WORKSHOPWEEK7

2. ***REASONING*** The torque is given by Equation 9.1, $\tau = F\ell$, where F is the magnitude of the applied force and ℓ is the lever arm. From the figure in the text, the lever arm is given by $\ell = (0.28 \text{ m}) \sin 50.0°$. Since both τ and ℓ are known, Equation 9.1 can be solved for F.

SOLUTION Solving Equation 9.1 for F, we have

$$F = \frac{\tau}{\ell} = \frac{45 \text{ N} \cdot \text{m}}{(0.28 \text{ m}) \sin 50.0°} = \boxed{2.1 \times 10^2 \text{ N}}$$

8. ***REASONING*** Each of the two forces produces a torque about the axis of rotation, one clockwise and the other counterclockwise. By setting the sum of the torques equal to zero $(\Sigma\tau = 0)$, we will be able to determine the distance x in the drawing

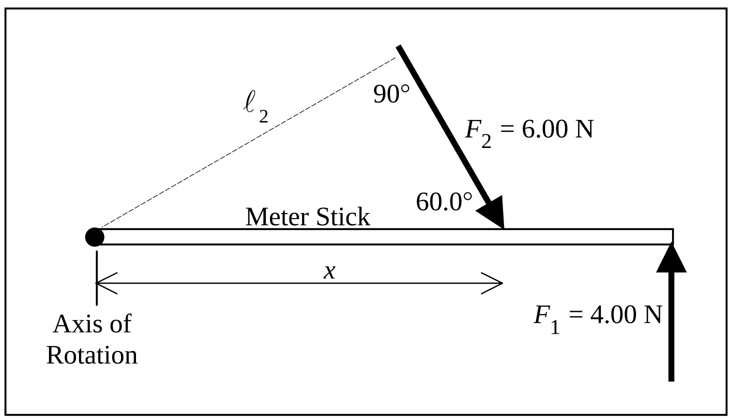

Table (Top view)

SOLUTION The torque τ_1 produced by the force F_1 is given by Equation 9.1 as $\tau_1 = +F_1\ell_1$, where the lever arm is $\ell_1 = 1.00$ m. It is a positive torque, since it tends to produce a counterclockwise rotation. The torque τ_2 produced by F_2 is $\tau_2 = -F_2\ell_2$, where $\ell_2 = x \sin 60.0°$. It is a negative torque, since it tends to produce a clockwise rotation. Setting the net torque equal to zero, we have

$$\underbrace{+F_1\ell_1 + \left(-F_2\ell_2\right)}_{\Sigma\tau} = 0 \qquad \text{or} \qquad +F_1\underbrace{\left(1.00 \text{ m}\right)}_{\ell_1} - F_2\underbrace{\left(x \sin 60.0°\right)}_{\ell_2} = 0$$

Solving for x gives

$$x = \frac{F_1\left(1.00 \text{ m}\right)}{F_2 \sin 60.0°} = \frac{\left(4.00 \text{ N}\right)\left(1.00 \text{ m}\right)}{\left(6.00 \text{ N}\right) \sin 60.0°} = \boxed{0.770 \text{ m}}$$

11. ***REASONING*** The drawing shows the forces acting on the person. It also shows the lever arms for a rotational axis perpendicular to the plane of the paper at the place where the person's toes touch the floor. Since the person is in equilibrium, the sum of the forces must be zero. Likewise, we know that the sum of the torques must be zero.

SOLUTION Taking upward to be the positive direction, we have

$$F_{\text{FEET}} + F_{\text{HANDS}} - W = 0$$

Remembering that counterclockwise torques are positive and using the axis and the lever arms shown in the drawing, we find

$$W\ell_{\text{W}} - F_{\text{HANDS}}\,\ell_{\text{HANDS}} = 0$$

$$F_{\text{HANDS}} = \frac{W\ell_{\text{W}}}{\ell_{\text{HANDS}}} = \frac{(584\text{ N})(0.840\text{ m})}{1.250\text{ m}} = 392\text{ N}$$

Substituting this value into the balance-of-forces equation, we find

$$F_{\text{FEET}} = W - F_{\text{HANDS}} = 584\text{ N} - 392\text{ N} = 192\text{ N}$$

The force on each hand is half the value calculated above, or $\boxed{196\text{ N}}$. Likewise, the force on each foot is half the value calculated above, or $\boxed{96\text{ N}}$.

