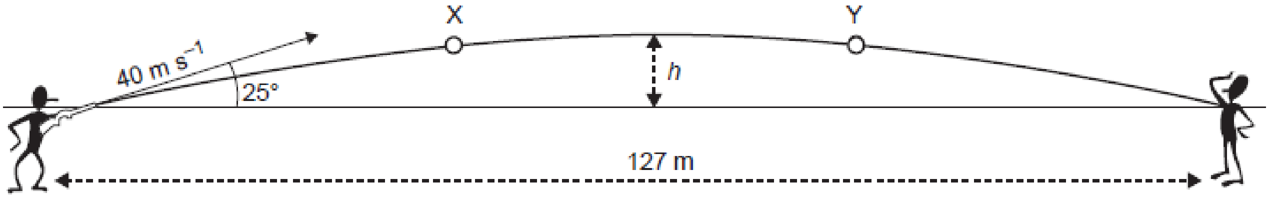
Multiple Choice

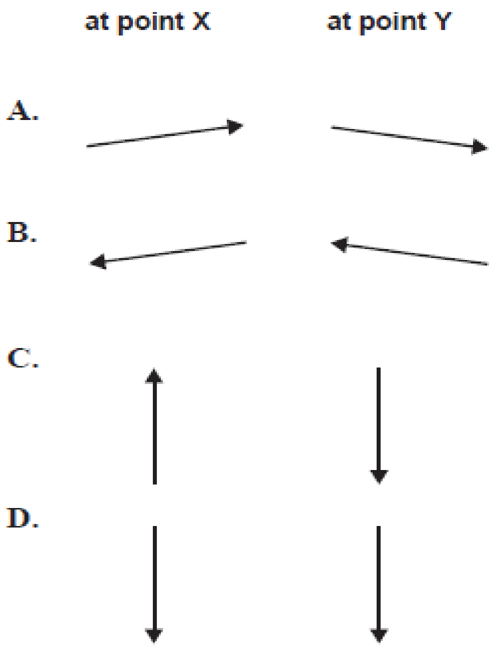
Daniel and John are playing paintball. Daniel fires a 'paintball' at an angle of 25° to the horizontal and a speed of 40.0 m s^{-1}. The paintball hits John, who is 127 m away. The height at which the ball hits John and the height from which the ball was fired are the same. The situation is shown below.



The acceleration due to gravity should be taken as 10 m s^{-2}, and air resistance should be ignored.

Example 1 (2007 Question 16, 2 marks)

Which of the following diagrams (**A – D**) below gives the direction of the force acting on the paintball at points X and Y respectively?



Later in the game, Daniel is twice as far away from John (254 m). John fires an identical paintball from the same height above the ground as before. The ball hits Daniel at the same height as before. In both cases the paintball reaches the same maximum height ***(h)*** above the ground.

Example 2 (2007 Question 17, 2 marks)

Which **one or more** of the following is the same in both cases?

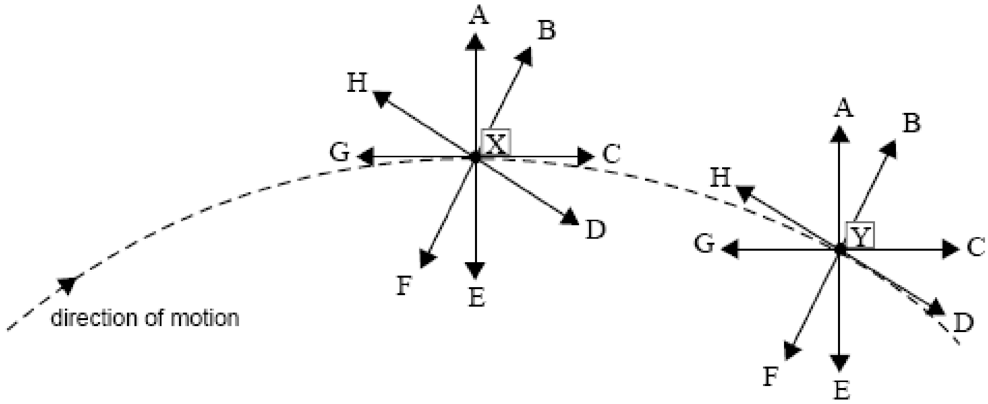
A. flight time

B. initial speed

C. acceleration

D. angle of firing

A car takes off from a ramp and the path of its centre of mass through the air is shown below.



