CSD2301 Practice Solutions
16. **Static Equilibrium**

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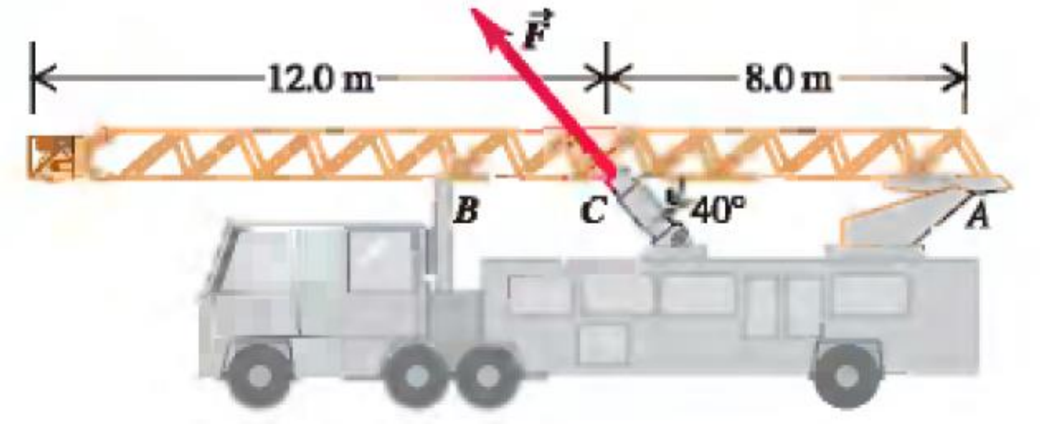
Practice Question 1

A ladder carried by a fire truck is 20.0 m long. The ladder weighs 2800 N and its center of gravity is at its center. The ladder is pivoted at one end (A) about a pin. Ignore friction torque at the pin. The ladder is raised into position by a force applied by a hydraulic piston at C. Point C is 8.0 m from A, and the Force F exerted by the piston makes and angle of 40° with the ladder. What magnitude must F have to just lift the ladder off the support bracket at B?



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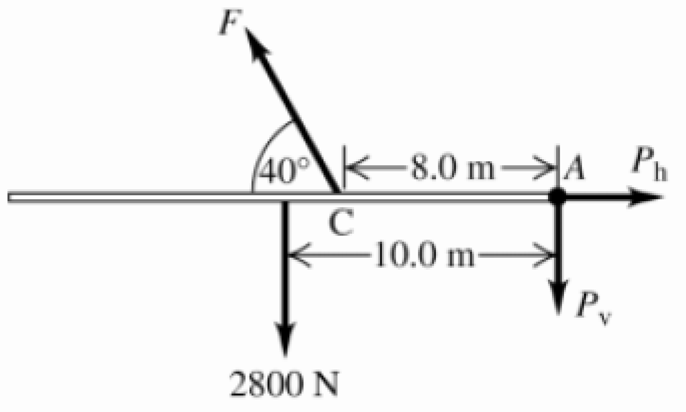
Take moments about point A,

F(8.0 m)sin 40° = (2800 N)(10.0 m), so F = 5.45 kN .



Practice Question 2

Two people carrying a heavy electric motor by placing it on a light board 2.00 m long. One person lifts at one end with a force of 400 N, and the other lifts the opposite end with a force of 600 N. (a) Assume the board is massless, what is the weight of the motor, and where along the board is the center of gravity location? (b) Suppose the board weighs 200 N, with the center of gravity at its center, and the two people exert the same forces as before. What is the weight of the motor in this case, and where is the center of gravity located?

Practice Question 2

IDENTIFY: Apply $\sum F_y = 0$ and $\sum \tau_z = 0$ to the board.

SET UP: Let $+y$ be upward. Let x be the distance of the center of gravity of the motor from the end of the board where the 400 N force is applied.

