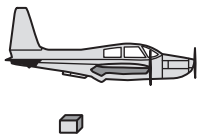
1 In areas of the world where a plane is unable to land, free fall airdrops can be used to deliver supplies.



Drop zone

A plane travelling at a speed of 75 m s^{-1} and at a height of 63 m releases a package of supplies.

(a) (i) Draw the path of the falling package on the diagram above.

(1)

(ii) Show that the time taken for the supplies to reach the ground is about 4 s.

(2)

(iii) Calculate the horizontal distance of the plane from the drop zone when rele the package.

(2)

Horizontal distance =

(b) (i) Show that the change in gravitational potential energy of the package during the fall is about 6 kJ.

mass of package = 10 kg

(2)

(ii) Show that the kinetic energy of the package on release is about 28 kJ.

(2)

(iii) Determine the kinetic energy of the package on impact.

(1)

Kinetic energy =

(iv) State why in practice the actual value for the kinetic energy on impact with the ground is less than the value you calculated in part (b)(iii).

(1)

(c) Most airdrops are not free fall and use parachutes.

State why using parachutes causes less damage to the package.

(1)

(Total for Question = 12 marks)

2 The photograph shows an athlete performing a long jump.

At take-off his horizontal speed is 8.0 m s^{-1} and his vertical speed is 2.8 m s^{-1}.

(a) Show that the total time the athlete spends in the air is about 0.6 s.

Assume that his centre of gravity is at the same height at take-off and landing.

(3)

(b) Calculate the horizontal distance jumped by the athlete.

(2)

Horizontal distance =

(c) In reality, when the athlete lands his centre of gravity is 50 cm lower than its position at take-off.

Calculate the extra horizontal distance this enables the athlete to jump.

(4)

Extra horizontal distance =

(Total for Question = 9 marks)

3 A student investigated the physics of football.

(a) She used the equations of motion to model the behaviour of a ball when kicked at different angles to the horizontal. She predicted the height of the ball when it reached the goal, presuming it was kicked from the same place, with the same initial speed, each time. The results are shown in the table below.

Angle to the horizontal / °	**Height of the ball when it reached the goal / m**
10	0.78
20	1.0
30	2.8
40	4.7

(i) State the significance of the negative value of height for an angle of 10°.

(1)

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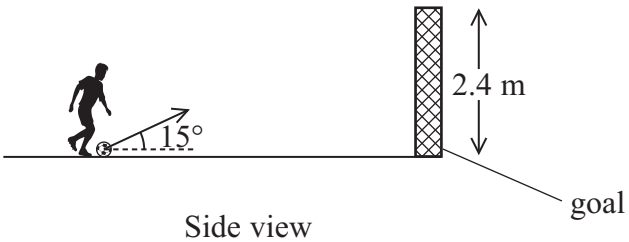
(ii) On the diagram below, sketch and label the predicted path of the ball for angles of 20° and 40°.

(2)

(b) (i) During a football match the ball is kicked towards the goal, at an angle of 15° to the horizontal, from a distance of 11 m as shown.



Side view

The ball has a diameter of 0.22 m and an initial speed of 26 m s ^{1}.

By means of a calculation, determine whether or not the ball will pass into the goal. You may ignore the effects of air resistance.

(6)

(ii) Air resistance would cause an additional force on the ball.

Explain the effect this would have on the ball's motion.

(2)

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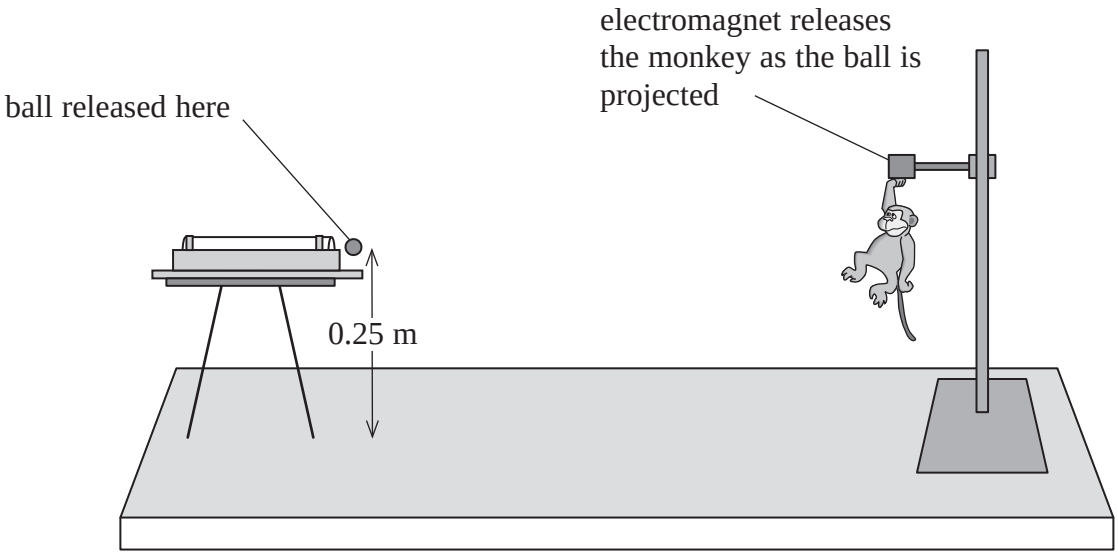
(Total for Question 11 marks)