First, model the motion of the car assuming that air resistance is small enough to neglect.

Example 3 (1999 Question 8, 1 mark)

Which **one** of the directions (**A**–**H**) best shows the direction of the **velocity** of the car at point X?

Example 4 (1999 Question 9, 1 mark)

Which **one** of the directions (**A**–**H**) best shows the direction of the **velocity** of the car at point Y?

Example 5 (1999 Question 10, 1 mark)

Which **one** of the directions (**A**–**H**) best shows the direction of the **acceleration** of the car at point X?

Example 6 (1999 Question 11, 1 mark)

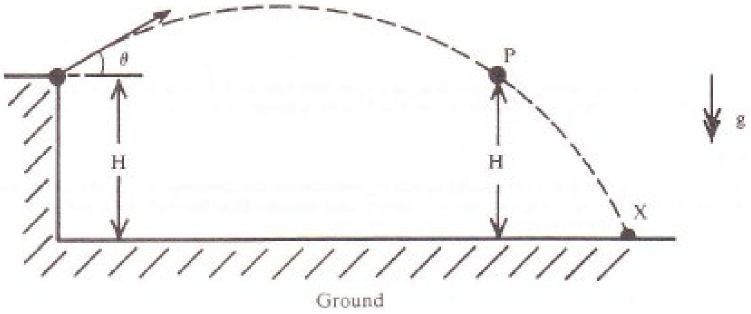
Which **one** of the directions (**A**–**H**) best shows the direction of the **acceleration** of the car at point Y?

Now, suppose that **air resistance cannot be neglected**.

Example 7 (1999 Question 12, 2 marks)

Which **one** of the directions (**A**–**H**) could be the direction of the **acceleration** of the car at point X?

A marble of mass *M* is projected at an angle θ from the top of a cliff of height *H*. At the instant of projection it has a kinetic energy of *E*. This situation is shown below together with the path of the projectile. Neglect air resistance.



Example 8 (1984 Question 8, 1 mark)

Which expression **(A - E)** below gives the maximum height above the ground reached by the marble?

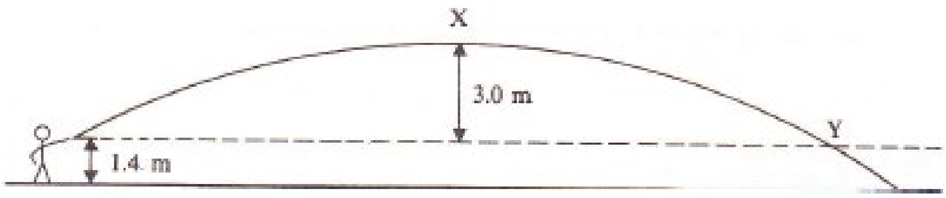
A. $H + \dfrac{E}{Mg}\sin\theta$

B. $H + \dfrac{2E}{Mg}$

C. $H + \dfrac{E}{Mg}$

D. $H + \dfrac{E}{Mg}\sin^2\theta$

E. $H + \dfrac{2E}{Mg}\sin^2\theta$



A boy throws a ball of mass 0.20 kg with an initial speed of 12 m s^{-1} from a height of 1.4 m above the ground. It travels in a path as shown in the diagram, reaching a maximum vertical height of
3.0 m above the starting point. *X* is the highest point the ball reaches.
Take *g* = 10 N kg^{-1} and neglect air resistance.

Example 9 (1980 Question 8, 1 mark)

What is the direction of the acceleration of the ball at the point *X*?

