Physics 113 – September 25, 2012

- Exam I - Oct 4 (0800 in Hoyt)
  Will arrange for pre-exam Q+A session
  Exam on material thru P.S. 4 and Workshop 3
  Allowed 1 side of 8.5x11 inch sheet w/ formulas, etc.

yes we will have class on Oct. 4
... For those of you lucky enough to have lab + workshop on Oct 4, It will be a Stellar day to remember!

hooray!!

- Recall - No lecture in Hoyt on 9/27/12
  Turn in P.S. 4 to locker in B+L by end of 9/27/12

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

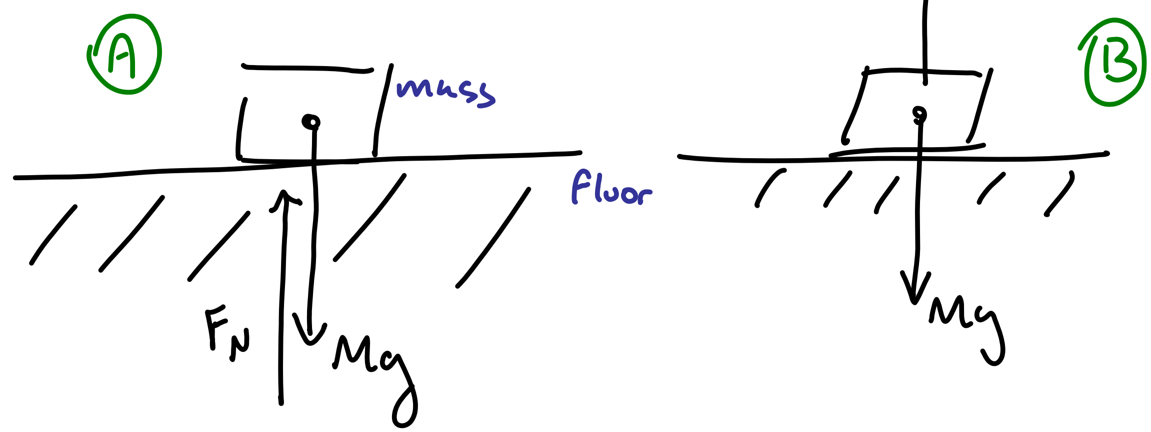
The Path to Enlightenment

1. understand Problem, Draw Neat diagram of overall problem
2. draw Free body diagram of ~~all~~ 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!

Let's continue with Newton's laws

Why does mass not crash thru floor?

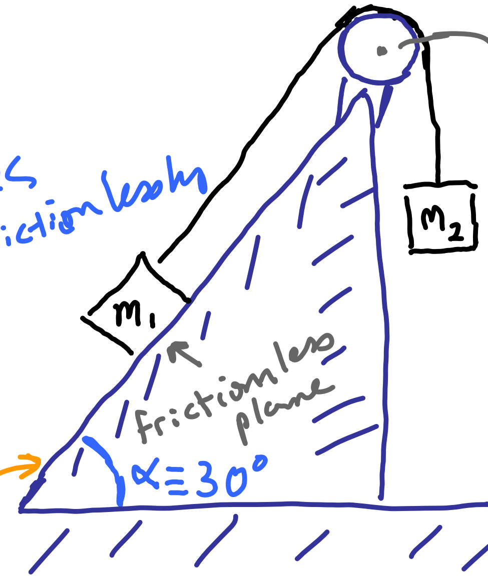
recall Newton's 3rd law



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

Another Example

recall

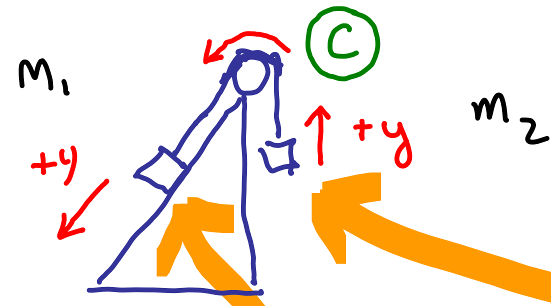


Put system in place + let it go

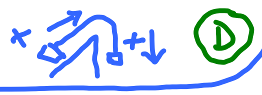
Describe subsequent motion of system
+
find tension in rope

