Solutions

Example 1 2007 Question 16, 76%

The only force acting is the weight force. This is always going to act vertically down.

$\therefore$ **D (ANS)**

Example 2 2007 Question 17, 30%

Since the second paintball reaches the same height, it must take the same time as before to reach this height and then all back to the starting height.

The acceleration due to gravity is constant.

$\therefore$ **A, C (ANS)**

Example 3 1999 Question 8, 80%

C (ANS)

Example 4 1999 Question 9, 80%

D (ANS)

Example 5 1999 Question 10, 63%

The only force acting is the weight force, so the acceleration is down.

E (ANS)

Example 6 1999 Question 11, 63%

E (ANS)

Same as previous question

Example 7 1999 Question 12, 63%

F (ANS)

Now there are two forces acting, the weight force down and the air resistance that is opposing the motion.

Example 8 1984 Question 8, 28%

Consider only the vertical direction.

Use $v^2 - u^2 = 2\,a\,h$,

where $v = 0$ (since it is at the top of the flight)

u = unknown,

$a = -g$

h = height above H.

Initial KE = $\frac{1}{2} M u^2 = E$

$$\therefore u^2 = \frac{2E}{M}$$

We need to consider the vertical direction

$u_{vertical} = u \sin\theta$

$\therefore u^2_{vertical} = u^2 \sin^2\theta$

$\therefore v^2 - u^2_{vetrical} = 2\,a\,h$ gives

$$0 - \frac{2E}{M}\sin^2\theta = -2gh$$

$$\therefore \frac{2E}{M}\sin^2\theta = 2gh,$$

$\therefore\ h = \frac{E}{Mg} \sin^2 \theta$

$\therefore$ Total height = $H + \frac{E}{Mg} \sin^2 \theta$

$\therefore$ **D (ANS)**

Example 9 1980 Question 8, 90%

At the point X, the only force acting is the weight. (We are specifically told to neglect air resistance).

$\therefore$ Net force (weight) is down.

$\therefore$ **D (ANS)**

Example 10 1968 Question 48, 87%

The path needs to be parabolic, because the acceleration due to 'g' is down. The mass will move horizontally at a constant speed, and accelerate downwards. The initial velocity is horizontal, but the angle at E depends on the relative horizontal and vertical speeds.

$\therefore$**B (ANS)**

Example 11 1968 Question 54, 50%

The inclined plane will provide an impulse to the ball in the vertical direction. This will allow initial horizontal velocity to be redirected to the vertical. So some of the initial KE is converted in GPE.

$\therefore$**C (ANS)**

Example 12 2008 Question 5, 75%

At the maximum height the vertical velocity is zero.

Initially the vertical component of the velocity is $30\sin(36.9^0)$

Using $v^2 – u^2 = 2gx$

$0^2 - (30\sin(36.9))^2 = -2 \times 10 \times x$

$\therefore$ **x = 16.2 m (ANS)**

Example 13 2008 Question 6, 75%

Since air resistance can be ignored, the only force acting on the ball is its weight force.

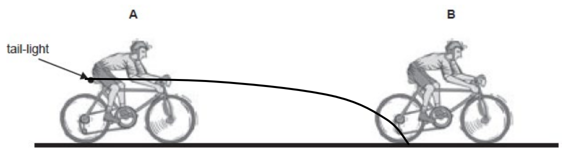
This will always be vertically down.

