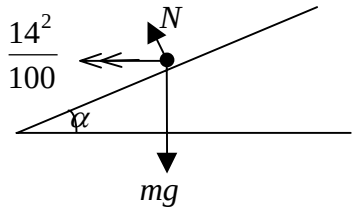
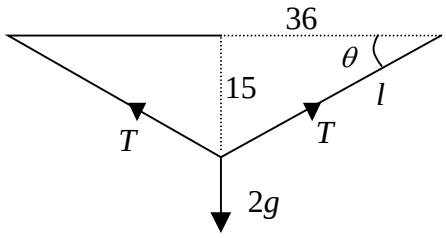
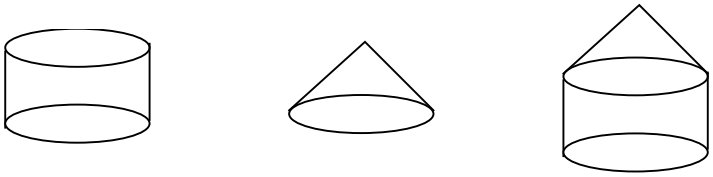
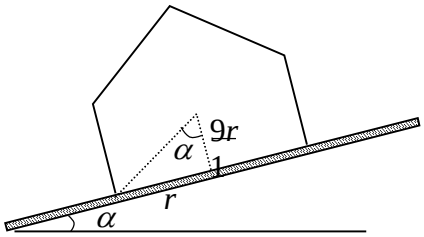
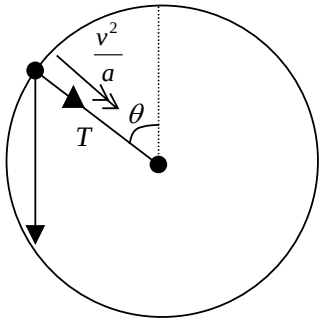
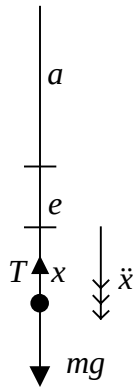
| Question Number | Scheme | Marks |
|---|---|---|
| **1.** |  <br>$R(\uparrow)$ $N\cos\alpha = mg$<br>$R(\rightarrow)$ $N\sin\alpha = \frac{m.14^2}{100}$<br>$\therefore \tan\alpha = \frac{14^2}{100\times 9.8} = 0.2$<br>$\alpha \approx 11.3°$ | M1 A1<br>M1 A1<br>M1 A1 ft<br>A1 (7)<br>**(7 marks)** |
| **2.**<br>(*a*) |  <br>$l^2 = 36^2 + 15^2$<br>$\Rightarrow l = 39$, ext = 9 cm<br>$T = \frac{\lambda\times 0.09}{0.3}$<br>$2T\sin\theta = mg \Rightarrow \frac{2\lambda\times 0.09}{0.3}\times\frac{15}{39} = 2\times 9.8$<br>$\lambda \approx 84.9$ | M1<br>A1<br>B1<br>M1 A1<br>A1 (6) |
| (*b*) | By taking P as single <u>point</u> from which to measure all distances | B1 (1)<br>**(7 marks)** |

| Question Number | Scheme | Marks |
|---|---|---|
| **3.** | $0.5\ddot{x} = -\dfrac{2}{x^2}$ | M1 |
| | $v\dfrac{\mathrm{d}v}{\mathrm{d}x} = -\dfrac{4}{x^2}$ | M1 |
| | $\int v\,\mathrm{d}v = -\int \dfrac{4}{x^2}\,\mathrm{d}x$ | M1 |
| | $\left[\dfrac{1}{2}v^2\right]_3^{\frac{3}{2}} = \left[\dfrac{4}{x}\right]_1^d$ | M1 A1 |
| | (limits or 'C') | A1 |
| | $\dfrac{9}{8} - \dfrac{9}{2} = 4\left(\dfrac{1}{d} - 1\right) \Rightarrow d = \dfrac{32}{5} = 6.4\text{ m}$ | M1 A1 (8) |
| | | **(8 marks)** |
| **4.** (*a*) | Elastic energy gained $= \dfrac{\lambda x^2}{2l}$ | M1 |
| | $\therefore \dfrac{\lambda.6^2}{2\times 12} = \text{PE lost} = 75\times 9.8\times 18$ | M1 A1 |
| | $\rightarrow \lambda = 8820$ N | M1 A1 ft (5) |
| (*b*) | At 2 m off ground $\dfrac{1}{2}\times 75\times v^2 = 75\times 9.8\times 17 - \dfrac{1}{2}\times\dfrac{8820\times 5^2}{12}$ | M1 A1 A1ft |
| | $\rightarrow v^2 = 88.2$ | |
| | $v \approx 9.39\text{ ms}^{-1}$ | M1 A1 (5) |
| | | **(10 marks)** |

