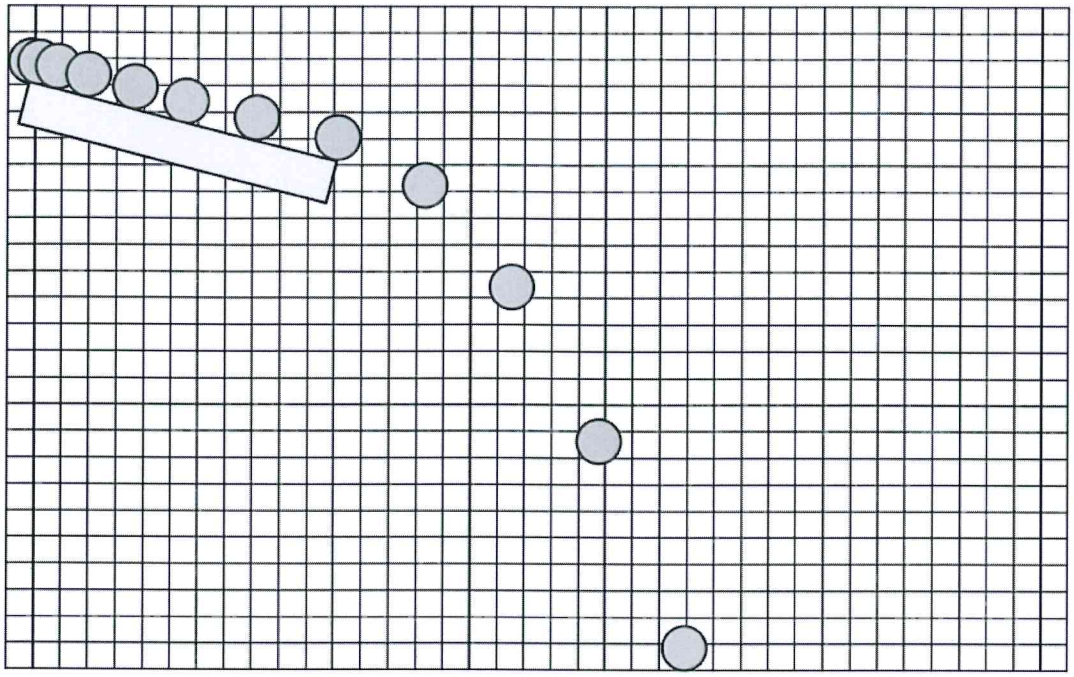
Chapter 7: Projectile Solution

Solution 1

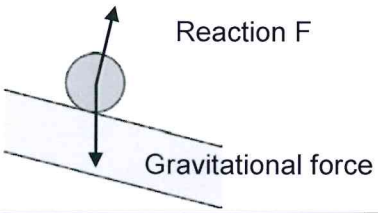
(19 marks)

Below is a diagram of a photograph taken using a strobe light flashing at 10.0 Hz. The camera is able to take multiple photographs of a single ball moving down a frictionless inclined plane over a short period of time. Each square on the background grid measures 5.0 cm × 5.0 cm. Ignore air resistance unless instructed otherwise.



(a) Draw and label the force(s) acting on the ball while it is on the inclined plane below.

(2 marks)



Description	Marks
Normal, perpendicular to surface shown and labelled	1
Gravitational force acting downwards NB maximum 1 mark if friction or resultant force shown and labelled	1
	Total 2

(b) As the ball leaves the inclined plane its motion changes. (2 marks)

(i) Describe the horizontal and vertical accelerations when the ball has left the inclined plane.

Description	Marks
Horizontally – acceleration changes to 0	1
Vertically – increases to 9.8 m s^{-2}	1
	Total 2

(ii) How would each of these accelerations be affected if air resistance was considered?