$\therefore$ **R (ANS)**

Example 14 2008 Question 7, 57%
Consider this motion in both the horizontal and the vertical directions.
Horizontal
Find the time it takes to travel the 72m horizontally.
$v_{horizontal} = 30\cos(36.9)$
$= 24 \text{ ms}^{-1}$
Using $v = \frac{d}{t}$
$\therefore t = \frac{72}{24}$
= 3 secs
Vertical
Use $x = ut + \frac{1}{2}gt^2$
$= 18 \times 3 - \frac{1}{2} \times 10 \times 3^2$
$= 54 - 45$
= 9 m (ANS)

Example 15 2007 Question 1, 53%
The time the ball takes to all is given by
$x = ut + \frac{1}{2}at^2$
On substitution, u = 0, a = 10 and t = 0.45
$\therefore x = \frac{1}{2} \times 10 \times 0.45^2$
= 1.0125 m
= 1.0 m (ANS)

Example 16 2007 Question 2, 53%
Mary will see the path to be parabolic. It will start from the initial position and will land directly underneath the seat when the bike is at position B.



Example 17 2007 Question 14, 65%
The horizontal component of the velocity is given by $40\cos25^0 = 36.25 \text{ m s}^{-1}$.

The horizontal velocity is also given by
$v = \frac{d}{t}$
$\therefore t = \frac{d}{v}$
$= \frac{127}{36.25}$
= 3.50 sec. (ANS)

Example 18 2007 Question 15, 65%

There are several ways of solving this problem. If the time of flight is 3.5 sec, then the paintball is falling for half the time, i.e. 1.75 sec.

Using $x = ut + \frac{1}{2}at^2$.
$u = 0$

$$\therefore x = \frac{1}{2} \times 10 \times 1.75^2$$
$$= 15.34 \text{ m}$$
$$\mathbf{= 15.3\ m} \qquad \textbf{(ANS)}$$

The other way to solve this question is to use the vertical component of the initial velocity and solve

$$v^2 - u^2 = 2gx$$
$$\therefore 0^2 - (40\sin25^0)^2 = 2 \times 10 \times x$$
$$\therefore x = 285.8 \div 20$$
$$\therefore \mathbf{x = 14.29\ m} \qquad \textbf{(ANS)}$$

Both answers were correct if working was shown.

Example 19 2000 Question 4, 57%

Newton's first law will explain the motion, and that is a body in motion will continue in motion unless a net force acts on it. The surfboards were travelling at $10ms^{-1}$ and were not strapped down therefore they continued in motion, as there was no net force in the horizontal plane acting on it.

Example 20 2000 Question 5, 59%

Since the time taken in this example is determined by the vertical plane, write down all the values you know for the vertical plane.
$x = 80m$
$u = 0\ ms^{-1}$
$v = ?$
$a = 10\ ms^{-2}$
$t = ?$
Then you find one of the equations that involves the three known values and will give you the unknown value. In this case:

$$x = ut + \frac{1}{2}at^2$$

$$80 = 0 \times t + \frac{1}{2} \times 10 \times t^2$$

$$\therefore t = \sqrt{\frac{2 \times 80}{10}}$$

$$\therefore \mathbf{t = 4.0\ s} \qquad \textbf{(ANS)}$$

Example 21 2000 Question 6, 59%

Since you now have the time take to hit the ground, and you know that it was travelling at $10ms^{-1}$, you simply use: $v = \frac{\Delta x}{\Delta t}$

Manipulate to get:

$\Delta x = v \times t$

$\therefore \Delta x = 10 \times 4.04$

$\therefore$ **Δx = 40.4 m (ANS)**

Example 22 1998 Question 11, 42%

In the vertical direction the initial velocity is $v\sin 30^0 = 5 \times 0.5 = 2.5$ m/s.

Use $v^2 = u^2 - 2gh$, to find the height.

Since v = 0, (in the vertical direction)

$0 = 2.5^2 - 2 \times 10 \times h$

$\therefore h = 0.3125$ m

You must add this to the height that it started from. $\therefore h = 1.2 + 0.32$

= 1.52 m (ANS)

Example 23 1998 Question 12, 33%

Since at the top of the flight, the speed is 4.33 m/s. Then $v = \frac{d}{t}$

$\therefore t = \frac{d}{v}$

$= \frac{2.87}{4.33}$

= 0.663 sec (ANS)

Note that the question specifies the number of sig.fig. that you must include in your answer. The zero at the start of the answer is not significant.

