10

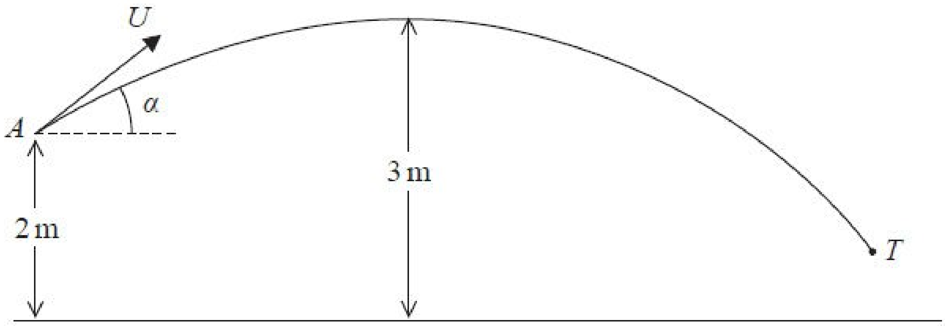

Figure 4

A boy throws a ball at a target. At the instant when the ball leaves the boy's hand at the point A, the ball is 2 m above horizontal ground and is moving with speed U at an angle α above the horizontal.

In the subsequent motion, the highest point reached by the ball is 3 m above the ground.
The target is modelled as being the point T, as shown in Figure 4.
The ball is modelled as a particle moving freely under gravity.

Using the model,

(a) show that $U^2 = \dfrac{2g}{\sin^2 \alpha}$.

(2)

The point T is at a horizontal distance of 20 m from A and is at a height of 0.75 m above the ground. The ball reaches T without hitting the ground.

(b) Find the size of the angle α

(9)

(c) State one limitation of the model that could affect your answer to part (b).

(1)

(d) Find the time taken for the ball to travel from A to T.

(3)

Question	Scheme	Marks	AOs
10(a)	Using the model and vertical motion: $0^2 = (U\sin\alpha)^2 - 2g \times (3-2)$	M1	3.3
	$U^2 = \dfrac{2g}{\sin^2\alpha}$ * GIVEN ANSWER	A1*	2.2a
		(2)	
(b)	Using the model and horizontal motion: $s = ut$	M1	3.4
	$20 = Ut\cos\alpha$	A1	1.1b
	Using the model and vertical motion: $s = ut + \frac{1}{2}at^2$	M1	3.4
	$-\frac{5}{4} = Ut\sin\alpha - \frac{1}{2}gt^2$	A1	1.1b
	sub for t: $-\frac{5}{4} = U\sin\alpha\left(\dfrac{20}{U\cos\alpha}\right) - \frac{1}{2}g\left(\dfrac{20}{U\cos\alpha}\right)^2$	M1 (I)	3.1b
	sub for U^2	M1(II)	3.1b
	$-\frac{5}{4} = 20\tan\alpha - 100\tan^2\alpha$	A1(I)	1.1b
	$(4\tan\alpha - 1)(100\tan\alpha + 5) = 0$	M1(III)	1.1b
	$\tan\alpha = \frac{1}{4} \Rightarrow \alpha = 14^0$ or better	A1(II)	2.2a
		(9)	
	N.B. For the last 5 marks, they may set up a quadratic in t, by substituting for $U\sin\alpha$ first, then solve the quadratic to find the value of t, then use $20 = Ut\cos\alpha$ to find α. The marks are the same but earned in a different order. Enter on ePen in the corresponding M and A boxes above, as indicated below.		
	Sub for $U\sin\alpha$ to give equation in t only	M1(II)	
	$-\frac{5}{4} = \sqrt{2g}\,t - \frac{1}{2}gt^2$	A1(I)	
	Solve for t	M1(III)	
	$t = \dfrac{5}{\sqrt{2g}}$ or 1.1 or 1.13 and use $20 = Ut\cos\alpha$	M1(I)	
	$\alpha = 14^0$ or better	A1(II)	
(b)	**ALTERNATIVE**		

1 Fig. 7 shows the trajectory of an object which is projected from a point O on horizontal ground. Its initial velocity is $40\,\text{m s}^{-1}$ at an angle of α to the horizontal.

