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| $1 \quad 17 \sin 50-2 \mathrm{~g}$ $\mathrm{v}^{2}=(17 \sin 50-2 \mathrm{~g})^{2}+(17 \cos 50)^{2}$ $\mathrm{v}=13(.0) \mathrm{ms}^{-1}$ | $\begin{array}{ll} \text { B1 } & \\ \text { M1 } & \\ \text { A1 } & {[3]} \end{array}$ | Vertical component of velocity <br> Pythagoras with 2 perpendicular components |
| :---: | :---: | :---: |
| 2 (i) 0.212 | B1 [1] | From (0.6/2) $\cos 45$ |
| (ii) (a) $\begin{aligned} & 0.3 \cos 45 \times(2 \times 7)=(2 \times 06 \sin 45) \times F \\ & F=3.5 \end{aligned}$ | $\begin{array}{cc} \text { M1 } & \\ \text { A1 } & {[2]} \end{array}$ | Moments about $A$ |
| $\begin{aligned} & \text { (ii) (b) } 0.3 \cos 45 \times(2 \times 7)=0.6 F \\ & F=4.95 \end{aligned}$ | $\begin{array}{ll} \text { M1 } & \\ \text { A1 } & {[2]} \end{array}$ | Or Ans (i)/ $\cos 45$ |
| 3 (i) $\begin{aligned} & x=(25 \cos 45) \mathrm{t} \\ & y=(25 \sin 45) t-g t^{2} / 2 \\ & y=x(25 \sin 45) /(25 \cos 45)-g\left[x /(25 \cos 45)^{2}\right] / 2 \\ & y=x-0.016 x^{2} \end{aligned}$ | B1  <br> B1  <br> M1  <br> A1  <br>   | Eliminates $t$ between 2 simultaneous equations |
| (ii) $2.4=x-0.016 x^{2}$ $\text { Distance }=57.5 \mathrm{~m}$ | $\begin{array}{ll} \text { M1 } & \\ \text { A1 } & {[2]} \end{array}$ | Creates and attempts to solve a quadratic equation $(x=2.5,60)$ |
| 4 (i) $\begin{aligned} & 0.4 \delta v / \delta t=0.2 v^{2} \\ & \int v^{-2} \delta v=-0.5 \int \delta t \\ & -v^{-1}=-0.5 t(+c) \\ & t=0, v=8, \text { hence } c=-0.125 \\ & v=1 /(0.125+0.5 t)=8 /(1+4 t) A G \end{aligned}$ | $\begin{array}{ll}\text { M1 } & \\ \text { A1 } & \\ & \\ \text { M1 } & \\ \text { A1 } & {[4]}\end{array}$ | Newton's Second Law with $a=\delta v / \delta t$ |
| $\text { (ii) } \begin{aligned} & \delta x / \delta t=8 /(1+4 t) \\ & x=8 \int \delta t /(1+4 t) \\ & x=\frac{8}{4} \ln (1+4 t)(+c) \\ & t=1.5, x=\frac{8}{4} * \ln (1+4 \times 1.5) \\ & O P=3.89 \mathrm{~m} \end{aligned}$ | M1* <br> A1 <br> D* <br> M1 <br> A1 | Accept $c=0$ assumed <br> Or limits used $\frac{8}{4}\left[\ln (1+4 t]_{0}^{1.5}\right.$ <br> 4 |


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| 5 (i) $\begin{aligned} & 0.2 \omega^{2} \times 1.2=6 \\ & \omega=5 \end{aligned}$ | $\begin{array}{ll} \text { M1 } & \\ \text { A1 } & {[2]} \end{array}$ | Uses radial acceleration on $R$, 1 force |
| :---: | :---: | :---: |
| (ii) $m \omega^{2} \times 2 \times 0.4=10-6$ $m=0.2 \mathrm{~kg}$ | M1 <br> A1 <br> [3] | Uses radial acceleration on $Q, 2$ forces |
| $\text { (iii) } \begin{aligned} & 0.2 \times(5 \times 1.2)^{2} / 2=\mathrm{M}(5 \times 0.4)^{2} / 2 \\ & M=1.8 \mathrm{~kg} \\ & 1.8 \times 5^{2} \times 0.4=\mathrm{T}-10 \\ & T=28 \mathrm{~N} \end{aligned}$ | $\begin{array}{cc} \text { M1 } & \\ \text { A1 } & \\ \text { DM1 } & \\ \text { A1 } & {[4]} \end{array}$ |  |
| 6 (i) $\begin{aligned} & \pi 0.6^{2} \times 0.6 \times 0.3-2 \pi 0.6^{3} / 3 \times 3 \times 0.6 / 8 \\ & =\left(\pi 0.6^{3}+2 \pi 0.6^{3} / 3\right) d \\ & d=0.09 \mathrm{~m} \end{aligned}$ | $\begin{array}{ll}\text { M1 } & \\ \text { A1 } & \\ \text { A1 } & \\ \text { A1 } & {[4]}\end{array}$ | Table of moments idea Correct elements Correct composite |
| (ii) $\begin{aligned} & \frac{2}{3} \pi 0.6^{3} \times \frac{3}{8} \times 0.6-\pi \times 0.6^{3} \times 0.3 \\ & +0.48 A \times 0.36=0 \\ & A=3 \pi / 16 \mathrm{~m}^{2} \end{aligned}$ <br> OR $\begin{aligned} & {\left[\frac{2}{3} \pi \times 0.6^{3}+\pi \times 0.6^{3}\right] \times 0.09=0.48 A \times 0.36} \\ & A=3 \pi / 16 \end{aligned}$ | M1  <br> A1  <br> A1  <br> A1  <br> M1  <br> A1  <br> A1  <br> A1  | Table of moments idea (about $O$ ) <br> Correct elements <br> Table of moments idea ( about $O$ ) <br> Correct elements |
| (iii) Increase in length $[=2 \times(0.6-0.48)]=0.24 \mathrm{~m}$ | B1 [1] | Remove cylinder with centre of mass a O |


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| $\begin{gathered} 7 \quad \text { (i) } \quad 0.8 g \sin 30=20 e / 0.4 \\ e=0.08 \mathrm{~m} \end{gathered}$ | M1 <br> A1 <br> [2] |  |
| :---: | :---: | :---: |
| (ii) $\begin{aligned} & 0.8 v^{2} / 2+20 \times 0.08^{2} /(2 \times 0.4) \\ & =0.8 \mathrm{~g}(0.4+0.08) \sin 30 \\ & v=2.1(0) \mathrm{ms}^{-1} \end{aligned}$ | M1 <br> A1 <br> A1 <br> A1 <br> [4] | Conservation of KE, PE, EE <br> Correct start terms, signs accurate <br> Correct final term, sign accurate |
| (iii) $\begin{aligned} & 0.8 g d \sin 30=20(\mathrm{~d}-0.4)^{2} /(2 \times 0.4) \\ & 25 d^{2}-24 d+4=0 \\ & d=0.745 \mathrm{~m} \end{aligned}$ | M1* <br> A1 <br> D* <br> M1 <br> A1 <br> [4] | $4 d=25(d-0.4)^{2}$ <br> Obtains and solves a 3 term quadratic equation. |

