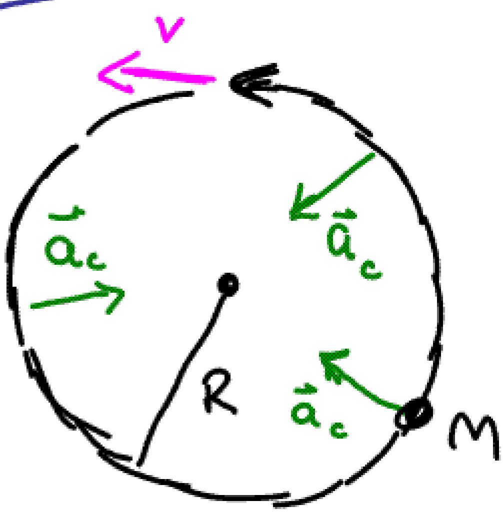
Physics 113 - September 26, 2006

Last Time



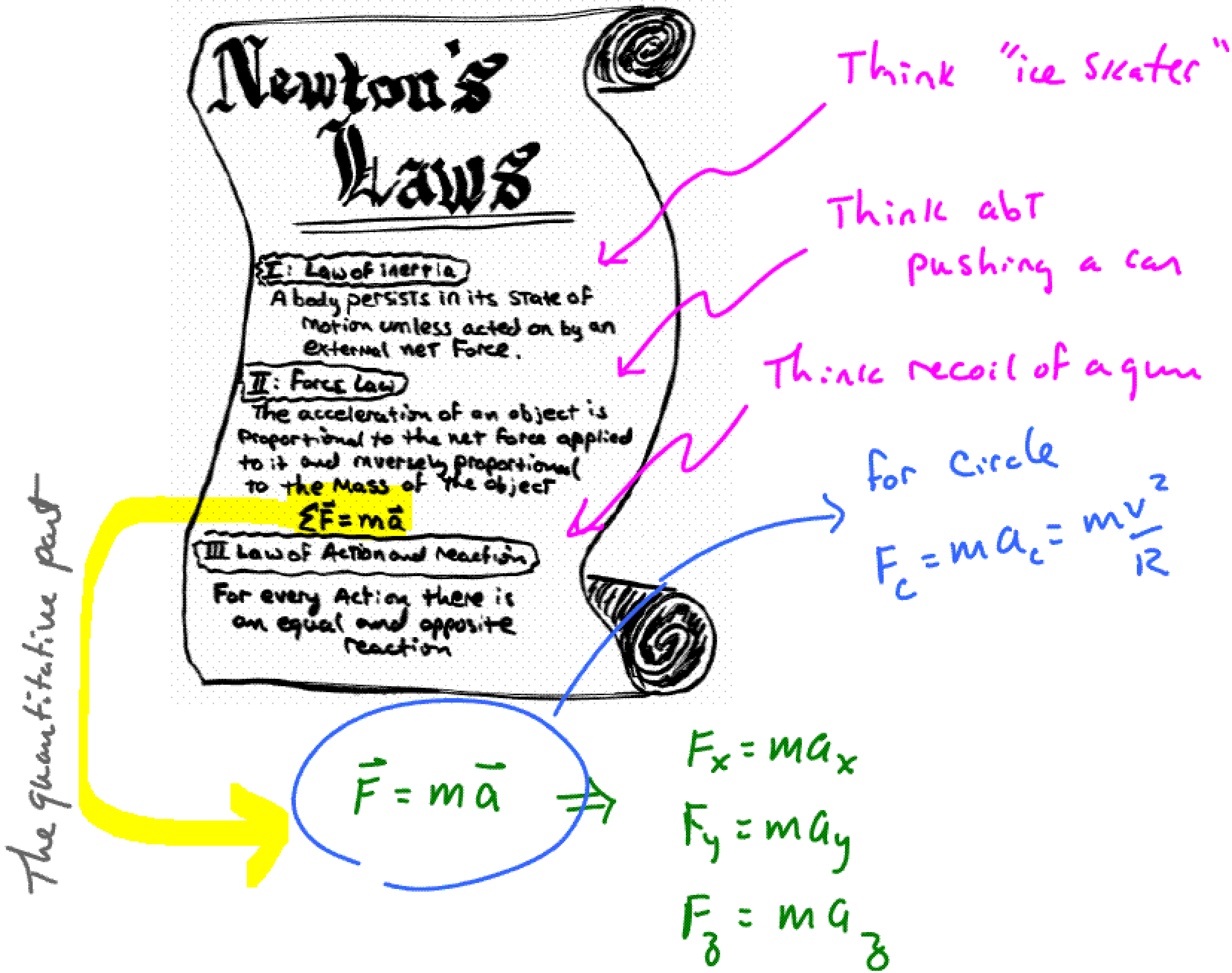
Circular Motion

$$|\vec{a}_c| = \frac{|\vec{v}|^2}{R}$$

$F = ma$

centripetal force

$$F_c = m a_c = m\frac{v^2}{r}$$



Newton's Laws
I: Law of inertia
A body persists in its state of motion unless acted on by an external net Force.
II: Force Law
The acceleration of an object is proportional to the net force applied to it and inversely proportional to the mass of the object
$\Sigma\vec{F} = m\vec{a}$
III Law of Action and Reaction
For every Action there is an equal and opposite reaction
Think "ice skater"
Think abt pushing a car
Think recoil of a gun
for circle
$F_c = ma_c = \frac{mv^2}{R}$
The quantitative part
$\vec{F} = m\vec{a}$ ⇒
$F_x = ma_x$
$F_y = ma_y$
$F_z = ma_z$

$$\vec{F} = -G\frac{m_1 m_2}{r^2}\hat{r}$$

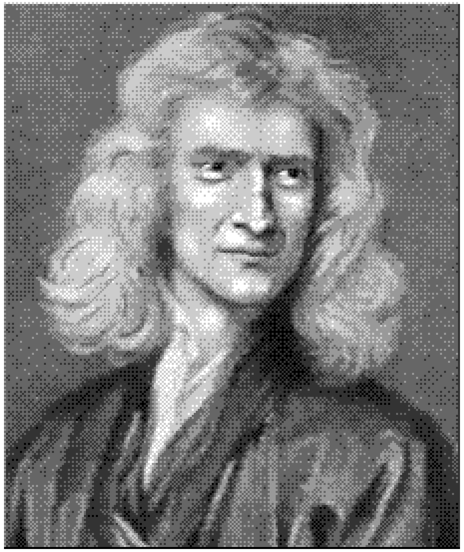
gravitational constant - sets scale

