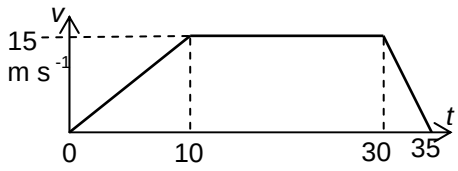
4761 Mechanics 1

Q 1		Mark	Comment	Sub
(i)		B1 B1 B1	Acc and dec shown as straight lines Horizontal straight section All correct with *v* and times marked and at least one axis labelled. Accept (*t*, *v*) or (*v*, *t*) used.	3
(ii)	Distance is found from the area area is $\frac{1}{2}\times10\times15+20\times15+\frac{1}{2}\times5\times15$ (or $\frac{1}{2}\times(20+35)\times15$) = 412.5 so distance is 412.5 m	M1 A1 A1	At least one area attempted or equivalent *uvast* attempted over one appropriate interval. Award for at least two areas (or equivalent) correct Allow if a trapezium used and only 1 substitution error. FT **their** diagram. cao (Accept 410 or better accuracy)	3
		6		
2 (i)	$\begin{pmatrix}6\\9\end{pmatrix}=1.5\mathbf{a}$ giving $\mathbf{a}=\begin{pmatrix}4\\6\end{pmatrix}$ so $\begin{pmatrix}4\\6\end{pmatrix}$ m s^{-2}	M1 A1	Use of N2L with an attempt to find **a**. Condone spurious notation. Must be a vector in proper form. Penalise only once in paper.	2
(ii)	Angle is $\arctan\left(\frac{6}{4}\right)$ = 56.309… so 56.3° (3 s. f.)	M1 F1	Use of arctan with **their** $\frac{6}{4}$ or $\frac{4}{6}$ or equiv. May use **F**. FT **their a** provided both cpts are +ve and non-zero.	2
(iii)	Using $\mathbf{s}=t\mathbf{u}+0.5t^2\mathbf{a}$ we have $\mathbf{s}=2\begin{pmatrix}-2\\3\end{pmatrix}+0.5\times4\begin{pmatrix}4\\6\end{pmatrix}$ so $\begin{pmatrix}4\\18\end{pmatrix}$ m	M1 A1 A1 7	Appropriate single ***uvast*** (or equivalent sequence of ***uvast***). If integration used twice condone omission of **r**(0) but not **v**(0). FT **their a** only cao. isw for magnitude subsequently found. Vector must be in proper form (penalise only once in paper).	3

Q 3		Mark	Comment	Sub
(i)	$m \times 9.8 = 58.8$ so m = 6	M1 A1	$T = mg$. Condone sign error. cao. CWO.	2
(ii)	Resolve $\rightarrow$ $58.8\cos 40 - F = 0$ F = 45.043… so 45.0 N (3 s. f.)	M1 B1 A1	Resolving **their** tension. Accept $s \leftrightarrow c$. Condone sign errors but not extra forces. (**their** T) × $\cos 40$ (or equivalent) seen Accept $\pm$ 45 only.	3
(iii)	Resolve $\uparrow$ $R + 58.8\sin 40 - 15 \times 9.8 = 0$ R = 109.204… so 109 N (3 s. f.)	M1 A1 A1	Resolving **their** tension. All forces present. No extra forces. Accept $s \leftrightarrow c$. Condone errors in sign. All correct cao	3
		8		
Q 4		**Mark**	**Comment**	**Sub**
(i)	Resultant is $\begin{pmatrix}4\\1\\2\end{pmatrix}+\begin{pmatrix}-6\\2\\4\end{pmatrix}=\begin{pmatrix}-2\\3\\6\end{pmatrix}$ Magnitude is $\sqrt{(-2)^2+3^2+6^2} = \sqrt{49} = 7$ N	M1 A1 M1 F1	Adding the vectors. Condone spurious notation. Vector must be in proper form (penalise only once in the paper). Accept clear components. Pythagoras on **their** 3 component vector. Allow e.g. -2^2 for $(-2)^2$ even if evaluated as – 4. FT **their** resultant.	4
(ii)	**F** + 2**G** + **H** = **0** So **H** = - 2**G** - **F** = $-\begin{pmatrix}-12\\4\\8\end{pmatrix}-\begin{pmatrix}4\\1\\2\end{pmatrix}$ = $\begin{pmatrix}8\\-5\\-10\end{pmatrix}$	M1 A1 A1	Either **F** + 2**G** + **H** = **0** or **F** + 2**G** = **H** Must see attempt at **H** = – 2 **G** – **F** cao. Vector must be in proper form (penalise only once in the paper).	3
		7		

