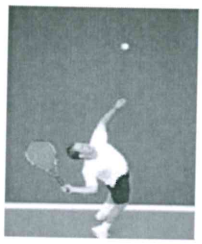
Exam Answers
Chapter 1·3 - Projectile Motion
Answer 1 2010:2:17

(11 marks)

While serving a tennis ball, a tennis player aims to hit the ball horizontally so that it lands in the opponent's court 5.50 m from the net. The height of the net is 0.900 m, the distance between the serve point and the net is 11.9 m and the ball is hit from a height of 2.80 m. Ignore air resistance.

(a) Draw a diagram to illustrate the path of the ball with all relevant distances labelled. (2 marks)



2.8m

0.90m

11.9 m 5.5 m

Description	Marks
All 4 distances recorded correctly, deduct marks for missing measurements.	1–2
	Total 2

(b) Calculate the time taken for the tennis ball to reach the net and the minimum initial speed that the tennis ball would need to just clear the net. (3 marks)

Description	Marks
Resolve vertically (2.8-0.9) $= 0 + 4.9\ t^2$	1
Time to reach net = 0.623 s	1
Speed = 11.9/ 0.623 = 19.1 m s^{-1}	1
	Total 3

(c) Calculate the length of time the ball is in the air. (3 marks)

Description	Marks
Resolve vertically, $s = ut + 4.9\ t^2$	1
$2.8 = 0 + 4.9\ t^2$	1
Time = 0.756 s	1
	Total 3

(d) Calculate the distance from the net that the ball will land on the opponent's side of the court. If you were unable to determine an answer in part (c) you should assume that the time of flight is 0.900 s and if you were unable to determine an answer to part (b) you should assume that the minimum initial speed is 20.0 m s^{-1}. (3 marks)

Description	Marks
Horizontal velocity remains unchanged at 19.1 m s^{-1}	1
Resolve horizontally $s = ut$ $= 19.1 \times 0.756 = 14.4$ m	1
Distance = 14.4 m from where it is hit , from net is 2.54 m	1
	Total 3

If use 19.1 m s^{-1} and 0.90 s then distance is 17.2 m - 11.9 m = 5.3 m (2 marks)

If use 20 m s^{-1} and 0.90 s then distance is 18.0 m -11.9 = 6.1 m (2 marks)

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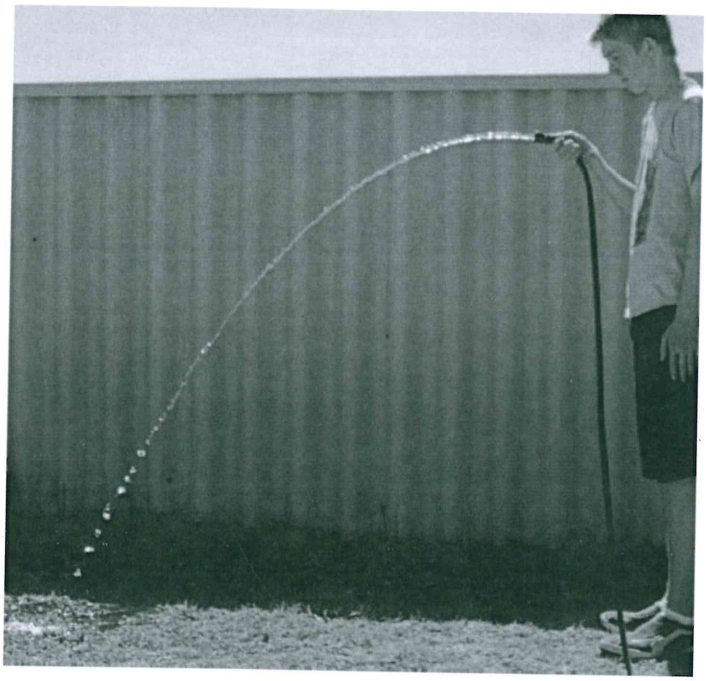
Answer 2 2011:1:7

