| 1 | $\begin{aligned} & \mathrm{T}=12 \mathrm{~N} \\ & \mathrm{~T}=0.3 \times 4^{2} / \mathrm{r} \\ & 12=4.8 /(2 \mathrm{~L}) \\ & \mathrm{L}=0.2 \end{aligned}$ | B1 <br> M1 <br> A1^ <br> A1 | 4 | $\begin{aligned} & \mathrm{T}=12(2 \mathrm{~L}-\mathrm{L}) / \mathrm{L} \\ & \mathrm{Accn}=v^{2} / \mathrm{r} \end{aligned}$ <br> ft candidates expression for T |
| :---: | :---: | :---: | :---: | :---: |
| 2 (i) | $\begin{aligned} & \mathrm{CoM}(\text { large })=0.6 /(\pi / 2) \text { or } \\ & \operatorname{CoM}(\mathrm{small})=0.3 /(\pi / 2) \\ & (\pi \times 0.6+\pi \times 0.3) \mathrm{D}= \\ & \pi \times 0.6(1.2 / \pi)-\pi \times 0.3(0.6 / \pi) \\ & \mathrm{D}=0.191 \mathrm{~m} \end{aligned}$ | B1 <br> M1 <br> A1 | 3 | $\mathrm{OR}(2+1) \mathrm{D}=2(1.2 / \pi)-1(0.6 / \pi)$ <br> Moments about ACB |
| (ii) | $\begin{aligned} & (\pi \times 0.6+\pi \times 0.3) \mathrm{H}= \\ & \pi \times 0.6 \times 0.6+\pi \times 0.3 \times 0.9 \\ & \mathrm{H}=0.7 \\ & \tan \theta=0.191 / 0.7 \\ & \theta=15.3^{\circ} \end{aligned}$ | M1 <br> A1 <br> M1 <br> A1 | 4 | OR $3 \mathrm{H}=2 \times 0.6+1 \times 0.9$ Moments about A |
| 3 (i) | $\begin{aligned} & 0.25 v \mathrm{~d} v / \mathrm{d} x=2+0.3 x^{2} \\ & v \mathrm{~d} v / \mathrm{d} x=1.2 x^{2}+8 \end{aligned}$ | M1 <br> A1 | 2 |  |
| (ii) | $\begin{aligned} & \int v \mathrm{~d} v=\int\left(1.2 x^{2}+8\right) \mathrm{d} x \\ & v^{2} / 2=0.4 x^{3}+8 x(+\mathrm{c}) \\ & \mathrm{v}=5.17 \end{aligned}$ | M1 <br> A1 <br> A1 | 3 | Allow $\mathrm{c}=0$ without working |
| (iii) | $0.25 v \mathrm{~d} v / \mathrm{d} x=0.3 x^{2}+1.5-0.75 x$ <br> Force is $0.5+0.75 x \mathrm{~N}$ towards O | $\begin{aligned} & \text { M1 } \\ & \text { A1 } \end{aligned}$ | 2 |  |
| 4 (i) | $\begin{aligned} & (0.9 a+0.9 a / 2) Y= \\ & 0.9 a \times 0.45+0.45 a \times 0.9 \times 2 / 3 \\ & Y=0.5 \mathrm{~m} \end{aligned}$ | M1 <br> A1 | 2 | $1.5 Y=1 \times 0.45+0.5 \times 0.6$ <br> Moments about AD |
| (ii) | $\begin{aligned} & (0.9 a+0.9 a / 2) X= \\ & 0.9 a \times a / 2+0.45 a \times(a+a / 3) \\ & X=7 a / 9 \end{aligned}$ | M1 <br> A1 | 2 | $1.5 X=1 \times a / 2+0.5 \times 4 a / 3$ |
| (iii) | $0.5 \times 6=(a-7 a / 9) \times 18$ $a=0.75$ | $\begin{aligned} & \text { M1 } \\ & \text { A1 } \\ & \text { A1 } \end{aligned}$ | 3 | $\mathrm{Ft}[Y \mathbf{i}$ and ( $a-X \mathbf{X i} \mathbf{i})$ ] |


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| 5 (i) | $\begin{aligned} & \theta\left(=\tan ^{-1} 0.45 / 0.6=36.87 . .\right)=36.9^{\circ} \\ & 0.4 v^{2} / 0.6=5 \cos \theta \\ & v=2.45 \mathrm{~ms}^{-1} \end{aligned}$ | B1 <br> M1 <br> A1 | 3 | $\text { Or } \tan \theta=3 / 4$ $\text { Or } \sqrt{6}$ |
