

4761

Mark Scheme

January 2008

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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)	<p>Distance is found from the area</p> <p>area is $\frac{1}{2} \times 10 \times 15 + 20 \times 15 + \frac{1}{2} \times 5 \times 15$</p> <p>(or $\frac{1}{2} \times (20 + 35) \times 15$)</p> <p>= 412.5 so distance is 412.5 m</p>	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)	$\begin{pmatrix} 6 \\ 9 \end{pmatrix} = 1.5\mathbf{a} \text{ giving } \mathbf{a} = \begin{pmatrix} 4 \\ 6 \end{pmatrix} \text{ so } \begin{pmatrix} 4 \\ 6 \end{pmatrix} \text{ m s}^{-2}$	M1 A1	Use of N2L with an attempt to find \mathbf{a} . Condone spurious notation. Must be a vector in proper form. Penalise only once in paper.	2
(ii)	<p>Angle is $\arctan\left(\frac{6}{4}\right)$</p> <p>= 56.309... so 56.3° (3 s. f.)</p>	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)	<p>Using $\mathbf{s} = t\mathbf{u} + 0.5t^2\mathbf{a}$ we have</p> $\mathbf{s} = 2 \begin{pmatrix} -2 \\ 3 \end{pmatrix} + 0.5 \times 4 \begin{pmatrix} 4 \\ 6 \end{pmatrix}$ <p>so $\begin{pmatrix} 4 \\ 18 \end{pmatrix} \text{ m}$</p>	M1 A1 A1	Appropriate single $uvast$ (or equivalent sequence of $uvast$). If integration used twice condone omission of $\mathbf{r}(0)$ but not $\mathbf{v}(0)$. FT their a only cao. isw for magnitude subsequently found. Vector must be in proper form (penalise only once in paper).	3
		7		

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 $58.8 \cos 40 - F = 0$ $F = 45.043\dots$ 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) $\times \cos 40$ (or equivalent) seen Accept ± 45 only.	3
(iii)	Resolve \uparrow $R + 58.8 \sin 40 - 15 \times 9.8 = 0$ $R = 109.204\dots$ 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)	$\mathbf{F} + 2\mathbf{G} + \mathbf{H} = \mathbf{0}$ So $\mathbf{H} = -2\mathbf{G} - \mathbf{F} = -\begin{pmatrix} -12 \\ 4 \\ 8 \end{pmatrix} - \begin{pmatrix} 4 \\ 1 \\ 2 \end{pmatrix}$ $= \begin{pmatrix} 8 \\ -5 \\ -10 \end{pmatrix}$	M1 A1 A1	Either $\mathbf{F} + 2\mathbf{G} + \mathbf{H} = \mathbf{0}$ or $\mathbf{F} + 2\mathbf{G} = \mathbf{H}$ Must see attempt at $\mathbf{H} = -2\mathbf{G} - \mathbf{F}$ cao. Vector must be in proper form (penalise only once in the paper).	3
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Q 5		Mark	Comment	Sub
	$a = 12 - 6t$ $a = 0$ gives $t = 2$ $x = \int (2 + 12t - 3t^2) dx$ $2t + 6t^2 - t^3 + C$ $x = 3$ when $t = 0$ so $3 = C$ and $x = 2t + 6t^2 - t^3 + 3$ $x(2) = 4 + 24 - 8 + 3 = 23$ m	M1 A1 F1 M1 A1 M1 A1 B1	Differentiation, at least one term correct. Follow their a Integration indefinite or definite, at least one term correct. Correct. Need not be simplified. Allow as definite integral. Ignore C or limits Allow $x = \pm 3$ or argue it is \int_0^2 from A then ± 3 Award if seen WWW or $x = 2t + 6t^2 - t^3$ seen with $+3$ added later. 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
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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 <i>uvast</i> , condone sign errors. cao Suitable <i>uvast</i> , condone sign errors. FT their <i>T</i> . [If <i>s</i> found first then it is cao. In this case when finding <i>T</i> , FT their <i>s</i> , if used.]	4
(ii) (A) (B)	N2L ↓: $80 \times 9.8 - T = 80 \times 1.5$ $T = 664$ so 664 N N2L ↓: $80 \times 9.8 - T = 80 \times (-1.5)$ $T = 904$ so 904 N	M1 B1 A1 M1 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 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: $T - (80 \times 9.8) - 116 - 80 = 80 \times (-1.8)$ $T = 836$ 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 <i>g</i> and hence may be obtained if all weights are omitted.]	4
		17		

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

Q7	continued			
(B)	<p>either Time to fall is $40 - 10 = 0.5 \times 9.8 \times t^2$</p> <p>$t = 2.47435\dots$ need $15.75 \times 2.47435\dots = 38.971\dots$ so 39.0 (3sf)</p> <p>or Need time so $10 = 28t - 4.9t^2$</p> <p>$4.9t^2 - 28t + 10 = 0$</p> <p>so $t = \frac{28 \pm \sqrt{28^2 - 4 \times 4.9 \times 10}}{9.8}$ so 0.382784... or 5.33150...</p> <p>Time required is 5.33150... $-\frac{20}{7} =$ 2.47435.. need $15.75 \times 2.47435\dots = 38.971\dots$ so 39.0 (3sf)</p>	<p>M1</p> <p>A1</p> <p>A1</p> <p>A1</p> <p>F1</p> <p>M1</p> <p>M1*</p> <p>A1</p> <p>M1</p> <p>F1</p>	<p>[SC1 if either and or methods mixed to give $\pm 30 = 28t - 4.9t^2$ or $\pm 10 = 4.9t^2$]</p> <p>Considering time from explosion with $u = 0$. Condone sign errors.</p> <p>LHS. Allow ± 30</p> <p>All correct cao</p> <p>FT their (iii) only.</p> <p>Equating $28t - 4.9t^2 = \pm 10$ Dep. Attempt to solve quadratic by a method that could give two roots.</p> <p>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]</p> <p>FT their (iii) only.</p>	5
(v)	<p>Horiz ($x =$) $21t$ Elim t between $x = 21t$ and $y = 28t - 4.9t^2$</p> <p>so $y = 28\left(\frac{x}{21}\right) - 4.9\left(\frac{x}{21}\right)^2$</p> <p>so $y = \frac{4x}{3} - \frac{0.1x^2}{9} = \frac{1}{90}(120x - x^2)$</p>	<p>B1</p> <p>M1</p> <p>A1</p> <p>E1</p>	<p>Intention must be clear, with some attempt made.</p> <p>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 $\frac{x^2}{441}$.</p> <p>Some simplification must be shown.</p> <p>[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]</p>	4
		19		