

Mark Scheme

Q1.

Question Number	Answer	Mark
	C is the correct answer This is because $s = \frac{1}{2}gt^2$. So if in one unit of time the sphere has fallen one unit of distance, i.e. from image 1 to image 2, then in 2 units of time it will have fallen 4 units of distance, i.e. from image 1 to R.	(1)

Q2.

Question Number	Answer	Mark
	B is the correct answer A is incorrect because the gradient gives a quarter of the acceleration C is incorrect because the gradient gives the wrong units D is incorrect because the gradient gives the wrong units	1

Q3.

Question Number	Answer	Mark
	The correct answer is C A is not the correct answer because the acceleration is not 5 m s^{-2} B is not the correct answer because the acceleration is not 9.81 m s^{-2} D is not the correct answer because this expression is not dimensionally correct and the acceleration is not 9.81 m s^{-2}	1

Q4.

Question Number	Answer	Mark
	C is the correct answer A is incorrect because the velocity should be squared B is incorrect because the displacement should be doubled and the velocity squared D is incorrect because the displacement should be doubled	(1)

Q5.

Question Number	Answer	Mark
	C is the correct answer as there is always an acceleration of 9.81 m s^{-2} A is not the correct answer as there is always an acceleration of 9.81 m s^{-2} B is not the correct answer as there is always an acceleration of 9.81 m s^{-2} D is not the correct answer as there is always an acceleration of 9.81 m s^{-2}	(1)

Q6.

Question Number	Answer	Mark
	D is the correct answer A is not correct because this gives the change in velocity of the object B is not correct because this gives the average velocity of the object C is not correct because this gives twice the distance travelled by the object	1

Q7.

Question Number	Answer	Mark
	The only correct answer is B as $s = vt$ and $s = 1.2 \times 0.9$ <i>A is not the correct answer as $s = vt$ and $s = 1.2 \times 0.9$</i> <i>C is not the correct answer as $s = vt$ and $s = 1.2 \times 0.9$</i> <i>D is not the correct answer as $s = vt$ and $s = 1.2 \times 0.9$</i>	(1)

Q8.

Question Number	Answer	Mark
	A is the correct answer B is incorrect because the distance has not been doubled and the time has not been squared C is incorrect because the distance is in the wrong unit D is incorrect because the distance is in the wrong unit, has not been doubled and the time has not been squared	1

Q9.

Question Number	Answer	Mark
	The only correct answer is D ($s \propto t^2$) A is not correct because $s = ut + \frac{1}{2}at^2$ and $u = 0$ B is not correct because $s = ut + \frac{1}{2}at^2$ and $u = 0$ C is not correct because $s = ut + \frac{1}{2}at^2$ and $u = 0$	1

Q10.

Question Number	Answer	Mark
	The only correct answer is D because kg m^{-3} is the unit for density (scalar) <i>A is not the correct answer as m s^{-1} is the unit for velocity (vector) and speed (scalar)</i> <i>B is not the correct answer as m s^{-2} is the unit for acceleration (vector)</i> <i>C is not the correct answer as kg m s^{-2} is the unit for force (vector)</i>	(1)

Q11.

Question Number	Acceptable Answer	Additional Guidance	Mark
	Use of $v^2 = u^2 + 2a\Delta s$ (1) $\Delta s = 1.1 \text{ m}$ (1) Comparison of (1.7 + their calculated Δs) with 3.0 m and consistent conclusion Or Comparison of their calculated Δs with 1.3 m and consistent conclusion Or Comparison of (3.0 – their calculated Δs) with 1.7 m and consistent conclusion (1)	allow use of any valid suvat method to determine Δs <u>Example calculation</u> $\Delta s = \frac{(-2.1 \text{ m s}^{-1})^2 - (5.1 \text{ m s}^{-1})^2}{2 \times (-9.81 \text{ m s}^{-2})} = 1.1 \text{ m}$ $s = 1.7 \text{ m} + 1.1 \text{ m} = 2.8 \text{ m}$ $2.8 \neq 3.0 \text{ m}$, so no	3

Q12.

