1. \[ \mathbf{F} = 55.0 \text{N} \]
\[ \mathbf{r} = \frac{1}{2} \mathbf{F} \cdot \mathbf{r} \]
\[ \mathbf{r} = (55.0 \text{N})(0.850 \text{m}) = 46.8 \text{ Nm} \]

It doesn't matter what height—the \( r \) is the same.

3. These two torques oppose one another. For equilibrium:
\[ T_1 = T_2 \]
\[ T_1 = r_1 F_1 = r_2 F_2 \rightarrow F_2 = \frac{(0.600 \text{ m})(175 \text{ N})}{(0.450 \text{ m})} \]
\[ F_2 = 233 \text{ N} \]

5. All torques \( F \) forces balance out: Equilibrium.

Don't know \( r_2 \) or \( N \), so set up torques to pivot at the fulcrum, where \( N \) is:

Then: \[ \tau_{\text{CM}} = T_1 + T_2 = \mathbf{W}_1 r_1 + \mathbf{W}_2 r_3 = \mathbf{W}_2 r_2 = T_2 = \tau_{\text{CM}} \]
\[ r_2 = \frac{W_1 r_1 + W_2 r_3}{W_2} = \frac{(26.0 \text{ kg})(1.60 \text{ m}) + (12 \text{ kg})(0.160 \text{ m})}{32.0 \text{ kg}} \]
\[ r_2 = 1.36 \text{ m} \] Is that reasonable?
5 cont, ...

Use net force to get N:

\[ F_{\text{net}} = ma = 0 \]

\[ F_{\text{net}} = N - w_1 - w_2 = 0 \]

\[ N = m_1 g + m_2 g + m_3 g \]

\[ = \left[ (26.0 \text{ kg}) + (12.0 \text{ kg}) + (32.0 \text{ kg}) \right] g \]

\[ = 686 \text{ N} \]

11. Earth-Sun system:

From inside cover: \( M_{\text{Sun}} = 1.99 \times 10^{30} \text{ kg} \)

\( M_{\text{Earth}} = 5.97 \times 10^{24} \text{ kg} \)

\( \rho \text{ cm} = M_{\text{Sun}} (\varnothing m) + M_{\text{Earth}} (1.50 \times 10^{11} \text{ m}) \)

\[ \frac{1}{(M_{\text{Sun}} + M_{\text{Earth}})} \]

\( = (5.97 \times 10^{24} \text{ kg})(1.50 \times 10^{11} \text{ m}) \)

\( \rightarrow 1.99 \times 10^{30} \text{ kg} \)

\( = 4.50 \times 10^5 \text{ m} \)

This is still well inside the Sun!
Each leg has $m = 4.0 \text{ kg}$.

First, look at the $x$-component forces. It starts with only the chain's $T$. So, there must be horizontal forces on each side of the hinge, one up and opposite to $T$.

For each $cm$, it is $\frac{1}{2} (1.30 \text{ m})$.

$$= 0.650 \text{ m}$$

At hinge (right leg): $\sum \tau_{cw} = \sum \tau_{ccw}$

$$T (0.50 \text{ m}) + W (\frac{1}{2} \times \frac{1}{2} \times 1.10 \text{ m}) = N (\frac{1}{2} \times 1.10 \text{ m})$$

(But what is $N$? Look at $F$'s in $y$):

$$N - W = 0$$

$$N = W = mg = (4.0 \text{ kg}) (9.8 \frac{\text{ m}}{\text{s}^2}) = 39.2 \text{ N}$$

$$T = (39.2 \text{ N}) (0.55 \text{ m}) - (39.2 \text{ N}) (0.275 \text{ m})$$

a) \[ T = 21.6 \text{ N} \]

b) $F = 21.6 \text{ N}$, opposite directions of $T$. Horizontal, as argued above.
21. Focus on the cheerleader's CM:

\[
\begin{align*}
\text{force due to} & \quad \text{right foot} \\
\text{left foot} & \quad \text{force due to} \\
.300 \text{ m} & \quad \text{left foot} \\
.900 \text{ m} & \quad \text{right foot} \\
W & = 700 \text{ N}
\end{align*}
\]

\[
\text{Note: } \sin \Theta = \frac{.300 \text{ m}}{.900 \text{ m}} \Rightarrow \Theta = 18.4^\circ
\]

\[
|F_r| = |F_l|, \text{ just by symmetry and the fact that } a_x = 0
\]

\[
\begin{align*}
\text{in } x-\text{dir:} & \\
F_r \cos \Theta + F_l \cos \Theta = 0 \\
F_r \sin \Theta + F_l \sin \Theta = W = 0
\end{align*}
\]

\[
2F_r \sin \Theta = W = 700 \text{ N}
\]

\[
F_r = \frac{700 \text{ N}}{2 \sin 18.4^\circ} = 1100 \text{ N}, \text{ so}
\]

\[
\text{Floor pushes above horizontal at } 18.4^\circ \text{ with force of } 1100 \text{ N},
\]

in order for foot to push oppositely on floor, in order for legs to push opposite of foot (N's 3rd). Note there are too many assumptions here about how legs push to make it a good Q.
37. Your head & neck, reduced to a free body torque diagram:

\[ \begin{align*}
\text{Y-axis:} & \quad F_j \left(5.0 \text{ cm}\right) = W \left(2.5 \text{ cm}\right) \\
\text{X-axis:} & \quad F_m = 50 \text{ N} \left(2.5 \text{ cm}\right) = 125 \text{ N}
\end{align*} \]

(a) To get \( F_m \), you can do a simple balance of torques about the joint:

I can use "cm" here b/c they cancel out.

\[ F_m \left(5.0 \text{ cm}\right) = W \left(2.5 \text{ cm}\right) \]

(b) To get \( F_j \), just look at forces in \( y \)-dir:

\[ F_j = F_m - W = 125 \text{ N} - 50 \text{ N} = 75 \text{ N} \]

(Almost 17 lbs!)

39. Lever system of Achilles tendon:

In the diagram it's shown that \( N = W \). (Why?) \( N = W = 75 \text{ lb} \left(90^\circ\right) \), \( N = 785 \text{ N} \)

(a) \[ \frac{F_A}{4 \text{ in}} \quad T_{cw} = T_{cw} \]

\[ (4 \text{ in}) F_A = (12 \text{ cm}) 785 \text{ N} \]

Almost 500 lbs! \[ F_A = 785 \text{ N} \]

(b) Use \( y \)-forces:

\[ F_A - F_p + N = 0 \]

\[ F_p = F_A + N = 2200 \text{ N} + 785 \text{ N} \]

\[ \frac{F_p}{2900 \text{ N}} \]
47. \[ T - W = 0 \text{ (we hope!)} \]
\[ T = (65\text{ kg})(9.8\text{ m/s}^2) = 637\text{ N} \]
\[ \Delta L = \frac{1}{E} \frac{F}{A} L_0 \]
\[ = \frac{637 \times 5 \times 10^{-11}}{\pi (0.00200 \text{ m})^2 (35.0 \text{ m})} \]

\[ \Delta L = 0.0887\text{ m} = 8.87\text{ cm} \]

This seems reasonable — some stretch but not too much. Good for rock climbing. (Note: Answer in book doesn't consider 
\[ \gamma \text{ is probably not very precise.} \]

48. \[ 900\text{ N} \]
\[ 20.0\text{ m} \text{ (Wow! Very tell.)} \]

\[ \Delta X = \frac{1}{S} \frac{F}{A} L_0 \]
\[ = \frac{3 \times 25 \times 10^{-11}}{\pi (0.04 \text{ m})^2} \]
\[ = 5.73 \times 10^{-4} \text{ m} \]
\[ = 0.573 \text{ mm} \]

Sheesh. Not much at all.