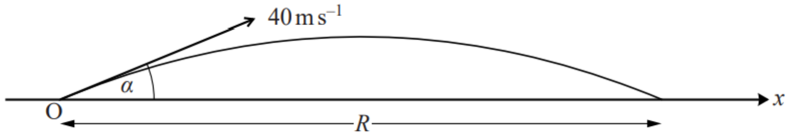

Fig. 7

(i) Show that, according to the standard projectile model in which air resistance is neglected, the flight time, T s, and the range, R m, are given by

$$T = \frac{80\sin\alpha}{g} \quad \text{and} \quad R = \frac{3200\sin\alpha\cos\alpha}{g}.$$ **[6]**

A company is designing a new type of ball and wants to model its flight.

(ii) Initially the company uses the standard projectile model.

Use this model to show that when $\alpha = 30°$ and the initial speed is $40\,\text{m s}^{-1}$, T is approximately 4.08 and R is approximately 141.4.

Find the values of T and R when $\alpha = 45°$. **[3]**

The company tests the ball using a machine that projects it from ground level across horizontal ground. The speed of projection is set at $40\,\text{m s}^{-1}$.

When the angle of projection is set at 30°, the range is found to be 125 m.

(iii) Comment briefly on the accuracy of the standard projectile model in this situation. **[1]**

The company refines the model by assuming that the ball has a constant deceleration of $2\,\text{m s}^{-2}$ in the horizontal direction.

In this new model, the resistance to the vertical motion is still neglected and so the flight time is still 4.08 s when the angle of projection is 30°.

(iv) Using the new model, with $\alpha = 30°$, show that the horizontal displacement from the point of projection, x m at time t s, is given by

$$x = 40t\cos 30° - t^2.$$

Find the range and hence show that this new model is reasonably accurate in this case. **[4]**

The company then sets the angle of projection to 45° while retaining a projection speed of $40\,\text{m s}^{-1}$. With this setting the range of the ball is found to be 135 m.

(v) Investigate whether the new model is also accurate for this angle of projection. **[3]**

(vi) Make one suggestion as to how the model could be further refined. **[1]**

1	(i)		Vertical motion: initial speed $40\sin\alpha$	B1	
			$h=(40\sin\alpha)t-\frac{1}{2}gt^2$		
			$h=0\Rightarrow t=0$ or $\dfrac{2\times 40\times\sin\alpha}{g}$	M1	Correct expression for h must be seen. Condone omission of the case $t=0$
			$\Rightarrow T=\dfrac{80\sin\alpha}{g}$	E1	Perfect argument (but still condone omission of $t=0$)
			Alternative		
			Vertical motion: initial speed $40\sin\alpha$	(B1)	
			$v=40\sin\alpha-gt$		
			When $v=0$, $t=\dfrac{T}{2}$	(M1)	Correct expression for v must be seen
			$\Rightarrow T=\dfrac{80\sin\alpha}{g}$	(E1)	Perfect argument
			Horizontal motion: initial speed $40\cos\alpha$	B1	
			$R=40\cos\alpha\times T$	M1	There must be evidence of intention to use T
			$\Rightarrow R=\dfrac{3200\sin\alpha\cos\alpha}{g}$	E1	Perfect argument
				[6]	
	(ii)		$\alpha=30°$:		
			$T=\dfrac{80\sin 30°}{9.8}\simeq 4.08$		
			$\Rightarrow R=\dfrac{3200\times\sin 30°\times\cos 30°}{9.8}=141.4$	B1	Both answers required for the mark. Evidence of substitution required
			$\alpha=45°$: $T=5.77$	B1	
			$\alpha=45°$: $R=163.3$	B1	Accept 3 significant figures
				[3]	
	(iii)		The standard model is not accurate; 125 is much less than 141.4	B1	The comment must be based on the figures given in the question
				[1]	
	(iv)		Horizontal motion: $s=ut+\frac{1}{2}at^2$	M1	Use of correct formula
			$x=40\cos 30°\times t-\frac{1}{2}\times 2\times t^2$		
			$x=40t\cos 30°-t^2$	A1	
			Flight time = 4.08 s		
			$R=40\times\cos 30°\times 4.08-\frac{1}{2}\times 2\times 4.08^2$	M1	
			$R=124.7$ This is close to the experimental result of 125 m	E1	A comparison with 125 m is required
				[4]	
	(v)		When $\alpha=45°$, $T=5.77$	M1	Use of correct formula, with substitution for α and T. FT their T from (ii) but not 4 SC1 for substituting for T but using $30°$ for α
			$R=40\times\cos 45°\times 5.77-\frac{1}{2}\times 2\times 5.77^2$		
			$R=129.9$	A1	
			129.9 m is not very close to 135 m so the model is not very accurate for this angle.	B1	Comparison of their 129.9 with 135 If 4.08 used for T and answer 98.8 obtained for R allow FT for this mark Allow argument that to get to 135m takes 6.07 s which is greater than 5.77 s
				[3]	
	(vi)		Allow for resistance in the vertical direction as well	B1	Any sensible comment, but do not award a mark for "Allow for air resistance" without mention of the vertical direction.
				[1]	