(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

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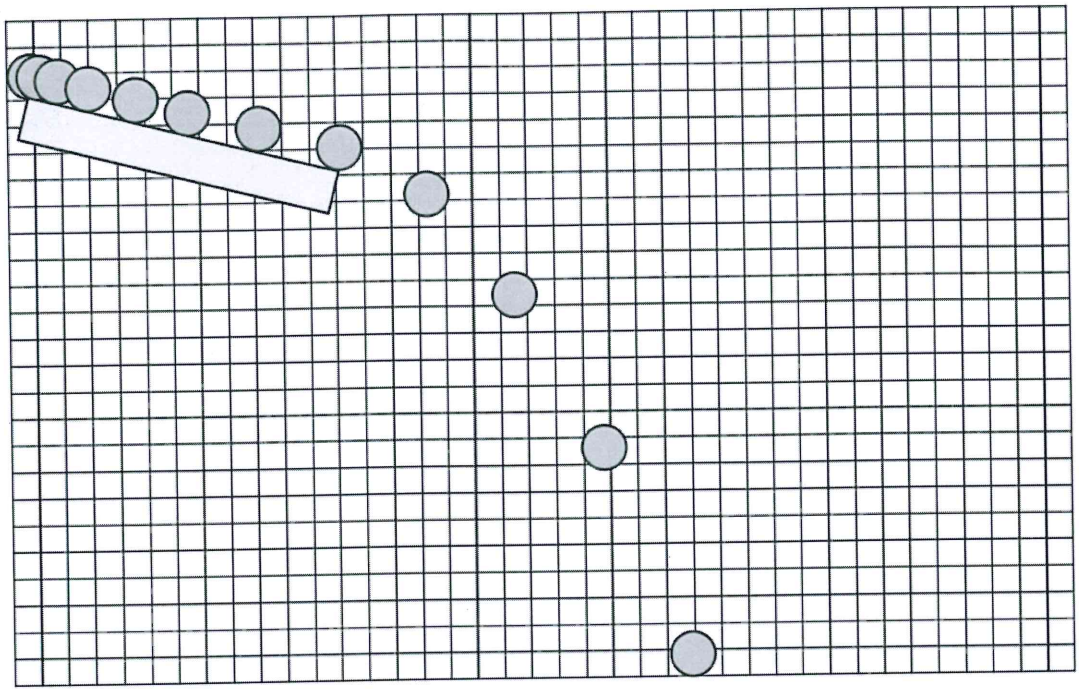
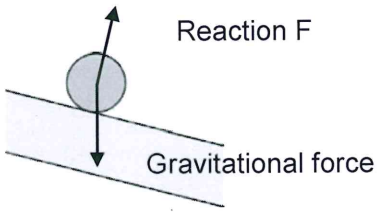
Answer 3 2011:2:19

(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

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Answer 3: continued

(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
$s = 0t + 0.5 \times 2.37 \times 0.7^2$ (calculation appropriate)	1
s = 0.58 m (answer close to value)	1
	Total 3

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Answer 4 2013:1:1

(5 marks)

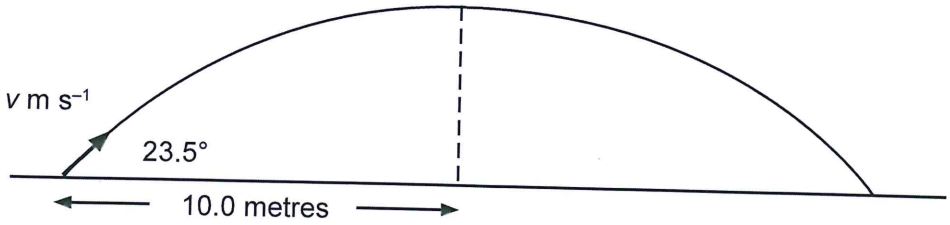
Mindy flicks a coin across a desk. The coin leaves the edge of the desk and lands at a point 0.455 m below the desk top and 1.45 m from the edge of the desk. Calculate the velocity in m s^{-1} of the coin as it leaves the desktop.

Description	Marks
$s_v=u_vt+1/2at^2$ $0.455=0+1/2(9.8)t^2$ $t=\sqrt{(2\times0.455/9.8)}$ $t=0.305$ s	1–3
$v_h=s_h/t=1.45/0.305$ $v_h=4.76$ m s^{-1}	1–2
Total	**5**

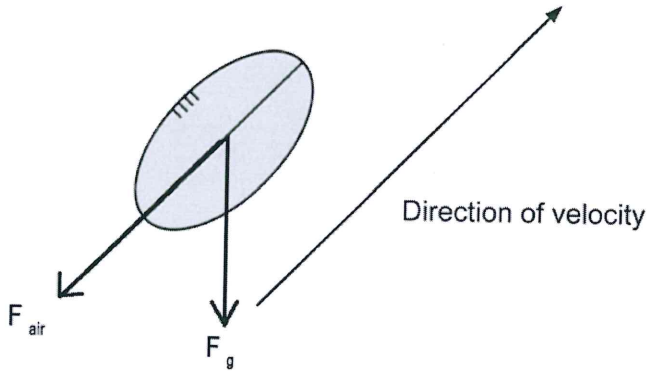
Answer 5 2013:2:13

(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.