Question Number	Answer	Additional Guidance	Mark
(a)	(Starting and stopping stopwatch) (1) involves human reaction time (So) there will be (large) <u>random</u> (1) errors	Ignore references to human error	2
(b)(i)	The length of the metal cylinder (1)	Ignore length of the tube	1
(b)(ii)	Use of $v^2 = u^2 + 2as$ (1) $a = 9.62 \text{ m s}^{-2}$ (1)	Allow any valid suvat method to determine acceleration <u>Example calculation</u> $a = \frac{(2.96 \text{ m})^2 - (1.39 \text{ m})^2}{2 \times 0.355 \text{ m}} = 9.619 \text{ m s}^{-2}$	2
	Total for question		5

Q13.

Question Number	Answer	Mark
(a)	Use of $s = ut + \frac{1}{2}at^2$ Allow any valid suvat method. (1) Uses difference in distances travelled by A and B of 9m (1) $t = 1.13$ (s) (1) <u>Example calculation</u> $(93 \text{ ms}^{-1} \times t) + 9 \text{ m} = (93 \text{ ms}^{-1} \times t) + \left(\frac{1}{2} \times 14 \text{ ms}^{-2} \times t^2\right)$ $9 \text{ m} = \left(\frac{1}{2} \times 14 \text{ ms}^{-2} \times t^2\right)$ $t = \sqrt{\frac{9 \text{ m}}{\frac{1}{2} \times 14 \text{ ms}^{-2}}} = \sqrt{1.29 \text{ s}} = 1.13 \text{ s}$	3
(b)	Use of $s = ut + \frac{1}{2}at^2$ Allow any valid suvat method. (1) Time for A to finish = 1.075 s Or Time for B to finish = 1.084 s (allow correctly calculated value for another quantity given in the question) (1) Comparison of time for A to finish with time for B to finish and valid conclusion Or comparison of time for A to finish with 1.13 s and valid conclusion (ecf from 13(b)) (allow valid conclusion based on comparison of calculated values for other quantities given in the question) (1) <u>Example calculation</u> $t_A = \frac{100 \text{ m}}{93} = 1.075 \text{ s}$ $109 = 93t_B + \frac{1}{2} \times 14 \times t_B^2$ $t_B = \frac{-93 + \sqrt{93^2 - 4 \times \left(\frac{14}{2}\right) \times (-109)}}{2 \times \frac{14}{2}} = 1.084 \text{ s}$ 1.075 s < 1.084 s so car A will finish first.	3
Total for question		6

Q14.

Question Number	Answer	Mark
	Use of $s = ut + \frac{1}{2}at^2$ with $u = 0$ and $a = g$ for flight time (1) Use of $s = ut + \frac{1}{2}at^2$ with $a = 0$ for horizontal displacement of stone (1) Distance travelled = 5.9 m (1)	3
	<u>Example of calculation</u> $12 \text{ m} = 0.5 \times 9.81 \text{ m s}^{-2} \times t^2$ $t = \sqrt{(12.0 \text{ m} \div 4.905 \text{ m s}^{-2})} = 1.56 \text{ s}$ $s_{\text{stone}} = 3.8 \text{ m s}^{-1} \times 1.56 \text{ s} = 5.94 \text{ m}$	
	Total for question	3

Q15.

Question Number	Answer	Mark
	Resolves horizontal and vertical component of velocity (1) Use of $s = ut + \frac{1}{2}at^2$ with $a = -g$ and $u = u_v$ (1) Use of $s = ut + \frac{1}{2}at^2$ with $a = 0$ and $u = u_h$ (1) Horizontal distance = 130 m (1)	4
	<u>Example calculation</u> $u_v = 37 \text{ m s}^{-1} \times \sin 53^\circ = 29.5 \text{ m s}^{-1}$ $t = 2 \times 29.5 \text{ m s}^{-1} \div 9.81 = 6.02 \text{ s}$ $u_h = 37 \text{ m s}^{-1} \times \cos 53^\circ = 22.3 \text{ m s}^{-1}$ $s_h = 22.3 \text{ m s}^{-1} \times 6.02 \text{ s} = 134.1 \text{ m}$	
	Total for question	4

Q16.