Attractive force

near Earth's surface

$$|F| = \frac{G M_E m}{R_E^2} = mg$$

$$= g = 9.8\ m/s^2 = 32\ ft/s^2$$



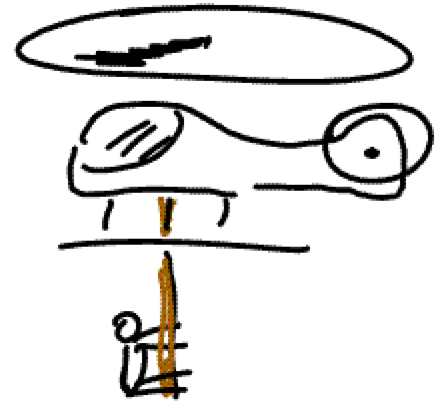
The Path to Enlightenment

1. understand Problem, Draw Neat diagram of overall problem
2. draw Free body diagram of each relevant object - label with forces
3. Choose convenient coordinate system for each object
4. Apply Newton's Second Law $\Sigma\vec{F} = m\vec{a}$ in appropriate orthogonal coordinates (coordinates chosen for each body must be related to those chosen for other bodies)
5. Keeping Symbols in place (No #'s yet!) Solve resulting set of equations Simultaneously
6. Check answer with limiting cases and dimensional Analysis!

Example

Air-sea rescue

man = mass 70 kg

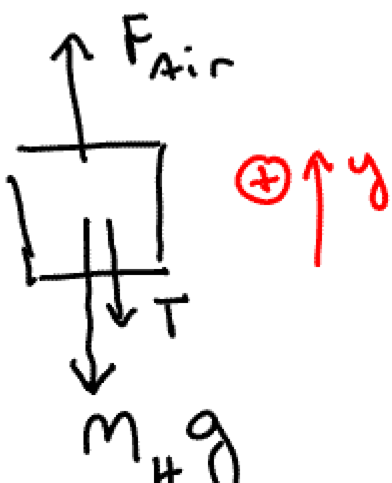


Helicopter Accelerates upward at 4 m/s²

FBD's

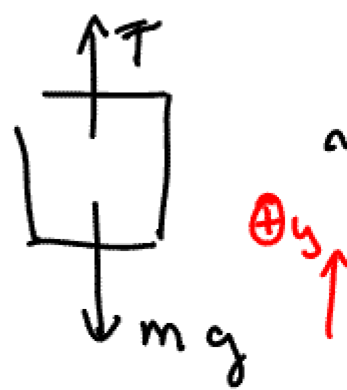
What Tension Must the rope withstand?

