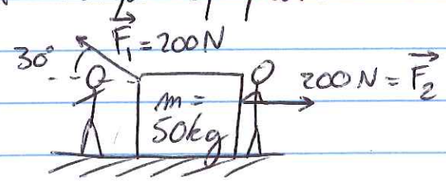
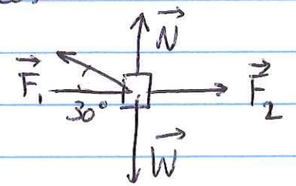
PHYS 107 - Week 4 - Wednesday

Question Forces 5-6

* Examples of problems with forces





$$\vec{F}_{net} = m\vec{a} \longrightarrow \begin{cases} x: -F_1\cos 30^\circ + F_2 = ma_x \\ y: F_1 \sin 30^\circ + N - mg = ma_y \end{cases}$$

$$a_x = \frac{1}{m}\left(-F_1\cos 30^\circ + F_2\right) = +0.54\ m/s^2$$

what about a_y? could it be non-zero?

↳ method: assume $a_y = 0$ → calculate N

since N can only "push", not "pull":

{ if $N \geq 0$, then a_y is indeed zero
{ if $N < 0$, then a_y is not zero, but $N = 0$

↳ $N = mg - F_1 \sin 30^\circ = +390\,N$, so $a_y = 0$ indeed

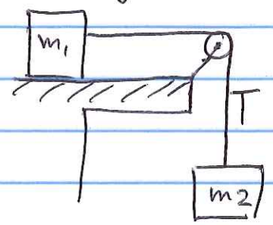
what if F_1 pulls harder? $F_1 = 1200\,N$

↳ $N = mg - F_1 \sin 30^\circ = -110\,N \rightarrow a_y \neq 0$

$$a_y = \frac{1}{m}\left(F_1 \sin 30^\circ - mg\right) = +2.2\ m/s^2$$

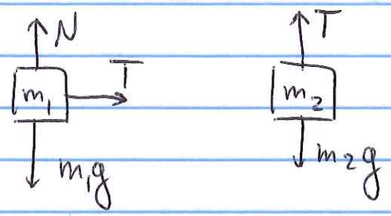
The box lifts off the floor.

* Pulley system on frictionless surface (shoulder)



what are the acceleration $\vec{a}_1$ and $\vec{a}_2$?
what is the tension in the rope?

Q Forces 6



$$\begin{cases} x: \ T = m_1 a_{1x} \\ y: \ N - m_1 g = 0 \end{cases} \qquad \begin{cases} x: \ a_{2x} = 0 \\ y: \ T - m_2 g = m_2 a_{2x} \end{cases}$$

Rope has a constant length, so $|a_{1x}| = |a_{2y}|$ but the signs are off, so $a_{1x} = -a_{2y}$

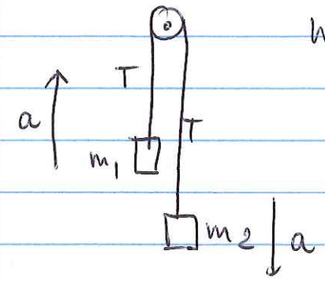
$$\begin{cases} T = m_1 a_{1x} \\ N = m_1 g \end{cases} \qquad \begin{cases} a_{2x} = 0 \\ T - m_2 g = -m_2 a_{1x} \end{cases}$$

$$\hookrightarrow \quad m_1 a_{1x} - m_2 g = -m_2 a_{1x}$$

$$a_{1x} = \frac{m_2 g}{m_1 + m_2}$$

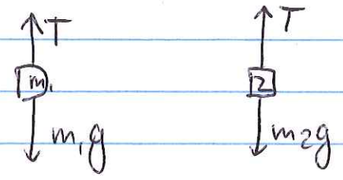
what happens when m_1 is very heavy? $\rightarrow$ a_{1x} very small
m_2 is very heavy? $\rightarrow$ a_{1x} close to g

* Atwood's machine



what are the acceleration and tension now?

Q Forces 7-a



$T - m_1 g = m_1 a \qquad T - m_2 g = -m_2 a$

opposite direction

$\rightarrow T = m_1 a + m_1 g \rightarrow (m_1 a + m_1 g) - m_2 g = -m_2 a$

$$a = \frac{m_2 - m_1}{m_2 + m_1} g$$

$\begin{cases} m_2 \text{ large} \rightarrow a = g \\ m_1 \text{ large} \rightarrow a = -g \end{cases}$

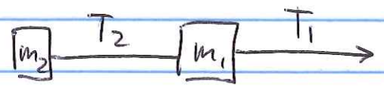
$$T = m_1 \frac{m_2 - m_1}{m_2 + m_1} g + m_1 g$$

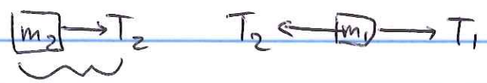
$$T = \frac{m_1 (m_2 - m_1) + m_1 (m_2 + m_1)}{m_2 + m_1} g = \frac{2 m_1 m_2}{m_2 + m_1} g$$

if $m_1 = 2m_2 \rightarrow T = \frac{4m_2}{3m_2} W_2 = \frac{4}{3} W_2 > W_2$

* Two connected objects

Q Forces 8





$a_2 = \frac{T_2}{m_2}$ $\quad a_1 = \frac{T_1 - T_2}{m_1}$

but $a_1 = a_2 \rightarrow \frac{T_2}{m_2} = \frac{T_1 - T_2}{m_1}$

$\rightarrow T_1 = \frac{m_1}{m_2} T_2 + T_2$

$T_1 > T_2$

* Friction = resistance against motion, against the direction of motion

How does this sliding friction resist motion?

micro bumps, or even chemical bonds

Is friction useful? Q Friction

No: - wear & tear
- inefficiencies in mechanical systems:
e.g. 20% of car's fuel goes to overcoming friction

Yes: - allows you to walk
- keeps nails in the wall 

Study of friction = tribology ☺
originated with da Vinci in 1600
1) independent of contact area
2) independent of relative velocity
3) proportional to normal force

It is different for moving and stationary objects.

→ larger force needed to overcome initial friction

* Kinetic friction: $f_k = \mu_k N$

μ_k ↑ coefficient of kinetic friction
- property of surfaces
- has no units

* Static friction: $0 \leq f_s \leq \mu_s N$

μ_s ↑ coefficient of static friction

f_s is as large as needed to keep object from moving