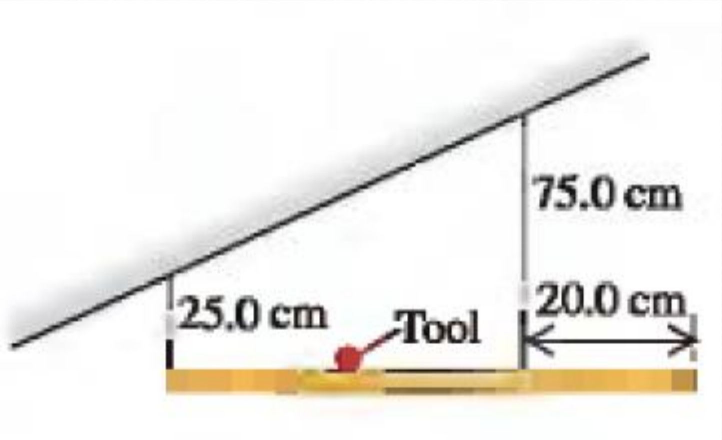
EXECUTE: **(a)** If the board is taken to be massless, the weight of the motor is the sum of the applied forces, 1000 N. The motor is a distance $\frac{(2.00\text{ m})(600\text{ N})}{(1000\text{ N})} = 1.20\text{ m}$ from the end where the 400 N force is applied, and so is 0.800 m from the end where the 600 N force is applied.

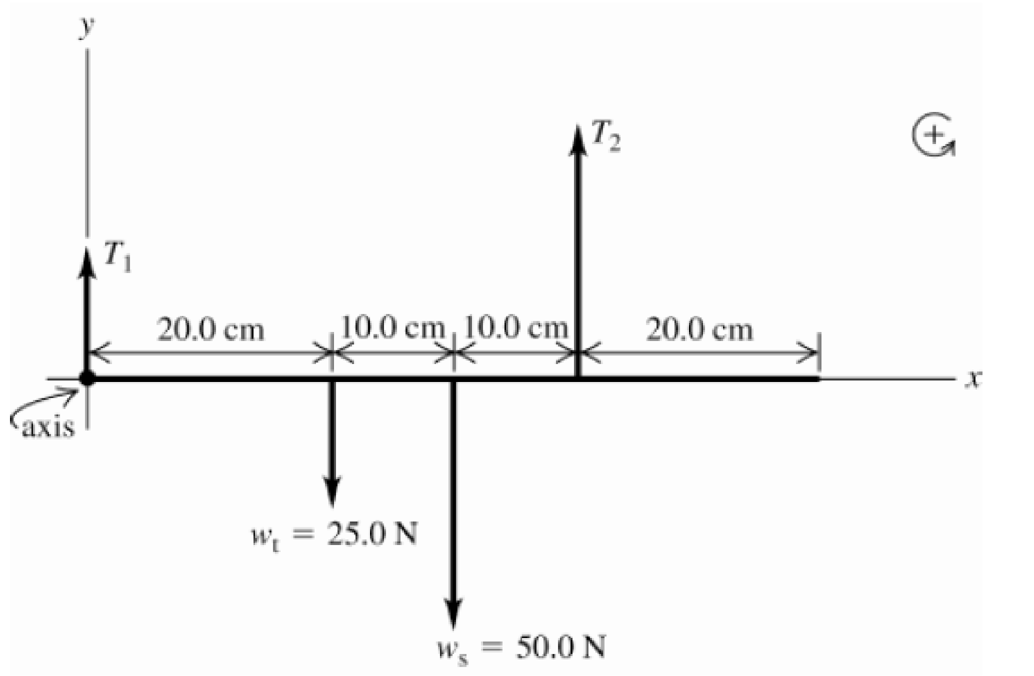
(b) The weight of the motor is $400\text{ N} + 600\text{ N} - 200\text{ N} = 800\text{ N}$. Applying $\sum \tau_z = 0$ with the axis at the end of the board where the 400 N acts gives $(600\text{ N})(2.00\text{ m}) = (200\text{ N})(1.00\text{ m}) + (800\text{ N})x$ and $x = 1.25\text{ m}$. The center of gravity of the motor is 0.75 m from the end of the board where the 600 N force is applied.

EVALUATE: The motor is closest to the end of the board where the larger force is applied.