motion — acceleration

Choose coordinates like so →

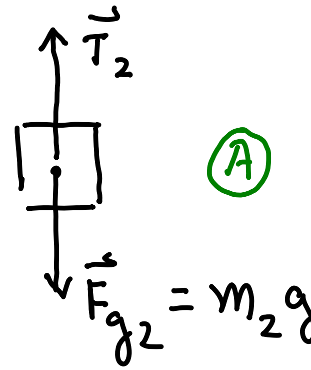


Could have made different choice



FBD of M_2

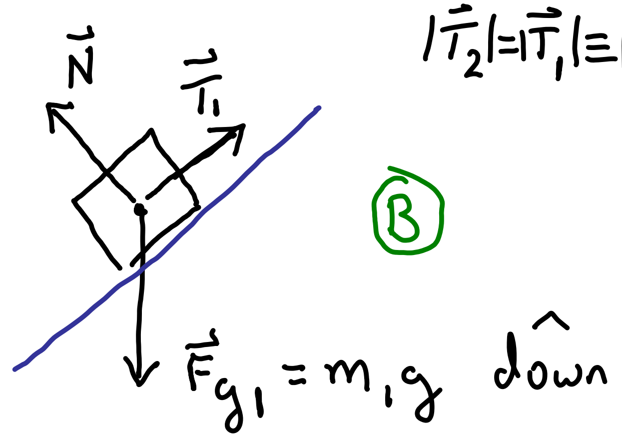
"Free Body Diagram"



motion of M_1 is along plane ... so makes sense to choose that direction as one of the axes for that mass

FBD of M_1

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

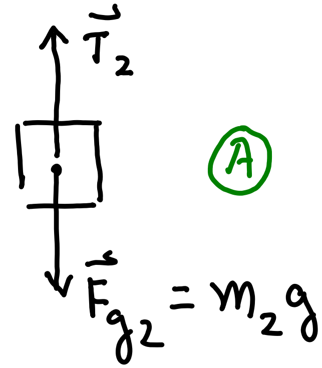


Newton's 2ND law applied to Mass 2

$\Sigma \vec{F} = m\vec{a}$

(B) $\Sigma \vec{F}_2 = m_2 \vec{a}_2 = m_2 \vec{a}_y$

(A)



