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

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

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| (iii) | $V_v = 35 \sin 63.4 - g[42/(35 \cos 63.4)]$ | M1 | 4 | $V_v = 4.495$ |
| | $\tan \alpha = 4.495/(35 \cos 63.4)$ | | | |
| | $\alpha = 15.9^\circ$ above the horizontal | A1 | | Accept $16(.0)^\circ$ |
| | $V^2 = 4.495^2 + (35 \cos 63.4)^2$ | M1 | | |
| | $V = 16.3 \text{ m s}^{-1}$ | A1 | | |
| | OR | | | |
| | $2a = 48$ | M1 | | $42 \times 2 - 7.2(1 + 2^2)$ |
| $V^2 = 35^2 - 2g \times 48$ | | | | |
| $V = 16.3 \text{ m s}^{-1}$ | A1 | | | |
| $\cos \alpha = 35 \cos 63.435/16.3$ | M1 | | | |
| $\alpha = 15.9^\circ$ | A1 | 4 | | |