Practice Question 3

A 60.0 cm uniform, 50.0 N shelf is supported horizontally by two vertical wires attached to the sloping ceiling as shown. A very small 25.0 N tool is placed on the shelf midway between the points where the wires are attached to it. Find the tension in each wire.





Taking moments about left hand side

EXECUTE: (a) $\sum \tau_z = 0$ gives $-w_t(0.200\text{ m}) - w_s(0.300\text{ m}) + T(0.400\text{ m}) = 0$.

T_2

$$T = \frac{(25.0\text{ N})(0.200\text{ m}) + (50.0\text{ N})(0.300\text{ m})}{0.400\text{ m}} = 50.0\text{ N}$$

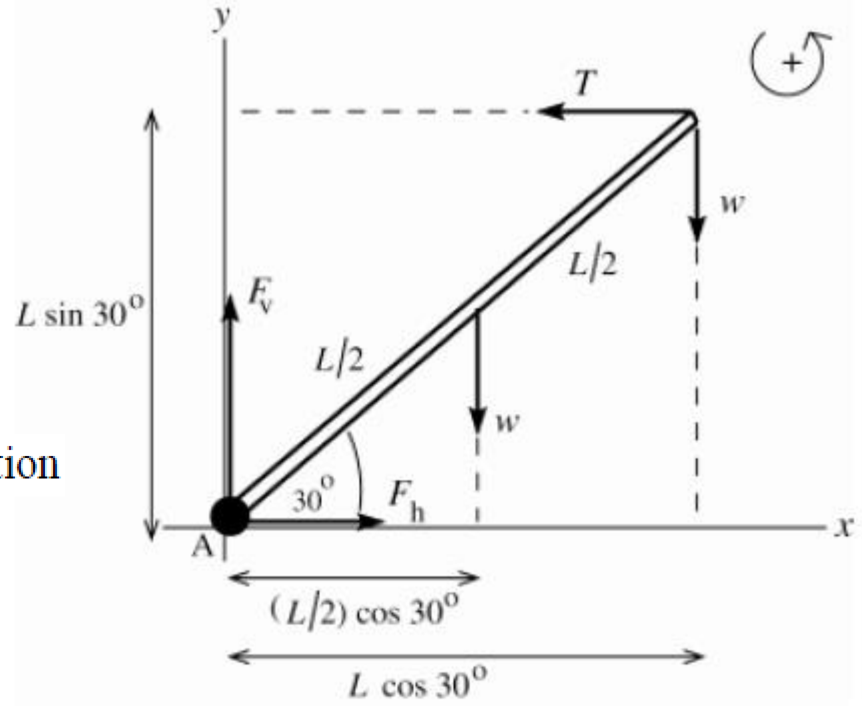
$\sum F_y = 0$ gives $T_1 + T_2 - w_t - w_s = 0$ and $T_1 = 25.0\text{ N}$. The tension in the left-hand wire is 25.0 N and the tension in the right-hand wire is 50.0 N.

Practice Question 4

Find the tenson T in the cable and the magnitude and direction of the force exerted on the strut by the pivot in the diagram as shown. Let the weight of the crate be w. The strut is uniform and also has the same weight, w.

$$\sum F_y = ma_y$$
$$F_v - w - w = 0$$
$$F_v = 2w$$

Sum torques about point A. The pivot force has zero moment arm for this axis and so doesn't enter into the torque equation.

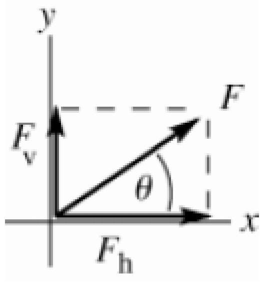


$$\tau_A = 0$$
$$TL\sin 30.0° - w\big((L/2)\cos 30.0°\big) - w(L\cos 30.0°) = 0$$
$$T\sin 30.0° - (3w/2)\cos 30.0° = 0$$
$$T = \frac{3w\cos 30.0°}{2\sin 30.0°} = 2.60w$$

Then $\sum F_x = ma_x$ implies $T - F_h = 0$ and $F_h = 2.60w$.

