PQ 6e Q and A

More Suvat

Q1

A hot air balloon is stationary, 50 m above the ground when an object is dropped vertically from it. How long does it take for the object to fall and what will be its speed just before it hits the ground?

$u = 0$; $s = 50$ m; $g = 9.8$ m s^{-2}; $t = ?$; $v = ?$

(a) $s = ut + \frac{1}{2}gt^2$; $50 = 0 + \frac{1}{2} \times 9.8 \times t^2$; $t^2 = 2 \times 50/9.8$; $t = 3.2$ s

(b) $v^2 = u^2 + 2as = 0 + 2 \times 9.8 \times 50$; $v = 31.3$ m s^{-1}

Q2

A ball is thrown vertically upwards at 58.8 m s^{-1}.

(a) How long will it take to reach its maximum height?

(b) What will be its speed at its maximum height?

(c) What will be its maximum height?

(d) How long will it take to fall from the maximum height back to the ground?

$u = +58.8$ m s^{-1}; $g = -9.8$ m s^{-2}; v at maximum height = 0

(a) $v = u + at$; $0 = 58.8 + (-9.8)t$; $t = 58.8/9.8 = 6$ s

(b) v at maximum height = 0

(c) $v^2 = u^2 + 2as$; $0 = 58.8^2 + 2 \times (-9.8)s$; $s = 58.8^2/2 \times 9.8 = 176.4$ m

(d) Same time as it took to reach maximum height, i.e. 6 s.

Q3

An object is thrown vertically up at 40 m s^{-1}.

(a) How long will it be before it returns to its launch position?

(b) How high will it rise?

(c) What will be its height above the launch position at time 3 s?

(d) When will it be 50 m above the launch point?

$u = +40$ m s^{-1}; $g = -9.8$ m s^{-2}; v at maximum height = 0; v back at ground level = -40 m s^{-1}

(a) $v = u + at$; $-40 = 40 - 9.8t$; $t = 80/9.8 = 8.16$ s

(b) $v^2 = u^2 + 2as$; $0 = 40^2 - 2 \times 9.8 \times s$; $s = 40^2/2 \times 9.8 = 81.6$ m

(c) $s = ut + \frac{1}{2}gt^2 = 40 \times 3 - 0.5 \times 9.8 \times 3^2 = 75.9$ m

(d) $s = ut + \frac{1}{2}gt^2$; $50 = 40t - 4.9t^2$; $4.9t^2 - 40t + 50 = 0$; $t = 1.54$ s or 6.62 s
i.e. at times 1.5 s (on the way up) and 6.6 s (on the way down)

Q4

A hot air balloon is rising vertically at 19.6 m s^{-1}. When it is 24.5 m above the ground, the pilot drops a sand bag vertically downwards.

(a) How long does it take for the bag to hit the ground?

(b) What will be the speed of the bag just before it hits the ground?

(c) Assuming the balloon rises at the same rate after the bag is dropped, what will be its altitude as the bag hits the ground?

Q4 continued

$u = +19.6\ \text{m s}^{-1}$; $s = -24.5\ \text{m}$; $g = -9.8\ \text{m s}^{-2}$

(a) $s = ut + \frac{1}{2}gt^2$; $-24.5 = 19.6t - 4.9t^2$; $4.9t^2 - 19.6t - 24.5 = 0$; $t = 5$ s (or -1 s meaningless)

(b) $v = u + at = 19.6 - 9.8 \times 5 = -29.4\ \text{m}$ or $29.4\ \text{m s}^{-1}$ down

(c) $s = ut + \frac{1}{2}gt^2 = 19.6 \times 5 = 98\ \text{m}$; total height $= 24.5 + 98 = 122.5\ \text{m}$

Q5

A 2.5 kg ball is dropped from the top of a 100 m high vertical cliff.

(a) How long does it take to reach the ground at the bottom of the cliff?

(b) What will be its speed just before it hits the ground?

(c) How will your answers to (a) and (b) be different if the mass of the ball is 4 kg? Explain why.

(d) How far does the ball fall in the first 3 s of its fall?