2

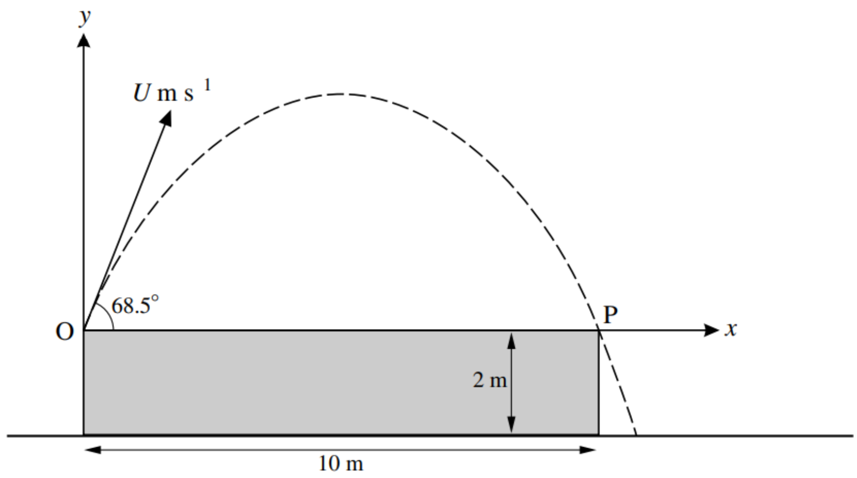

Fig. 7

Fig. 7 shows a platform 10 m long and 2 m high standing on horizontal ground. A small ball projected from the surface of the platform at one end, O, just misses the other end, P. The ball is projected at 68.5° to the horizontal with a speed of $U\,\text{m s}^{-1}$. Air resistance may be neglected.

At time t seconds after projection, the horizontal and vertical displacements of the ball from O are x m and y m.

(i) Obtain expressions, in terms of U and t, for

(*A*) x,

(*B*) y. **[3]**

(ii) The ball takes T s to travel from O to P.

Show that $T = \dfrac{U \sin 68.5°}{4.9}$ and write down a second equation connecting U and T. **[4]**

(iii) Hence show that $U = 12.0$ (correct to three significant figures). **[3]**

(iv) Calculate the horizontal distance of the ball from the platform when the ball lands on the ground. **[5]**

(v) Use the expressions you found in part **(i)** to show that the cartesian equation of the trajectory of the ball in terms of U is

$$y = x \tan 68.5° - \frac{4.9x^2}{U^2(\cos 68.5°)^2}.$$

Use this equation to show again that $U = 12.0$ (correct to three significant figures). **[4]**

