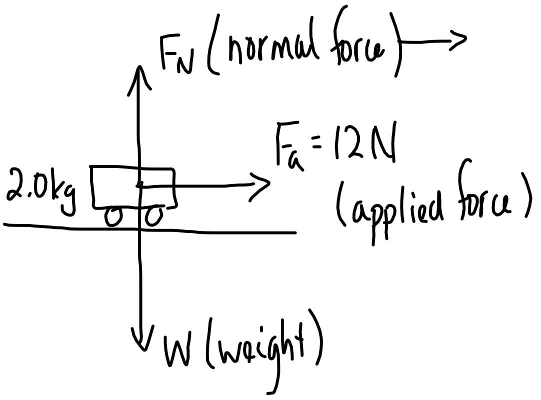
Example
A force of 12 N acts horizontally to the right on a frictionless cart of mass 2.0 kg
Determine the acceleration of the car.



$F_a = 12N$
$m = 2.0kg$
$a = ??$

$\vec{F}_{net} = m\vec{a}$

$F_a = ma$

$a = \frac{F_a}{m}$

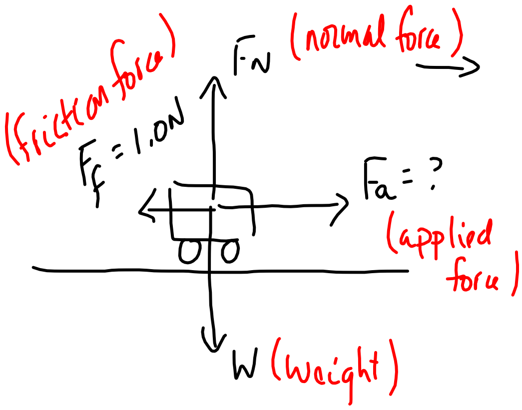
$kg \cdot ms^{-2}$

$a = \frac{12N}{2.0kg}$

$a = 6.0\ ms^{-2}$ horizontally

$\vec{a} = 6.0\ ms^{-2}$ [right]

Example
The cart (mass 2.0 kg) is to be accelerated horizontally to the right by 6.0 m s^{-2} againts a constant friction force of 1.0 N. What force is required?



$F_f = 1.0N$
$m = 2.0kg$
$a = 6.0\ ms^{-2}$
$F_a = ?$

$\vec{F}_{net} = m\vec{a}$

$F_a - F_f = ma$

$F_a = \underbrace{ma}_{F_{net}} + F_f$

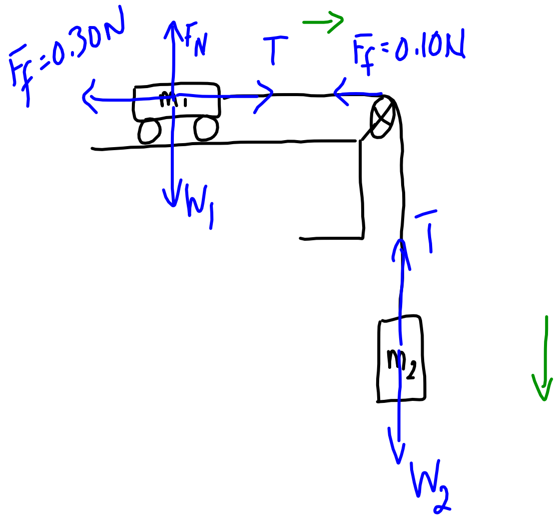
$F_a = (2.0kg)(6.0ms^{-2}) + 1.0N$

$F_a = 12N + 1.0N$

$F_a = 13N$

$\vec{F_a} = 13N$ [right]

Example
A trolley of mass 0.20 kg is on a horizontal surface and is connected by a string to a mass of 0.10 kg. The string passes over a pulley such that the weight of the 0.10 kg mass causes the trolley to accelerate. There is a friction force of 0.10 N in the pulley and a friction force of 0.30 N in the wheels of the trolley. Calculate the acceleration of the trolley along the surface.

