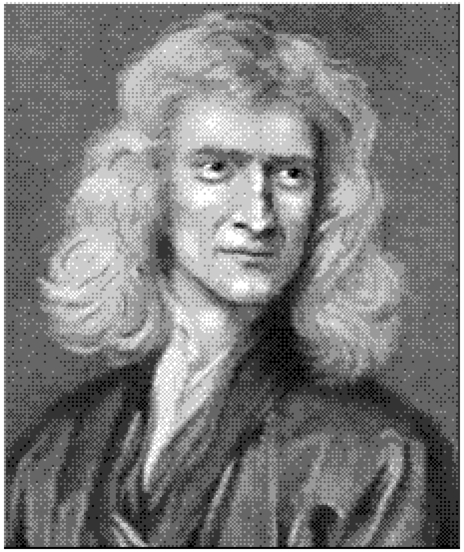
Physics 113 - September 28, 2006

Normal force, Friction, Newton's Law Problems

Class issues:

- Exam during lecture time
  October 5, 2006
- Allowed calculators
- Prefer if you use black or blue pen
- Partial credit given on MOST problems
- Allowed to bring in 8.5x11 inch sheet of paper (Non-Topologically enhanced) with formulas/examples ... can use both sides
- Will have Q+A session in B+L 106 on Wed. Oct. 4 from 4-5:30 PM
- Workshops go on as usual next week

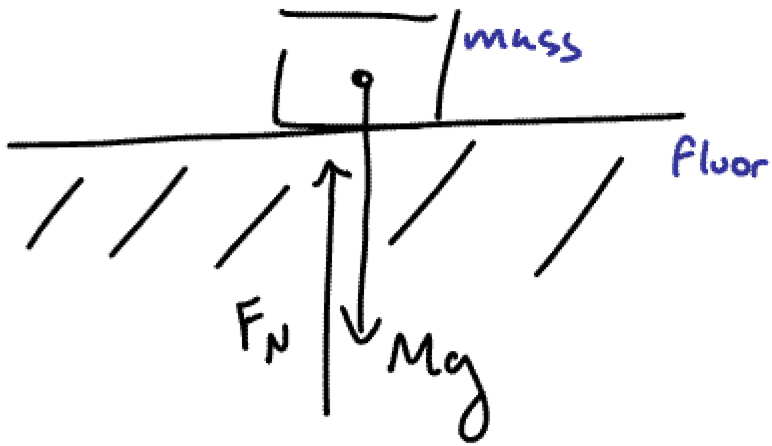
Last time:

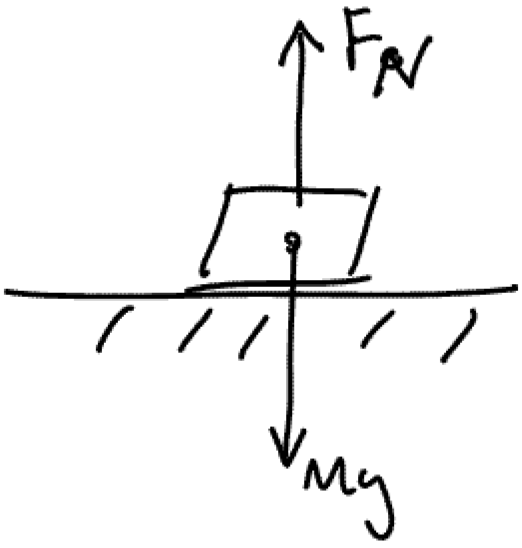


The Path to Enlightenment

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!

Why does mass NOT crash thru floor?