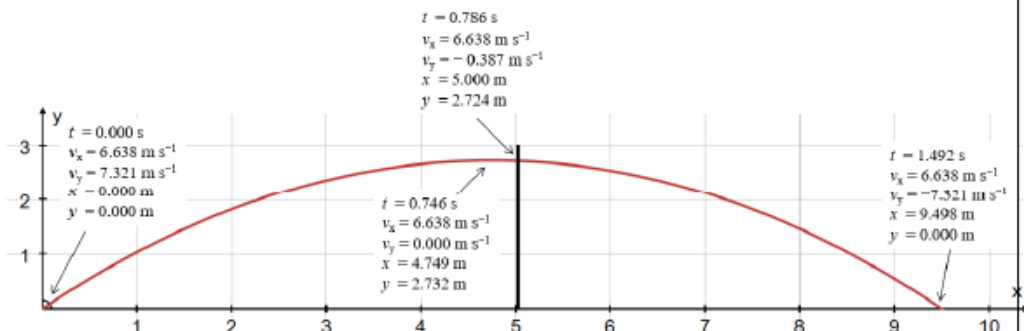
Question Number	Answer	Mark
	• Reference to $s = ut + \frac{1}{2} at^2$ with $u = 0$ (1) • Correct variable labels on graph axes to give a straight line through origin. (1) • Reference to time in s and distance in m (this can be taken from the axes labels or a suitable unit conversion) (1) • Straight line through origin. (1) • Correct method to determine g using their graph. (1)	(5)

Q17.

Question Number	Answer	Mark
(a)	The ball fell a smaller distance (during each flash of the laboratory strobe) Or Each image of the ball would be smaller (using the laboratory strobe) (1) The uncertainty was less (with the laboratory strobe) MP2 dependent on MP1 (1)	2
(b)(i)	(allow a for g throughout) $s = (ut + \frac{1}{2}gt^2)$ and g is constant (1) Comparison of $s = \frac{1}{2}gt^2 (+ut)$ with $y = mx (+c)$ Or s is proportional to t^2 so the gradient of graph is constant (1)	2
(b)(ii)	Use of $s = \frac{1}{2}at^2$ and a pair of corresponding values from the graph Or Pair of corresponding values from the graph used to determine gradient (1) $g = 10.0 \text{ m s}^{-2}$ (allow answers in the range 9.8 m s^{-2} to 10.1 m s^{-2}) (dependent on MP1) (answer must be consistent with their calculation) (1) <u>Example of calculation</u> $\frac{\Delta h}{\Delta t^2} = \frac{0.30}{0.060} = 5.00$ $g = 5.00 \text{ m s}^{-2} \times 2 = 10.00 \text{ m s}^{-2}$	2
Total for question		6

Q18.

Question Number	Answer	Mark
(a)	Use of correct trigonometry to calculate horizontal component (1) [$9.7 \cos 49^\circ$ or $9.7 \sin 41^\circ$ seen] Use of $s = ut + \frac{1}{2}at^2$ with $a = 0$ [i.e. use of $s = vt$] $t = 0.79 \text{ (s)}$ [NB reverse argument scores 2 marks (Rule 4.2)] (1) <u>Example of calculation</u> (1) $v_H = 9.70 \text{ m s}^{-1} \times \cos 49^\circ = 6.36 \text{ m s}^{-1}$ $t = 5.00 \text{ m} \div 6.36 \text{ m s}^{-1} = 0.786 \text{ s}$	3

(b)	Use of correct trigonometry to calculate vertical component (1) [$9.7 \sin 49^\circ$ or $9.7 \cos 41^\circ$ seen] Use of $s = ut + \frac{1}{2}at^2$ (1) $s = 2.7 \text{ m}$ (ecf from (a)) (1) ["show that" value also gives 2.72 m] Correct conclusion from valid comparison using student's calculated value (1) Or Use of $v^2 = u^2 + 2as$ (1) Max height = 2.7 m [no ecf] (1) Correct conclusion from valid comparison using student's calculated value (1) [allow any valid <i>suvat</i> method, allow ecf if method involves t from (a)] 4 <u>Example of calculation</u> $v_v = 9.70 \text{ m s}^{-1} \times \sin 49^\circ = 7.32 \text{ m s}^{-1}$ $s = 7.32 \text{ m s}^{-1} \times 0.79 \text{ s} - 0.5 \times 9.81 \text{ m s}^{-2} \times (0.79 \text{ s})^2 = 2.72 \text{ m}$ $2.72 \text{ m} < 3.00 \text{ m}$ so ball does not go over the wall [Significant moments ...] 	
Total for question		7