helicopter



mass man

man ≡ m



$$\Sigma F_y = ma_y = T - mg$$

$$T = ma_y + mg = m(a+g)$$

70 kg

$4\ m/s^2$

$9.8\ m/s^2$

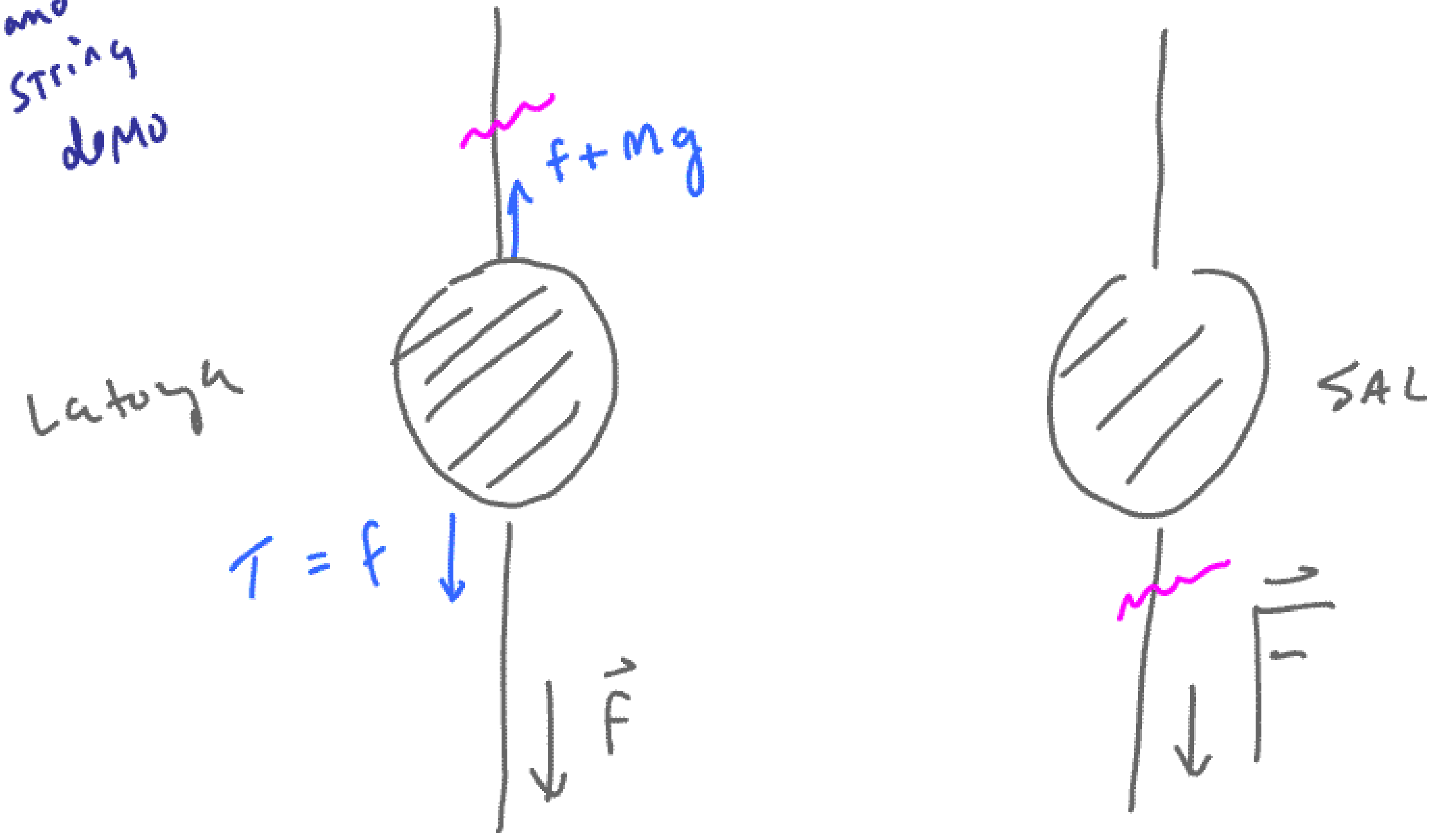
$F = ma$

Newtons $= kg\ m/s^2$

$T = 966$ Newtons

units okay

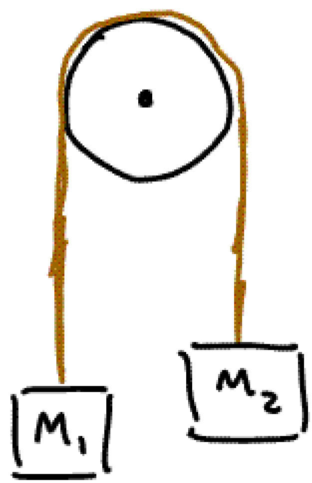
ball and string demo



Example

Pulley
frictionless