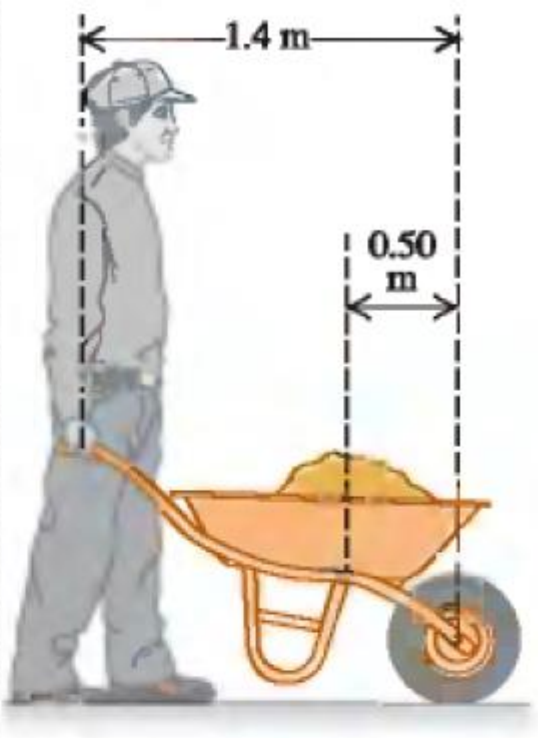
We now have the components of $\vec{F}$ so can find its magnitude and direction

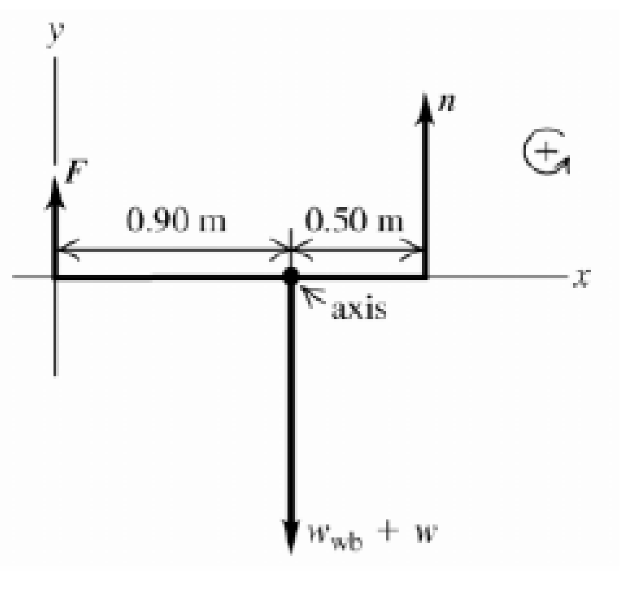
$$F = \sqrt{F_h^2 + F_v^2}$$
$$F = \sqrt{(2.60w)^2 + (2.00w)^2}$$
$$F = 3.28w$$
$$\tan\theta = \frac{F_v}{F_h} = \frac{2.00w}{2.60w}$$
$$\theta = 37.6°$$



Practice Question 5

Suppose that you can lift no more than 650 N unaided. (a) How much can you lift using a 1.4 m wheelbarrow that weighs 80.0 N and whose center of gravity is 0.50 m from the center of the wheel? The center of gravity of the load carried in the wheelbarrow is also 0.50 m from the center of the wheel. (b) Where does the force come from to enable you to lift more than 650 N using the wheelbarrow?





F = 650 N , w_{wb} = 80.0 N and w is the weight of the load placed in the wheelbarrow.

EXECUTE: (a) $\sum \tau_z = 0$ with the axis at the center of gravity gives $n(0.50\text{ m}) - F(0.90\text{ m}) = 0$ and

$n = F\left(\frac{0.90\text{ m}}{0.50\text{ m}}\right) = 1170\text{ N}$. $\sum F_y = 0$ gives $F + n - w_{wb} - w = 0$ and

$w = F + n - w_{wb} = 650\text{ N} + 1170\text{ N} - 80.0\text{ N} = 1740\text{ N}$.

(b) The extra force is applied by the ground pushing up on the wheel.

EVALUATE: You can verify that $\sum \tau_z = 0$ for any axis, for example for an axis where the wheel contacts the ground.