Projectiles AQA M1 2005-2010 Mark Schemes

Jan 05

8(a)	Ball is a particle No air resistance	B1 B1	2	One appropriate assumption Second appropriate assumption
(b)(i)	$0 = 12\sin 40° - 9.8t$ $t = \dfrac{12\sin 40°}{9.8} = 0.787$ s	M1 A1 M1 A1	4	Equation to find time at maximum height Correct equation Solving for t Correct time
(ii)	$h = 12\sin 40° \times 0.7871 - 4.9 \times 0.7871^2$ $= 3.04$ m	M1 A1 A1	3	Substituting time from previous into expression for height Correct expression AG; correct height from correct working
(c)	$2.44 = 12\sin 40°t - 4.9t^2$ $4.9t^2 - 12\sin 40°t + 2.44 = 0$ $t = 0.4385$ or 1.136 $s = 12\cos 40° \times 1.136 = 10.4$ m	M1 A1 A1 m1 A1 M1 A1	7	Equation for time to get to the bar, based on height being 2.44 Correct LHS Correct RHS Solving quadratic Correct time / times Substituting their larger time into an expression for the horizontal displacement Correct distance
	Total		**16**	

Jan 06

5(a)	$s = ut + \frac{1}{2}at^2$			
	$0 = 2\frac{1}{2}ut - \frac{1}{2}gt^2$	M1 A1		full method required for time (equation of motion, or standard result)
	$0 = t\left(2\frac{1}{2}u - \frac{1}{2}gt\right)$	m1		
	$t = \frac{5u}{g}$	A1	4	(if $g = 9.8$ used, lose last A1)
(b)	$OA = 6u \times \frac{5u}{g}$	M1		
	$= \frac{30u^2}{g}$	A1	2	cao
(c)	$\text{speed}^2 = (6u)^2 + \left(2\frac{1}{2}u\right)^2$	M1		
	$\text{speed} = 6\frac{1}{2}u$	A1	2	cao
(d)	Least speed, at top, $= 6u$	B1	1	
	Total		**9**	

Q	Solution	Marks	Total	Comments
7(a)	$0^2 = (50\sin 40°)^2 + 2\times(-9.8)h$	M1A1		Equation for h with $v = 0$ and a component of velocity. Correct equation
	$h = \dfrac{(50\sin 40°)^2}{2\times 9.8} = 52.7$	dM1 A1		Solving for h Correct h
	Alt			
	$0 = 50\sin 40° - 9.8t$	(M1)		Equation for t with $v = 0$ and a component of velocity
	$t = \dfrac{50\sin 40°}{9.8} = 3.280$	(A1)		Correct t
	$h = 50\sin 40°\times 3.280 - \dfrac{1}{2}\times 9.8\times 3.280^2$	(dM1)		Expression for h with a component of velocity
	$= 52.7$ ALLOW 52.6	(A1)	4	Correct h
(b)	$6 = 50\sin 40°t - 4.9t^2$	M1A1		Forming a quadratic in t. Correct terms with any signs
	$0 = 4.9t^2 - 50\sin 40°t + 6$	A1		Correct equation
	$t = \dfrac{50\sin 40° \pm \sqrt{(50\sin 40°)^2 - 4\times 4.9\times 6}}{2\times 4.9}$	dM1		Solving quadratic
	$= 0.192$ or 6.37 $t = 6.37$	A2	6	Correct solution selected
	Alt			
	$46.7 = 4.9t_1^2$	(M1) (dM1)		Finding two times Equation for time to go down
	$t_1 = 3.087$	(A1)		Correct time
	$t_2 = 3.280$	(A1)		Time to go up
	$t = 3.087 + 3.280 = 6.37$	(A2)		Correct total
	Total		**10**	

Jan 08

7(a)	It is a particle /No air resistance / lift forces act on the ball.	B1 B1	2	Particle Other acceptable assumption Deduct one mark for each additional incorrect assumption.
(b)	$V\sin 40°t - \frac{1}{2}\times 9.8t^2 = 0$ $t = \frac{V\sin 40°}{4.9}$ $s = V\cos 40° \times \frac{V\sin 40°}{4.9}$ **AG** $= \frac{V^2\cos 40°\sin 40°}{4.9}$	M1 A1 dM1 A1 M1 A1	6	Vertical equation to find t. Correct equation (Equals zero may be implied) Solving for t Correct t Finding range with their t Correct range from correct working SC Quoting the formula for the range 2 marks.
(c)	$76 < \frac{V^2\cos 40°\sin 40°}{4.9} < 82$ $\sqrt{\frac{76\times 4.9}{\cos 40°\sin 40°}} < V < \sqrt{\frac{82\times 4.9}{\cos 40°\sin 40°}}$ $27.5 < V < 28.6$	M1 A1 A1 A1	4	An equation to find one value of V. Correct value for V Other value of V correct Correct range of values Accept 27.5 – 28.6 but not 28.6-27.5 For using values close to 76 and 82 deduct one mark.
	Total		**12**	