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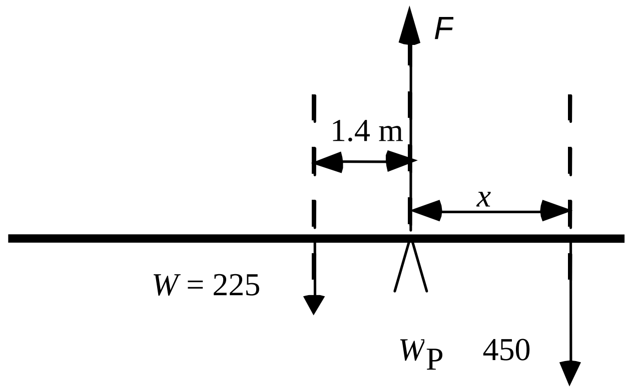
12. ***REASONING*** When the board just begins to tip, three forces act on the board. They are the weight W of the board, the weight W_{P} of the person, and the force F exerted by the right support.



Since the board will rotate around the right support, the lever arm for this force is zero, and the torque exerted by the right support is zero. The lever arm for the weight of the board is equal to one-half the length of the board minus the overhang length: 2.5 m – 1.1 m = 1.4 m.

The lever arm for the weight of the person is *x*. Therefore, taking counterclockwise torques as positive, we have

$$-W_P x + W(1.4 \text{ m}) = 0$$

This expression can be solved for *x*.

SOLUTION Solving the expression above for *x*, we obtain

$$x = \frac{W(1.4 \text{ m})}{W_P} = \frac{(225 \text{ N})(1.4 \text{ m})}{450 \text{ N}} = \boxed{0.70 \text{ m}}$$

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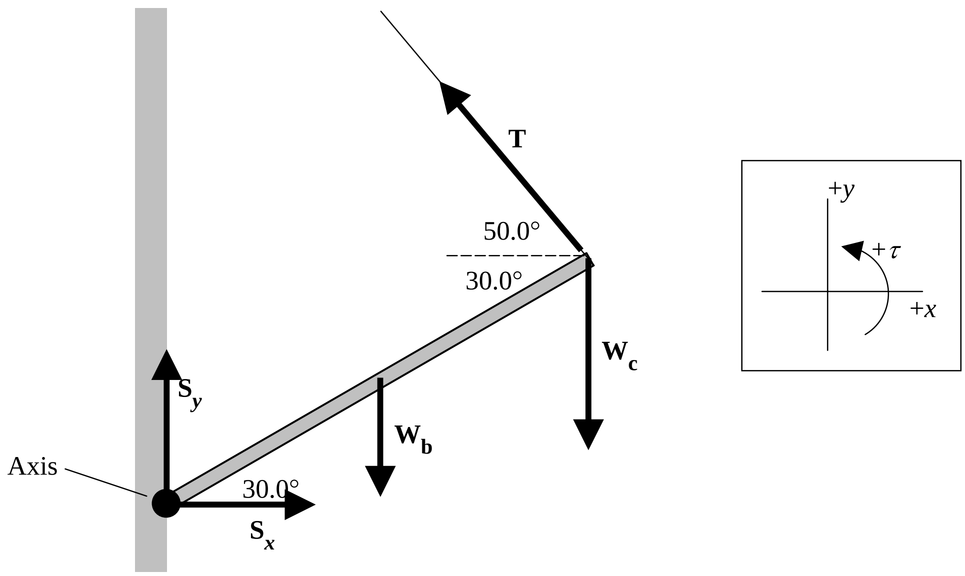
66. ***REASONING*** The drawing shows the beam and the five forces that act on it: the horizontal and vertical components $\mathbf{S}_x$ and $\mathbf{S}_y$ that the wall exerts on the left end of the beam, the weight $\mathbf{W}_b$ of the beam, the force due to the weight $\mathbf{W}_c$ of the crate, and the tension **T** in the cable. The beam is uniform, so its center of gravity is at the center of the beam, which is where its weight can be assumed to act. Since the beam is in equilibrium, the sum of the torques about any axis of rotation must be zero $(\Sigma\tau = 0)$, and the sum of the forces in the horizontal and vertical directions must be zero $(\Sigma F_x = 0,\ \Sigma F_y = 0)$. These three conditions will allow us to determine the magnitudes of $\mathbf{S}_x$, $\mathbf{S}_y$, and **T**.



