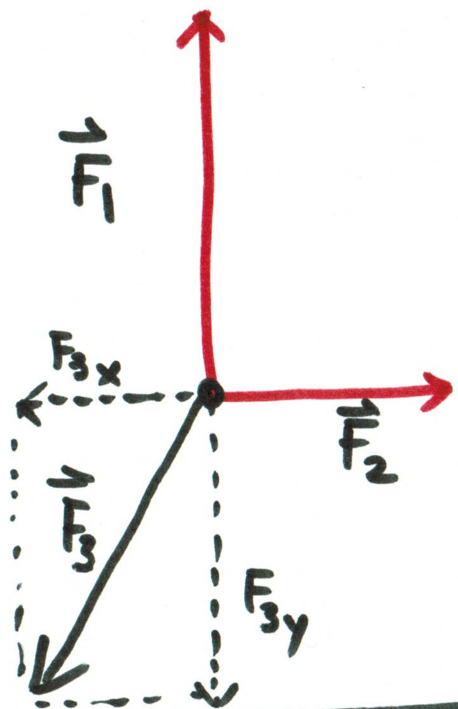
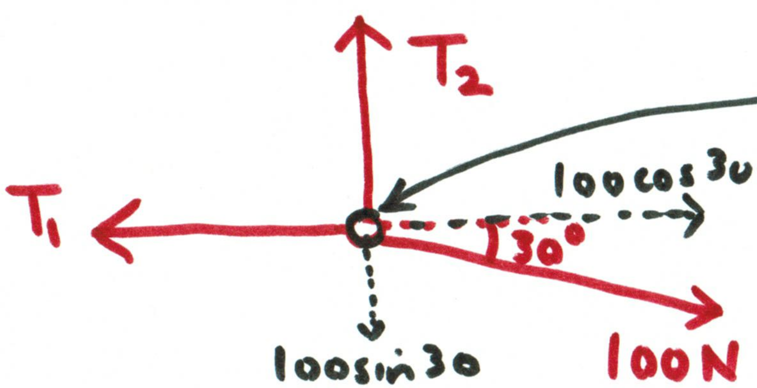
WHITEBOARD PROBLEM 6.1



F_{3x} must cancel $\vec{F}_2$

& F_{3y} " " $\vec{F}_1$

$\therefore$ $\vec{F}_3$ must look as drawn if it has x & y components as argued above



Since ring is in equilibrium,

T_1 must equal $100 \cos 30 = 86.6\,N$

& T_2 " " $100 \sin 30 = 50\,N$

in directions shown.