Massless

Atwood's Machine



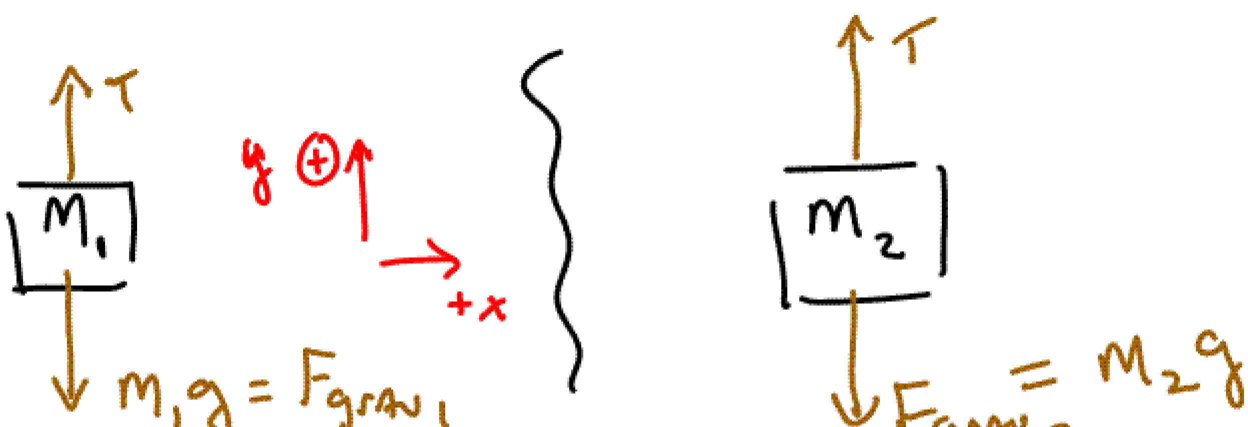
$m_1 = 6\,kg$

$m_2 = 10\,kg$

What is the Acceleration of the system?

What is tension in rope

FBD's



$$\sum F_x = m_1 a_x = 0$$

$$\sum F_{y_1} = m_1 a_{1y} = T - m_1 g$$

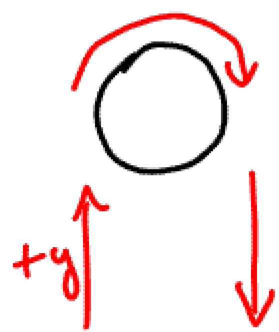
~~$\sum F_{y_2} = m_2 a_{2y} = T - m_2 g$~~

