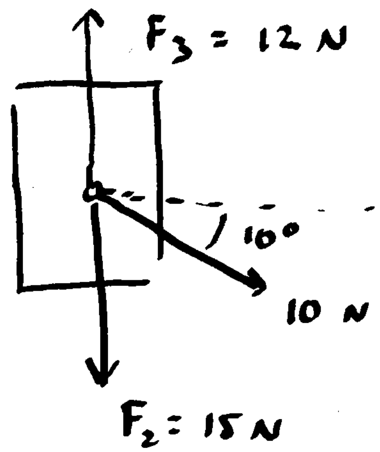
Newton's Laws – Example 2

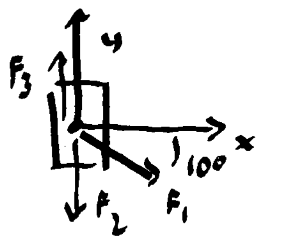
Hyenas pulling on an Antelope carcass

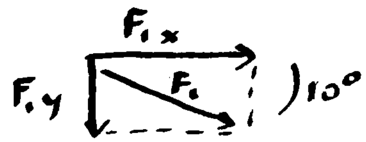


$m_{antelope} = 300\,kg$

Assume NO friction in this Example

Which way does the carcass move?
What is $|\vec{a}|$?





$F_{1x} = F_1 \cos 10$

$F_{1y} = -F_1 \sin 10$

$\Sigma F_x = (m_{Antelope})\, a_x = F_1 \cos 10$

$\Sigma F_y = (m_{ANT})\, a_y = \overset{+F_3}{\cancel{+12\,N}} \; \overset{-F_2}{\cancel{-15\,N}} - F_1 \sin 10$

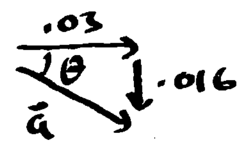
x eqn $\quad (300\,kg)\, a_x = 10 \cos 10$ Newtons

$a_x = 0.03\ m/s^2$

y eqn $\quad (300\,kg)\, a_y = 12 - 15 - 10 \sin 10$

$a_y = -0.016\ m/s^2$

$|\vec{a}| = \sqrt{a_x^2 + a_y^2} = 0.034\ m/s^2$

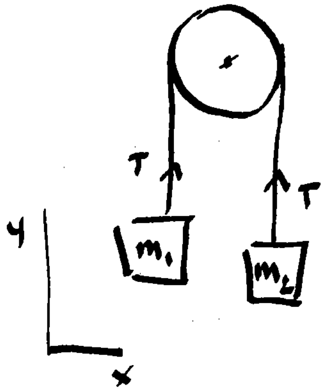


$\tan\theta = \frac{.016}{.03}$

$\theta = 28°$

Newton's laws

Example 3



$m_1 = 6$ kg

$M_2 = 10$ kg

Pulley is frictionless

What is acceleration of the system?
What is the tension in the rope?

MASS 1

$\Sigma F_x = 0$

$a_x = 0$

$\Sigma F_y = T - m_1 g = m_1 a_y$

MASS 2

$\Sigma F_x = 0$

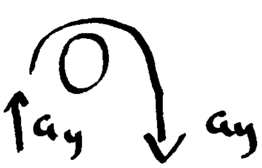
$a_x = 0$

$\Sigma F_y = T - M_2 g = M_2 a_y$

but Need consistency

a_y is related in two cases

T is related in two cases



MASS 1

a_y "+" ↑

T "+" ↑

→

MASS 2

a_y "+" ↓

F "+" ↓

$T - m_1 g = m_1 a_y$

$-T + M_2 g = M_2 a_y$

Mass 1

$$T = m_1 a_y + m_1 g = m_1(a_y + g)$$

Mass 2

$$T = m_2(g - a_y)$$

$$\therefore$$

$$m_1(a_y + g) = m_2(g - a_y)$$

$$m_1 a_y + m_1 g = m_2 g - m_2 a_y$$

$$a_y(m_1 + m_2) = g(m_2 - m_1)$$

$$a_y = \frac{g(m_2 - m_1)}{(m_1 + m_2)} = \frac{9.8\,m/s^2\,(4\,kg)}{16\,kg} = 2.45\,m/s^2$$

What is T?

$$T = m_1(a_y + g) = \cancel{kg}\ 6\,kg(2.45\,m/s^2 + 9.8\,m/s^2)$$

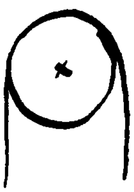
$$= 73.5\,N\ !$$

This used eqn from Mass 1

Same as that for mass 2?

$$T = m_2(g - a_y) = 10\,kg(9.8\,m/s^2 - 2.45\,m/s^2)$$

$$= 73.5\,N\ !$$



~ String just transfers force if pulley is frictionless

Limiting cases: if $m_1 = m_2$ $a_y = 0$ ✓

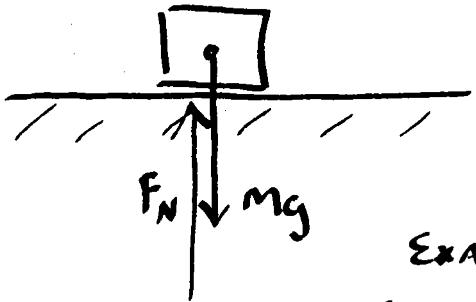
$m_2 \gg m_1$ a_y big + positive

$m_2 \ll m_1$ a_y big + negative

✓

Earth exerts a grav. force on you downward right?

What keeps you from falling thru the floor?