(C) $F_y = m_2 a_y$

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

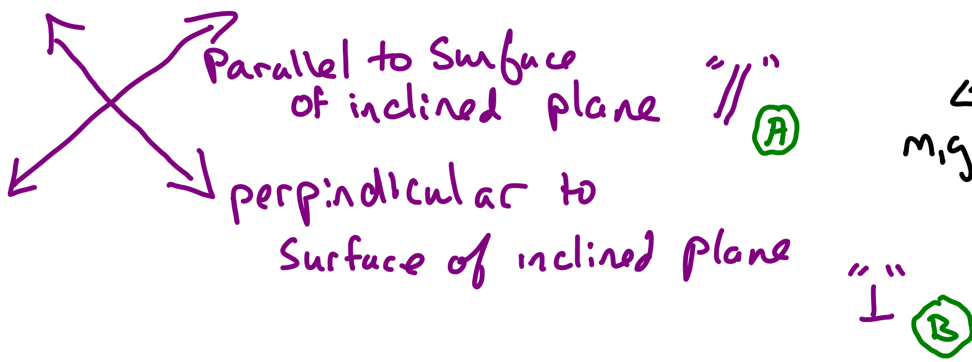
$|\vec{T}_2| = |\vec{T}_1| = T$

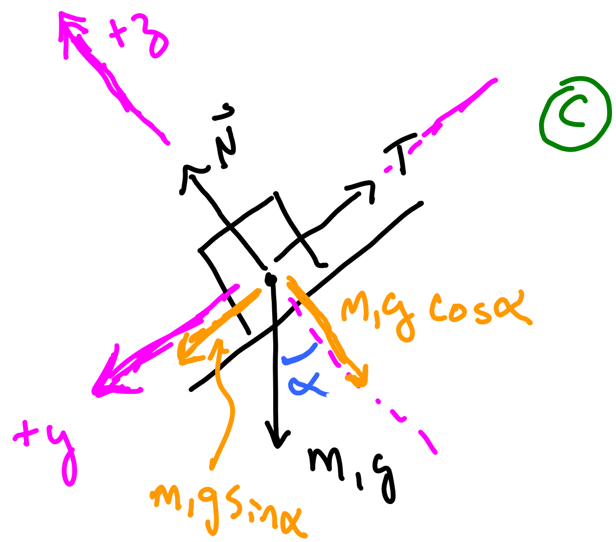
Tension in the rope is just T

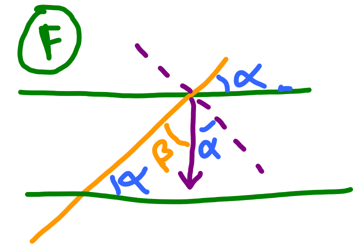
same for each mass

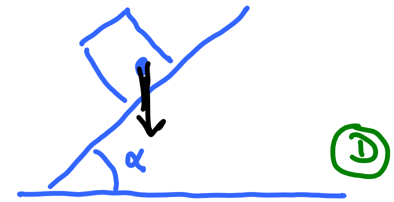
Apply Newton's 2ND law to Mass 1

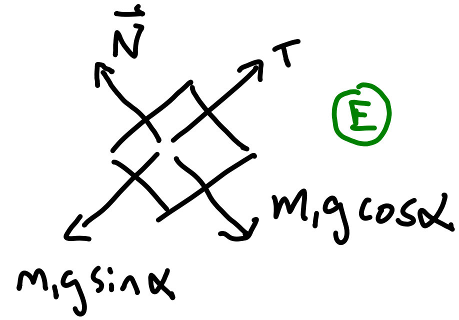
Resolve vectors along axes











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

// ≡ parallel

⊥ ≡ Perpindicular

in y direction // surface of plane

Earlier From Mass 2 (p.6)

(A)

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

(C)

$M_2 a_y = T - m_2 g$

in direction along z or ⊥ to surf. of plane

(B)

$m_1 a_z = 0 = N - m_1 g \cos\alpha$ → can use To solve for N (Not asked for)

2 equations

2 unknowns → a_y, T

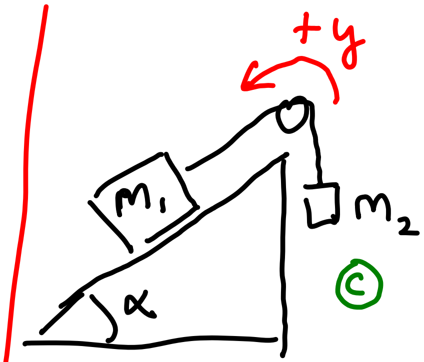
Soluble

This is what problem asks us to determine

Do the algebra and convince yourself that :

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

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



Ⓒ

T is a Force

units are Newtons (N)

$F = ma \rightarrow 1\,N = 1\,kg\,\frac{m}{s^2}$

9

Are we correct ?

