of projection.

8 A stone is thrown vertically upwards with speed 10 m s^{-1} from the edge of a cliff 30 m above the sea. Find
(a) the time it takes to reach the sea
(b) its speed when it hits the sea.

9 A ball is thrown vertically upwards with speed 12 m s^{-1}.
(a) Find its speed when it is 5 m above the point of projection.
(b) Explain why the ball has this speed twice.

C · Reasoning No calculator.

10 True or false? Explain each answer.
(a) At its greatest height, a ball thrown upwards has zero acceleration.
(b) A ball projected upwards from the ground at 9.8 m s^{-1} reaches its greatest height after 1 s and lands after 2 s.
(c) In the model, a heavy ball dropped from a tower lands before a light ball dropped at the same time.

11 Take $g = 10$ m s^{-2}. A ball is thrown vertically upwards with speed 20 m s^{-1} from a point 25 m above the ground. Find
(a) the greatest height above the ground
(b) the time of flight
(c) the speed with which it hits the ground.

12 A tennis ball and a flat sheet of paper are dropped at the same time from the same height.
(a) What does the model of this lesson predict?
(b) What actually happens? Which modelling assumption fails?
(c) Why are answers found with $g = 9.8$ given to 2 s.f.?

D · Algebra and "show that" Letters: u, h, g. Up positive, so a = −g.

13 A ball is projected vertically upwards from the ground with speed u m s^{-1}. Show that

(a) it reaches its greatest height, $\frac{u^2}{2g}$ metres, after $\frac{u}{g}$ seconds

(b) it lands after $\frac{2u}{g}$ seconds.

14 A stone is thrown vertically upwards with speed 4.9 m s^{-1} from a point 9.8 m above the ground. Show that its time of flight, T seconds, satisfies $T^2 - T - 2 = 0$, and find T.

15 A particle is projected vertically with speed u m s^{-1} from a point h metres above the ground.
(a) Show that it hits the ground with speed $\sqrt{(u^2 + 2gh)}$, whether it is projected upwards or downwards.
(b) Find this speed when $u = 7$ and $h = 20$.

E · Exam-style question Show your method: marks are for working.

16 A ball is projected vertically upwards with speed 15.4 m s^{-1} from a point A, which is 8 m above the ground. The ball is modelled as a particle moving freely under gravity.
(a) Find the greatest height above the ground reached by the ball. [3 marks]
(b) Find the time from projection until the ball hits the ground. [3 marks]
(c) Find the speed with which the ball hits the ground. [2 marks]