Q 5		Mark	Comment	Sub
	$a = 12 - 6t$	M1 A1	Differentiation, at least one term correct.	
	a = 0 gives t = 2	F1	Follow **their** a	
	$x = \int (2 + 12t - 3t^2)\mathrm{d}x$	M1	Integration indefinite or definite, at least one term correct.	
	$2t + 6t^2 - t^3 + C$	A1	Correct. Need not be simplified. Allow as definite integral. Ignore C or limits	
	x = 3 when t = 0	M1	Allow x = ± 3 or argue it is $\int_0^2$ from A then ± 3	
	so $3 = C$ and $x = 2t + 6t^2 - t^3 + 3$	A1	Award if seen WWW or $x = 2t + 6t^2 - t^3$ seen with +3 added later.	
	$x(2) = 4 + 24 - 8 + 3 = 23$ m	B1	FT **their** t and **their** x if obtained by integration but not if -3 obtained instead of +3. [If 20 m seen WWW for displacement award SC6] [Award SC1 for position if constant acceleration used for displacement and then +3 applied]	8
		8		

Q 6		Mark	Comment	Sub
(i)	$3.5 = 0.5 + 1.5T$ so T = 2 so 2 s $s = \frac{3.5+0.5}{2} \times 2$ so s = 4 so 4 m	M1 A1 M1 F1	Suitable *uvast*, condone sign errors. cao Suitable *uvast*, condone sign errors. FT **their** T. [If s found first then it is cao. In this case when finding T, FT **their** s, if used.]	4
(ii) **(A)**	N2L ↓: $80 \times 9.8 - T = 80 \times 1.5$ T = 664 so 664 N	M1 B1 A1	Use of N2L. Allow weight omitted and use of $F = mga$ Condone errors in sign but do not allow extra forces. weight correct (seen in (A) or (B)) cao	
(B)	N2L ↓: $80 \times 9.8 - T = 80 \times (-1.5)$ T = 904 so 904 N	M1 A1	N2L with all forces and using $F = ma$. Condone errors in sign but do not allow extra forces. cao [Accept 904 N seen for M1 A1]	5
(iii)	N2L ↑: $2500 - 80 \times 9.8 - 116 = 80a$ a = 20 so 20 m s^{-2} upwards.	M1 A1 A1 A1	Use of N2L with $F = ma$. Allow 1 force missing. No extra forces. Condone errors in sign. ± 20, accept direction wrong or omitted upwards made clear (accept diagram)	4
(iv)	N2L ↑ on equipment: $80 - 10 \times 9.8 = 10a$ $a = -1.8$ N2L ↑ **either** all: $T - (80+10) \times 9.8 - 116 = 90 \times (-1.8)$ **or** on man: T – (80×9.8) – 116 – 80 = 80×(– 1.8) T = 836 so 836 N	M1 A1 M1 A1	Use of N2L on equipment. All forces. $F = ma$. No extra forces. Allow sign errors. Allow ± 1.8 N2L for system or for man alone. Forces correct (with no extras); accept sign errors; **their** ± 1.8 used cao [NB The answer 836 N is independent of the value taken for g and hence may be obtained if all weights are omitted.]	4
		17		

Q 7		Mark	Comment	Sub
(i)	Horiz $21t = 60$ 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	Symmetry or *uvast* FT their (iii) with $t = \frac{20}{7}$ [SC1 if 90 m seen]	2
(B)	see next page			

Q7	continued			
(B)	**either** Time to fall is $40-10=0.5\times9.8\times t^2$ t = 2.47435… need $15.75\times2.47435..=38.971..$ so 39.0 (3sf) **or** Need time so $10=28t-4.9t^2$ $4.9t^2-28t+10=0$ so $t=\frac{28\pm\sqrt{28^2-4\times4.9\times10}}{9.8}$ so 0.382784… or 5.33150… Time required is 5.33150… $-\frac{20}{7}$ = 2.47435.. need $15.75\times2.47435..=38.971..$ so 39.0 (3sf)	 M1 A1 A1 A1 F1 M1 M1* A1 M1 F1	[SC1 if **either** and **or** methods mixed to give $\pm30=28t-4.9t^2$ or $\pm10=4.9t^2$] Considering time from explosion with u = 0. Condone sign errors. LHS. Allow ±30 All correct cao FT **their** (iii) only. Equating $28t-4.9t^2=\pm10$ Dep. Attempt to solve quadratic by a method that could give two roots. 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] FT **their** (iii) only.	5
(v)	Horiz $(x=)\ 21t$ Elim t between $x=21t$ and $y=28t-4.9t^2$ so $y=28\left(\frac{x}{21}\right)-4.9\left(\frac{x}{21}\right)^2$ so $y=\frac{4x}{3}-\frac{0.1x^2}{9}=\frac{1}{90}\left(120x-x^2\right)$	B1 M1 A1 E1	Intention must be clear, with some attempt made. 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 $\frac{x^2}{441}$. 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		