adamjee maths

A-LEVEL MATHS / EDEXCEL / FREE RESOURCES

Projectiles

Mark scheme

4 questions

Exam questions and marking instructions remain credited to their board.

Contents

1 June 2025 - Paper 3 Mechanics - Q5

2 June 2023 - Paper 3 Mechanics - Q5

3 October 2021 - Paper 3 Mechanics - Q4

4 October 2020 - Paper 3 Mechanics - Q5

5(a)	Using horizontal motion	M1	3.3
	$14\cos\theta \times t = 40$	A1	1.1b
	Using vertical motion	M1	3.4
	$(s =)14\sin\theta \times t - \frac{1}{2}gt^2$ oe with down as positive.	A1	1.1b
	OR		
	Using the equation of the path		
	$(s =)40\tan\theta - \frac{g \times 40^2}{2 \times 14^2 \cos^2\theta}$ oe	M2 A2	
	$(H =)$ 30 or 30.0	A1	1.1b
		(5)	
5(b)	Using vertical motion **OR** Using cons. of energy	M1	2.1
	$0^2 = (14\sin\theta)^2 - 2gh$ $\quad$ $\frac{1}{2}m(14^2 - (14\cos\theta)^2) = mgh$	A1	1.1b
	32 (m)	A1**ft**	1.1b
		(3)	
			(8 marks)

Notes:

N.B. Penalise the use of g = 9.81 **once** (the first time it is used) for the whole question.
All marks available if they use a different letter for θ

5(a)	M1	Complete method, using the horizontal motion, to give an equation in t and θ only, condone sin/cos confusion and sign errors (θ may or may not be substituted for)
	A1	Correct equation (t and/or θ may or may not be substituted for)
	M1	Complete method, using the vertical motion, to give an equation in t and θ only, condone sin/cos confusion and sign errors (t and/or θ may or may not be substituted for)
	A1	Correct equation (t and/or θ may or may not be substituted for) **N.B.** Just mark the RHS of the equation for this A mark.
	OR	
	M2 A2	Quoting and using correctly the equation of the path. **N.B.** No marks if they misquote the equation and no marks if they put in 14 and/or 40 incorrectly. These 4 marks are indivisible i.e. all 4 or 0.
	A1	H = 30 or 30.0 to 2 or 3 sf, after use of g = 9.8, **obtained correctly**.

5(b)	M1	Complete method to give equation in h and θ only, condone sin/cos confusion and sign errors They may find t first: $0 = 14\sin\theta - gt \Rightarrow t = \dfrac{14\sin\theta}{g}$ then $h = (14\sin\theta)\dfrac{14\sin\theta}{g} - \dfrac{1}{2}g\left(\dfrac{14\sin\theta}{g}\right)^2$ or $h = -\dfrac{1}{2}(-g)\left(\dfrac{14\sin\theta}{g}\right)^2$ or $h = \dfrac{(14\sin\theta + 0)}{2}\left(\dfrac{14\sin\theta}{g}\right)$
	A1	Correct equation
	A1**ft**	$\lvert$their $H\rvert + 2$, to 2sf or 3sf

Question	Scheme	Marks	AOs

5(a)	Use horizontal motion to give an equation in *T* and α only: $28\cos\alpha \times T = 40$	M1	3.4
	$T = \dfrac{10}{7\cos\alpha}$ *	A1*	1.1b
		(2)	
5(b)	Use vertical motion to give an equation in *T* and α only	M1	3.3
	$20 = (28\sin\alpha)T - \dfrac{1}{2}gT^2$	A1	1.1b
	Eliminate *T* to give an unsimplified equation in α only: $20 = (28\sin\alpha) \times \dfrac{10}{7\cos\alpha} - \dfrac{1}{2}g\left(\dfrac{10}{7\cos\alpha}\right)^2$	M1	1.1b
	Use $\sec^2\alpha = 1 + \tan^2\alpha$ oe to give an unsimplified equation in **tan α only** : $20 = 40\tan\alpha - \dfrac{1}{2}g \times \dfrac{100}{49}(1 + \tan^2\alpha)$	M1	3.1b
	$\tan^2\alpha - 4\tan\alpha + 3 = 0$ * (allow $0 = \tan^2\alpha - 4\tan\alpha + 3$)	A1*	2.2a
		(5)	
5(c)	Solve and use of $\tan\alpha = 3$ or $\sin\alpha = \dfrac{3}{\sqrt{10}}$ or $\alpha = 71.565..^o$ to find an equation in *H* only.	M1	3.1b
	$0 = (28\sin\alpha)^2 - 2gH$ **where** $\tan\alpha = 3$ $(\alpha = 71.565..^o)$	M1	3.4
	H = 36 or 36.0 (m)	A1	1.1b
		(3)	
5(d)	e.g. spin of the ball, the wind, the dimensions or shape of the ball, ball is modelled as a particle, uses an inaccurate value of *g*, motion takes place in 3D not in 2D, *g* could be variable. B0 if mass or weight are mentioned. B0 for ground may not be horizontal.	B1	3.5b
		(1)	