→ check units ✔

→ limiting cases ✔

Ⓓ look at a_y if $m_1 >> m_2$ ✔ +

Ⓔ look at a_y if $m_1 << m_2$ ✔ −

Ⓕ let $\alpha = 90^\circ \Rightarrow$ ✔

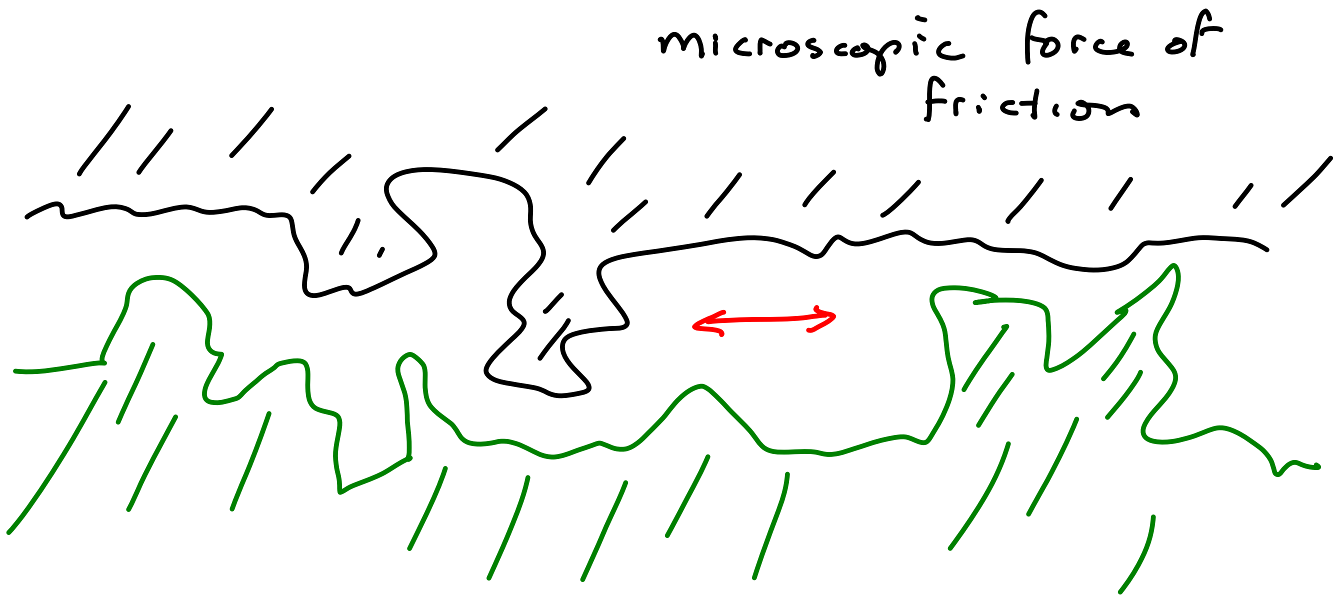
$\sin\alpha = 1$

Solutions simplify to what we found in last lecture

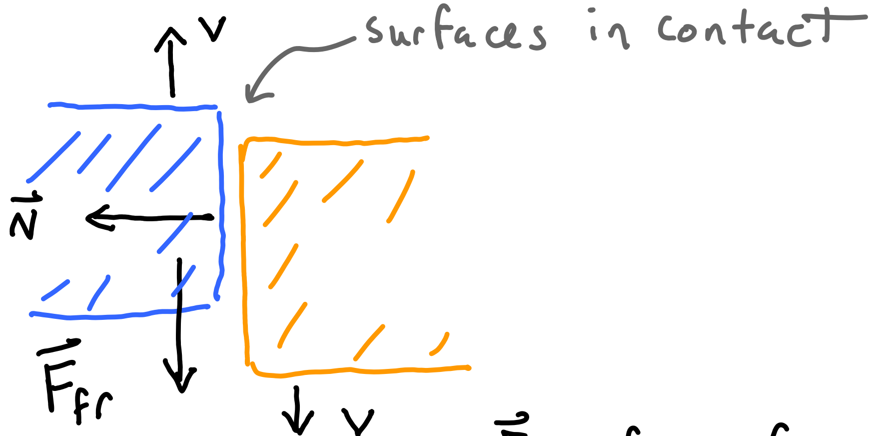
End of material for Exam I

Beginning of material for Exam II
(of course all this material will make use of what comes before)

friction



Rub hands together



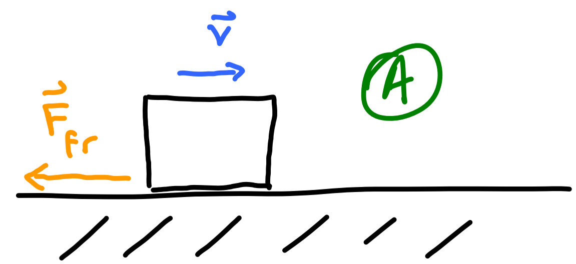
$\vec{N}$ ≡ Normal force of orange on the blue