Question Number	Answer	Mark
(a)	Use of trigonometry (1) Vertical component = $34 \text{ (m s}^{-1}\text{)}$ (1) <u>Example of calculation</u> $52 \text{ m s}^{-1} \times \sin 41^\circ = 34.1 \text{ m s}^{-1}$	2
(b)	<u>Method 1:</u> Use of $s = ut + \frac{1}{2}at^2$ with $s = 11 \text{ m}$ and $a = -9.81 \text{ m s}^{-2}$ (1) Use of quadratic formula (1) $t = 6.62 \text{ (s)}$ [Allow ecf from (a)] (1) <u>Method 2:</u> Use of $v = u + at$, with $v = 0$ to find time to max height [3.48 s] (1) Use of $s = \frac{1}{2}(u + v)t$, or other correct <i>suvat</i> equation, to find max height [59.3 m] And Use of $s = ut + \frac{1}{2}at^2$ to find time to fall to 11 m [3.14 s] (1) $t = 6.62 \text{ (s)}$ depending on rounding of (a) [Allow ecf from (a)] (1) (allow ecf from (a)) [Allow any valid <i>suvat</i> method] <u>Example of calculation</u> Let time to max height = t $11 \text{ m} = 34.1 \text{ m s}^{-1} \times t - \frac{1}{2} \times 9.81 \text{ m s}^{-2} \times t^2$ $4.91 \times t^2 - 34.1 \text{ m s}^{-1} \times t + 11 \text{ m} = 0$ $t = (34.1 \pm \sqrt{(34.1)^2 - 4 \times 11 \times 4.91}) \text{ m s}^{-1} \div 9.81 \text{ m s}^{-2}$ $= 6.62 \text{ s (or } 0.34 \text{ s)}$	3

(c)	Resolves for horizontal component of velocity (1) Use of $s = vt$ (1) 260 m so no (1) (Allow ecf from (b) with correct conclusion based on student's value) <u>Example of calculation</u> Horizontal component of velocity = $52 \text{ m s}^{-1} \times \cos 41^\circ = 39.2 \text{ m s}^{-1}$ $s = 39.2 \text{ m s}^{-1} \times 6.62 \text{ s} = 260 \text{ m}$ Distance required 245 m to 255 m and $260 \text{ m} > 255 \text{ m}$ so no. time = 3.48 s max height = 59.32 m distance = 136.5 m time = 0.00 s horizontal velocity = 34.12 m s^{-1} vertical velocity = 39.24 m s^{-1} time = $3.48 \text{ s} + 3.14 \text{ s} = 6.62 \text{ s}$ height = 11.0 m distance = $136.5 \text{ m} + 123.7 \text{ m} = 260.2 \text{ m}$	3
Total for question		8

Question Number	Answer	Mark
(a)	Resolves velocity to find vertical component (1) Use of $v = u + at$ (1) Time to max height = 3.3 (s) (1) <u>Example of calculation</u> $u_v = 50 \text{ m s}^{-1} \sin(40^\circ) = 32.1 \text{ m s}^{-1}$ $v = u + at$ with $v = 0$ $t = 32.1 \text{ m s}^{-1} \div 9.81 \text{ m s}^{-2} = 3.28 \text{ s}$	3
(b)	Use of $v_H = v \cos \theta$ (1) Use of $s = ut$ to calculate horizontal distance (1) Use of $s = ut + \frac{1}{2}at^2$ to calculate maximum height or other <i>suvat</i> equation (1) Maximum height = 53 m (allow ecf from (a)) (1) Use of $\tan \theta$ to calculate vertical height of hill (1) Compares height of hill with maximum height (accept conclusion based on candidate's values).	

