

Mark Scheme

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

| Q 1 | | mark | | |
|------|--|--------------------------|--|---|
| (i) | Differentiate $\mathbf{v} = 2t \mathbf{i} + (5 - 4t) \mathbf{j}$ Differentiate $\mathbf{a} = 2 \mathbf{i} - 4 \mathbf{j}$ | M1 A1 M1 F1 | At least 1 cpt correct Award for RHS seen 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} | 4 |
| (ii) | $\mathbf{F} + 12 \mathbf{j} = 4(2 \mathbf{i} - 4 \mathbf{j})$ $\mathbf{F} = 8 \mathbf{i} - 28 \mathbf{j}$ | M1 A1 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} . cao | 3 |
| | total | 7 | | |

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

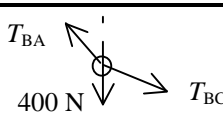
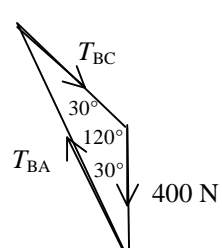
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Solutions and mark scheme

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

| Q 4 | | mark | | |
|------|---|--|--|---|
| (i) | <p>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</p> | M1 A1 | <p>Other methods must be complete. Allow $g = \pm 9.8, \pm 10$</p> <p>Accept with consistent signs</p> | 2 |
| (ii) | <p>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 $21t - 4.9t^2$)</p> <p>either Sub $t = 1.5$ to show both have same value State height as 11.475 m</p> <p>or $15t - 4.9t^2 = 22.5 - 4.9t^2$ giving $t = 1.5$ and height as 11.475 m</p> | M1 A1 M1 A1 E1 A1 M1 A1 | <p>Allow $g = \pm 9.8, \pm 10$</p> <p>Allow $g = \pm 9.8, \pm 10$</p> <p>Award only if used correctly</p> <p>(or sub $t = 3.64$ into $21t - 4.9t^2$ for 1st & $t = 1.5$ for 2nd) cao. Accept any reasonable accuracy. Don't award if only one correctly used equation obtained.</p> <p>Both. t shown. Ht cao (to any reasonable accuracy)</p> | |
| | <p>Sol (2) t seconds after second particle projected its height is $15t - 4.9t^2$ and the first particle has fallen $4.9t^2$</p> <p>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</p> | M1 A1 B1 M1 E1 A1 | <p>Allow $g = \pm 9.8, \pm 10$</p> <p>Or other correct method</p> <p>cao. Accept any reasonable accuracy. Don't award if only one correctly used equation obtained.</p> | 6 |
| | total | 8 | | |

Solutions and mark scheme

| Q 5 | | 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> | <p>M1</p> <p>B1</p> <p>A1</p> <p>F1</p> | <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</p> <p>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> | <p>E1</p> <p>E1</p> | <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 |
| | total | 7 | | |

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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

| Q 7 | | mark | | |
|-------|---|---|--|---|
| (i) | <p>Horiz $(40 \cos 50)t$</p> <p>Vert $(40 \sin 50)t - 4.9t^2$</p> | <p>B1</p> <p>M1</p> <p>A1</p> | <p>Use of $s = ut + 0.5at^2$ with $a = \pm 9.8$ or ± 10.</p> <p>Allow $u = 40$. Condone $s \leftrightarrow c$.</p> <p>Any form</p> | 3 |
| (ii) | <p>Need $(40 \sin 50)t - 4.9t^2 = 0$</p> <p>so $t = \frac{40 \sin 50}{4.9}$</p> <p>$= 6.2534\dots$ so 6.253 s (3 d. p.)</p> <p>Range is $(40 \cos 50) \times 6.2534\dots$</p> <p>$= 160.78\dots$ so 161 m (3 s. f.)</p> | <p>M1</p> <p>M1</p> <p>E1</p> <p>M1</p> <p>A1</p> | <p>Equating their y to zero. Allow quadratic y only</p> <p>Dep on 1st M1. Attempt to solve.</p> <p>Clearly shown [or M1 (allow $u = 40$ and $s \leftrightarrow c$) A1 time to greatest height; E1]</p> <p>Use of their horiz expression</p> <p>Any reasonable accuracy</p> | 5 |
| (iii) | <p>Time AB is given by $(40 \cos 50)T = 30$ so $T = 1.16679\dots$ so 1.17 s</p> <p>then</p> <p>either</p> <p>By symmetry, time AC is time AD – time AB</p> <p>so time AC is $6.2534\dots - \frac{30}{40 \cos 50}$</p> <p>$= 5.086\dots$ so 5.09 s (3 s. f.)</p> <p>or</p> <p>height is $(40 \sin 50)T - 4.9T^2$</p> <p>and we need</p> <p>$(40 \sin 50)t - 4.9t^2 = (40 \sin 50)T - 4.9T^2$</p> <p>solved for larger root</p> <p>i.e. solve $4.9t^2 - (40 \sin 50)t + 29.08712\dots = 0$</p> <p>for larger root giving 5.086...</p> | <p>M1</p> <p>A1</p> <p>M1</p> <p>A1</p> <p>M1</p> <p>A1</p> | <p>Equating their linear x to 30.</p> <p>Symmetry need not be explicit. Method may be implied. Any valid method using symmetry.</p> <p>cao</p> <p>Complete method to find time to second occasion at that height</p> <p>cao</p> | 4 |
| (iv) | <p>$\mathcal{H} = 40 \cos 50$</p> <p>$\mathcal{H} = 40 \sin 50 - 9.8 \times 5.086\dots$</p> <p>Need $\arctan \frac{\mathcal{H}}{\mathcal{H}}$</p> <p>So $-36.761\dots^\circ$</p> <p>so 36.8° below horizontal (3 s.f.)</p> | <p>B1</p> <p>M1</p> <p>A1</p> <p>M1</p> <p>A1</p> | <p>Must be part of a method using velocities.</p> <p>Use of vert cpt of vel Allow only sign error.</p> <p>FT use of their 5.086..</p> <p>May be implied. Accept $\arctan \frac{\mathcal{H}}{\mathcal{H}}$ but not use of \mathcal{H}.</p> <p>Accept ± 36.8 or equivalent. Condone direction not clear.</p> | 5 |
| | total | 17 | | |