

Solutions

2.1 $mg = \frac{3mge}{2a}$: $e = \frac{2a}{3}$.

2.2 Moments about A: $T(3a) = mg \cdot \frac{3a}{2}$, so $T = \frac{mg}{2}$; then $\frac{mg}{2} = \frac{mge}{a}$ gives $e = \frac{a}{2}$.

2.3 Vertically: $2T \cos 30^\circ = mg$, so $T = \frac{mg}{\sqrt{3}}$; extension $e = \frac{mgL}{\sqrt{3}\lambda}$.

3.1 (a) The geometry: B is at horizontal distance $\sqrt{(2a)^2 - (1.2a)^2} = 1.6a$ from the vertical through A and $1.2a$ below the level of AC; the rod's midpoint is $0.8a$ horizontally from the vertical through A. Moments about A: $T \cdot 1.6a = mg \cdot 0.8a$, so $T = \frac{1}{2}mg$. (b) Hooke's law: $\frac{1}{2}mg = \frac{2mg}{L}(1.2a - L)$, i.e. $\frac{L}{4} = 1.2a - L$, so $\frac{5L}{4} = 1.2a$ and $L = 0.96a = \frac{24}{25}a$.

3.2 Moments about A: the beam's midpoint is at horizontal distance $2a \cos 45^\circ = \sqrt{2}a$ and the string at B acts horizontally at height $4a \sin 45^\circ = 2\sqrt{2}a$, so equilibrium needs $T \cdot 2\sqrt{2}a = 2mg \cdot \sqrt{2}a$, i.e. $T = mg$. But the string's length is fixed by the geometry: B and C are both at height $2\sqrt{2}a$, so the string has length $2\sqrt{2}a$ and extension $2\sqrt{2}a - 2.5a \approx 0.328a$, giving an available tension $T = \frac{4mg(0.328a)}{2.5a} \neq mg$. The tension the geometry supplies cannot match the tension the moments demand, so the beam cannot rest in this position.

Local review guidance: moment arms from the hinge with the string's perpendicular distance; Hooke's law with the correct natural length; geometric feasibility checked. This is authored classroom guidance.