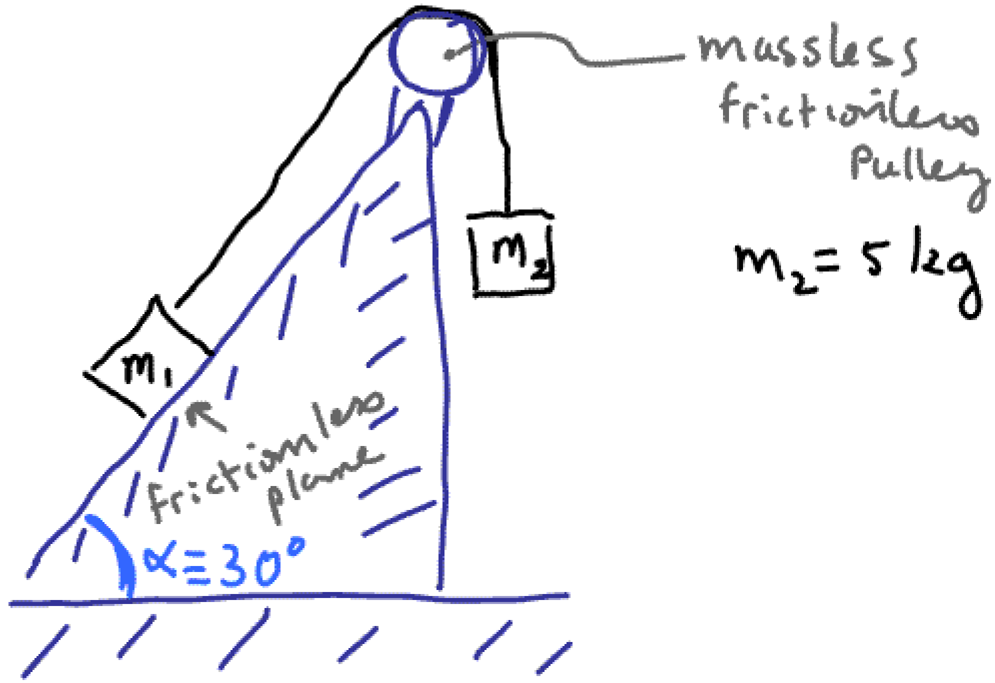
Normal force ⤳ usually $\vec{N}$ or $\vec{F}_N$

Then we did examples ...

Time to do more Examples ...

