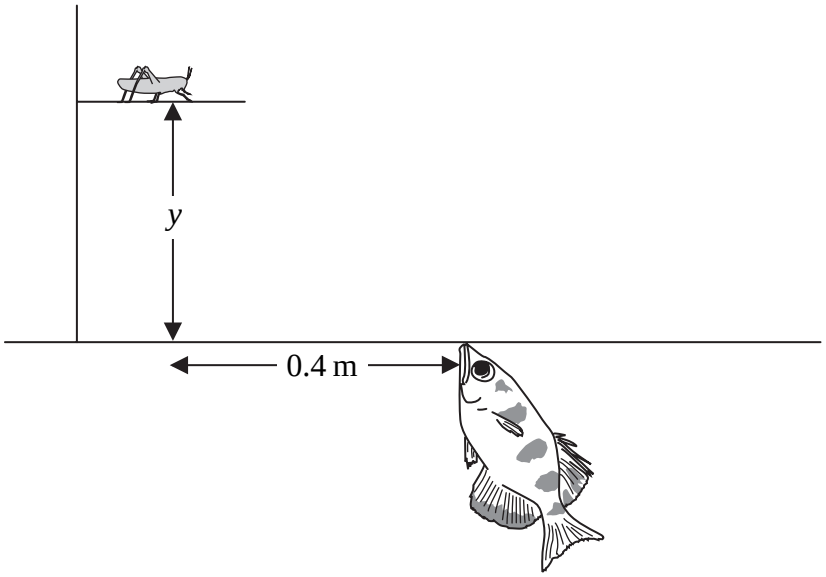
1 Archer fish spit water droplets at insects from the surface of the water.

(a) The Archer fish spits a droplet of water with a velocity of 3.5 m s^{-1} at an angle of 70° to the horizontal, aiming for an insect on a branch above the surface of the water. The horizontal distance to the insect is 0.4 m.



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

(2)

(ii) Calculate the vertical distance, *y*, to the insect if the droplet hits the insect.

(5)

Distance =

(b) Sketch the path of the water droplet on the diagram above.

(1)

(Total for Question = 8 marks)

2 Champagne bottles are often opened by 'firing' the cork out of the bottle. The world record for the horizontal distance travelled by a fired cork is 53 m.

The high pressure inside the bottle produces an average force of 150 N on the cork as it leaves the bottle. This force acts on the cork over a distance of 2.5×10^{-2} m.

(a) Show that the work done on the cork is about 4 J.

(2)

(b) Calculate the maximum speed at which the cork could leave the bottle.

mass of cork = 7.5×10^{-3} kg

(2)

Speed =

(c) The cork is fired from ground level at an angle of 40° to the horizontal with a speed of 32 m s^{-1}.

(i) Show that the vertical component of the velocity is about 20 m s^{-1}.

(1)

(ii) Calculate the horizontal distance travelled by the cork through the air.

(5)

Distance =

(d) Suggest an explanation for the difference between your calculated value and the world record distance.

(2)

(Total for Question = 12 marks)

3 An archer stands 15 m from a target. An arrow is fired horizontally at 36 m s^{-1} towards the target.

(a) (i) On the diagram draw the path of the arrow.

(1)

(ii) Show that the time taken for the arrow to reach the target is about 0.4 s.

(2)

(iii) The archer fires the arrow horizontally from a height of 1.5 m above the ground.

Calculate the height above the ground at which the arrow strikes the target.

(3)

Height above ground =

(b) Explain how your answer to part (a)(iii) would be affected if the archer stood closer to the target.

(2)

(Total for Question = 8 marks)

4 The photograph shows what happens when soft mint sweets are dropped into a bottle containing a fizzy drink. There is a sudden release of gas which forces a long stream of fluid out of the bottle.

A student decides to calculate the amount of kinetic energy transferred to the fluid in this process. In one experiment, the student places the bottle at an angle of 50° to the horizontal, adds the sweets and measures the maximum horizontal distance travelled by the fluid. The student then calculates that the fluid left the bottle at a speed of 7.5 m s ^{1}.

(a) (i) Show that the initial horizontal component of the fluid's velocity is about 5 m s ^{1}.

(1)

.....

.....

(ii) Show that the initial vertical component of the fluid's velocity is about 6 m s ^{1}.

(1)

.....

.....

(iii) Use these values to calculate the maximum horizontal distance travelled by the fluid. Assume the fluid leaves the bottle at ground level.

(4)

.....

.....

.....

.....

.....

(b) (i) Calculate the total amount of kinetic energy transferred to the fluid.

total mass of bottle, contents and sweets before the experiment 2.24 kg
total mass of bottle, contents and sweets after the experiment 0.79 kg

(2)

.....

.....

.....

Kinetic energy .....

(ii) Give a reason why your value of kinetic energy might be higher than the true value.

(1)

.....

.....

(iii) Explain why your value of kinetic energy might be lower than the true value.

(2)

.....

.....

.....

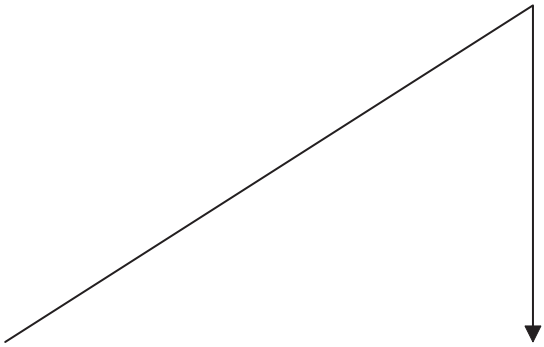
.....

(Total for Question 11 marks)

5 In the fifteenth century, an explanation of projectile motion went as follows:

When you throw an object you give it a force called impetus. It moves in a straight line until the impetus is used up. Then the object falls vertically to the ground.

The diagram shows the path described.



(a) Correct the diagram to show the path followed by a projectile according to modern observations. Assume it has the same initial direction.

(1)

(b) Explain why a projectile follows the path you have drawn. Your answer should include reference to horizontal velocity.

(3)

.....

.....

.....

.....

.....

(c) When a toy balloon is hit quickly up at an angle, it appears to follow a path similar to the one described by the fifteenth century explanation.

Explain why the balloon follows this path.

(3)

.....

.....

.....

.....

(Total for Question = 7 marks)

6 (a) State what is meant by work done.

(1)

.....

.....

.....

(b) A car of mass 1.5×10^3 kg is travelling on a country road towards a village at 55 miles per hour. The speed limit in the village is 30 miles per hour.

When the brakes are applied, there is a constant braking force of 3750 N.

Calculate the minimum distance before reaching the village that the driver should apply the brakes to avoid exceeding the speed limit.

55 miles per hour 24.6 m s ^{1}

30 miles per hour 13.4 m s ^{1}

(3)

.....

.....

.....

.....

.....

.....

.....

Minimum distance .....

(Total for Question 4 marks)