Or Use of $v_H = v \cos \theta$ (1) Use of $s = ut$ to calculate horizontal distance (1) Use of $s = ut + \frac{1}{2}at^2$ to calculate maximum height or other <i>suvat</i> equation (1) Maximum height = 53 m (allow ecf from (a)) (1) Use of $\tan \theta$ to calculate minimum angle of hill for a hit (1) Compares angle of hill with minimum angle (accept conclusion based on candidate's values). Or (1) (1) Use of $v_H = v \cos \theta$ (1) Use of $s = ut$ to calculate horizontal distance (1) Use of $s = ut + \frac{1}{2}at^2$ to calculate maximum height or other <i>suvat</i> equation (1) Maximum height = 53 m (allow ecf from (a)) (1) Use of $\tan \theta$ to calculate horizontal distance to 52.6 m height along hill Compares horizontal distances (accept conclusion based on candidate's values). <u>Example of calculation</u> $v_H = 50 \text{ m s}^{-1} \times \cos(40^\circ) = 38.3 \text{ m s}^{-1}$ $s_H = v_H \times t$ $s_H = 38.3 \text{ m s}^{-1} \times 3.28 \text{ s} = 125 \text{ m}$ maximum height of rock = $s_v = u_v t + \frac{1}{2}at^2$ with $a = -g$ $s_v = 32.1 \text{ m s}^{-1} \times 3.28 \text{ s} - \frac{1}{2} \times 9.81 \text{ m s}^{-2} \times (3.28 \text{ s})^2 = 52.6 \text{ m}$ vertical height of hill at horizontal distance of 125 m = $125 \text{ m} \times \tan(20^\circ)$ = 45.7 m 45.7 m < 52.6 m, so no	6
Total for question	9

Q21.

Question Number	Answer	Mark
(a)	Use of appropriate trigonometry (1) $v_x = 32 \text{ m s}^{-1}$ and $v_y = 15 \text{ m s}^{-1}$ (1) 2 <u>Example of calculation</u> $v_x = 35 \text{ m s}^{-1} \times \cos 25^\circ = 31.7 \text{ m s}^{-1}$ $v_y = 35 \text{ m s}^{-1} \times \sin 25^\circ = 14.8 \text{ m s}^{-1}$	
(b)	Use of $s = u_x t$ to find time taken to travel 100 m horizontally (1) Use of $s = u_y t + \frac{1}{2} a t^2$ with $a = -g$ to find distance fallen in time t Accept other correct SUVAT methods (1) Distance fallen = 2.1 m (1) Conclusion consistent with comparison of student's values, e.g. $2.1 \text{ m} < 3.0 \text{ m}$ so rider lands on other side of river (1) Or Use of correct SUVAT method with $a = -g$ to find time to descend by 3 m. (1) Use of $s = u_x t$ to find horizontal distance travelled in time t. (1) Distance travelled = 102 m (1) Conclusion consistent with comparison of student's values (1) Or Use of $s = u_x t$ to find time taken to travel 100 m horizontally (1) Use of correct SUVAT method with $a = -g$ to find time to descend by 3 m. (1) Time = 3.21 s (1) Conclusion consistent with comparison of student's values, e.g. $3.15 \text{ s} < 3.21 \text{ s}$ so rider lands on other side of river (1) 4 <u>Example of calculation</u> time taken to travel 100 m = $100 \text{ m} \div 31.7 \text{ m s}^{-1} = 3.15 \text{ s}$ vertical displacem = $14.8 \times 3.15 - 0.5 \times 9.81 \times 3.15^2 = -2.12 \text{ m}$ $2.1 \text{ m} < 3.0 \text{ m}$, so rider lands on other side of river	

(c)	Air resistance act to oppose the motion of the motorcyclist	(1)	3
	So it decreases the time for which the motorcyclist is in the air		
	Or There is deceleration in the horizontal direction		
	Or Speed in horizontal direction is reduced		
	Or The (maximum) height reached by the motorcyclist is reduced	(1)	
	Horizontal distance travelled is reduced (dependent on MP1 or MP2)	(1)	
Total for question			9

Q22.

Question Number	Answer	Mark
(a)(i)	Initial angle at approximately 30° (by eye) with approximately parabolic shape. 	1
(a)(ii)	- Use of $v^2 = u^2 + 2as$ (with u and v the correct way around) Or Loss of KE = gain of GPE (i.e. $u_v^2 = 2gh$) - See $u \sin 30^\circ$ for initial vertical component of velocity u_v $u = 57 \text{ (m s}^{-1}\text{)}$ <u>Example of calculation</u> $0^2 = (u \sin 30^\circ)^2 + (2 \times -9.81 \text{ N kg}^{-1} \times 42 \text{ m})$ $u_v = u \sin 30^\circ = 28.7 \text{ m s}^{-1}$ $u = 57.4 \text{ m s}^{-1}$	3