A horizontal, to the right

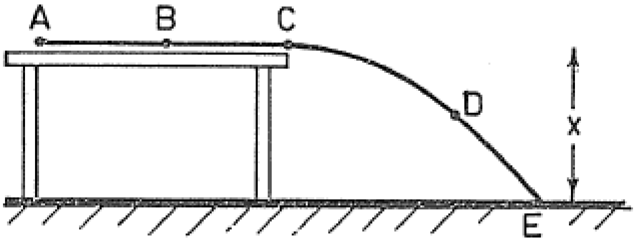
B horizontal, to the left

C vertically up

D vertically down

E in the direction *X* to *Y*

F no direction, as the acceleration is zero



A mass slides with uniform speed on a horizontal frictionless table. At point C it leaves the table and moves under the influence of gravity along the path CDE, striking the floor at the point E.

Example 10 (1968 Question 48, 1 mark), 87%

Which of the following correctly describes the path CDE

A. A parabola which must always make an angle of 45^0 with the floor at the point E.

B. A parabola which must have a horizontal tangent at the point C.

C A circular path whose radius is determined by the relation $\frac{v^2}{r} = g$

D. A circular path which must have a horizontal tangent at the point C and which meets the floor at an angle of 45^0 at the point E.

Assume now that the mass reaches the point E with equal vertical and horizontal components of velocity, i.e. $U = V$. The mass makes an elastic collision with a fixed **inclined plate** at E and rebounds in the vertical direction.

Example 11 (1968 Question 54, 1 mark), 50%

The rebound height will be greater than the height *x* of the table. Which of the following is the correct reason for this?
The extra gravitational potential energy required is equal to:

A. The impulse delivered to the ball on striking the plate.

B. The elastic potential energy stored in the interatomic force fields in the plate.

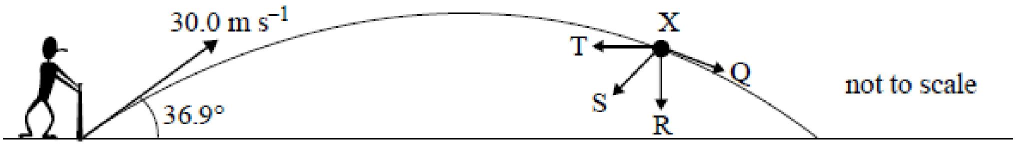
C The kinetic energy which is associated with the horizontal motion of the mass on the table.

D. The work done by the equal and opposite interaction forces between the ball and the plate.

Extended questions

Use the following information to answer Questions 5 – 7.

A batsman hits a cricket ball (from ground level) at a speed of 30.0 m s^{-1} and at an angle of 36.9° to the horizontal as shown below. Air resistance can be ignored.



Example 12 (2008 Question 5, 2 marks)

What is the maximum height that the ball reaches?
You must show your working.

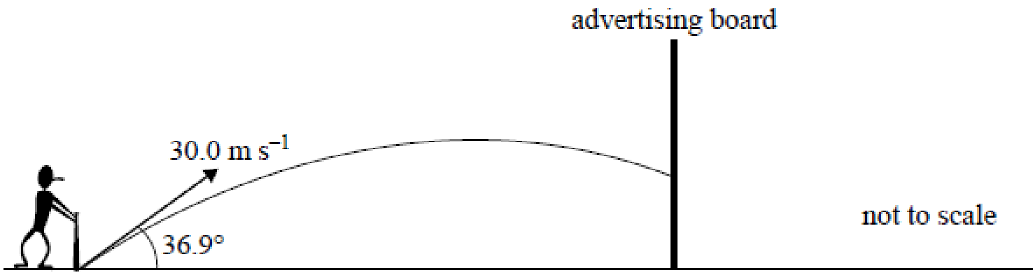
Example 13 (2008 Question 6, 2 marks)

Which of the arrows **(Q – T)** best represents the resultant force on the ball at point X?

An advertising board is now placed on the boundary of the cricket ground at a distance 72.0 m from the batsman as shown below.

Example 14 (2008 Question 7, 3 marks)

Assuming the ball is hit exactly the same way as in the previous question, at what height above the ground will the ball strike the advertising board?
You must show your working.