(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)

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Chapter 1·3 - Projectile Motion
Answer 5: continued

(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)

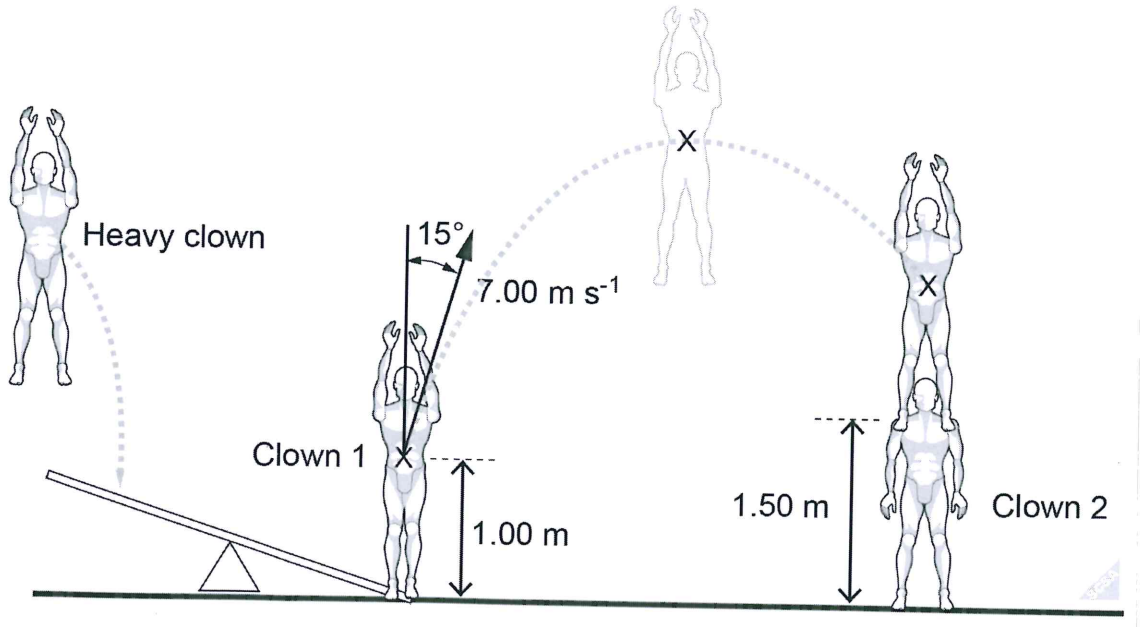
Description	Marks
$s_v = u_v t + \frac{1}{2}at^2$ and $u = v - at$ $s_v = v_v t - \frac{1}{2}at^2$ (or realising the distance is the same if falling for 1.33/2 s) $= 0 \times 1.33/2 - \frac{1}{2}(-9.8) \times (1.33/2)^2$ = 2.17 m (no penalty for lack of units if number expressed in metres)	1–3
Total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

Answer 6 2014:2:15

(10 marks)

Clown 1 is standing on a seesaw. As part of the circus act a heavy clown will jump from a height and land on the opposite side of the seesaw to Clown 1. This will launch Clown 1 into the air with a velocity of 7.00 m s^{-1} at an angle of 15° to the vertical.

Clown 1 will travel through the air and land on the shoulders of Clown 2, following the trajectory shown with a dotted line (diagram is not drawn to scale). The centre of mass of Clown 1 is shown with an 'X'.



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Answer 6: continued

(a) On the diagram above, draw an arrow to show the direction of acceleration of Clown 1's centre of mass at the point of maximum height. (1 mark)

Description	Marks
Arrow should be pointed downwards at the top point of the parabola. Slightly to the left is acceptable, but not to the right.	1
Total	**1**

(b) Describe qualitatively **two** effects of air resistance on projectile motion in this case. (2 marks)

Description	Marks
Clown 1 will not reach maximum height	1
Clown 1's horizontal velocity will not be constant and decrease over time. Range decreases or horizontal distance is less.	1
Total	**2**

(c) Show by calculation that the total time Clown 1 is in the air is just over 1.1 s. Ignore air resistance. (4 marks)

Description		Marks
$v_v = v \cos\theta = 7 \cos 15^0$ $= 6.76 \text{ m s}^{-1}$		1–2
$s=ut+\frac{1}{2}at^2$ $1.5=6.76t+\frac{1}{2}(-9.8)t^2$	Or $s=ut+\frac{1}{2}at^2$ $s=6.76(1.1)+\frac{1}{2}(-9.8)(1.1)^2$	1
t= 1.102 s (just over)	s=1.507 m (not quite to 1.5m)	1
	Total	**4**

(d) Determine the initial horizontal distance between Clown 1 and Clown 2. Ignore air resistance. Show **all** workings. (3 marks)

Description	Marks
$v_h = v \sin\theta = 7\sin 15°$ $= 1.81 \text{ m s}^{-1}$	1–2
$s_h = v_h \times t = 1.81 \times 1.10$ $s_h = 1.99 \text{ m}$	1
Total	**3**