| :---: | :---: | :---: | :---: | :---: |
| (ii) | $\begin{aligned} & T \sin \theta=0.4 \mathrm{~g} \\ & T=6.67 \mathrm{~N} \\ & 0.4 \omega^{2} \times 0.6=6.67 \cos \theta \\ & \omega=4.71 \mathrm{rad}^{-1} \end{aligned}$ | M1 <br> A1 <br> M1 <br> A1 | 4 | Accept $0.66,6 \frac{2}{3}, 20 / 3$ <br> Accept $4.72 \mathrm{rads}^{-1}$ |
| 6 (i) | $\begin{aligned} & \mathrm{EE}=8(0.9 \pi-1.2)^{2} /(2 \times 1.2) \\ & 8.83=0.2 \mathrm{~g} \mathrm{x} 0.9+0.2 v^{2} / 2+ \\ & 8(0.9 \pi / 2-1.2)^{2} /(2 \times 1.2) \\ & v=8.29 \mathrm{~ms}^{-1} \end{aligned}$ | $\begin{aligned} & \text { B1 } \\ & \text { M1 } \\ & \text { A1 } \\ & \text { A1 } \end{aligned}$ | 4 | Initial $\mathrm{EE}=8.83 \mathrm{~J}$ |
| (ii) | $\begin{aligned} & \theta=1.2 / 0.9=4 / 3 \mathrm{rad}\left(=76.4^{\circ}\right) \\ & 8.83=0.2 \mathrm{~g} \times 0.9+0.2 \mathrm{~g} \times 0.9 \cos \theta \\ & +0.2 v^{2} / 2 \\ & v=8.13 \mathrm{~ms}^{-1} \end{aligned}$ | B1 <br> M1 <br> A1 | 3 | $\begin{aligned} & 0.2 \times 8.29^{2} / 2=0.2 \mathrm{~g} \times 0.9 \cos \theta \\ & +0.2 v^{2} / 2 \end{aligned}$ |
| $7 \quad$ (i) | $\begin{aligned} & a=14 k-0.8\left(1+k^{2}\right) \text { and } \\ & 2 a=42 k-7.2\left(1+k^{2}\right) \\ & 42 k-7.2\left(1+k^{2}\right)=2\left[14 k-0.8\left(1+k^{2}\right)\right] \\ & k=1 / 2 \text { and } 2 \\ & \theta=\tan ^{-1} k \\ & \theta=63.435 \end{aligned}$ | $\begin{aligned} & \text { M1 } \\ & \text { M1 } \\ & \text { B1 } \\ & \text { M1 } \\ & \text { A1 } \end{aligned}$ | 5 | Creates 2 simultaneous equations <br> Creates a single equation in $k$ <br> Both values <br> With 1 of the candidates value of $k$ |
| (ii) | $\begin{aligned} & t=14 /(35 \cos 63.435) \\ & t(=0.89442 . .)=0.894 \mathrm{~s} \end{aligned}$ | $\begin{aligned} & \text { M1 } \\ & \text { A1 } \end{aligned}$ | 2 |  |


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| (iii) | $V_{v}=35 \sin 63.4-\mathrm{g}[42 /(35 \cos 63.4)]$ <br> $\tan \alpha=4.495 /(35 \cos 63.4)$ <br> $\alpha=15.9^{\circ}$ above the horizontal <br> $V^{2}=4.495^{2}+(35 \cos 63.4)^{2}$ <br> $V=16.3 \mathrm{~m}^{-1}$ | M1 |  | $V_{v}=4.495$ |
| :---: | :--- | :--- | :--- | :--- |
|  | A1 |  | Accept $16(.0)^{\circ}$ |  |
| OR | A1 | 4 |  |  |
| $2 a=48$ |  |  |  |  |
| $V^{2}=35^{2}-2 \mathrm{~g} \mathrm{x} 48$ |  |  |  |  |
| $V=16.3 \mathrm{~ms}^{-1}$ | M1 |  | $42 \times 2-7.2\left(1+2^{2}\right)$ |  |
| $\cos \alpha=35 \cos 63.435 / 16.3$ |  |  |  |  |
| $\alpha=15.9^{\circ}$ | A1 |  |  |  |