Example 15 (2007 Question 1, 2 marks)

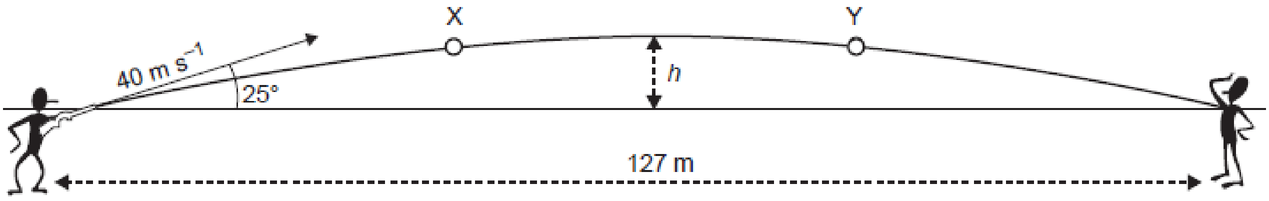
Fred is riding his bike on a level road at a speed of 5.0 m s^{-1}. The tail-light breaks off. It takes 0.45 s to reach the ground.
How far above the ground was the tail-light when it was attached?

Mary was watching Fred and saw the tail-light fall. Her view of the events is shown below. Fred was at position A when the tail-light broke off, and at position B when it hit the ground.

Example 16 (2007 Question 2, 2 marks)

On the Figure sketch the path of the tail-light **as seen by Mary**, and indicate the final position of the tail-light.

Daniel and John are playing paintball. Daniel fires a 'paintball' at an angle of 25° to the horizontal and a speed of 40.0 m s^{-1}. The paintball hits John, who is 127 m away. The height at which the ball hits John and the height from which the ball was fired are the same. The situation is shown below.



The acceleration due to gravity should be taken as 10 m s^{-2}, and air resistance should be ignored.

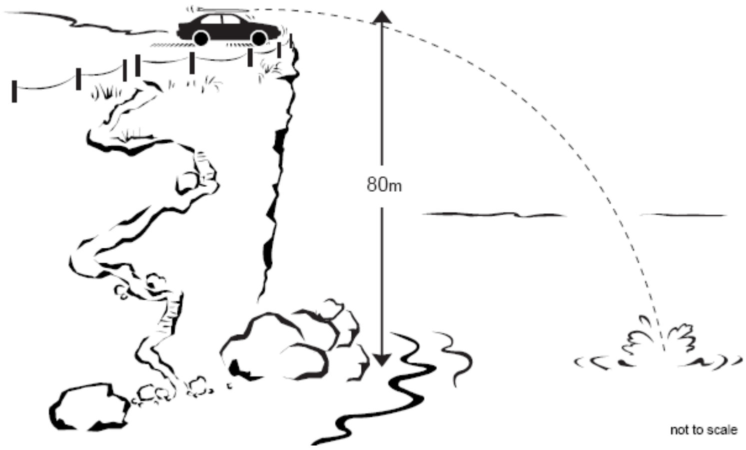
Example 17 (2007 Question 14, 2 marks)

What is the time of flight of the paintball?

Example 18 (2007 Question 15, 3 marks)

What is the value of ***h***, the maximum height above the firing level?

Su and Harry go for a day's surfing with surfboards strapped to the roof of their car. They enter the cliff-top car-park and brake suddenly as they park their car. A surfboard breaks free from the roof strap, and continues forward in a horizontal direction with an initial speed of 10 m s^{-1}.
When it breaks free the surfboard is initially 80 m above the surface of the sea.



Example 19 (2000 Question 4, 2 marks)

Use one or more of Newton's laws to explain why the surfboard continues forward after the car brakes suddenly.

Example 20 (2000 Question 5, 3 marks)

The path of the surfboard as it continues over the cliff may be modelled as projectile motion without air resistance. Calculate the time from the instant the surfboard breaks free until it hits the water.