need consistency in coordinates between bodies

+y ↓

$$\sum F_{y_2} = m_2 a_{2y} = -T + m_2 g$$

need consistency



Assume $T = |T_{on\,1}| = |T_{on\,2}|$

$$a = a_{1y} = a_{2y}$$

$$m_1 a = T - m_1 g$$

$$m_2 a = -T + m_2 g$$

N equations, N unknowns → N=2, can solve

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

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

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

$$m_1 a + m_1 g = m_2 g - m_2 a$$

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

$$a = \left(\frac{m_2-m_1}{m_1+m_2}\right)g$$

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

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

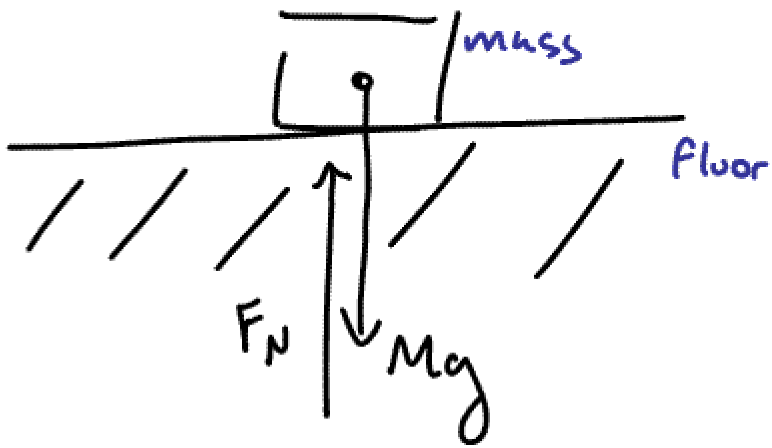
$$T = \frac{2 g m_1 m_2}{m_1 + m_2}$$

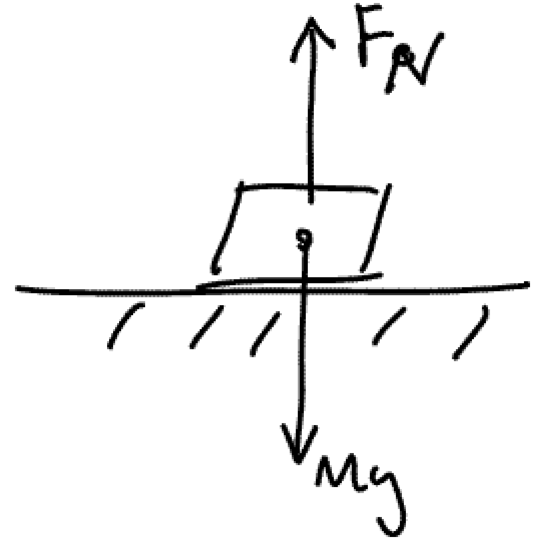
check units!

check behavior for limiting cases!

(let $m_1 \to$ large or $m_2 \to$ large)

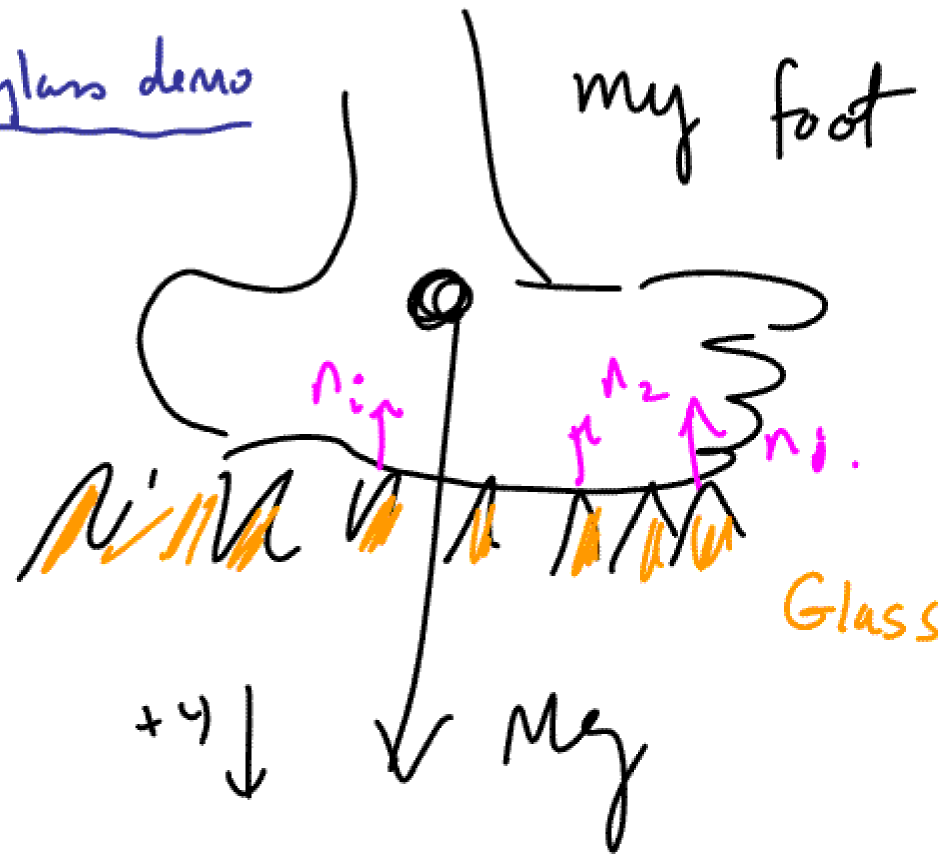
Why does mass not crash thru floor?





Normal force ⤳ usually $\vec{N}$ or $\vec{F}_N$

Walk on glass demo



$$\sum F_y = 0 = Mg - \sum_i n_i$$