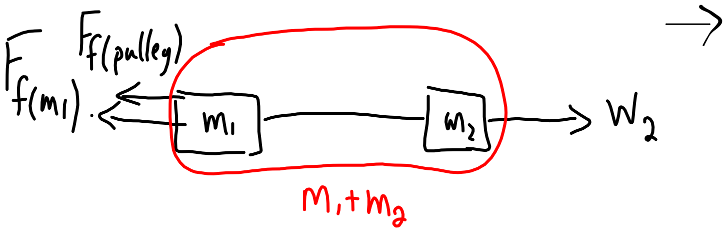


$m_1 = 0.20\,kg$

$m_2 = 0.10\,kg$

$F_{f(pulley)} = 0.10N$

$F_{f(m_1)} = 0.30N$



$$\vec{F}_{net} = m\vec{a}$$

$$W_2 - F_{f(pulley)} - F_{f(m_1)} = (m_1 + m_2)a$$

$$a = \frac{m_2 g - F_{f(pulley)} - F_{f(m_1)}}{m_1 + m_2}$$

$$a = \frac{(0.10kg)(9.81ms^{-2}) - 0.10N - 0.30N}{0.20kg + 0.10kg}$$

$$a = \frac{0.981N - 0.10N - 0.30N}{0.30kg}$$

$$a \doteq 1.9\,ms^{-2}$$

$$\vec{a} \doteq 1.9\,ms^{-2}\ [right]$$

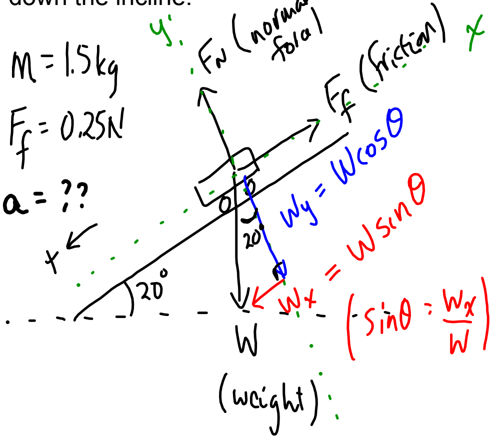
Newton's Second Law (continued)

Example
The diagram shows a dynamics trolley of mass 1.5 kg on a board which is inclined at 20°to the horizontal. A friction force of 0.25 N acts between the trolley and the board. Draw and label a FBD. Calculate the acceleration of the trolley down the incline.

$m = 1.5\,kg$

$F_f = 0.25\,N$

$a = ??$



$$\vec{F}_{net} = m\vec{a}$$

$$W_x - F_f = ma$$

$$a = \frac{W_x - F_f}{m}$$

$$a = \frac{W\sin\theta - F_f}{m}$$

$$a = \frac{mg\sin\theta - F_f}{m}$$

$$a = \frac{(1.5\,kg)(9.81\,ms^{-2})\sin 20° - 0.25\,N}{1.5\,kg}$$

$$a = \frac{\underset{W_x}{5.03\,N} - \underset{\text{Friction (kinetic)}}{0.25\,N}}{1.5\,kg}$$

$$\frac{\cancel{kg}\cdot ms^{-2}}{\cancel{kg}}$$

$$a = 3.2\,m/s^2$$

$$\vec{a} = 3.2\,m/s^2\ [\text{down incline}]$$

ms^{-2}

What angle ($\theta > 0$), will give an acceleration of $0\,ms^{-2}$? (i.e. $\vec{F}_{net} = 0$)

i.e. $W_x = F_f$

$$mg\sin\theta = F_f$$

$$\sin\theta = \frac{F_f}{mg}$$

$$\theta = \sin^{-1}\left(\frac{F_f}{mg}\right)$$

$$\theta = \sin^{-1}\left(\frac{0.25\,N}{(1.5\,kg)(9.81\,ms^{-2})}\right)$$

F_f actually changes with the angle.

$$\theta = 0.97°$$

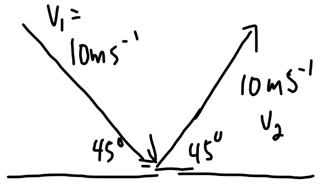
Example

A billiard ball of mass 0.15kg moving with a velocity of 10 m s^{-1} inclined at 45^{o} to the edge of the table bounces off the edge of the table at the same angles but with no change in speed. The ball is in contact with the edge of the table for 5.0 x 10^{-2} s. Determine the force acting on the ball during its collision with the edge of the table.

$m = 0.15\,kg \quad \Delta t = 5.0 \times 10^{-2}\,s$

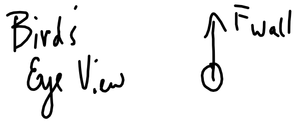
$\vec{F}_{net} = m\vec{a}$

$F_{wall} = m a$ ← ??

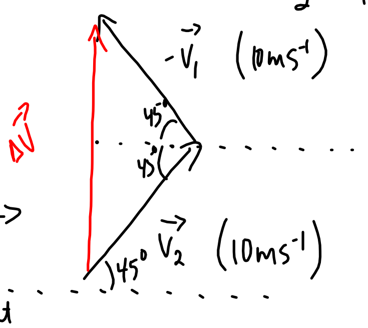


Recall $\vec{a} = \frac{\Delta\vec{v}}{\Delta t}$

$\vec{a} = \frac{\vec{v}_2 - \vec{v}_1}{\Delta t}$ ← need to do vector subtraction



Vector subtraction: $\vec{v}_2 - \vec{v}_1 = \vec{v}_2 + (-\vec{v}_1)$



due to symmetry we know that this is straight away from the wall

$c^2 = a^2 + b^2$

$c^2 = 10^2 + 10^2$

$c = (\sqrt{200})\,m\,s^{-1} = \Delta v$

$\vec{a} = \frac{\Delta\vec{v}}{\Delta t}$

$\vec{a} = \frac{(\sqrt{200})\,m\,s^{-1}}{5.0 \times 10^{-2}\,s}$ [away from wall]

$\vec{a} \doteq 2.8 \times 10^{2}\,m\,s^{-2}$ [away from wall]

$\vec{F}_{net} = m\vec{a}$

$\vec{F}_{wall} = m\vec{a}$

$\vec{F}_{wall} = (0.15\,kg)(2.8 \times 10^{2}\,m\,s^{-2})$ [away fr. wall]

$\vec{F}_{wall} \doteq 42\,N$ [away from the wall]