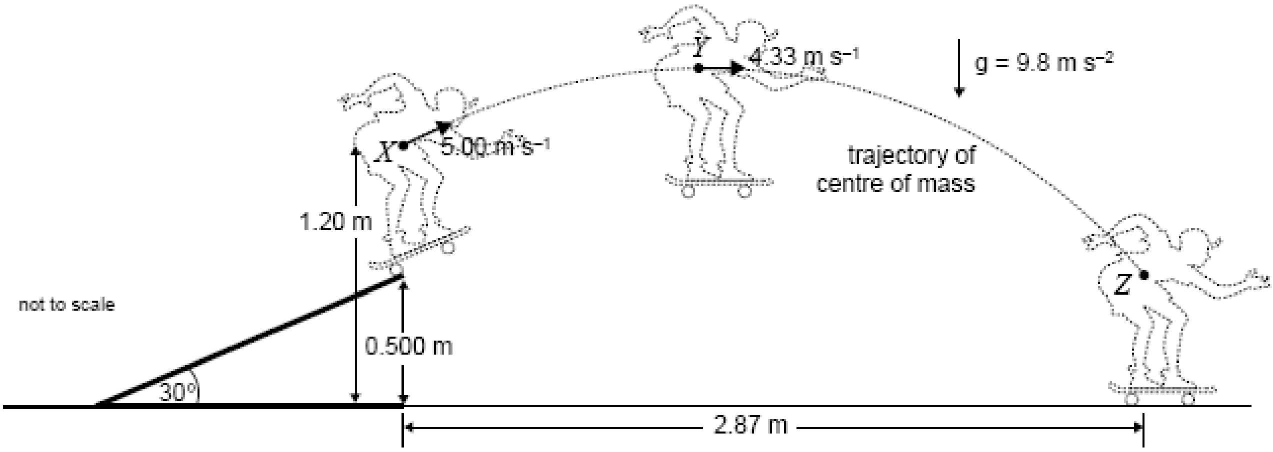
Example 21 (2000 Question 6, 2 marks)

Calculate the **horizontal** distance travelled by the surfboard, from where it breaks free to where it first strikes the water.

A skateboarder rides up a ramp as shown below. At the instant the skateboard leaves the ramp the centre of mass of the skateboard and rider is 1.20 m above the ground and is initially moving with a speed of 5.0 m s^{-1} at an angle of 30° above the horizontal.

The parabola *XYZ* is the path of the centre of mass of skateboard and rider.

In the following calculations assume that air resistance is negligible.



When the skateboarder is at the highest point of the motion (*Y*), the speed of the centre of mass is 4.33 m s^{-1}.

Example 22 (1998 Question 11, 3 marks)

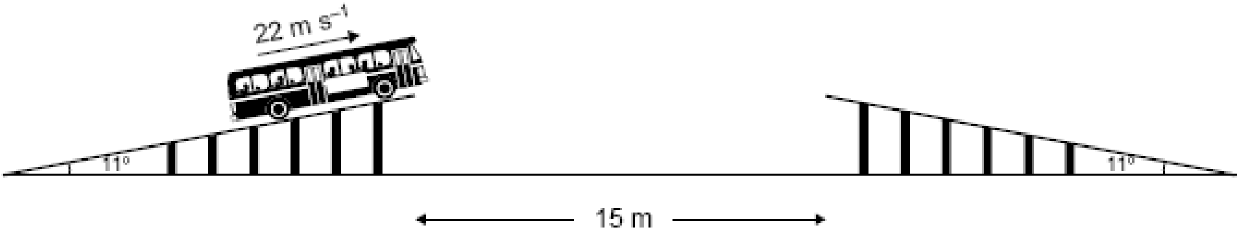
Calculate the height **above the ground** of the centre of mass at the highest point of the motion (*Y*).

When the skateboard touches the ground the centre of mass has moved a horizontal distance of 2.87 m from point *X*.

Example 23 (1998 Question 12, 3 marks)

Calculate the total time for the centre of mass to travel from *X* to *Z*. (Give your answer to three significant figures.)

In the film *Speed* a bus travelling at 22 m s^{-1} is driven over a 15 m gap in an incomplete freeway as shown. The take-off angle is 11° above the horizontal. In calculating the answers to questions 11 and 12 assume that air resistance is negligible.