2		mark	notes
(i) (A)	$x = Ut\cos 68.5°$	B1 1	
(i) (B)	$y = Ut\sin 68.5° - 4.9 \times t^2$	M1 A1 2	Allow 'u' = U. Allow $s \leftrightarrow c$. Allow g as g, ±9.8, ±9.81, ±10. Allow +2. Accept not 'shown'. Do not allow +2. Allow e.g $+ 0.5 \times (-9.8) \times t^2$ instead of $-4.9t^2$. Accept g not evaluated
(ii)	**either** At D, $y = 0$ so $U\sin 68.5° T - 4.9 \times T^2 = 0$ $\Rightarrow T(U\sin 68.5° - 4.9T) = 0$ so $T = 0$ (at C) or $T = \frac{U\sin 68.5°}{4.9}$ (at D) **or** Use (i)(A) and put $x = 10$ with $t = T$ to get $UT\cos 68.5° = 10$	 M1 M1 E1 M1 M1 E1 B1 4	 Equating correct y to 0 or **their** y to correct value. Attempting to factorise (or solve). Allow ÷ T without comment. Properly shown. Accept no ref to $T = 0$. Accept $T = 0$ given as well without comment. Find time to top Double time to the top
(iii)	Eliminating T from the results in (ii) gives $U\cos 68.5° \times \frac{U\sin 68.5°}{4.9} = 10$ so $U = 11.98729\ldots$ so 12.0 (3 s. f.)	 M1 M1 E1 3	 Substituting, using correct expressions or **their** expressions from (ii). Attempt to solve for U^2 or U. Some evidence seen. e.g. $142.8025.. < U^2 < 145.2025...$ with clear statement, or 11.9… seen with clear statement or 11.98… seen. Accept 11.98… seen for full marks.
(iv)	**continued**		
(iv)	Require $Ut\sin 68.5° - 4.9t^2 = -2$ Solving $4.9t^2 - Ut\sin 68.5° - 2 = 0$ $t = -0.1670594541\ldots, 2.4431591\ldots$ (Using 12: – 0.1669052502.. , 2.445478886..) Require $U\cos 68.5° \times 2.44\ldots - 10$ $= 0.7336\ldots$ so 0.734 m (3 s. f.) (Using 12 consistently, 0.7552… so 0.755 (3 s. f.))	M1 M1 A1 M1 A1 5	Equating correct y to -2 or **their** y to correct value. Allow use of U, 11.987… or 12. Allow implicit '= 0' Dep on 1st M1. Attempt to solve a 3 term quadratic to find at least the +ve root. Allow if two correct roots seen WW. Accept only + ve root given Alternative method of e.g. finding time to highest point and then time to the ground. M1 all times attempted, at least one by a sound method. M1 both methods sound and complete. A1. Dep on first M1. Allow **their** expression for x. Allow ' – 10' omitted. cao. Accept $0.73 \le x \le 0.76$
(v)	Eliminate t from (i) (B) using $t = \frac{x}{U\cos 68.5°}$ from (i)(A) so $y = x\tan 68.5° - \frac{4.9x^2}{U^2(\cos 68.5°)^2}$ We require $y = 0$ when $x = 10$ so $U = 11.98729\ldots$ so 12.0 (3 s. f.)	 M1 E1 M1 E1 4	 May be implied. FT their (i). Clearly shown. Must see attempt to solve. Or use $x = 10.73\ldots$ when $y = -2$. Must see evidence of fresh calculation or statement that they have now got the same expression for evaluation.
		19	

3

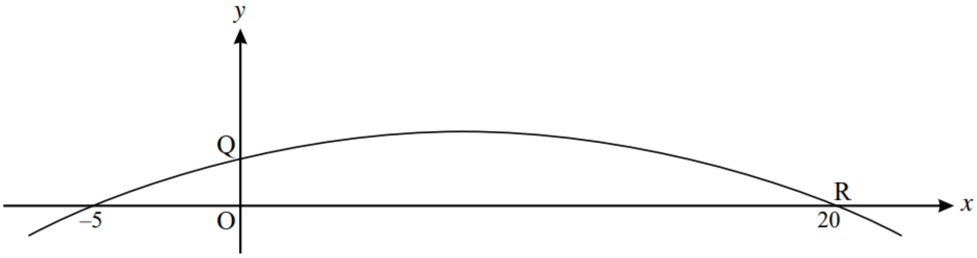

Fig. 7

Fig. 7 shows the graph of $y = \frac{1}{100}(100 + 15x - x^2)$.

For $0 \leqslant x \leqslant 20$, this graph shows the trajectory of a small stone projected from the point Q where y m is the height of the stone above horizontal ground and x m is the horizontal displacement of the stone from O. The stone hits the ground at the point R.

(i) Write down the height of Q above the ground. **[1]**

(ii) Find the horizontal distance from O of the highest point of the trajectory and show that this point is 1.5625 m above the ground. **[5]**

(iii) Show that the time taken for the stone to fall from its highest point to the ground is 0.565 seconds, correct to 3 significant figures. **[3]**

(iv) Show that the horizontal component of the velocity of the stone is $22.1\,\text{m s}^{-1}$, correct to 3 significant figures. Deduce the time of flight from Q to R. **[5]**

(v) Calculate the speed at which the stone hits the ground. **[4]**

3 (i)	$y(0) = 1$	B1		1
(ii)	**Either** $\frac{1}{2}(20+5)-5=7.5$ **or** $y(7.5)=\frac{1}{100}(100+15\times7.5-7.5^2)$ $=\frac{25}{16}$ (1.5625) so 1.5625 m	M1 A1 A1 M1 A1 A1 M1 E1	Use of symmetry e.g. use of $\frac{1}{2}(20+5)$ 12.5 o.e. seen 7.5 cao Att pt at y' and to solve $y' = 0$ $k(15-2x)$ where $k=1$ or $\frac{1}{100}$ 7.5 cao, seen as final answer FT **their** 7.5 A [SC2 only showing 1.5625 leads to $x = 7.5$]	5