$F_N \equiv$ Normal Force

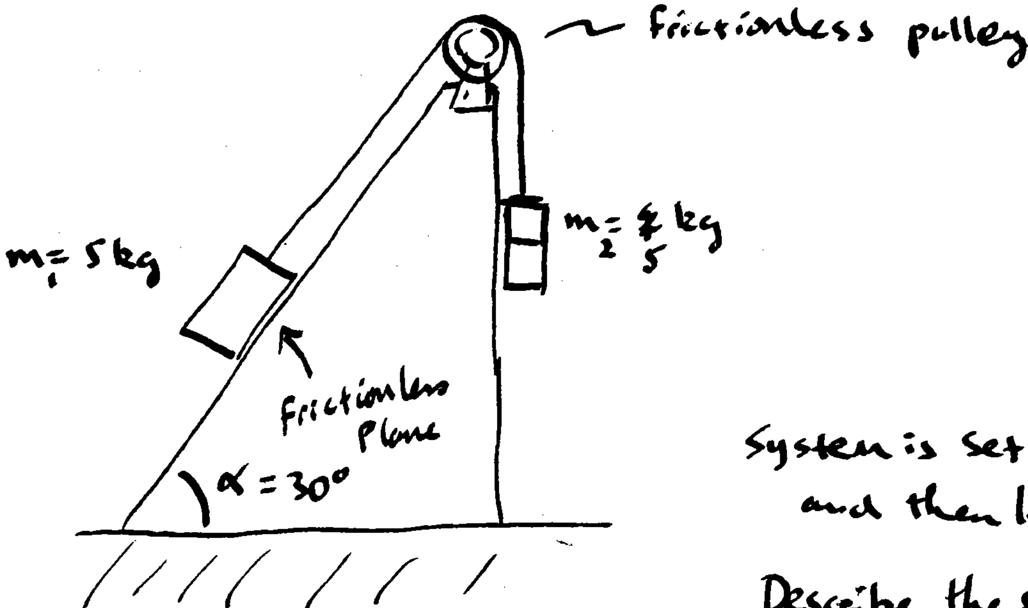
Example of a contact force

force is exerted normal to the surface making contact

due to "Material integrity"

comes out of Newton's 3rd law "Action - reaction"

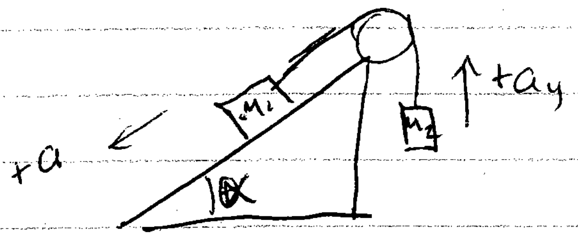
Newton's Laws Example 4

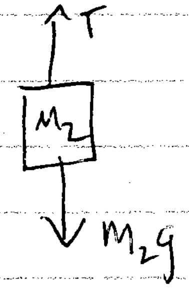


System is set in place and then let go.

Describe the ~~suegeent~~ subsequent motion

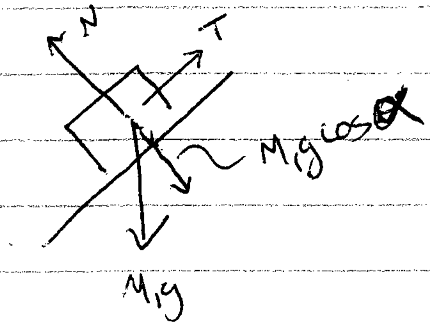
$\alpha = 30^\circ$
$M_1 = 5\ kg$
$M_2 = 5\ kg$





$\Sigma F_y = M_2 a$

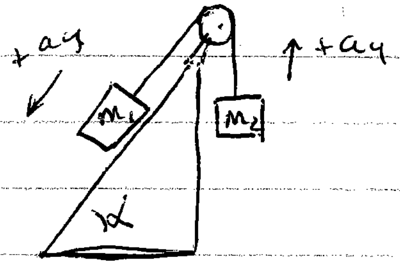
$$\boxed{T - m_2 g = M_2 a_y} \quad \mathrm{II}$$



$$\Sigma F_\perp = m_1 a_\perp = \boxed{0 = N - m_1 g \cos\theta} \quad \mathrm{I}$$

$$\therefore N = m_1 g \cos\alpha$$

$$\Sigma F_\parallel = \boxed{m_1 a_\parallel = m_1 g \sin\alpha - T} \quad \mathrm{III}$$



$$\text{I} \quad N - m_1 g \cos\alpha = 0$$

$$\text{II} \quad T - m_2 g = m_2 a_y$$

$$\text{III} \quad m_1 g \sin\alpha - T = m_1 a_y$$

$\text{I} \rightarrow \quad N = m_1 g \cos\alpha = (5\text{ kg})(9.8\text{ m/s}^2)\cos 30 = 42.4\text{ N}$

$\text{II} \rightarrow \quad T = m_2 a_y + m_2 g$

sub in III

$$m_1 g \sin\alpha - m_2 a_y - m_2 g = m_1 a_y$$

$$m_1 g \sin\alpha - m_2 g = a_y (m_1 + m_2)$$

$$\boxed{\frac{m_1 g \sin\alpha - m_2 g}{m_1 + m_2} = a_y}$$

units ok

Big $m_2 \rightarrow a_y$ is neg

Big $m_1 \rightarrow a_y$ is +

solve for T

$$T = m_2 g + \frac{m_2 m_1 g \sin\alpha - m_2^2 g}{m_1 + m_2}$$

$$T = \frac{m_1 m_2 g + \cancel{m_2^2 g} + m_1 m_2 g \sin\alpha - \cancel{m_2^2 g}}{m_1 + m_2}$$

$$\boxed{T = \frac{m_1 m_2 g (1 + \sin\alpha)}{m_1 + m_2}}$$