

Mark Scheme

Paper 4761	Name Mechanics 1	Session Jan	Year 2005	
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Solutions and mark scheme

Q 1		mark		
(i)	Differentiate $\mathbf{v} = 2t \mathbf{i} + (5 - 4t) \mathbf{j}$	M1 A1	At least 1 cpt correct Award for RHS seen	4
	Differentiate $\mathbf{a} = 2 \mathbf{i} - 4 \mathbf{j}$	M1 F1	Do not award if \mathbf{i} and \mathbf{j} lost in \mathbf{v} . At least 1 cpt correct. FT FT from their 2 component \mathbf{v}	
(ii)	$\mathbf{F} + 12 \mathbf{j} = 4(2 \mathbf{i} - 4 \mathbf{j})$	M1 A1	N2L. Allow $\mathbf{F} = mg \mathbf{a}$. No extra forces. Allow $12\mathbf{j}$ omitted Allow wrong signs otherwise correct with their vector \mathbf{a} .	3
	$\mathbf{F} = 8 \mathbf{i} - 28 \mathbf{j}$	A1	cao	
	total	7		

Q 2		mark		
(i)				
(A)	the pulleys are smooth and the string is light	E1	Accept only 'the pulley is smooth'.	2
(B)	the string is inextensible	E1		
(ii)	Diagrams	B1	All forces present with labels and arrows. Acc not reqd.	1
	For X, N2L upwards $T - 2g = 2a$	M1 A1	N2L. Allow $F = mga$. All forces present Award for equation for X or Y or combined Any form	5
	For Y, N2L downwards $4g - T = 4a$	A1		
	Solve for a and T $a = \frac{g}{3}$ (3.27 (3 s. f.))	A1		
	$T = \frac{8}{3}g$ (26.1 (3 s. f.))	F1		
	total	8		

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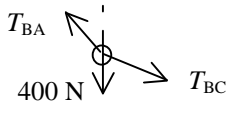
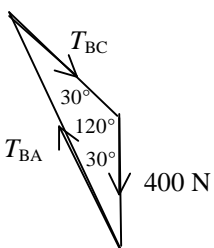
Solutions and mark scheme

Q3		mark		
(i)	$\begin{pmatrix} x \\ -7 \\ z \end{pmatrix} + \begin{pmatrix} 4 \\ y \\ -5 \end{pmatrix} + \begin{pmatrix} 5 \\ 4 \\ -7 \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix}$ Equating components gives $x = -9, y = 3, z = 12$	M1 A1 A1 A1	[Allow SC 2/4 if 9, -3, -12 obtained]	4
(ii)	We need $\sqrt{5^2 + 4^2 + (-7)^2}$ $= \sqrt{90}$ or 9.48683... so 9.49 (3 s. f.)	M1 A1	Any reasonable accuracy	2
	total	6		

Q4		mark		
(i)	Height reached by first particle is given by $0 = 21^2 - 2 \times 9.8 \times s$ so $s = 22.5$ so 22.5 m	M1 A1	Other methods must be complete. Allow $g = \pm 9.8, \pm 10$ Accept with consistent signs	2
(ii)	Sol (1) t seconds after second particle projected its height is $15t - 4.9t^2$ and the first particle has height $22.5 - 4.9t^2$ (or $21t - 4.9t^2$) either Sub $t = 1.5$ to show both have same value State height as 11.475 m or $15t - 4.9t^2 = 22.5 - 4.9t^2$ giving $t = 1.5$ and height as 11.475 m	M1 A1 M1 A1 E1 A1 M1 A1	Allow $g = \pm 9.8, \pm 10$ Allow $g = \pm 9.8, \pm 10$ Award only if used correctly (or sub $t = 3.64$ into $21t - 4.9t^2$ for 1 st & $t = 1.5$ for 2 nd) cao. Accept any reasonable accuracy. Don't award if only one correctly used equation obtained. Both. t shown. Ht cao (to any reasonable accuracy)	
	Sol (2) t seconds after second particle projected its height is $15t - 4.9t^2$ and the first particle has fallen $4.9t^2$ Collide when $15T - 4.9T^2 + 4.9T^2 = 22.5$ so $T = 1.5$ $H = 22.5 - 4.9 \times 1.5^2 = 11.475$ m	M1 A1 B1 M1 E1 A1	Allow $g = \pm 9.8, \pm 10$ Or other correct method cao. Accept any reasonable accuracy. Don't award if only one correctly used equation obtained.	6
	total	8		

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Solutions and mark scheme

Q5		mark		
(i)		B1	Different labels. All forces present with arrows in correct directions. Condone no angles.	1
(ii)	<p>Using triangle of forces</p>  <p>Triangle isosceles so tension in BC is 400 N Tension in BA is $2 \times 400 \times \cos 30 = 400\sqrt{3}$ N (693 N, (3 s. f.))</p>	M1 B1 A1 F1	<p>Attempt at triangle of forces. Ignore angles and arrows. Accept 90, 60, 30 triangle.</p> <p>Triangle, arrows, labels and angles correct</p> <p>cao FT BC only</p> <p>[If resolution used, M1 for 1 equn; M1 for 2nd equn + attempt to elim; A1; F1. For M marks all forces present but allow $s \leftrightarrow c$ and sign errors. No extra forces. If Lami used: M1 first pair of equations in correct format, condone wrong angles. A1. M1 second pair in correct format, with correct angles. F1 FT their first answer if necessary.]</p>	4
(iii)	<p>Resolve at B perpendicular to the line ABC</p> <p>Weight has unbalanced component in this direction</p>	E1 E1	<p>Attempt to argue unbalanced force</p> <p>Complete, convincing argument.</p> <p>[or Resolve horiz and establish tensions equal E1 Resolve vert to show inconsistency. E1]</p>	2
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Solutions and mark scheme