(iii)	$4.9t^2=\frac{25}{16}$ (1.5625) $t^2 = 0.31887\ldots$ so $t = \pm\,0.56469\ldots$ Hence 0.565 s (3 s. f.)	M1 A1 E1	Use of $s=ut+0.5at^2$ with $u = 0$. Condone use of $\pm10,\ \pm9.8,\ \pm9.81$. If sequence of *suvat* used, complete method required. In any method only error accepted is sign error AG. Condone no reference to –ve value. www. 0.565 must be justified as answer to 3 s. f.	3
(iv)	$\dot{x}=\frac{12.5}{0.56469...}=22.1359...$ so 22.1 m s^{-1} (3 s. f.)) **Either** Time is $\frac{20}{12.5}\times0.56469...$ s so 0.904 s (3 s. f.) **or** Time is $\frac{20}{22.1359...}$ s = 0.903507… so 0.904 s (3 s. f.) **or** (iii) + $\frac{7.5}{\textbf{their }\dot{x}}$ so 0.904 s (3 s. f.)	M1 B1 E1 M1 A1 M1 A1 M1 A1	or 25 / (2×0.56469..) Use of 12.5 or equivalent 22.1 must be justified as answer to 3 s. f. Don't penalise if penalty already given in (iii). cao Accept 0.91 (2 s. f.) cao Accept 0.91 (2 s. f.) cao Accept 0.91 (2 s. f.)	5
(v)	$v=\sqrt{\dot{x}^2+\dot{y}^2}$ $\dot{y}^2=0^2+2\times9.8\times\frac{25}{16}$ or $\dot{y}=0+9.8\times0.5646...$ $=\frac{245}{8}$ (30.625) $\dot{y}=\pm5.539...$ so $v=\sqrt{490+30.625}=22.8172\ldots$ m s^{-1} so 22.8 m s^{-1} (3 s. f.)	M1 M1 A1 A1	Must have attempts at both components Or equiv. $u = 0$. Condone use of $\pm10,\ \pm9.8,\ \pm9.81$. Accept wrong s (or t in alternative method) Or equivalent. May be implied. Could come from (iii) $v^2 = u^2 + 2as$ used there. Award marks again. cao. www	4

4 Sandy is throwing a stone at a plum tree. The stone is thrown from a point O at a speed of 35 m s^{-1} at an angle of α to the horizontal, where $\cos\alpha = 0.96$. You are *given* that, t seconds after being thrown, the stone is $(9.8t - 4.9t^2)$ m higher than O.

When descending, the stone hits a plum which is 3.675 m higher than O. Air resistance should be neglected.

Calculate the horizontal distance of the plum from O. **[6]**

5 Small stones A and B are initially in the positions shown in Fig. 6 with B a height H m directly above A.

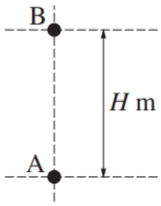

Fig. 6

At the instant when B is released from rest, A is projected vertically upwards with a speed of 29.4 m s^{-1}. Air resistance may be neglected.

The stones collide T seconds after they begin to move. At this instant they have the same speed, $V \text{ m s}^{-1}$, and A is still rising.

By considering when the speed of A upwards is the same as the speed of B downwards, or otherwise, show that $T = 1.5$ and find the values of V and H. **[7]**

4		Mark	Comment	Sub
	either			
	We need $3.675 = 9.8t - 4.9t^2$	*M1	Equating given expression or **their** attempt at y to ± 3.675 . If **they** attempt y, allow sign errors, $g = 9.81$ etc. and $u = 35$.	
	Solving $4t^2 - 8t + 3 = 0$	M1*	Dependent. Any method of solution of a 3 term quadratic.	
	gives $t = 0.5$ or $t = 1.5$	A1	cao. Accept only the larger root given	
		F1	Both roots shown and larger chosen provided both +ve. Dependent on 1st M1. [Award M1 M1 A1 for 1.5 seen WW]	
	or			
		M1	Complete method for total time from motion in separate parts. Allow sign errors, $g = 9.81$ etc. Allow $u = 35$ initially only.	
	Time to greatest height $0 = 35 \times 0.28 - 9.8t$ so $t = 1$	A1	Time for 1st part	
	Time to drop is 0.5	A1	Time for 2nd part	
	total is 1.5 s	A1	cao	
	then			
	Horiz distance is $35 \times 0.96t$	B1	Use of $x = u\cos\alpha t$. May be implied.	
	So distance is $35 \times 0.96 \times 1.5 = 50.4$ m	F1	FT **their** quoted t provided it is positive.	6
		6		