Example 24 (1997 Question 11, 3 marks)

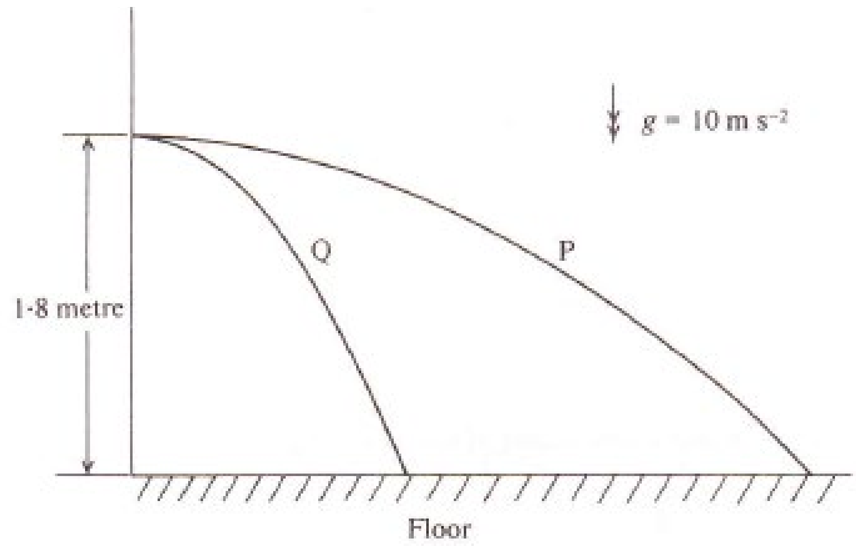
After take-off, what time does it take for the bus to reach the **highest** point in its flight?

Example 25 (1997 Question 12, 3 marks)

Does the bus land on the other section of the freeway? Show your calculations and reasoning.

Two projectiles *P* and *Q*, each of mass 2.0 kg are given initial horizontal velocities from a point
1.8 m above the floor. The path of each projectile is shown in the diagram.
Assume air resistance is zero and take g = 10 m s^{-2}.

Projectile	initial horizontal velocity
P	5.0 m s^{-1}
Q	2.0 m s^{-1}



Example 26 (1985 Question 5, 1 mark)

Calculate the KE, in Joules, of *P* immediately before it strikes the floor.

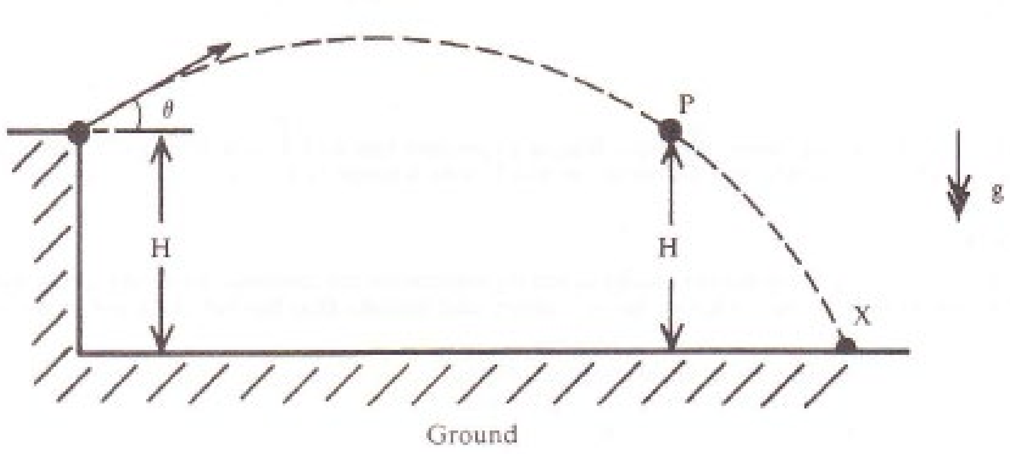
Example 27 (1985 Question 6, 1 mark)

Calculate the value of the ratio $\dfrac{\text{time of flight of } P}{\text{time of flight of } Q}$

Example 28 (1985 Question 7, 1 mark)

Calculate the horizontal distance travelled by *P* before it strikes the floor.