| Question Number | Scheme | Marks |
|---|---|---|
| **5.** (*a*) |  | |
| | Vol. $\pi r^3$ $\frac{1}{3}\pi r^2 h$ $\pi r^3 + \frac{1}{3}\pi r^2 h$ | M1 A1 |
| | Dist of CM $\frac{r}{2}$ $r + \frac{h}{4}$ $\bar{x}$ | B1 B1 |
| | $\frac{\pi r^4}{2} + \frac{1}{3}\pi r^2 h\left(r + \frac{h}{4}\right) = \left(\pi r^3 + \frac{1}{3}\pi r^2 h\right)\bar{x}$ | M1 A1 A1ft |
| | $\rightarrow \bar{x} = \frac{6r^2 + 4hr + h^2}{4(3r + h)}$ | A1 (8) |
| (*b*) |   $h = 2r \Rightarrow \bar{x} = \frac{18r}{20} = \frac{9r}{10}$ | M1 A1 |
| | $\therefore \tan\alpha = \frac{r}{9r/10} = \frac{10}{9}$ | M1 A1 ft |
| | $\alpha \approx 48^\circ$ | A1 (5) |
| | | **(13 marks)** |

| Question Number | Scheme | Marks |
|---|---|---|
| **6.** |  | |
| (*a*) | $R(\searrow)\ T + mg\cos\theta = \dfrac{mv^2}{a}$ | M1 A1 |
| | Energy $\dfrac{1}{2}mu^2 - \dfrac{1}{2}mv^2 = mga(1+\cos\theta)$ | M1 A1 A1 |
| | $u^2 = 3ga \rightarrow v^2 = ga\,(1 - 2\cos\theta)$ | |
| | $\therefore T = -mg\cos\theta + \dfrac{mv^2}{a} = mg(-3\cos\theta + 1)$ | M1 A1 |
| | $T = 0 \Rightarrow \cos\theta = \dfrac{1}{3}$ | M1 A1 (9) |
| (*b*) | $v^2 = \dfrac{ga}{3}$ | B1 |
| | $\sin^2\theta = 1 - \left(-\dfrac{1}{3}\right)^2 = \dfrac{8}{9}$ | M1 A1 |
| | $\text{Ht} = \dfrac{v^2\sin^2\theta}{2g} = \dfrac{ga}{3}\cdot\dfrac{8}{9}\cdot\dfrac{1}{2g} = \dfrac{4a}{27}$ | M1 M1 A1 (6) |
| | | **(15 marks)** |

| Question Number | Scheme | Marks |
|---|---|---|
| **7.** |  | |
| (*a*) | In equilibrium $\frac{6mge}{a} = mg \Rightarrow e = \frac{a}{6}$ | M1 A1 (2) |
| (*b*) | $m\ddot{x} = -\frac{6mg(e+x)}{a} + mg$ | M1 A1 A1 |
| | $\rightarrow \ddot{x} = -\frac{6g}{a}x \Rightarrow$ SHM | M1 A1 |
| | Period $= \left(\frac{2\pi}{\omega}\right) = 2\pi\sqrt{\frac{a}{6g}}$ | A1 (6) |
| (*c*) | Greatest speed $= a\omega = \frac{a}{3}\sqrt{\frac{6g}{a}} = \frac{1}{3}\sqrt{6ga}$ | M1 A1 (2) |
| (*d*) | $x = \frac{a}{3}\cos\omega t$ | M1 |
| | String slack $\Rightarrow x = -e \Rightarrow -\frac{a}{6} = \frac{a}{3}\cos\omega t$ | M1 A1 |
| | $\Rightarrow \omega t = \frac{2\pi}{3},\ t = \frac{2\pi}{3}\sqrt{\frac{a}{6g}}$ | M1 A1 ft |
| | | (5) |
| | | **(15 marks)** |