5		Mark	Comment	Sub
	Method 1			
	$\uparrow\ v_A = 29.4 - 9.8T \qquad \downarrow\ v_B = 9.8T$	M1	Either attempted. Allow sign errors and $g = 9.81$ etc	
		A1	Both correct	
	For same speed $29.4 - 9.8T = 9.8T$	M1	Attempt to equate. Accept sign errors and $T = 1.5$ substituted in both.	
	so $T = 1.5$	E1	If 2 subs there must be a statement about equality	
	and $V = 14.7$	F1	FT T or V, whichever is found second	
	$H = 29.4 \times 1.5 - 0.5 \times 9.8 \times 1.5^2$ $+ 0.\ \times 9.8 \times 1.5^2$	M1	Sum of the distance travelled by each attempted	
	$= 44.1$	A1	cao	
	Method 2			
	$V^2 = 29.4^2 - 2 \times 9.8 \times x = 2 \times 9.8 \times (H - x)$	M1	Attempts at V^2 for each particle equated. Allow sign errors, 9.81 etc. Allow h_1, h_2 without $h_1 = H - h_2$	
		B1	Both correct. Require $h_1 = H - h_2$ but not an equation.	
	$29.4^2 = 19.6H$ so $H = 44.1$	A1	cao	
	Relative velocity is 29.4 so	M1	Any method that leads to T or V	
	$T = \dfrac{44.1}{29.4}$	E1		
	Using $v = u + at$	M1	Any method leading to the other variable	
	$V = 0 + 9.8 \times 1.5 = 14.7$	F1		
			Other approaches possible. If 'clever' ways seen, reward according to weighting above.	7
		7		

1 A small firework is fired from a point O at ground level over horizontal ground. The highest point reached by the firework is a horizontal distance of 60 m from O and a vertical distance of 40 m from O, as shown in Fig. 7. Air resistance is negligible.

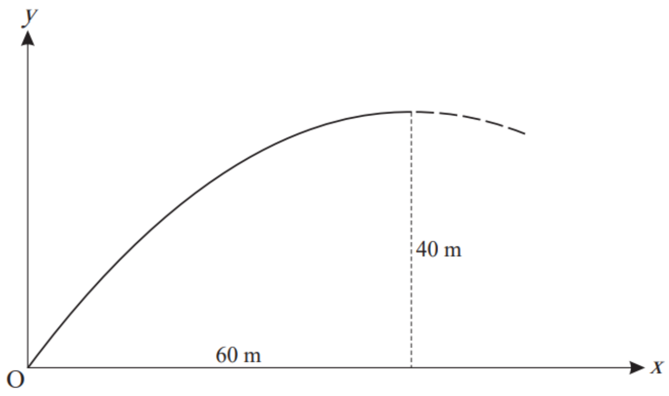

Fig. 7

The initial horizontal component of the velocity of the firework is $21\ \text{m s}^{-1}$.

(i) Calculate the time for the firework to reach its highest point and show that the initial vertical component of its velocity is $28\ \text{m s}^{-1}$. [4]

(ii) Show that the firework is $(28t - 4.9t^2)$ m above the ground t seconds after its projection. [1]

When the firework is at its highest point it explodes into several parts. Two of the parts initially continue to travel horizontally in the original direction, one with the original horizontal speed of $21\ \text{m s}^{-1}$ and the other with a quarter of this speed.