Example 24 1997 Question 11, 40%

Note that the examiners use g = 10N/kg.

Consider the vertical component of the velocity.

$v = u - gt$

where v = 0 and $u = 22 \sin 11^0$

$\therefore 0 = 22\sin 11^0 - 10 \times t$

$\therefore t = 4.198 \div 10$

$\therefore t = 0.42$

$\therefore$ 0.42 sec (ANS)

Example 25 1997 Question 12, 40%

Yes

You need to assume that the other part of the bridge is the same height as the first side.

If it takes 0.4198 sec to get to the top, then it will take 0.8396 sec to be back to the original height. The horizontal distance travelled in this time

= vcos11 × 0.8396

= 22cos 11 × 0.8396

= 18.13 m (ANS)

Example 26 1985 Question 5, 49%

The total energy of *P* remains constant.

∴ PE + KE = constant

At the start

PE + KE = mgh + ½mv^2

= 2.0 x 10 x 1.8 + ½ x 2.0 x 5^2

= 36 + 25

= 61J

This has all been transformed into PE just before it lands.

∴ 61 J (ANS)

Example 27 1985 Question 6, 80%

Both projectiles are launched from the same height. Therefore they will both take the same time to fall to the ground.

∴ 1 (ANS)

Example 28 1985 Question 7, 68%

To calculate the distance travelled horizontally, you need to know how long it took to fall to the ground.

Then use d = v x t.

Vertically

$x = ut + \frac{1}{2}at^2$

u =0

∴ 1.8 = ½ x 10 x t^2

∴ 0.36 = t^2

∴ t = 0.6 s

Horizontally

d = v x t

∴ d = 5.0 x 0.6

= 3.0 m (ANS)

Example 29 1984 Question 6, 85%

The total energy of *P* remains constant.

∴ PE + KE = constant

Since P is the same height as the start the PE will be the same. Therefore KE_P = $KE_{initial}$

∴ E (ANS)

Example 30 1984 Question 7, 44%

The total energy at the start is equal to the total energy at X.
Initially
Total energy = PE + KE
= MgH + E
At X
KE = MgH + E
$\therefore \frac{1}{2}Mv^2 = MgH + E$

$\therefore$ **v =** $\sqrt{\frac{2(MgH + E)}{M}}$ **(ANS)**

Example 31 1982 Question 5, 74%
This question just requires you to work out how long it takes a ball to drop from 5 m to the ground.
Use Vertically
$x = ut + \frac{1}{2}at^2$ (u =0)
$\therefore 5.0 = \frac{1}{2} \times 10 \times t^2$
$\therefore 1.0 = t^2$
$\therefore$ **t = 1 s (ANS)**

Example 32 1982 Question 6, 79%
If the initial horizontal speed was 6.0 m/s then (in 1.0 sec) it will travel
6.0 m (ANS)

Example 33 1980 Question 4, 92%
$KE = \frac{1}{2}mv^2$
$= \frac{1}{2} \times 0.2 \times 12^2$
= 14. 4 J (ANS)

Example 34 1980 Question 5, 79%
$\Delta PE = mgh$
$= 0.2 \times 10 \times 3.0$
= 6 J (ANS)

Example 35 1980 Question 6, 58%
Initially the ball had 14.4 J of KE, as it rises to point X it gains 6 J of PE, therefore it must lose 6 J of KE
$\therefore KE_X = 14.4 - 6.0$
$\therefore$ **KE_X = 8.4 J (ANS)**

Example 36 1980 Question 7, 71%
$KE_X = \frac{1}{2}mv^2$
$\therefore 8.4 = \frac{1}{2} \times 0.2 \times v^2$
$\therefore v^2 = 84$
$\therefore$ **v = 9.2 m s^{-1} (ANS)**

