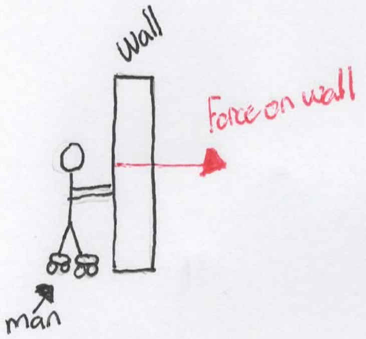
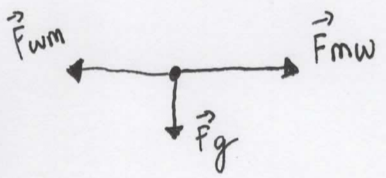
7. A 62-kg man on roller blades is standing still in front of a wall. By pushing against the wall he propels himself backward with a velocity of -2.5 m/s. his hands are in contact with the wall for 0.72 s. Ignore friction and wind resistance. Find the magnitude and direction of the average force he exerts on the wall (which has the same magnitude, but opposite direction, as the force that the wall applies to him).

Solution



FBD $\hat{j}\ \hat{x}$



Knowns

mass = 62 kg

Velocity$_f$ = - 2.5 m/s

Time = 0.72 s

equations

$\Sigma \vec{P}_i = \Sigma \vec{P}_f$

$\Sigma \vec{F} \Delta t = \Delta \vec{P}$

1. $\Sigma \vec{P}_i = \Sigma \vec{P}_f$

$\cancel{m\vec{v}_i} = m v_f$

$0 = (62\,kg)(-2.5\,m/s)$

$0 = -155\ \frac{kg\,m}{s}$

$\Delta \vec{p} = (\vec{p}_f - \vec{p}_i)$

$\Delta \vec{p} = -155\ \frac{kg\,m}{s}$

2. $\Sigma \vec{F} \cdot \Delta t = \Delta \vec{p}$

rearrange equation

$\Sigma \vec{F} = \frac{\Delta \vec{p}}{\Delta t}$

$\Sigma \vec{F} = \frac{-155\ \frac{kg\,m}{s}}{0.72\,s}$

$\Sigma \vec{F} = -215.3\ N$

$\boxed{\text{Magnitute} = 215.3\ N}$

$\boxed{\text{direction} = \text{opposite of wall, in negative x}}$

50. When jumping straight down, you can be seriously injured if you land stiff-legged. One way to avoid injury is to bend your knees upon landing to reduce the force of the impact. A 62 kg woman just before contact with the ground has a speed of 4.7 m/s.

(a) In a stiff-legged landing she comes to a halt in 3.2 ms. Find the average net force that acts on her during this time.

(b) When she bends her knees, she comes to a halt in 0.23 s. Find the average force now.

(c) During the landing, the force of the ground on the woman points upward, while the force due to gravity points downward. The average net force acting on the woman includes both of these forces. Taking into account the directions of these forces, find the force of the ground on the woman in parts (a) and (b).

Solution:

Knowns:

$m = 62\ kg$

$v_i = 4.2\ m/s$

$v_f = 0\ m/s$

$\Delta t_{stiff} = 3.2\ ms$

$\Delta t_{bent} = 0.23\ s$

Unknowns:

ΣF_{stiff}, ΣF_{bent}

$F_{N stiff}$, $F_{N bent}$

a) Stiff-legged

block, ground

1) First convert time to seconds: $\Delta t = 3.2\ ms \left(\frac{s}{1000\ ms}\right) = 0.0032\ s$

2) Find the change in momentum:

$$\Delta \vec{P} = \vec{P}_f - \vec{P}_i$$
$$= m\cancel{v_f}^{0} - mv_i$$
$$= -(62\ kg)(4.2\ m/s)$$
$$\Delta \vec{P} = -260.4\ kg \cdot m/s$$

3) Find the avg net force: $\Sigma \bar{F} = \frac{|\Delta \vec{P}|}{\Delta t} = \frac{260.4\ kg \cdot m/s}{0.0032\ s} = \boxed{81\,375\ N}$

b) Bent-legged

block, ground

1) the change in momentum is the same as part a)

2) Find the avg net force: $\Sigma \bar{F} = \frac{|\Delta \vec{P}|}{\Delta t} = \frac{260.4\ kg \cdot m/s}{0.23\ s} = \boxed{1132\ N}$

c) Find the force of the ground on the women for a) and b):

a. Stiff-legged

$$\Sigma \bar{F} = F_N + F_g$$
$$F_N = \Sigma \bar{F} - F_g$$
$$= (81\,375\ N) - (-607.6\ N)$$
$$= \boxed{81\,983\ N}$$

F_N, $\uparrow +x$, F_g

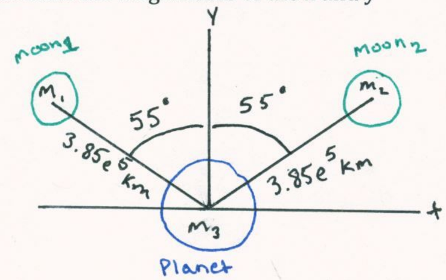
$F_g = mg = (62\ kg)(-9.8\ m/s^2) = -607.6\ N$

b. Bent-legged

$$\Sigma \bar{F} = F_N + F_g$$
$$F_N = \Sigma \bar{F} - F_g$$
$$= (1132\ N) - (-607.6\ N)$$
$$= \boxed{1740\ N}$$

$\uparrow +x$, F_N, F_g

There is a planet with two moons . The mass of this planet is two times the mass of the moons which have equal masses. The radius between the center of the planet and the center of each moon is 385,000 kilometers. Moon 1 is at an angle of 55 degrees in the –x direction relative to the y axis. Moon 2 is at an angle of 55 degrees in the +x direction relative to the y-axis. Calculate the magnitudes of the x and y center of mass for this in terms of m.



$$y_{cm} = \frac{m_1 y + m_2 y + m_3 \cancel{y}^{\,0}}{m_1 + m_2 + m_3}$$

$m_1 = m_2 = \frac{1}{2} m_3$

$m_1 + m_2 = 2m$

$2m = m_3$

$$y_{cm} = \frac{my + my}{m + m + 2m}$$

$$= \frac{2my}{4m}$$

$$= \frac{y}{2m}$$

$$= \frac{3.85 \times 10^5 \text{ km} \cos(55)}{2m}$$

$$y_{cm} = \frac{1.10 \times 10^5 \text{ km}}{m}$$

$$x_{cm} = \frac{m_1 x + m_2 x + m_3 \cancel{x}^{\,0}}{m_1 + m_2 + m_3}$$

$$x_{cm} = \frac{mx + mx}{4m}$$

$$= \frac{2mx}{4m}$$

$$= \frac{x}{2m}$$

$$= \frac{3.85 \times 10^5 \text{ km} \sin 55}{2m}$$

$$x_{cm} = \frac{1.58 \times 10^5 \text{ km}}{m}$$

$$\boxed{\langle x, y \rangle = \left\langle \frac{1.58 \times 10^5 \text{ km}}{m}, \frac{1.10 \times 10^5 \text{ km}}{m} \right\rangle}$$