		(11 marks)
Notes:		
5a	M1	Correct no. of terms, dim correct, condone sin/cos confusion and sign errors
	A1*	Correct printed answer correctly obtained. Allow $\frac{10}{7\cos\alpha} = T$ OR $T = \frac{40}{28\cos\alpha} = \frac{10}{7\cos\alpha}$ OR $\frac{40}{28\cos\alpha} = \frac{10}{7\cos\alpha} = T$ OR *t* instead of *T*
5b	M1	Correct no. of terms, dim correct, condone sin/cos confusion and sign errors
	A1	Correct equation
	M1	Eliminate *T*, using either the given answer in (a) or their own *T* expression, from their equation to give an unsimplified equation in α only
	M1	Use $\sec^2\alpha = 1 + \tan^2\alpha$ to produce an equation in $\tan\alpha$ only
	A1*	Given answer correctly obtained. **N.B.** Must be α (or *a*) in the final answer but allow a different angle in the working.
5c	M1	Solve given equation and select larger value of $\tan\alpha$ and use it to try to obtain an equation in *H* only.
	M1	Complete method to give an equation in ***H* only**, using **<u>larger</u>** value of α , correct no. of terms, dim correct, condone sin/cos confusion and sign errors.
	A1	cao. Must be positive, (allow a negative value, changed to a positive answer). **N.B.** This answer comes from use of *g* = 9.8, so must be rounded to 2 or 3 sf.
5d	B1	B0 if any incorrect extras

Question	Scheme	Marks	AOs

4(a)	Use $s = ut + \frac{1}{2}at^2$ vertically or any complete method to give an equation in t only	M1	3.4
	$-70 = 65\sin\alpha \times t - \frac{1}{2} \times g \times t^2$	A1	1.1b
		M (A)1	1.1b
	$t = 7$ (s)	A1	1.1b
		(4)	
4(b)	Horizontal velocity component at $A = 65\cos\alpha$ (60)	B1	3.4
	Complete method to find vertical velocity component at A	M1	3.4
	$65\sin\alpha - g \times 7$ **OR** $\sqrt{(-25)^2 + 2g \times 70}$ (45)	A1**ft**	1.1b
	Sub for trig and square, add and square root : $\sqrt{60^2 + (-45)^2}$	M1	3.1b
	75 Accept 80 (m s^{-1})	A1	1.1b
		(5)	
4(c)	e.g. an approximate value of g has been used, the dimensions of the stone could affect its motion, spin of the stone, $g = 10$ instead of 9.8 has been used, g has been assumed to be constant, wind effect, shape of the stone	B1	3.5b
		(1)	
			(10 marks)

Notes:

4a	M1	Complete method, correct no. of terms, condone sign errors and sin/cos confusion
	A1	Correct equation in t only with at most one error
	M(A)1	Correct equation in t only
		N.B. For 'up and down' methods etc, the two A marks are for all the equations that they use, lose a mark for each error.
	A1	Cao (g = 9.8 , 7.1 or 7.11) (g = 9.81 , 7.1 or 7.12)
4b	B1	Seen, including on a diagram.
	M1	Condone sign errors and sin/cos confusion
	A1**ft**	Correct expression; accept negative of this, follow their t
	M1	Sub for trig and use Pythagoras
	A1	Cao (g = 9.8 or 9.81 , 75 or 74.8)

4c	B1	B0 if incorrect extras

Question	Scheme	Marks	AOs
	Allow column vectors throughout this question		

5(a)	Using horizontal motion	M1	3.3
	$U\cos 45^\circ t = 100$	A1	1.1b
	Using vertical motion	M1	3.4
	$U\sin 45^\circ t - \frac{1}{2}gt^2 = -25$	A1	1.1b
	Solve problem by eliminating t and solving for U	M1	3.1b
	$U = 28$*	A1*	1.1b
		(6)	
5(b)	Using vertical motion	M1	3.4
	$0^2 = (28\sin 45^\circ)^2 - 2gh$	A1	1.1b
	Greatest height = 45 m	A1	1.1b
		(3)	
5(c)	New value > 28	B1	3.5a
		(1)	
5(d)	e.g. wind effects, more accurate value of g, spin of ball, include size of the ball, not model as a particle, shape of ball	B1	3.5c
		(1)	
			(11 marks)

Notes:

5a	M1	Complete method to give equation in U and t only, condone sin/cos confusion and sign errors
	A1	Correct equation
	M1	Complete method to give equation in U and t only, condone sin/cos confusion and sign errors
	A1	Correct equation (g does not need to be substituted)
	M1	Must have earned the previous two M marks. Eliminate t and solve for U. **N.B**. They may solve for t first ($100 - \frac{1}{2}gt^2 = -25$) and then use it to find U.
	A1*	Exact given answer correctly obtained with no wrong working (e.g. g = 9.81 used) or approximation seen.
5b	M1	Complete method to give equation in h only (allow if U not substituted), condone sin/cos confusion and sign errors

	A1	Correct equation (g does not need to be substituted) (A0 if U is used instead of 28)
	A1	cao
5c	B1	Clear statement
5d	B1	Penalise incorrect extras i.e. B0 if there are incorrect extras. The ground being horizontal, the cliff being vertical, .. are not part of the model so B0 Include weight/mass of the ball B0

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