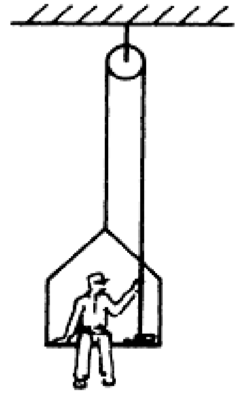
Bosun's Chair



A painter weighing 180 lb working from a "bosun's" chair hung down the side of a tall building, desires to move in a hurry. He pulls down on the fall rope with such a force that he presses against the chair with only a force of 100 lb. The chair itself weighs 30.0 lb.

(a) What is the acceleration of the painter and the chair?

(b) What is the total force supported by the pulley?

Solution by Gert Hamacher

The problem statement contains information on inner forces, so we must look at the man and the chair separately. We neglect the masses of the rope and the pulley.

w_m - weight of the man $= m_m \cdot g = 180lb$

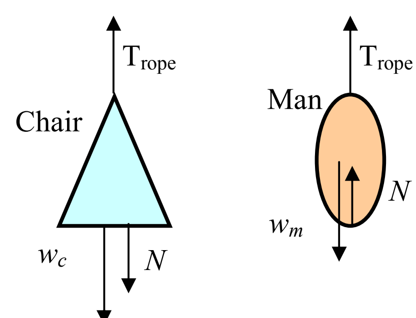
w_c - weight of the chair $= m_c \cdot g = 30lb$

N - the normal (inner) force between the man and the chair $= 100lb$

T_{rope} - the tension on the rope

g - the acceleration of gravity

a - the acceleration of the man/chair system



free body diagrams

(a) By Newton's 2nd law:

(a.1)
$$\text{total force on man} = T_{rope} + N - w_m = m_m \cdot a$$
$$\therefore T_{rope} + N = w_m + m_{man} \cdot a$$

(a.2)
$$\text{total force on chair} = T_{rope} - N - w_c = m_c \cdot a$$
$$\therefore T_{rope} - N = w_c + m_c \cdot a$$

Subtracting Eq. (a.2) from Eq. (a.1),

$$2N = (w_m + m_m \cdot a) - (w_c + m_c \cdot a)$$
$$\therefore a = \frac{2N - w_m + w_c}{m_m - m_c} = \frac{2N - w_m + w_c}{w_m - w_c} \cdot g = \frac{2 \cdot 100 - 180 + 30}{180 - 30} \cdot g = \tfrac{1}{3} g.$$

(b) The total force supported by the pulley equals the total tension on the rope (both sides) = $2T_{rope.}$ Adding Eq. (a.1) to Eq. (a.2),

$$2T_{rope} = (w_m + w_c) + (m_m + m_c) \cdot a = (w_m + w_c) + (w_m + w_c) \cdot \frac{\frac{1}{3} g}{g} = \frac{4}{3} \cdot (180 + 30) = 280.$$

$\therefore$ total force supported by pulley $= 280lb.$