recall

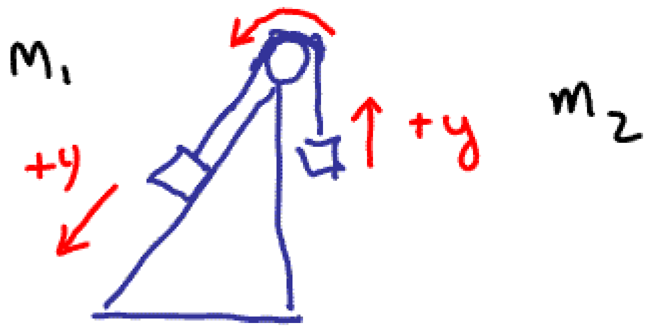
$m_1 = 5\,kg$



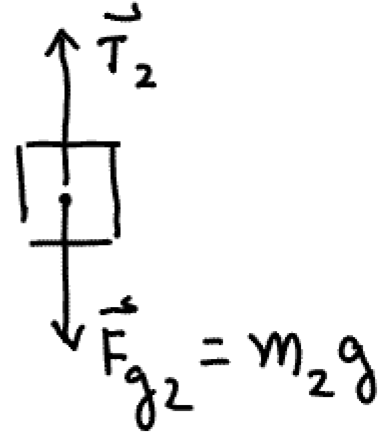
Put system in place + let it go

Describe subsequent motion of system
+
find tension in rope

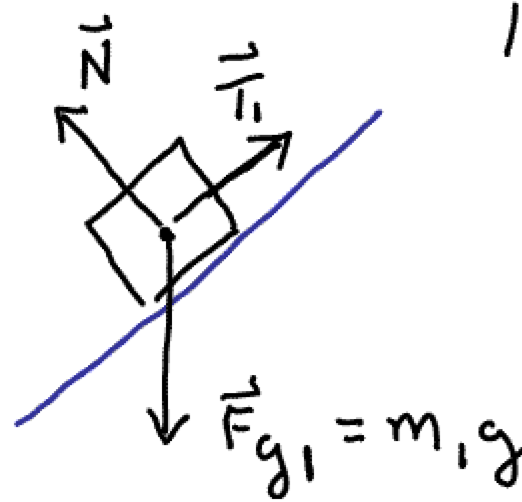
acceleration



FBD of M_2

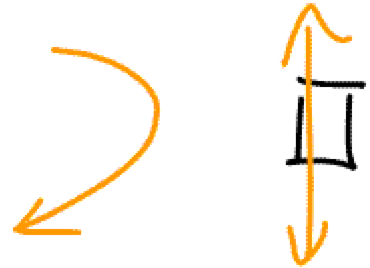


FBD of M_1



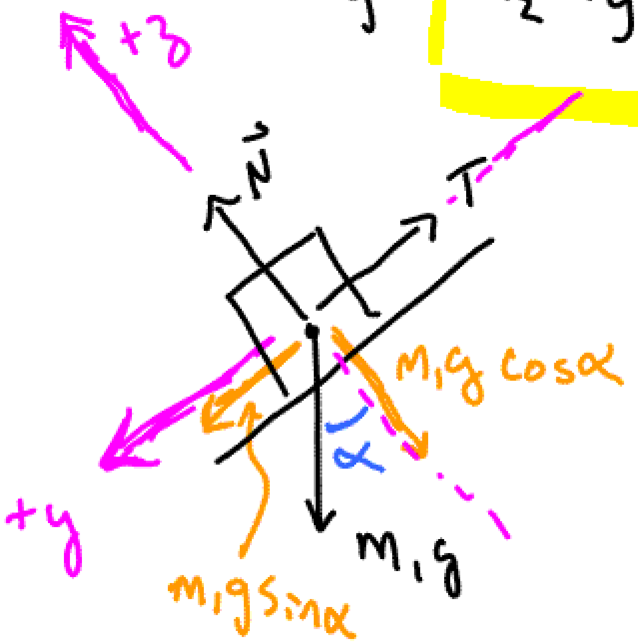
$$|\vec{T}_2| = |\vec{T}_1| \equiv |\vec{T}|$$

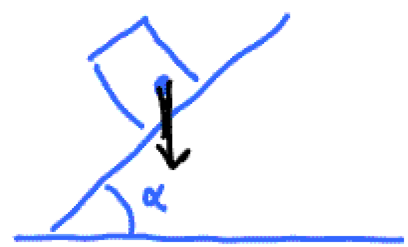
$$\sum \vec{F}_2 = m_2 \vec{a}_2 = m_2 \vec{a}_y$$

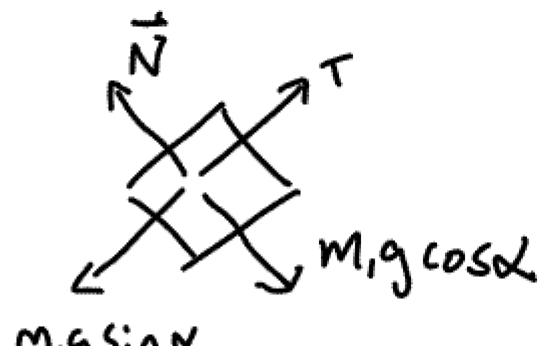


$$F_y = m_2 a_y$$

$$F_y = m_2 a_y = T - m_2 g$$







$$\sum \vec{F}_1 = m_1 \vec{a}_1$$

// ≡ parallel

$\perp$ ≡ Perpendicular

in y direction // surface of plane

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

in direction along z or $\perp$ to surf. of plane

$$m_1 a_z = 0 = N - m_1 g \cos\alpha$$

→ can use To Solve for N (NoT asked for)