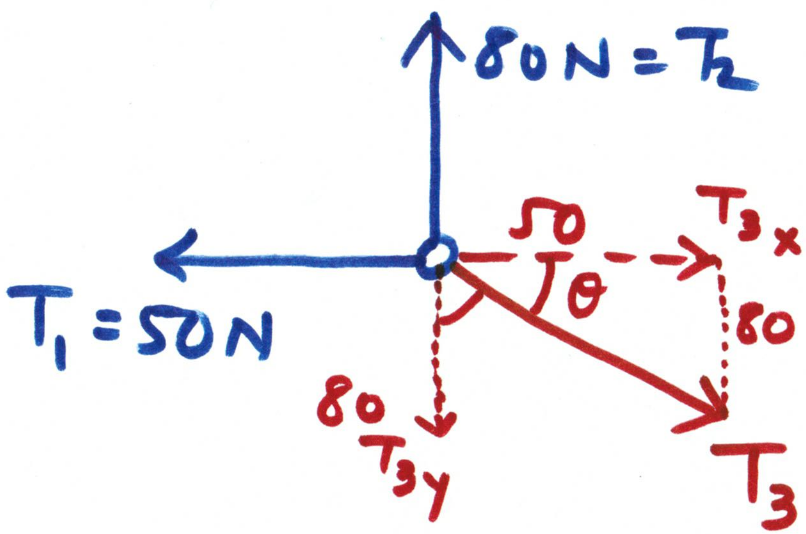
WHITEBOARD PROBLEM 6.2

$$\vec{F}_{net} = m\vec{a}$$

EQUILIBRIUM

2D: $(F_{net})_x = ma_x = 0$

$(F_{net})_y = ma_y = 0$



$T_{3x} = T_1$ b/c $a_x = 0$

$T_{3y} = T_2$, b/c $a_y = 0$

$$T_3 = \sqrt{T_{3x}^2 + T_{3y}^2}$$

$$T_3 = \sqrt{50^2 + 80^2} = 94.3\,N$$

$$\tan\theta = \frac{T_{3y}}{T_{3x}} = \frac{80}{50}$$

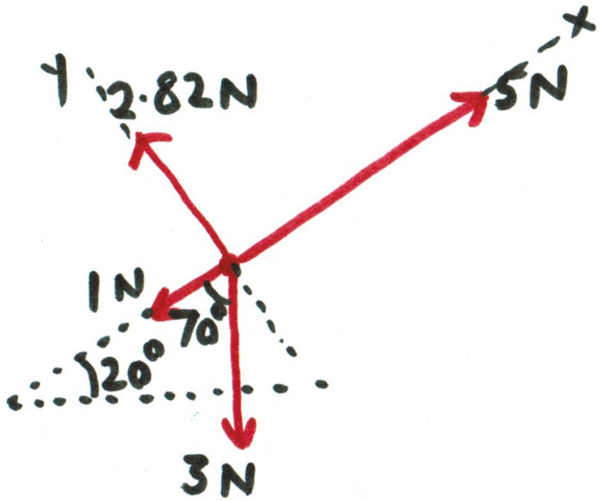
$$\Rightarrow \theta = \tan^{-1}(8/5) = 58^\circ$$

WHITEBOARD 6.3

I'LL DO (b) & (c) here. Rest assigned for HW.

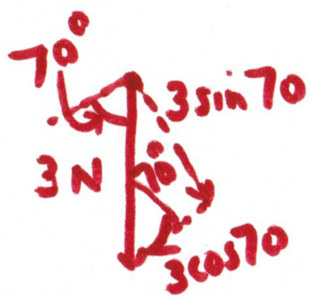
b) $a_x = \dfrac{F_{x\,net}}{m} = \dfrac{4-2}{2} = 1\ m/s^2$; $a_y = \dfrac{3-2-1}{2} = 0$

c)



$$a_x = \frac{5-1-3\cos 70}{2} = 1.49\ m/s^2$$

$$a_y = \frac{2.82-3\sin 70}{2} = 0$$



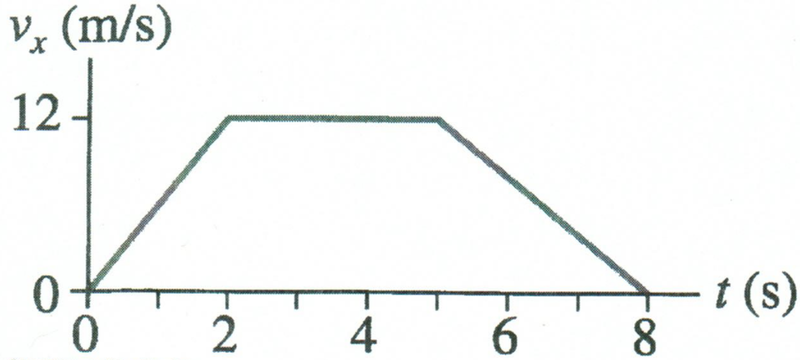
Alternatively, you could have done

$$a_x = \frac{5-1-3\sin 20}{2} = 1.49\ m/s^2$$

& $$a_y = \frac{2.82-3\cos 20}{2} = 0$$

WHITEBOARD 6.4

The figure below shows the velocity graph of a 2.0 kg object as it moves along the x-axis. What is the net force acting on this object at t = 1s? At t = 4s? At t = 7s?



@ t=1 s slope is constant over 1s:

$$\frac{12\ m/s - 0.0\ m/s}{2.0\,s - 0.0\,s} = 6\ m/s^2 = a$$

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

$\vec{F} = 2.0\,kg \cdot 6\ m/s^2$

$\boxed{= 12.\ N\ \hat{\imath}}$

@ t=4s slope = 0 m/s²

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

$\vec{F} = 2.0\,kg\ (0\ m/s^2) = \boxed{0N}$

@ t=7s again the slope is constant

$$\frac{0\ m/s - 12\ m/s}{8.0s - 5.0s} = -4.0\ m/s$$

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

$\vec{F} = 2.0\,kg\ (-4.0\ m/s^2) = -8.0N\ \hat{\imath}$

6.5

WHITEBOARD 6.5

A 50kg box hangs from a rope.
what is the tension in the rope if:

(A) when box is @ rest → static equilibrium → $a = 0\,m/s^2$

$$\sum F = \cancel{ma} \quad F_T - F_g = 0N$$

$$F_T = mg = (50kg)(9.8\,m/s^2)$$

$$F_T = 490N$$

(B) box is rising @ <u>constant</u> speed → dynamic equilibrium

again $a_y = 0\,m/s^2$

$$\sum F = F_T - F_g = 0N$$

$$F_T = F_g = 490N$$

(C) we don't care about velocity... only Δv b/c this implies acc.