(a)(iii)	• Use of trig to determine the horizontal component of the initial velocity (1) • <u>METHOD 1</u> (1) • Use of suitable equation(s) of motion to determine the time of flight (1) • Use of $v = s/t$ to determine the horizontal distance travelled by the flare (1) • Comparison of distance to boat to distance flare travelled with conclusion consistent with student's value e.g. 7.9 km is less than 8.0 km so the flare can be seen. <u>Example of calculation</u> $0 = (57.4 \text{ m s}^{-1} \times \sin 30^\circ \times t) - (0.5 \times 9.81 \text{ N kg}^{-1} \times t^2)$ $t = 5.85 \text{ s}$ $s = (57.4 \text{ m s}^{-1} \times \cos 30^\circ \times 5.85 \text{ s}) = 49.7 \text{ m s}^{-1} \times 5.85 \text{ s} = 291 \text{ m}$	4
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	<u>METHOD 2</u> • Use of $v = s/t$ to determine the time to reach 200 m • Use of $s = ut + \frac{1}{2}at^2$ to find height reached after 200 m travel • Explains conclusion consistent with student's value e.g. flare above the sea and in range so visible	
(b)	• Air resistance/drag is ignored Or air resistance/drag is (presumed to be) negligible (1)	1
	Total for question	9

Q23.

Question Number	Answer	Additional Guidance	Mark
(a)	Acceleration of the shot is constant (1) Because air resistance will be negligible Or the only force acting is weight (1)		2
(b)(i)	Use of $s = ut + \frac{1}{2}at^2$ with $a = 0$ (1) $u_{\text{horizontal}} = 8.82 \text{ (m s}^{-1}\text{)}$ (to at least 3 significant figures) (1)	<u>Example calculation</u> $14.2 \text{ m} = u_{\text{horizontal}} \times 1.61 \text{ s}$ $u_{\text{horizontal}} = \frac{14.2 \text{ m}}{1.61 \text{ s}} = 8.8199 \text{ m s}^{-1}$	2

Question Number	Answer	Additional Guidance	Mark
(b)(ii)	Use of $s = ut + \frac{1}{2}at^2$ with $a = (-)9.81 \text{ m s}^{-2}$ and $s = (-)1.85 \text{ m}$ (1) Use of Pythagoras to determine u Or Use of appropriate trigonometry to determine u (1) $u = 11 \text{ m s}^{-1}$ [ecf from (b)(i)] (1) Use of appropriate trigonometry to determine θ (1) $\theta = 37^\circ$ [ecf from (b)(i)] (1)	<u>Example calculation</u> $u_{\text{vertical}} = \frac{\frac{1}{2} \times 9.81 \text{ m s}^{-2} \times (1.61 \text{ s})^2 - 1.85 \text{ m}}{1.61 \text{ s}}$ $= 6.75 \text{ m s}^{-1}$ $u^2 = (8.82 \text{ m s}^{-1})^2 + (6.75 \text{ m s}^{-1})^2 = 123.4 \text{ m}^2 \text{ s}^{-2}$ $u = \sqrt{123.4 \text{ m}^2 \text{ s}^{-2}} = 11.1 \text{ m s}^{-1}$ $\tan \theta = \frac{6.75 \text{ m s}^{-1}}{8.82 \text{ m s}^{-1}} = 0.765$ $\theta = \tan^{-1}(0.765) = 37.4^\circ$	5
	Total for question		9

Q24.

Question Number	Answer	Mark
(a)(i)	Use of trigonometry to determine u_h (1) Use of $s = ut + \frac{1}{2}at^2$ with $a = 0$ (1) Time = 32 (s) (1) <u>Example calculation</u> $u_h = 500 \text{ m s}^{-1} \times \cos(22^\circ) = 4.64 \times 10^2 \text{ m s}^{-1}$ $t = \frac{15 \times 10^3 \text{ m}}{4.64 \times 10^2 \text{ m s}^{-1}} = 32.4 \text{ s}$	3
(a)(ii)	Use of trigonometry to determine u_v (1) Use of $s = ut + \frac{1}{2}at^2$ with $a = -g$ (1) (Allow use of any valid suvat method to determine s) (1) Adds launch height (1) Height above ship = $3.0 \times 10^3 \text{ m}$ [ecf from (a)(i)] (1) ("show that" value gives $3.2 \times 10^3 \text{ m}$) <u>Example calculation</u> $u_v = 500 \text{ m s}^{-1} \times \sin 22^\circ = 1.87 \times 10^2 \text{ m s}^{-1}$ $s = 1.87 \times 10^2 \text{ m s}^{-1} \times 32 \text{ s} - 0.5 \times 9.81 \text{ m s}^{-2} \times (32 \text{ s})^2 = 9.61 \times 10^2 \text{ m}$ Height = $9.61 \times 10^2 \text{ m} + 2 \times 10^3 \text{ m} = 2.96 \times 10^3 \text{ m}$	4
(b)	(As the launch angle increased) the horizontal (component of) velocity / speed decreased (1) (and) the vertical (component of) velocity / speed increased (1) So the time (in air) increases (1) Horizontal distance travelled = time (in air) $\times$ horizontal velocity (which will reach a maximum value) (1)	4
Total for question		11