Description	Marks
Horizontally – becomes a negative acceleration	1
Vertically – decreases to less than 9.8 m s^{-2}	1
	Total 2

Solution 1 cont

(c) Use the diagram to determine the horizontal velocity of the ball after it has left the inclined plane. Express your answer to an appropriate number of significant figures. (3 marks)

Description	Marks
A displacement and time value accurately determined e.g. s = 0.64 m, t = 0.4 s	1
v = s/t =0.64/0.4 v = 1.6 m s^{-1}	1
Value within ±0.2, sig fig important	1
	Total 3

(d) The angle of the plane to the horizontal is 14°. Determine the component of gravitational acceleration that acts along the inclined plane. (2 marks)

Description	Marks
$\sin 14^\circ = a_{Slope} / 9.8$	1
a_{Slope} = 2.37 m s^{-2}	1
	Total 2

(e) Calculate the horizontal component of the ball's acceleration. Given that the ball starts from rest on the first strobe light flash and reaches the end of the inclined plane on the eighth flash, use the horizontal component of acceleration to determine the ball's horizontal velocity component as it leaves the inclined plane. (5 marks)

Description	Marks
t = 0.70 s (8-1 flashes × $^1/_{10}$ of a second)	1
$\cos 14^\circ = a_H / a_{Slope}$	1
a_H = 2.30 m s^{-2}	1
v = u + at = 0 + 2.30 × 0.70	1
v = 1.61 m s^{-1}	1
	Total 5

(f) Use the motion of the ball to calculate the length of the inclined plane. (3 marks)

Description	Marks
Sorry markers, a number of methods exist for this one. Give credit where physics calculations and reasoning exists. Example below. (1 mark only if length measurements from graph are used)	
a_{Slope} = 2.37 m s^{-2}; t= 0.7 s from (e) or graph (uses appropriate values)	1
s = 0t + 0.5 × 2.37 × 0.7^2 (calculation appropriate)	1
s = 0.58 m (answer close to value)	1
	Total 3

Solution 2

(5 marks)

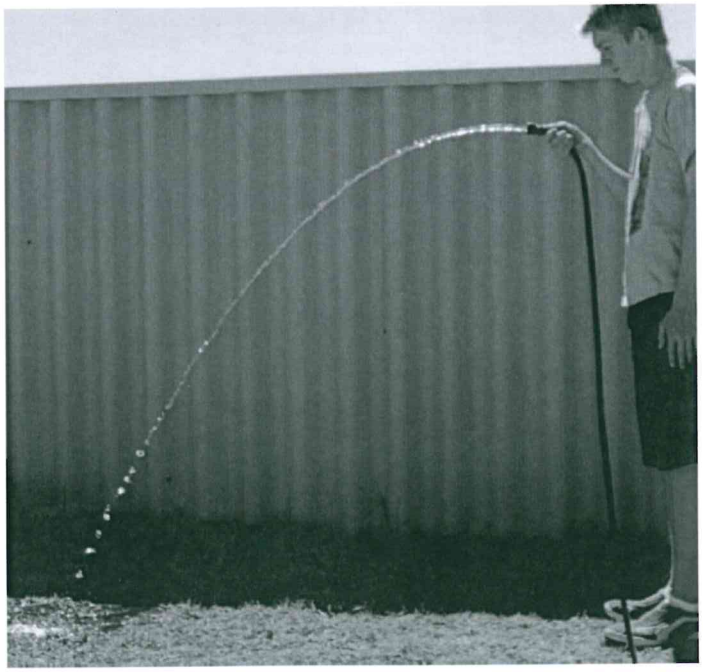
Mindy flicks a coin across a desk. The coin leaves the edge of the desk and lands at a point 0.455 m below the desk top and 1.45 m from the edge of the desk. Calculate the velocity in m s^{-1} of the coin as it leaves the desktop.