4 The monkey and hunter is a thought experiment to illustrate the independence of the horizontal and vertical motion of a projectile.

A student models the experiment by projecting a table tennis ball horizontally at a toy monkey. The ball and monkey are initially at the same height, 0.25 m, above the bench.

The monkey drops at the instant the ball is projected. The monkey and the ball will always meet irrespective of their horizontal separation.



(a) (i) Show that the time taken for the ball to fall to the bench is about 0.2 s.

(2)

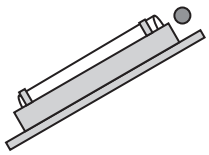
(ii) The ball is projected with a horizontal velocity of 2.6 m s^{-1}.

Calculate the horizontal distance that the ball should travel if the ball is to hit the monkey as it reaches the bench.

(2)

Horizontal distance =

(b) A variation of this experiment is where the monkey is initially higher so that the ball has to be projected upwards towards the monkey. The two objects will still always meet.



(i) Complete the diagram above to show the paths of the ball and the monkey.

(2)

(ii) The ball is projected with a velocity of 3.0 m s^{-1} at an angle of 20° to the horizontal. If the monkey is at a horizontal distance of 0.50 m, how far will it have fallen when it meets the ball?

(3)

Distance fallen =

(Total for Question = 9 marks)

5 The 'Stealth' roller coaster at the Thorpe Park theme park is advertised as reaching 135 km hour^{-1} from rest in 2.3 seconds.

Most roller coasters are driven slowly up to the top of a slope at the start of the ride. However the carriages on 'Stealth' are initially accelerated horizontally from rest at ground level by a hydraulic launch system, before rising to the top of the first slope.

(a) (i) Calculate the average acceleration of the carriages.

135 km hour^{-1} = 37.5 m s^{-1}

(2)

Average acceleration =

(ii) Calculate the minimum average power which must be developed by the launch system.

mass of carriages and passengers = 10 000 kg

(3)

Minimum average power =

(iii) Suggest why the power in (ii) is a minimum value.

(1)

*(b) The force required to launch ‘Stealth’ is not always the same. The ride is monitored and the data from preceding launches is used to calculate the required force.

If the mass of the passengers for a particular ride is significantly more than for preceding launches, this can lead to ‘rollback’. This is when the carriages do not quite reach the top of the first slope and return backwards to the start.

Explain why ‘rollback’ would occur in this situation.

(3)

(c) Suggest why roller coasters may have a greater acceleration when the lubricating oil between the moving parts has had time to warm up.

(2)

(Total for Question = 11 marks)

6 The photograph shows an arrangement used to launch a light, foam rocket at a school science competition.

The rocket is launched at the level of one end of a long table and lands at the other end at the same level. The students measure the horizontal distance travelled by the rocket and the time of flight.

(a) The rocket travels 1.88 m in a time of 0.88 s.

(i) Show that the horizontal component of the initial velocity of the rocket is about 2 m s ^{1}.

(2)

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(ii) Show that the vertical component of the initial velocity of the rocket is about 4 m s ^{1}.

(2)

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(iii) Calculate the initial velocity of the rocket.

(4)

Magnitude of initial velocity .....

Angle to the horizontal of the initial velocity .....

(b) The students obtained their data by filming the flight. When they checked the maximum height reached by the rocket they found it was less than the height predicted using this velocity.

(i) Suggest why the maximum height reached was less than predicted.

(1)

(ii) Give two advantages of filming the flight to obtain the data.

(2)

1 .....

2 .....

(Total for Question 11 marks)