Mechanics Year 2 exam questions - AQA

NOTE:
Please be aware that in the Year 12 collections, you will find questions from the Year 13 papers. However, these questions are intentionally included because they align with Year 12 content and topics. That's the reason why you are missing some questions here, please have a look at the Year 12 collection!
Happy studying!

Ch 21 Projectiles

June 2022 Question 12 Paper 2

13 **In this question use $g = 9.8\,\text{m s}^{-2}$**

A ball is projected from a point on horizontal ground with an initial velocity of $7\,\text{m s}^{-1}$ at an angle θ above the horizontal.

The ball reaches a maximum vertical height of h metres above the ground.

13 (a) Show that

$$h = 2.5\sin^2\theta$$

[3 marks]

13 (b) Hence, given that $0° \le \theta \le 60°$, find the maximum value of h.

[2 marks]

13 (c) Nisha claims that the larger the size of the ball, the greater the maximum vertical height will be.

State whether Nisha is correct, giving a reason for your answer.

[1 mark]

ANSWER

Q	Marking instructions	AO	Marks	Typical solution
13(a)	Obtains $7\sin\theta$ for vertical component of initial velocity	1.1b	B1	$u = 7\sin\theta$ $v^2 = u^2 + 2as$ $0 = 49\sin^2\theta - 19.6h$ so $h = 2.5\ \sin^2\theta$
	Uses $v^2 = u^2 + 2as$ with $v = 0$ Or uses appropriate constant acceleration equations that form a complete method to obtain h eg finds t then subs into $s = ut + \frac{1}{2}at^2$	3.3	M1	
	Completes argument substituting $s = h, v = 0$, $u = 7\sin\theta$ and $a = -9.8$ to show the given result. Accept negative values used consistently **AG**	2.1	R1	
	Subtotal		**3**	

Q	Marking instructions	AO	Marks	Typical solution
13(b)	Substitutes any value of θ in the range $0 < \theta \le 60$ to obtain a height greater than zero	1.1a	M1	$\theta = 60°$ $h = 2.5\sin^2 60$ $h = 1.9$
	Deduces h = 1.9 AWRT 1.9 or $\frac{15}{8}$	2.2a	A1	
	Subtotal		**2**	

Q	Marking instructions	AO	Marks	Typical solution
13(c)	States that Nisha is incorrect **and** refers to air resistance or ball modelled as a particle	3.5a	E1	Nisha is incorrect The model ignores air resistance which gets greater as ball gets larger
	Subtotal		**1**	

November 2021 Question 18 Paper 2

18 Two particles, P and Q, are projected at the same time from a fixed point X, on the ground, so that they travel in the same vertical plane.

P is projected at an acute angle $\theta°$ to the horizontal, with speed $u\,\mathrm{m\,s^{-1}}$

Q is projected at an acute angle $2\theta°$ to the horizontal, with speed $2u\,\mathrm{m\,s^{-1}}$

Both particles land back on the ground at exactly the same point, Y.

Resistance forces to motion may be ignored.

18 (a) Show that

$$\cos 2\theta = \frac{1}{8}$$

[6 marks]

18 (b) P takes a total of 0.4 seconds to travel from X to Y.

Find the time taken by Q to travel from X to Y.

[4 marks]

18 (c) State one modelling assumption you have chosen to make in this question.

[1 mark]

ANSWER

Q	Marking Instructions	AO	Marks	Typical Solution
18(a)	States or uses an appropriate component of either the horizontal or vertical velocity	1.1b	B1	$0 = t_P u \sin\theta - \frac{1}{2} g t_P^2$
	Considers vertical motion and uses an appropriate constant acceleration equation for one particle	3.3	M1	$t_P = \dfrac{2u\sin\theta}{g}$
	Finds a correct expression for t_P and t_Q PI by correct equation for the ranges	3.4	A1	$t_Q = \dfrac{4u\sin 2\theta}{g}$
	States horizontal distance $= ut\cos\theta$ or $2ut\cos 2\theta$	3.3	B1	$t_P u\cos\theta = t_Q \times 2u\cos 2\theta$
	Equates their expressions for the ranges of the two particles and substitutes their expressions for t_P and t_Q	3.4	M1	$\dfrac{2u^2\sin\theta\cos\theta}{g} = \dfrac{8u^2\sin 2\theta\ \cos 2\theta}{g}$
	Completes reasoned argument by simplifying to get an equation in θ only and then using $\sin 2\theta = 2\sin\theta\cos\theta$ to reach given answer AG	2.1	R1	$2\sin\theta\cos\theta = 8\sin 2\theta\ \cos 2\theta$ $\frac{1}{8} = \cos 2\theta$
	Subtotal		**6**	