SOLUTION

a. We will begin by taking the axis of rotation to be at the left end of the beam. Then the torques produced by $\mathbf{S}_x$ and $\mathbf{S}_y$ are zero, since their lever arms are zero. When we set the sum of the torques equal to zero, the resulting equation will have only one unknown, *T*, in it. Setting the sum of the torques produced by the three forces equal to zero gives (with *L* equal to the length of the beam)

$$\Sigma\tau = -W_b\left(\tfrac{1}{2}L\cos 30.0°\right) - W_c\left(L\cos 30.0°\right) + T\left(L\sin 80.0°\right) = 0$$

Algebraically eliminating *L* from this equation and solving for *T* gives

$$T = \frac{W_b\left(\tfrac{1}{2}\cos 30.0°\right) + W_c\left(\cos 30.0°\right)}{\sin 80.0°}$$

$$= \frac{(1220\text{ N})\left(\tfrac{1}{2}\cos 30.0°\right) + (1960\text{ N})(\cos 30.0°)}{\sin 80.0°} = \boxed{2260\text{ N}}$$

b. Since the beam is in equilibrium, the sum of the forces in the vertical direction must be zero:

$$\Sigma F_y = +S_y - W_b - W_c + T\sin 50.0° = 0$$

Solving for S_y gives

$$S_y = W_b + W_c - T\sin 50.0° = 1220\text{ N} + 1960\text{ N} - (2260\text{ N})\sin 50.0° = \boxed{1450\text{ N}}$$

The sum of the forces in the horizontal direction must also be zero:

$$\Sigma F_x = +S_x - T\cos 50.0° = 0$$

so that

$$S_x = T\cos 50.0° = (2260\text{ N})\cos 50.0° = \boxed{1450\text{ N}}$$

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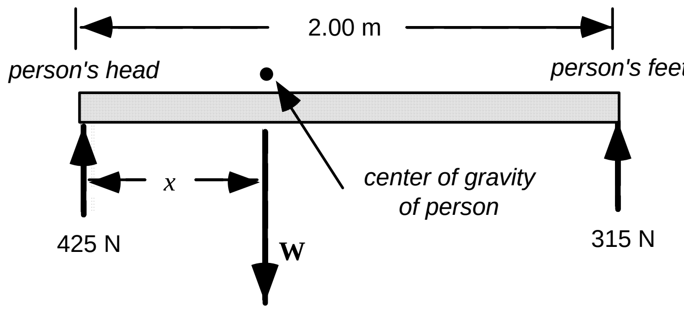
67. **SSM** **WWW** ***REASONING AND SOLUTION*** The figure below shows the massless board and the forces that act on the board due to the person and the scales.



a. Applying Newton's second law to the vertical direction gives

$$315\text{ N} + 425\text{ N} - W = 0 \qquad \text{or} \qquad \mathbf{W} = \boxed{7.40\times10^2\text{ N, downward}}$$

b. Let x be the position of the center of gravity relative to the scale at the person's head. Taking torques about an axis through the contact point between the scale at the person's head and the board gives

$$(315\text{ N})(2.00\text{ m}) - (7.40\times10^2\text{ N})x = 0 \qquad \text{or} \qquad x = \boxed{0.851\text{ m}}$$