Example 37 1975 Question 1, 80%
Impulse is the change in momentum.
Initially the velocity of the ball was 0, therefore it didn't have any momentum.
Once shot from the catapult it had a momentum given by

$p = mv$

$\therefore\ p = 0.024 \times 16$

= 0.38 N s **(ANS)**

Example 38 1975 Question 2, 65%
The initial vertical velocity is given by

$v\sin\theta = 16 \sin 30^0$

$= 8\ ms^{-1}$

At the maximum vertical displacement the vertical velocity = 0.
Use $v = u - gt$

$\therefore 0 = 8 - 10t$

$\therefore$ **t = 0.8 sec (ANS)**

Example 39 1975 Question 3, 63%
Use $v^2 - u^2 = 2ax$, in the vertical direction.

$\therefore\ 0 - 8^2 = 2 \times -10 \times h$

$\therefore$ **h = 3.2 m (ANS)**

Example 40 1975 Question 4, 34%
At the top of the flight the KE is due to the horizontal motion of the ball. Since we are not told anything about air resistance (it didn't exist, in Physics exams in 1975), we will ignore it.
$\therefore$ the horizontal speed is constant.
Initially the horizontal speed was $16 \cos 30^0$

$\therefore\ v_{horizontal} = 13.856\ ms^{-1}$

$\therefore\ KE = ½ mv^2$

$= ½ \times 0.024 \times 13.856^2$

$\therefore$ **KE = 2.3 J (ANS)**

Example 41 1975 Question 5, 73%
At the point X, the only force acting is the weight. (We can neglect air resistance).

$\therefore$ **a = 10 m s^{-2} (down)** **(ANS)**

Example 42 1974 Question 1, 83%
Horizontally
The ball is travelling at 2.0 ms^{-1} for 0.4 s

$\therefore$ **d = 0.8 m (ANS)**

Example 43 1974 Question 2, 72%
Vertically
$x = ut + ½ at^2$
∴ $h = 0 + ½ \times 10 \times 0.4^2$
∴ **h = 0.8 m (ANS)**

Example 44 1974 Question 3, 56%
The KE of the ball just before it hits the ground is the same as the sum of the PE and KE at the start.
∴ Total energy = KE + PE
$= ½ mv^2 + mgh$
$= ½ \times 0.1 \times 2^2 + 0.1 \times 10 \times 0.8$
$= 0.2 + 0.8$
$= 1.0$ J
At the ground KE = 1.0 J
∴ $½ mv^2 = 1.0$
∴ $½ \times 0.1 \times v^2 = 1.0$
∴ $v^2 = 20$
∴ **v = 4.5 ms^{-1} (ANS)**

Example 45 1974 Question 4, 41%
The ball hits the ground at an angle because it has both a vertical and horizontal component to its velocity.
The horizontal component is constant,
∴ 2.0 ms^{-1}.
Use trigonometry to find the angle. Use cos, since the horizontal component is 2.0 and the 'hypotenuse' is 4.5
∴ $\theta = \cos^{-1} \frac{2}{4.5}$
∴ **θ = 63.4^0 (ANS)**

Example 46 1974 Question 5, 31%
If the ball rises to 0.5 m, it will take the same time to fall from 0.5 m.
To find the time to fall from 0.5 m use
$x = ut + ½gt^2$.
Let u = 0, as it is falling from rest.
∴ $0.5 = ½ \times 10 \times t^2$
∴ $t^2 = 0.1$
∴ $t = 0.316$
The time between bounce will be twice this.
∴ **0.63 sec (ANS)**

Example 47 1974 Question 6, 23%
The height the ball will bounce up to is dependent on the KE after each collision.
It is loses the same proportion of energy, then it will lose the same proportion of rebound height.
Initially $\frac{h_f}{h_i} = \frac{0.5}{0.8}$

$h_{new} = \frac{5}{8} \times 0.5$

$\therefore$ **h_{new} = 0.31 m** **(ANS)**