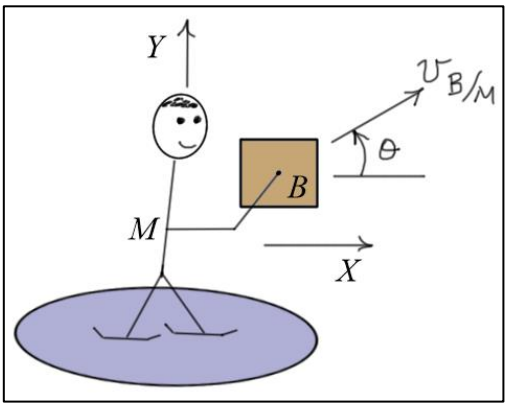
Elementary Dynamics Example #25: (Conservation of Momentum)

Given: $v_{B/M} = 2$ (m/s), $m_B = 8$ (kg), $m_M = 70$ (kg), $\theta = 30$ (deg)

system (block and man) is initially at rest
man throws block in $\Delta t = 1.5$ (sec)

man is on ***ice***, legs are ***rigid***
arm mass is ***negligible***



Find: a) velocity of man just after releasing block
b) average normal force the ice exerts on man

Solution: (using ***conservation of momentum***)

a) Linear momentum is conserved for the system in the *X* direction, and the relative velocity can be used to relate the absolute velocities.

$$\boxed{0 = m_M (v_M)_x + m_B (v_B)_x} \quad \text{and} \quad \boxed{(v_{B/M})_x = (v_B)_x - (v_M)_x = 2\cos(30)}$$

Simultaneous equations:

$$\boxed{\begin{aligned} 70(v_M)_x + 8(v_B)_x &= 0 \\ -(v_M)_x + (v_B)_x &= 2\cos(30) \end{aligned}} \Rightarrow \boxed{\begin{aligned} (v_M)_x &= -0.1776 \text{ (m/s)} \\ (v_B)_x &= +1.5544 \text{ (m/s)} \end{aligned}}$$

b) Impulse and momentum in the *Y* direction

$$\boxed{\underbrace{\sum (mv_y)_1}_{\text{zero}} + \sum I_{1\to 2} = \sum (mv_y)_2}$$ (1 is before the throw and 2 is just after)

$$\boxed{\sum I_{1\to 2} = (N_{\text{avg}} - m_M g - m_B g)\Delta t = 1.5(N_{\text{avg}} - 78g)}$$

$$\boxed{\sum (mv_y)_2 = \underbrace{0}_{\text{neglecting momentum of the arms}} + m_B (v_B)_y = 8(2\sin(30)) = 8}$$

Solving,

$$\boxed{N_{\text{avg}} = 771 \text{ (N)} = 78.6 \text{ (kg)}}$$ (just slightly larger than the combined weights of the man and block)