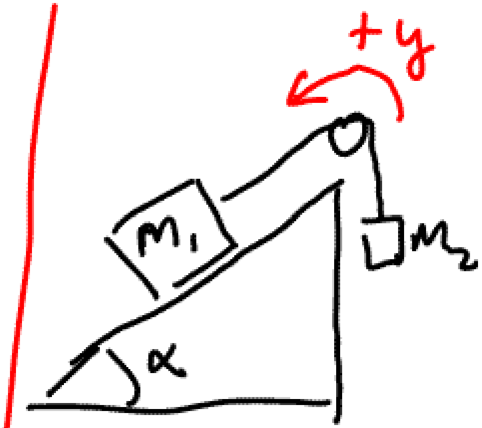
2 eqns
2 unknowns ⇒ a_y, T

$$m_2 a_y = T - m_2 g$$

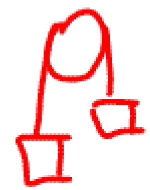
Copied from last page

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

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

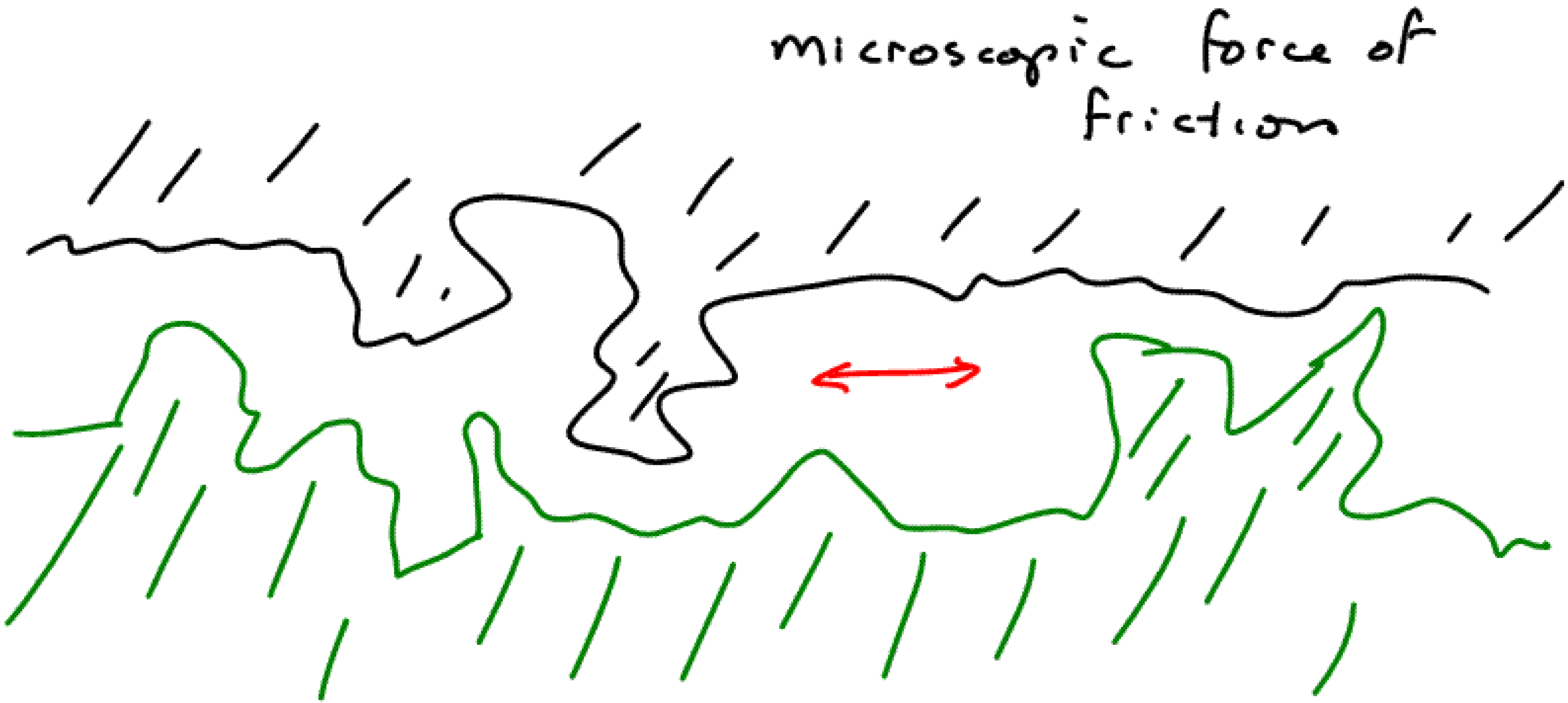


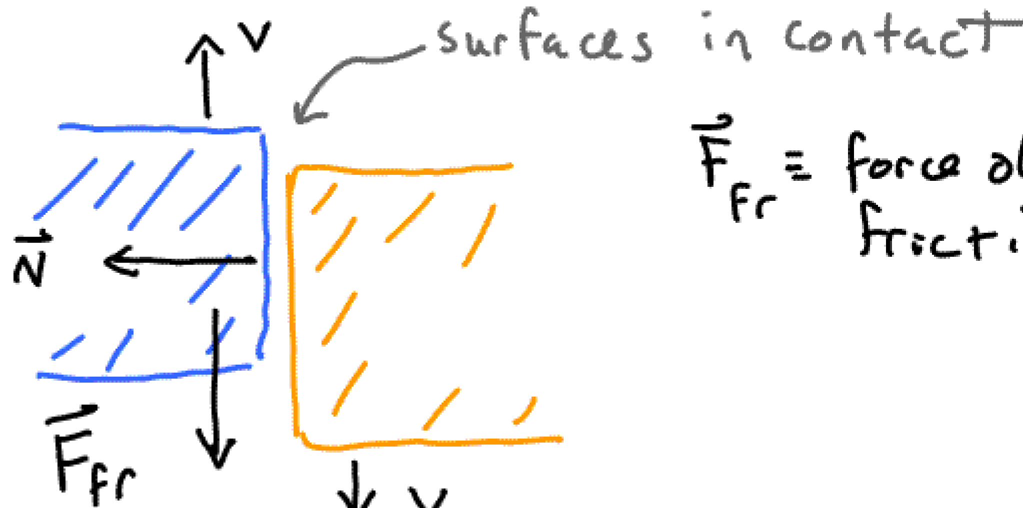
$\alpha = 90^\circ \Rightarrow$



End of Material for Exam 1

Friction





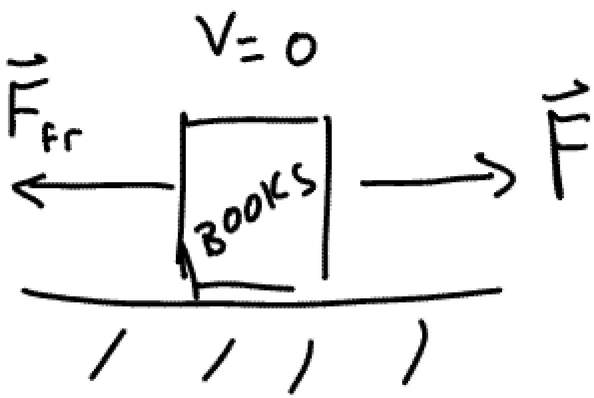
$\vec{N}$ = Normal force of orange on the blue

$\vec{F}_{fr}$ = force of friction

$$|\vec{F}_{fr}| \propto |\vec{N}|$$

$$|\vec{F}_{fr}| = \mu_k |\vec{N}|$$

Coefficient of kinetic friction



Force of friction opposes $\vec{F}$ which is trying to move Books

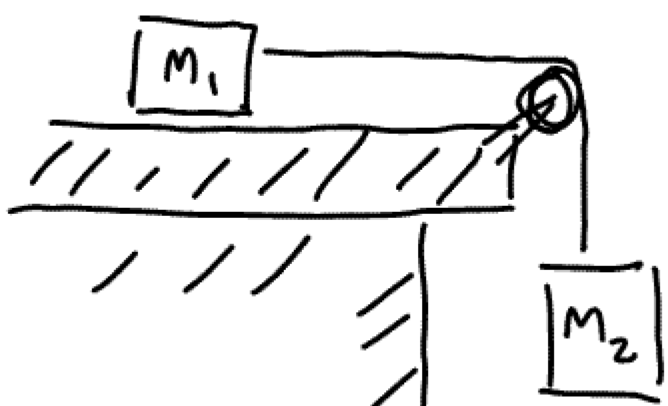