Jan 09

Q	Solution	Marks	Total	Comments
8				If candidates have already used $g = 9.81$ do not penalise again on this question.
(a)	$0^2 = (28\sin 50°)^2 + 2\times(-9.8)s$ $s = \frac{(28\sin 50°)^2}{2\times 9.8} = 23.5$ m **OR** $0 = 28\sin 50° - 9.8t$ $t = \frac{28\sin 50°}{9.8} = 2.1887$ $s = 28\sin 50°\times 2.1887 - 4.9\times 2.1887^2 = 23.5$	M1 A1 dM1 A1 (M1) (A1) (dM1) (A1)	4	M1: Equation to find the max height, with $v = 0$, $u = 28\sin 50°$ or $u = 28\cos 50°$ and –9.8 or $-g$. A1: Correct equation dM1: Solving for the height A1: Correct height. Awrt 23.5 Note: If using a memorised formula, either 4 marks if final answer correct, 3 marks if substituted correctly but evaluated incorrectly, otherwise zero. M1: Equation to find time to the max height, with $v = 0$, $u = 28\sin 50°$ or $u = 28\cos 50°$ and –9.8 or $-g$. A1: Correct time dM1: Finding the height with their time and $u = 28\sin 50°$ or $u = 28\cos 50°$ and –4.9 or $-g/2$ A1: Correct height. Awrt 23.5

Q	Solution	Marks	Total	Comments
8(b)	$2 = 28\sin 50°t - 4.9t^2$	M1		M1: Quadratic equation in t with a ± 2, $u = 28\sin 50°$ or $u = 28\cos 50°$ and -4.9 or $-g/2$.
		A1		A1: Correct terms
		A1		A1: Correct signs for equation
	$0 = 4.9t^2 - 28\sin 50°t + 2$ $t = 0.0953$ or $t = 4.282$	dM1		dM1: Solving the quadratic equation
	$t = 4.282 = 4.28$ s (to 3 sf) **AG**	A1		A1: Correct larger time selected from two values.
	OR			
		(M1)		M1: Calculation of two times, which sum or differ to give the time of flight.
	$0 = 28\sin 50° - 9.8t$ $t = \dfrac{28\sin 50°}{9.8} = 2.1887$	(A1)		A1: Correct time by equation for zero vertical component of velocity or maximum height.
	OR $23.5 = 28\sin 50°t - 4.9t^2$ $t = 2.1887$			
	$21.5 = 4.9t^2$	(dM1)		dM1: Correct expression for time to fall.
	$t = \sqrt{\dfrac{21.5}{4.9}} = 2.0947$	(A1)		A1: Correct time.
	2.1887 + 2.0947 = 4.2834 = 4.28 (to 3sf) **AG**	(A1)	5	A1: Correct time. Accept 4.29 if their answer rounds to 4.29.

Q	Solution	Marks	Total	Comments
8(c)	$v_x = 28\cos 50°$ $(= 18.00\ \text{ms}^{-1})$	B1		B1: Horizontal component, need not be evaluated.
	$v_y = 28\sin 50° - 9.8 \times 4.282 = -20.51\ \text{ms}^{-1}$	M1		M1: Equation for vertical component with $28\sin 50°$ (or $28\cos 50°$ if sin50° used for horizontal component), -9.8 and awrt 4.28.
		A1		A1: Correct vertical component. Awrt $\pm$ 20.5
	$v = \sqrt{18.00^2 + 20.51^2} = 27.3\ \text{ms}^{-1}$	dM1		dM1: Finding speed with a + sign inside the square root.
		A1F	5	A1F: Correct speed. Awrt 27.3. Intermediate values can be implied by final answer.
	Total		**14**	

Jan 10

Q	Solution	Marks	Total	Comments
7(a)	$5=\frac{1}{2}\times 9.8t^2$	M1 A1		M1: Equation based on vertical motion with no velocity component, with ±5 and ±9.8 A1: Correct equation
	$t=\sqrt{\frac{5}{4.9}}=1.01$ s **AG**	A1	3	A1: Correct time from correct working. Must see square root or $t^2=1.02$ OE Note: If $g=9.81$ is used for the first time deduct one mark. Should still get 1.01 seconds.
(b)	$15=V\times\sqrt{\frac{5}{4.9}}$	M1		M1: Using distance = speed×time OE
	$V=15\sqrt{\frac{4.9}{5}}=14.8$	A1	2	A1: Correct speed. Accept AWRT 14.8 or 14.9. Note: If $g=9.81$ is used for the first time deduct one mark. Should get 14.9 ms^{-1} from $g=9.81$.
(c)	$v_V=\pm 9.8\times\sqrt{\frac{5}{4.9}}\left(=\pm 9.899\right)$ or $v_V=\sqrt{2\times 9.8\times 5}=9.899$	M1A1		M1: Calculating vertical component of velocity. A1: Correct value. Accept 9.9 or similar
	$v=\sqrt{9.899^2+14.8^2}=17.8$ ms^{-1}	dM1 A1F	4	dM1: Finding magnitude (with addition not subtraction of squares inside the square root). A1: Correct speed. Accept AWRT 17.8 or AWRT 17.9. Note: If $g=9.81$ is used for the first time deduct one mark. Should get 17.9 ms^{-1} from $g=9.81$
(d)	$\tan\alpha=\frac{9.899}{14.8}$ or $\frac{14.8}{9.899}$ $\alpha=34°$	M1 A1F A1F	3	M1: Use of one of trig equations shown. A1F: Anything which rounds to 34° or 56° A1F: 34° CAO (33° scores M1A1A0)
	$\sin\alpha=\frac{9.899}{17.8}$ or $\frac{14.8}{17.8}$ $\alpha=34°$	(M1) (A1F) (A1F)		Only follow through if all method marks in (b) and (c) have been awarded (except the dM if tan used) .
	$\cos\alpha=\frac{14.8}{17.8}$ or $\frac{9.899}{17.8}$ $\alpha=34°$	(M1) (A1F) (A1F)		
(e)	Particle Experiences no air resistance **or** no wind **or** only gravity **or** no other forces acting **or** no spin.	B1 B1	2	B1: Particle assumption B1: Other assumption. Ignore any other assumptions.
	Total		**14**	