Description	Marks
$s_v = u_v t + 1/2 a t^2$ $0.455 = 0 + 1/2(9.8)t^2$ $t = \sqrt{(2 \times 0.455/9.8)}$ t=0.305 s	1–3
$v_h = s_h/t = 1.45/0.305$ v_h = 4.76 m s^{-1}	1–2
Total	**5**

Solution 3

(5 marks)

Mick is watering the lawn and wants to estimate the initial velocity of the water coming from the hose. Use information from the photograph to estimate the magnitude of the initial velocity of the water. Express your answer to an appropriate number of significant figures.



Description	Marks
Estimate initial height 1.5 m Estimate distance = 1.5 m (accept 1–2 m as 1 sig fig)	1
$s = ut + \frac{1}{2} at^2$ (1 mark using an appropriate formula with $u_v = 0$)	1
$1.5 = 0t + \frac{1}{2} 9.8t^2$ $t = \sqrt{(2 \times 1.5/9.8)} = 0.55$ s (accept 0.45 s to 0.63 s)	1
$v = s/t = 1.5/0.55 = 2.7$ m s^{-1} (2.2 to 3.1 acceptable)	1
(1 mark answer sig fig/direction)	1
	Total 5

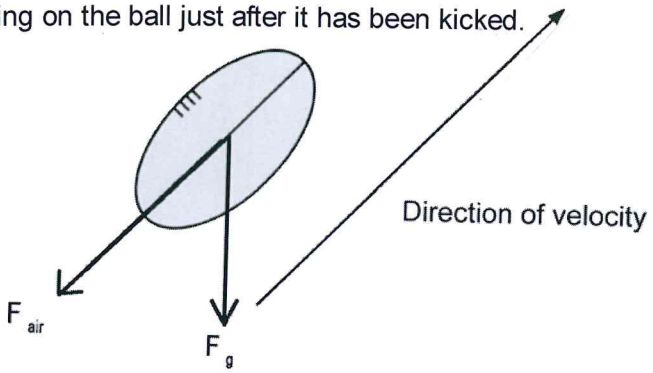
Solution 4

(14 marks)

Gary is playing in a park and decides to kick a ball over a branch of a large tree. He places the ball on the ground to kick it. The path of the ball is shown in the diagram. The tree is 10.0 m away. Gary kicks the ball with a velocity *v* at an angle of 23.5° to the horizontal. The ball will just clear the branch.

Solution 4 cont

(a) Draw the force(s) acting on the ball just after it has been kicked. (2 marks)



Description	Marks
F_g down	1
Air resistance in the opposite direction to motion	1
Total	**2**

(NB: arrows not labelled only 1 mark)

(b) The ball is in the air for 1.33 s. Assuming no air resistance, determine:

(i) the initial velocity of the ball in m s^{-1} (4 marks)

Description	Marks
$v_h = s_h/t = 2 \times 10/1.33$ $= 15.0$ m s^{-1}	1–2
$v = v_h/\cos 23.5° = 15.0/\cos 23.5° =$ $v = 16.4$ m s^{-1} (or 16.3)	1–2
Total	**4**

(ii) the height of the branch (3 marks)

Description	Marks
$s_v = u_v t + \frac{1}{2}at^2$ and $u = v - at$ $s_v = v_v t - \frac{1}{2}at^2$ (or realising the distance is the same if falling for 1.33/2 s) $= 0 \times 1.33/2 - \frac{1}{2}(-9.8) \times (1.33/2)^2$ = 2.17 m (no penalty for lack of units if number expressed in metres)	1–3
Total	**3**

(iii) the distance in metres on the opposite side of the tree that Gary should place his sister so she can catch the ball when it is 1.25 m above the ground. (5 marks)

Description	Marks
2.17 - 1.25 = 0.92 m down from the branch $s_v = u_v t + \frac{1}{2}at^2$ $t = \sqrt{(2 \times s_v/a)} = \sqrt{(2 \times (0.92)/(-9.8))} = 0.433$ s past the tree	1–3
$s_H = v_H \times t = 15 \times 0.433$ $s_h = 6.50$ m	1–2
Total	**5**

(NB: A range of methods can be used giving answers of 6.4–6.6 depending on prior rounding)