Q5 continued

$m = 2.5$ kg; $s = +100$ m; $g = 9.8$ m s^{-2}; $u = 0$

(a) $s = ut + \frac{1}{2}gt^2$; $100 = 0 + 4.9t^2$; $t^2 = 100/4.9$; $t = 4.5$ s

(b) $v = u + at = 0 + 9.8 \times 4.5 = 44.3$ m s^{-1}

(c) They will not be different because all objects fall at the same rate. object.

(d) $s = ut + \frac{1}{2}gt^2 = 0 + 0.5 \times 9.8 \times 3^2 = 44.1$ m

Gravitational acceleration is independent of the mass of the falling

Q6

A stone is thrown vertically up from the ground at 39.2 m s^{-1} near a tree which is 39.2 m high.

(a) What will be its speed at its highest point?

(b) How long does it take to reach the highest point?

(c) What will be its speed when it is halfway back to the ground?

$u = +39.2$ m s^{-1}; $v = 0$; $g = -9.8$ m s^{-2}

(a) 0

(b) $v = u + at$; $0 = 39.2 - 9.8t$; $t = 4$ s

(c) $v^2 = u^2 + 2as$; $0 = 39.2^2 - 2 \times 9.8 \times s$; $s = 39.2^2/2 \times 9.8 = 78.4$ m

When halfway down the height is $78.4/2 = 39.2$ m

$v^2 = u^2 + 2as = 39.2^2 - 2 \times 9.8 \times 39.2 = 768.32$; $v = 27.7$ m s^{-1}

(Its maximum height is 78.4 m and it takes 2.83 s to fall to the halfway point.)

Q7

Object A was dropped from rest from the top of a 150 m high cliff. How long after this should object B be thrown vertically down at 6.0 m s^{-1} so that they both hit the ground at the same time?

$u = 0$; $s = 150$ m; $g = -9.8$ m s^{-2}; thrown $u = 6$ m s^{-1}

Time free fall: $s = ut + \frac{1}{2}gt^2$; $150 = 0 + 0.5 \times 9.8 \times t^2$; $t^2 = 150/0.5 \times 9.8 = 30.61$; $t = 5.53$ s

Thrown: $150 = 6t + 4.9t^2$; $t = 4.95$ s (or –6.18 s)

Time = 5.53 – 4.95 = 0.58 s later

Q8

Object A is thrown vertically upwards from the edge of a 78.4 m high cliff at 29.4 m s^{-1}. It rises, then falls to the ground at the bottom of the cliff. Object B is dropped vertically downwards from rest at the instant that A is thrown upwards.

(a) How far does A rise?

(b) How long does A take to reach its maximum height?

(c) What total distance does A fall?

(d) How long does it take A to fall from maximum height to the ground?

(e) What is the speed of A just before it hits the ground?

(f) How long does B take to hit the ground?

(g) How long after B does A hit the ground?

Q8 continued

A: $u = +29.4\ \text{m s}^{-1}$; $s = -78.4\ \text{m}$; $g = -9.8\ \text{m s}^{-2}$; B: $u = 0$

(a) $v^2 = u^2 + 2as$; $0 = 29.4^2 - 2 \times 9.8s$; $s = 29.4^2/2 \times 9.8 = 44.1\ \text{m}$

(b) $v = u + at$; $0 = 29.4 - 9.8t$; $t = 29.4/9.8 = 3\ \text{s}$

(c) $s = 44.1 + 78.4 = 122.5\ \text{m}$

(d) $s = ut + \frac{1}{2}gt^2$; $122.5 = 0 + 0.5 \times 9.8 \times t^2$; $t^2 = 122.5/0.5 \times 9.8 = 25$; $t = 5.0\ \text{s}$

(e) $v^2 = u^2 + 2as = 29.4^2 + 2 \times (-9.8) \times (-78.4) = 2401$; $v = 49.0\ \text{m s}^{-1}$

(f) $s = ut + \frac{1}{2}gt^2$; $78.4 = 0 + 0.5 \times 9.8\ t^2$; $t^2 = 78.4/0.5 \times 9.8 = 16$; $t = 4\ \text{s}$

(g) $t = (3 + 5) - 4 = 4\ \text{s}$