Q 6		mark		
(i)	Area under curve $0.5 \times 2 \times 20 + 0.5 \times (20 + 10) \times 4 + 0.5 \times 10 \times 1$ $= 85 \text{ m}$	M1 B1 A1	Attempt to find any area under curve or use const accn results Any area correct (Accept 20 or 60 or 5 without explanation) cao	3
(ii)	$\frac{20 - 10}{4} = 2.5$ upwards	M1 A1 B1	$\Delta v / \Delta t$ accept ± 2.5 Accept -2.5 downwards (allow direction specified by diagram etc). Accept 'opposite direction to motion'.	3
(iii)	$v = -2.5t + c$ $v = 20$ when $t = 2$ $v = -2.5t + 25$	M1 M1 A1	Allow their a in the form $v = \pm at + c$ or $v = \pm a(t - 2) + c$ cao [Allow $v = 20 - 2.5(t - 2)$] [Allow 2/3 for different variable to t used, e.g. x . Allow any variable name for speed]	3
(iv)	Falling with negligible resistance	E1	Accept 'zero resistance', or 'no resistance' seen.	1
(v)	$-1.5 \times 4 + 9.5 \times 2 + 7 = 20$ $-1.5 \times 36 + 9.5 \times 6 + 7 = 10$ $-1.5 \times 49 + 9.5 \times 7 + 7 = 0$	E1 E1	One of the results shown All three shown. Be generous about the 'show'.	2
(vi)	$\int_2^7 (-1.5t^2 + 9.5t + 7) dt$ $= \left[-0.5t^3 + 4.75t^2 + 7t \right]_2^7$ $= \left(-\frac{343}{2} + \frac{19 \times 49}{4} + 49 \right) - (-4 + 19 + 14)$ $= 81.25 \text{ m}$	M1 A1 A1 A1 M1 A1 A1	Limits not required A1 for each term. Limits not required. Condone $+ c$ Attempt to use both limits on an integrated expression Correct substitution in their expression including subtraction (may be left as an expression). cao.	7
	total	19		

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Solutions and mark scheme

Q7		mark		
(i)	Horiz $(40 \cos 50)t$ Vert $(40 \sin 50)t - 4.9t^2$	B1 M1 A1	Use of $s = ut + 0.5at^2$ with $a = \pm 9.8$ or ± 10 . Allow $u = 40$. Condone $s \leftrightarrow c$. Any form	3
(ii)	Need $(40 \sin 50)t - 4.9t^2 = 0$ so $t = \frac{40 \sin 50}{4.9}$ $= 6.2534\dots$ so 6.253 s (3 d. p.) Range is $(40 \cos 50) \times 6.2534\dots$ $= 160.78\dots$ so 161 m (3 s. f.)	M1 M1 E1 M1 A1	Equating their y to zero. Allow quadratic y only Dep on 1 st M1. Attempt to solve. Clearly shown [or M1 (allow $u = 40$ and $s \leftrightarrow c$) A1 time to greatest height; E1] Use of their horiz expression Any reasonable accuracy	5
(iii)	Time AB is given by $(40 \cos 50)T = 30$ so $T = 1.16679\dots$ so 1.17 s then either By symmetry, time AC is time AD – time AB so time AC is $6.2534\dots - \frac{30}{40 \cos 50}$ $= 5.086\dots$ so 5.09 s (3 s. f.) or height is $(40 \sin 50)T - 4.9T^2$ and we need $(40 \sin 50)t - 4.9t^2 = (40 \sin 50)T - 4.9T^2$ solved for larger root i.e. solve $4.9t^2 - (40 \sin 50)t + 29.08712\dots = 0$ for larger root giving 5.086...	M1 A1 M1 A1 M1 A1	Equating their linear x to 30. Symmetry need not be explicit. Method may be implied. Any valid method using symmetry. cao Complete method to find time to second occasion at that height cao	4
(iv)	$\mathcal{H} = 40 \cos 50$ $\mathcal{H} = 40 \sin 50 - 9.8 \times 5.086\dots$ Need $\arctan \frac{\mathcal{H}}{\mathcal{H}}$ So $-36.761\dots^\circ$ so 36.8° below horizontal (3 s.f.)	B1 M1 A1 M1 A1	Must be part of a method using velocities. Use of vert cpt of vel Allow only sign error. FT use of their 5.086.. May be implied. Accept $\arctan \frac{\mathcal{H}}{\mathcal{H}}$ but not use of $\frac{\mathcal{H}}{\mathcal{H}}$. Accept ± 36.8 or equivalent. Condone direction not clear.	5
	total	17		