Q25.

Question Number	Answer	Additional Guidance	Mark
(a)(i)	Use of $s = ut + \frac{1}{2}at^2$ with $a = 0$ (1) Use of appropriate trigonometry to determine θ Or Use of appropriate trigonometry to determine horizontal component of initial velocity (1) $\theta = 80.9^\circ$ (to at least 3 significant figures) (1)	<u>Example of calculation</u> $u_{\text{horizontal}} = \frac{2930 \text{ m}}{7.50 \text{ s}} = 391 \text{ m s}^{-1}$ $\theta = \cos^{-1} \left(\frac{391 \text{ m s}^{-1}}{2460 \text{ m s}^{-1}} \right) = 80.9^\circ$	3

(a)(ii)	Use of appropriate trigonometry to determine vertical component of velocity (1) Use of $v = u + at$ with $a = 1.63 \text{ m s}^{-2}$ with u and a having the same sign convention (1) Use of Pythagoras equation (1) $v = 2470 \text{ m s}^{-1}$ (ecf from (a)(i)) (1) OR Use of appropriate trigonometry to determine vertical component of velocity (1) Use of $s = ut + \frac{1}{2}at^2$ with $a = 1.63 \text{ m s}^{-2}$ with u and a having the same sign convention (1) Uses principle of conservation of energy (1) $v = 2470 \text{ m s}^{-1}$ (ecf from (a)(i)) (1)	<u>Example of calculation</u> $u_{\text{vertical}} = 2460 \text{ m s}^{-1} \times \sin(80.9^\circ) = 2429 \text{ m s}^{-1}$ $v_{\text{vertical}} = 2429 \text{ m s}^{-1} + 1.63 \text{ m s}^{-2} \times 7.50 \text{ s} = 2441 \text{ m s}^{-1}$ $v_{\text{final}} = \sqrt{(391 \text{ m s}^{-1})^2 + (2441 \text{ m s}^{-1})^2} = 2472 \text{ m s}^{-1}$ <u>Example of calculation</u> $u_{\text{vertical}} = 2460 \text{ m s}^{-1} \times \sin(80.9^\circ) = 2429 \text{ m s}^{-1}$ $s = 2429 \text{ m s}^{-1} \times 7.50 \text{ s} + 0.5 \times 1.63 \text{ m s}^{-2} \times (7.50 \text{ s})^2 = 18300 \text{ m}$ $m \times 1.63 \text{ m s}^{-2} \times 18300 \text{ m} + \frac{1}{2} \times m \times (2460 \text{ m s}^{-1})^2 = \frac{1}{2} \times m \times v^2$ $v = \sqrt{2 \times \left(1.63 \text{ m s}^{-2} \times 18300 \text{ m} + \frac{1}{2} \times (2460 \text{ m s}^{-1})^2 \right)}$ $= 2472 \text{ m s}^{-1}$	4
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(b)(i)	The horizontal (component of) velocity is the same (1) And the time taken to reach the surface of Earth is less (than time taken to reach the surface of the Moon) (1) So the (horizontal) distance travelled is less (dependent on MP2) (1)	If no other mark scored allow 1 mark for air resistance decreases the horizontal component of velocity.	3
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(b)(ii)	Max TWO from: Air resistance acts (on the projectile) (1) Or Drag acts (on the projectile) The projectile would decelerate horizontally (1) The (vertical) acceleration would not be constant Or The (vertical) acceleration would not be 9.81 m s^{-2} (1)		2
	Total for question		12