Q	Marking instructions	AO	Marks	Typical solution
18(b)	Obtains exact value for $\cos\theta$ or Obtains θ = 41.4⁰ AWRT PI by obtaining t = 1.2	1.1b	B1	$\cos\theta = \frac{3}{4}$ $t_P\cos\theta = t_Q \times 2\cos 2\theta$
	Uses $t_P\cos\theta = t_Q \times 2\cos 2\theta$ OE and substitutes $t_P = 0.4$ or θ = their 41.4 or $\cos\theta =$ their $\frac{3}{4}$ and $\cos 2\theta = \frac{1}{8}$ or Uses $0 = ut_P sin\theta - \frac{gt_P^2}{2}$ OE and substitutes $t_P = 0.4$ and θ = their 41.4 or $sin\theta =$ their $\frac{\sqrt{7}}{4}$ to obtain u AWFW $u = [2.96, 2.97]$	3.1b	M1	$\cos\theta = \frac{3}{4}$, $\cos 2\theta = \frac{1}{8}$, $t_P = 0.4$ $0.4 \times \frac{3}{4} = t_Q \times 2 \times \frac{1}{8}$ $t_Q = 1.2$ seconds

	Completes substitution in $t_P\, u\cos\theta = t_Q \times 2\,u\cos 2\theta$ or uses $t_P \cos\theta = t_Q \times 2\cos 2\theta$ and finds a value for t_Q or Deduces t_Q = 1.6 $\cos\theta$ or 0.625t_Q= $\cos\theta$ OE or Uses $0 = 2ut_Q sin2\theta - \frac{gt_Q^2}{2}$ substituting their values of u and θ to find t_Q Note $sin2\theta = \frac{3\sqrt{7}}{8}$	3.4	M1	
	Obtains t_Q = 1.2 AWRT 1.2	1.1b	A1	
	Subtotal		**4**	

Q	Marking instructions	AO	Marks	Typical solution
18(c)	States any suitable assumption For example: Acceleration is constant X and Y are at the same height	3.5b	E1	X and Y are at the same height
	Subtotal		**1**	

November 2020 Question 17 Paper 2

17 A ball is projected forward from a fixed point, *P*, on a horizontal surface with an initial speed $u\,\mathrm{m\,s^{-1}}$, at an acute angle θ above the horizontal.

The ball needs to first land at a point at least d metres away from *P*.

You may assume the ball may be modelled as a particle and that air resistance may be ignored.

Show that

$$\sin 2\theta \geq \frac{dg}{u^2}$$

[6 marks]

ANSWER

Q	Marking Instructions	AO	Marks	Typical Solution
17	Models vertical motion using a suitable constant acceleration equation, to find the time of flight. Condone consistent sine/ cosine error	3.3	M1	Vertically: $0 = t \times u\sin\theta - 0.5 \times g \times t^2$
	Obtains correct equation or inequality for t Must use g not numerical value	1.1b	A1	$t = \dfrac{2u\sin\theta}{g}$
	Models horizontal displacement Condone consistent sine/ cosine error	3.3	M1	Horizontally: $x = u\,t\cos\theta$ $x = u\,\frac{2u\sin\theta}{g}\cos\theta,$
	Obtains correct equation or inequality to model horizontal displacement	1.1b	A1	using $\sin 2\theta = 2\sin\theta\cos\theta$
	Eliminates t, where t is time of flight, from their horizontal and vertical models to obtain an expression in terms of u, g and θ only.	3.4	M1	$x = \dfrac{u^2\sin 2\theta}{g}$ Since $x \geq d$
	Completes reasoned argument to obtain stated result. Must justify stated inequality must have used correct resolution of u throughout	2.1	R1	$\dfrac{u^2\sin 2\theta}{g} \geq d$ $\sin 2\theta \geq \dfrac{dg}{u^2}$
	Total		**6**	

June 2018 Question 16 Paper 2

16 **In this question use $g = 9.81\,\text{m s}^{-2}$**

A particle is projected with an initial speed u, at an angle of 35° above the horizontal.

It lands at a point 10 metres vertically below its starting position.

The particle takes 1.5 seconds to reach the highest point of its trajectory.

16 (a) Find u.

[3 marks]

16 (b) Find the total time that the particle is in flight.

[3 marks]

ANSWER

Q	Marking Instructions	AO	Marks	Typical Solution
16(a)	Uses $v = u + at$ with $v = 0$ for the vertical motion Condone cos or sign error	AO3.4	M1	$0 = u \sin 35 - 9.81 \times 1.5$ $u = 25.7\ \text{m s}^{-1}$
	Obtains correct equation	AO1.1b	A1	
	Obtains correct u to 3 significant figures **CAO**	AO1.1b	A1	
16(b)	Uses $s = ut + \frac{1}{2}at^2$ with $s = -10$ and their u for vertical motion Condone cos or sign error	AO3.4	M1	$-10 = (25.7\sin 35)t - \frac{1}{2} \times 9.81t^2$ t = 3.571 Time in flight is 3.57 seconds
	Obtains correct equation	AO1.1b	A1F	
	Obtains correct time of flight with units AWRT 3.6 **CAO**	AO3.2a	A1	
	Total		**6**	