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

| 5 | (i) | $\theta(= tan^{-1}0.45/0.6 = 36.87..) = 36.9°$ | B1 | | Or $tan\theta = 3/4$ |
|---|---|---|---|---|---|
| | | $0.4v^2/0.6 = 5\cos\theta$ | M1 | | |
| | | $v = 2.45\,ms^{-1}$ | A1 | 3 | Or $\sqrt{6}$ |
| | (ii) | $T\sin\theta = 0.4g$ | M1 | | |
| | | $T = 6.67\,N$ | A1 | | Accept 0.66, $6\frac{2}{3}$, 20/3 |
| | | $0.4\omega^2 \times 0.6 = 6.67\cos\theta$ | M1 | | |
| | | $\omega = 4.71\,rad\,s^{-1}$ | A1 | 4 | Accept $4.72\,rad\,s^{-1}$ |
| 6 | (i) | $EE = 8(0.9\pi – 1.2)^2/(2 \times 1.2)$ | B1 | | Initial EE = 8.83 J |
| | | $8.83 = 0.2g \times 0.9 + 0.2v^2/2 +$ $8(0.9\pi/2 – 1.2)^2/(2 \times 1.2)$ | M1 A1 | | |
| | | $v = 8.29\ m\,s^{-1}$ | A1 | 4 | |
| | (ii) | $\theta = 1.2/0.9 = 4/3$ rad (=76.4°) | B1 | | |
| | | $8.83 = 0.2g \times 0.9 + 0.2g \times 0.9\cos\theta$ $+ 0.2v^2/2$ | M1 | | $0.2 \times 8.29^2/2 = 0.2g \times 0.9\cos\theta$ $+ 0.2v^2/2$ |
| | | $v = 8.13\ m\,s^{-1}$ | A1 | 3 | |
| 7 | (i) | $a = 14k – 0.8(1 + k^2)$ and $2a = 42k – 7.2(1 + k^2)$ | M1 | | Creates 2 simultaneous equations |
| | | $42k – 7.2(1 + k^2) = 2[14k – 0.8(1 + k^2)]$ | M1 | | Creates a single equation in $k$ |
| | | $k = 1/2$ and 2 | B1 | | Both values |
| | | $\theta = \tan^{-1}k$ | M1 | | With 1 of the candidates value of $k$ |
| | | $\theta = 63.435$      AG | A1 | 5 | |
| | (ii) | $t = 14/(35\cos63.435)$ | M1 | | |
| | | $t (= 0.89442..) = 0.894\,s$ | A1 | 2 | |

| **(iii)** | $V_v = 35\sin63.4 - g[42/(35\cos63.4)]$ <br> $\tan\alpha = 4.495/(35\cos63.4)$ | **M1** | | $V_v = 4.495$ |
|---|---|---|---|---|
| | $\alpha = 15.9°$ above the horizontal | **A1** | | Accept 16(.0)° |
| | $V^2 = 4.495^2 + (35\cos63.4)^2$ | **M1** | | |
| | $V = 16.3 \text{ m}s^{-1}$ | **A1** | 4 | |
| | OR | | | |
| | $2a = 48$ <br> $V^2 = 35^2 - 2g \times 48$ | **M1** | | $42 \times 2 - 7.2(1 + 2^2)$ |
| | $V = 16.3 \text{ m}s^{-1}$ | **A1** | | |
| | $\cos\alpha = 35\cos63.435/16.3$ | **M1** | | |
| | $\alpha = 15.9°$ | **A1** | 4 | |

© UCLES 2016