$$|\vec{F}_{fr}| = \mu_s |\vec{N}|$$

coefficient of STATIC friction

$\mu_s N \equiv$ limiting value (largest value) that STATIC frictional force can have

$$F_{fr_{\text{STATIC}}} \leq \mu_s N$$

Example



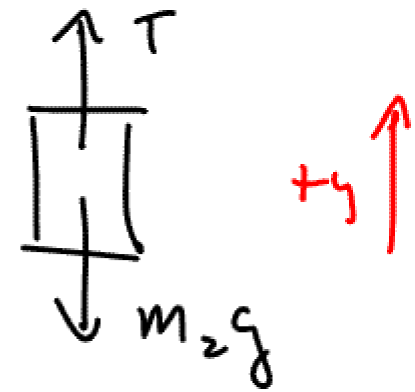
Suppose System is at rest in equilibrium (No Accel, No Motion)

$M_2 = 20\,kg$

$M_1 = 10\,kg$

What is smallest μ_s (bet table + M_1) that can lead to this condition

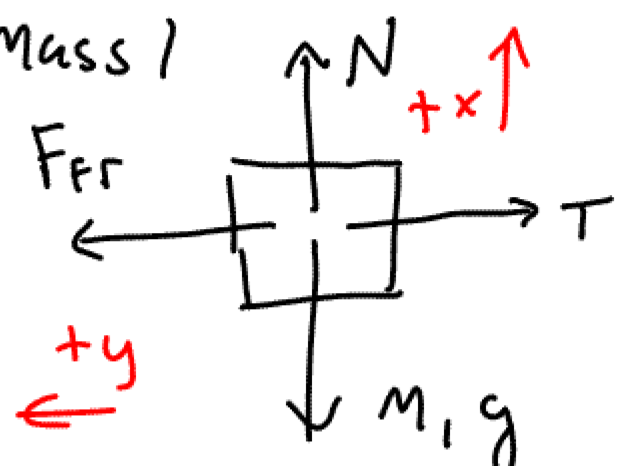
FBD mass 2



$$\Sigma F_y = m_2 a_{y2} = 0 = T - m_2 g$$

$$T = m_2 g$$

FBD Mass 1



$\perp$ to Table

$$\sum F_x = m_1 a_{1\perp} = 0 = N - m_1 g$$

$$N = m_1 g$$

// to Table

$$\sum F_y = m_1 a_y = 0 = F_{fr} - T$$

$$F_{fr} = T$$

$$\mu_s N = T$$

Smallest μ_s

$$\mu_s = \frac{m_2}{m_1}$$

Sub in

$$\mu_s m_1 g = m_2 g$$