A marble of mass *M* is projected at an angle θ from the top of a cliff of height *H*. At the instant of projection it has a kinetic energy of *E*. This situation is shown below together with the path of the projectile. Neglect air resistance.



Example 29 (1984 Question 6, 1 mark)

What is the kinetic energy of the marble at point *P*?

Example 30 (1984 Question 7, 1 mark)

Write an expression in terms of *E*, *M*, *g* and *H* for the speed of the marble at the point *X*.

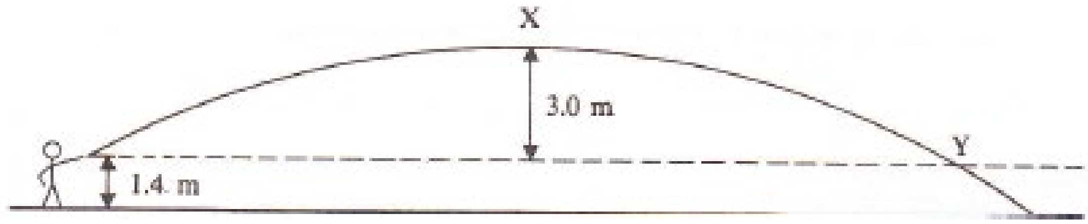
A ball is shot off a ledge horizontally with a speed of 6.0 m s^{-1}.
The ledge is 5.0 m above the ground. (Take g = 10 m s^{-2})

Example 31 (1982 Question 5, 1 mark)

How long after the ball leaves the ledge does it strike the ground?

Example 32 (1982 Question 6, 1 mark)

How far horizontally from the ledge will the ball strike the ground?



A boy throws a ball of mass 0.20 kg with an initial speed of 12 m s^{-1} from a height of 1.4 m above the ground. It travels in a path as shown in the diagram, reaching a maximum vertical height of
3.0 m above the starting point. *X* is the highest point the ball reaches.

Take g = 10 N kg^{-1} and neglect air resistance.

Example 33 (1980 Question 4, 1 mark)

What is the kinetic energy of the ball immediately after it leaves the boy's hand?

Example 34 (1980 Question 5, 1 mark)

By how much does the potential energy at point *X* exceed the potential energy of the ball as it leaves the boy's hand?

Example 35 (1980 Question 6, 1 mark)

What is the kinetic energy of the ball at point *X*?

Example 36 (1980 Question 7, 1 mark)

What is the speed of the ball at point *X*?

A ball bearing of mass 0.024 kg is shot from a catapult with an initial velocity of 16 m s^{-1} at an angle of 30^0 to the horizontal. (Take g = 10 m s^{-2})

Example 37 (1975 Question 1, 1 mark)

What was the magnitude of the impulse given to the ball bearing by the catapult?

Example 38 (1975 Question 2, 1 mark)

After what time interval has it reached its maximum vertical displacement?

Example 39 (1975 Question 3, 1 mark)

What is the maximum vertical displacement of the ball bearing?

Example 40 (1975 Question 4, 1 mark)

What is the kinetic energy of the ball bearing when it reaches its maximum height?

Example 41 (1975 Question 5, 1 mark)

What is the magnitude of the acceleration of the ball bearing when it reaches its maximum height?

A ball of mass 0.1 kg rolls on a horizontal table at 2 m s^{-1}. It hits the ground 0.4 seconds after rolling off the edge. (Take *g* = 10 m s^{-2})

Example 42 (1974 Question 1, 1 mark)

What is the horizontal distance from the edge of the table to the point where it hits the ground?

Example 43 (1974 Question 2, 1 mark)

What is the height of the table?

Example 44 (1974 Question 3, 1 mark)

At what speed does the ball hit the ground?

Example 45 (1974 Question 4, 1 mark)

At what angle to the horizontal does it hit the ground?

The ball bounces, and rises to a height of 0. 5 m.

Example 46 (1974 Question 5, 1 mark)

How much time will elapse between the first and the next time it hits the ground?

Example 47 (1974 Question 6, 1 mark)

If, on the second bounce, it loses the same proportion of its kinetic energy as it did on the first bounce, how high will it rise after the second bounce?