$\vec{F}_{Fr}$ ≡ force of friction

$\vec{F}_{Fr}$ = force of friction of orange on blue

(yes there is also an equal and opposite force of Blue on orange ... not shown)

Kinetic Friction – Force of friction between Surfaces Moving with respect to each other



Force of friction opposes the motion

(B) $|\vec{F}_{fr}| \propto |\vec{N}|$

$\propto$: is proportional too

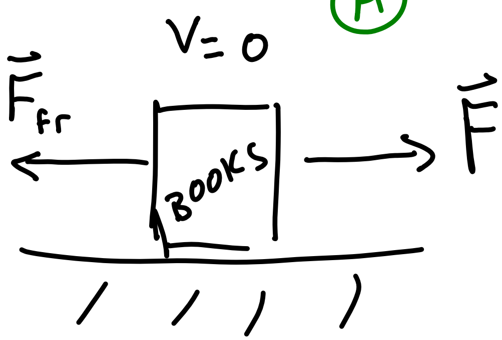
(C) $|\vec{F}_{fr}| = \mu_k |\vec{N}|$

μ_k: proportionality constant

μ_k: Coefficient of kinetic friction

Static Friction – Force of friction between surfaces <u>Not</u> moving with respect to each other

(A)



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

(C)

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

μ_s: coefficient of static friction

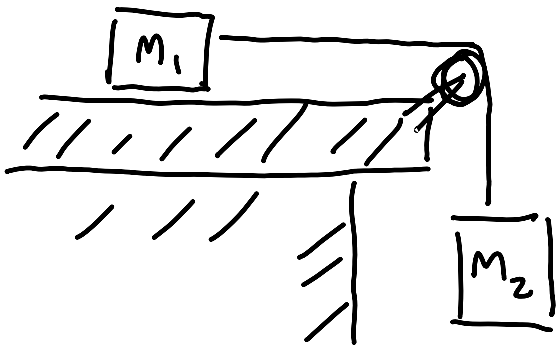
Watch out for this subtlety

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

$$F_{fr\,\text{static}} \leq \mu_s N$$

(B)

Example

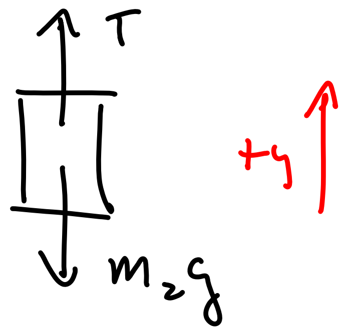


Suppose System is
at rest
in equilibrium
(No Accel, No Motion)

Let $M_2 = 20kg$
$M_1 = 10kg$

Determine the smallest μ_s (between surface of table and M_1) that can lead to this situation

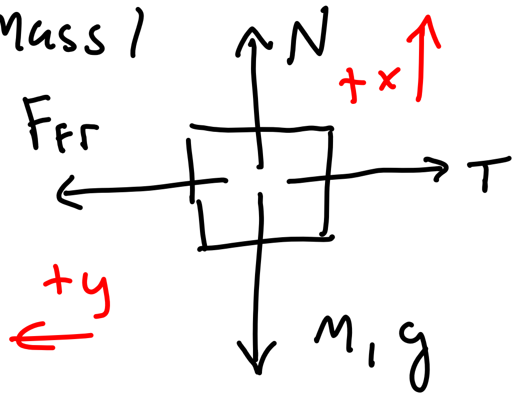
FBD MASS 2



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

$$T = m_2 g$$

FBD Mass 1



(A)

// to Table (B)

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

$$F_{fr} = T$$

$$\mu_s N = T$$ (D)

⊥ to Table (C)

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

$$N = m_1 g$$

Sub in

$$T = m_2 g$$ From last page

$$\mu_s m_1 g = m_2 g$$ (E)

or

$$\mu_s = \frac{m_2}{m_1}$$ (F)

Ans. to Problem

units? unitless ✓