(iii) State why the two parts are always at the same height as one another above the ground and hence find an expression in terms of t for the distance between the parts t seconds after the explosion. [3]

(iv) Find the distance between these parts of the firework

(*A*) when they reach the ground, [2]

(*B*) when they are 10 m above the ground. [5]

(v) Show that the cartesian equation of the trajectory of the firework before it explodes is $y = \frac{1}{90}(120x - x^2)$, referred to the coordinate axes shown in Fig. 7. [4]

1		Mark	Comment	
(i)	Hor $21t = 60$ so $\frac{20}{7}$ s (2.8571…) **either** $0 = u - 9.8 \times \frac{20}{7}$ **or** $-u = u - 9.8 \times \left(\frac{40}{7}\right)$ **or** $40 = u \times \frac{20}{7} - 4.9\left(\frac{20}{7}\right)^2$ so u = 28 so 28 m s^{-1}	M1 A1 M1 E1	Use of horizontal components and a = 0 or $s = vt - 0.5at^2$ with v = 0. Any form acceptable. Allow M1 A1 for answer seen WW. [If $s = ut + 0.5at^2$ and u = 0 used without justification award M1 A0] [If u = 28 *assumed* to find time then award SC1] Use of $v = u + at$ (or $v^2 = u^2 + 2as$) with v = 0. **or** Use of v = u + at with v = – u and appropriate t. **or** Use of $s = ut + 0.5at^2$ with s = 40 and appropriate t Condone sign errors and, where appropriate, $u \leftrightarrow v$. Accept signs not clear but not errors. Enough working must be given for 28 to be properly shown. [NB u = 28 may be found first and used to find time]	4
(ii)	$y = 28t - 0.5 \times 9.8t^2$	E1	*Clear & convincing* use of g = – 9.8 in $s = ut + 0.5at^2$ or $s = vt - 0.5at^2$ **NB: AG**	1
(iii)	Start from same height with same (zero) vertical speed at same time, same acceleration Distance apart is $0.75 \times 21t = 15.75t$	E1 M1 A1	For two of these reasons 0.75×21t seen **or** 21t and 5.25t both seen with intention to subtract. Need simplification - LHS alone insufficient. CWO.	3
(iv) (A)	**either** Time is $\frac{20}{7}$ s by symmetry so $15.75 \times \frac{20}{7} = 45$ so 45 m **or** Hit ground at same time. By symmetry one travels 60 m so the other travels 15 m in this time ($\frac{1}{4}$ speed) so 45 m.	B1 B1 B1 B1	Symmetr or *uvast* FT their (iii) with $t = \frac{20}{7}$ [SC1 if 90 m seen]	2
(B)	see next page			

1	continued			
(B)			[SC1 if **either** and **or** methods mixed to give $\pm 30 = 28t - 4.9t^2$ or $\pm 10 = 4.9t^2$]	
	either Time to fall is $40 - 10 = 0.5 \times 9.8 \times t^2$	M1	Considering time from explosion with *u* = 0. Condone sign errors.	
		A1	LHS. Allow ± 30	
		A1	All correct	
	$t = 2.47435\ldots$	A1	cao	
	need $15.75 \times 2.47435.. = 38.971..$ so 39.0 (3sf)	F1	FT **their** (iii) only.	
	or Need time so $10 = 28t - 4.9t^2$	M1	Equating $28t - 4.9t^2 = \pm 10$	
	$4.9t^2 - 28t + 10 = 0$	M1*	Dep. Attempt to solve quadratic by a method that could give two roots.	
	so $t = \frac{28 \pm \sqrt{28^2 - 4 \times 4.9 \times 10}}{9.8}$			
	so 0.382784… or 5.33150…	A1	Larger root correct to at least 2 s. f. Both method marks may be implied from two correct roots alone (to at least 1 s. f.). [SC1 for either root seen WW]	
	Time required is 5.33150… $-\frac{20}{7}$ = 2.47435..	M1		
	need $15.75 \times 2.47435.. = 38.971..$ so 39.0 (3sf)	F1	FT **their** (iii) only.	5
(v)	Horiz $(x =)\ 21t$	B1		
	Elim *t* between $x = 21t$ and $y = 28t - 4.9t^2$	M1	Intention must be clear, with some attempt made.	
	so $y = 28\left(\frac{x}{21}\right) - 4.9\left(\frac{x}{21}\right)^2$	A1	*t* completely and correctly eliminated from their expression for *x* and correct *y*. Only accept wrong notation if subsequently explicitly given correct value e.g $\frac{x^2}{21}$ *seen* as $\frac{x^2}{441}$.	
	so $y = \frac{4x}{3} - \frac{0.1x^2}{9} = \frac{1}{90}\left(120x - x^2\right)$	E1	Some simplification must be shown.	
			[SC2 for 3 points shown to be on the curve. Award more only if it is made clear that (a) trajectory is a parabola (b) 3 points define a parabola]	4
		19		