1. Group Problem

Use dynamics for the I-beam. All accelerations are zero.

Sum of forces on beam = 0
Sum of torques on beam = 0

Choose axis of rotation at end of beam.

Neglect the size of the mechanic.

Free body diagram of bar:

Take axis at end of beam. + is out.

\[ \sum \tau = \frac{L}{2} W_b - H y L = 0 \]

\[ H = \sqrt{H_x^2 + H_y^2} \]

Target: H, T

Plan unknowns

Find T

\[ T_y = T \sin \theta \quad [1] \]

Find \( T_y \)

\[ H_y + T_y - W_b - W_m = 0 \quad [2] \]

Find \( H_y \)

\[ \frac{L}{2} W_b - H_y L = 0 \quad [3] \]

3 unknowns, 3 equations – ok

What is the force on each attachment to the wall? Compare to 500 lbs.

\[ W_b = 120 \, \text{lb} \]

\[ W_m = 150 \, \text{lb} \]

\[ 9 \, \text{ft} = L \]
Solve [3] for \( H_y \)

\[
\frac{L}{2} W_b - H_y L = 0
\]

\[
H_y L = \frac{L}{2} W_b
\]

\[
H_y = \frac{\frac{L}{2} W_b}{L} = \frac{W_b}{2}
\]

put into [2] and solve for \( T_y \)

\[
\frac{W_b}{2} + T_y - W_b - W_m = 0
\]

\[
\frac{W_b}{2} + W_m = T_y \quad \text{put into [1] and solve for } T
\]

\[
\frac{W_b}{2} + W_m = T \sin \theta
\]

\[
\frac{W_b + W_m}{2 \sin \theta} = T
\]

Check units: weight is a force so this is the correct units for \( T \)

\[
\frac{120 \text{ lb}}{2} + \frac{150 \text{ lb}}{\sin 30^\circ} = 420 \text{ lb} = T \quad \text{The force on the bolts holding the cable is ok.}
\]

Now solve for \( H \)

Plan

Find \( H \) unknowns

\[
H = \sqrt{H_x^2 + H_y^2} \quad \text{[1]} \quad H_y, H_x
\]

Find \( H_y \)

\[
\frac{L}{2} W_b - H_y L = 0 \quad \text{[2]}
\]

Find \( H_x \)

\[
H_x - T_x = 0 \quad \text{[3]} \quad T_x
\]

Find \( T_x \)

\[
T_x = T \cos \theta \quad \text{[4]}
\]

4 unknowns, 4 equations
Solve \([4]\) for \(T_x\) and put into \([3]\)

\[ T_x = T \cos \theta \]

\[ H_x - T \cos \theta = 0 \] solve for \(H_x\) and put into \([1]\)

\[ H_x = T \cos \theta \]

\[ H = \sqrt{(T \cos \theta)^2 + H_y^2} \]

Solve \([2]\) for \(H_y\) and put into \([1]\)

\[ \frac{L}{2} W_b - H_y L = 0 \]

\[ \frac{W_b}{2} = H_y \]

\[ H = \sqrt{(T \cos \theta)^2 + \left(\frac{W_b}{2}\right)^2} \]

Check units: Weight and \(T\) are forces so the units of \(H\) are force which is correct.

\[ H = \sqrt{(420 \text{lb})^2 + (60 \text{lb})^2} \]

\[ H = 424 \text{ lb} \] The force on the hinge is ok

Evaluate:

\[ \frac{W_b + W_m}{2 \sin \theta} = T \] The tension in the cable increases if the weight of the bar or the weight of the mechanics increases. This is reasonable.

\[ H = \sqrt{(T \cos \theta)^2 + \left(\frac{W_b}{2}\right)^2} \]

The force on the hinge increases if the weight of the bar increases. This is reasonable.
The force on the hinge increases if the force on the cable increases. This is reasonable because the cable pushes the bar into the wall.