Told $a_y = 5.0\,m/s^2$

$$\sum F = T - F_g = ma_y$$

$$T = ma_y + F_g \qquad F_g = ma_g$$

$$= 50kg(5.0\,m/s^2) + 50kg(9.8\,m/s^2)$$

$$= 250N + 490N$$

$$= 740N$$

(D) Same as (C) except $a_y = -5.0\,m/s^2$

$$T = ma_y + F_g$$

$$= 50kg(-5.0\,m/s^2) + 50kg(9.8\,m/s^2)$$

$$= -250N + 490N$$

$$= 240N$$

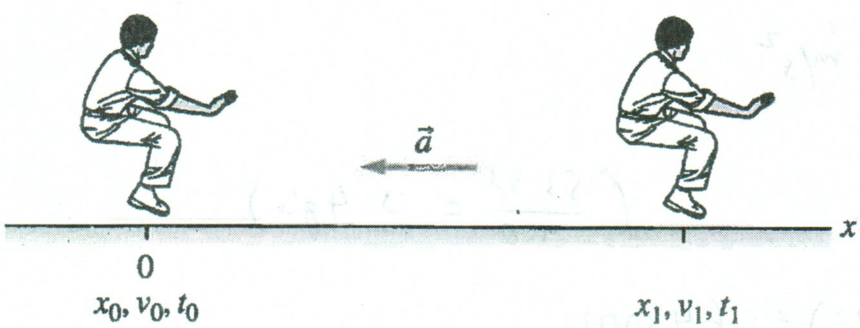
WHITEBOARD 6.6

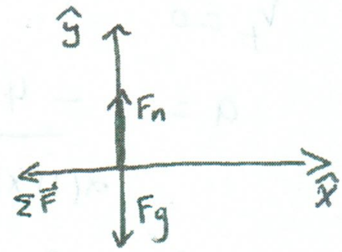
6.34 Cars are designed with a "crumple-zone" in the front of the car. In the event of an impact, the passenger compartment decelerates over ~1m. An occupant restrained by seat belts and air bags decelerates with the car. In contrast, a passenger not wearing a seat belt or using an air bag decelerates over a distance of 5mm.

(A) A 60kg person is in a head-on collision. The cars speed at impact is 15 m/s. Estimate the net force of the person if the air bag deploys and they are wearing a seat belt.

(B) Same situation as (A), except no air bags or seat belts.

(C) Compare with the person's 'weight' (m*g)





Known	Find
$v_i = 15\ m/s$	F
$v_f = 0.0\ m/s$	
$\Delta x = 1.0\ m$ (A)	
$\Delta x = 0.005\ m$ (B)	
$m = 60\ kg$	

(A) Find acceleration

$$v_f^2 = v_i^2 + 2a(x_f - x_i)$$

$$a = \frac{v_f^2 - v_i^2}{2(x_f - x_i)} = \frac{(0\ m/s)^2 - (15\ m/s)^2}{2(1.0m - 0.0m)} = -112.5\ m/s^2$$

$$\Sigma F = ma = (60\ kg)(-112.5\ m/s^2) = -6750\ N$$

↑ to the left

(B) Same approach as (A)

$$v_f^2 = v_i^2 + 2a(x_f - x_i)$$

$$a = \frac{v_f^2 - v_i^2}{2(x_f - x_i)} = \frac{(0\ m/s)^2 - (15\ m/s)^2}{2(0.005m - 0.0m)} = -22500\ m/s^2$$

$$\Sigma F = ma = 60\ kg(-22500\ m/s^2) = -1{,}350{,}000\ N$$
$$= -1.4 \times 10^6\ N$$

(C) weight $= m a_g = (60\ kg)(9.8\ m/s^2) = 588\ N$

(A) $\frac{6750N}{588N} = 11.5$ g's $\left(\frac{112.5}{9.8}\right)$

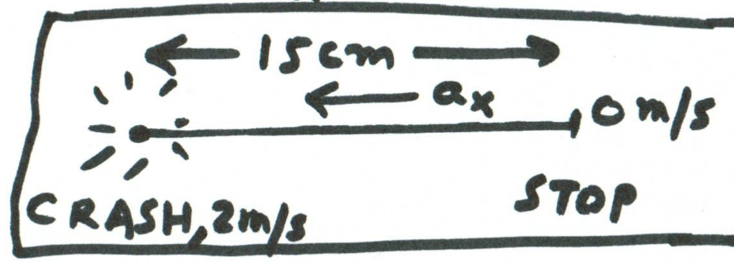
(B) $\frac{1.4 \times 10^6 N}{588} = 2296$ g's $\left(\frac{22500}{9.8}\right)$

$= 2.30 \times 10^3$ g's

WHITEBOARD 6.7

$m = 1200\text{ kg}$, $\Delta x = 15 \times 10^{-2}\text{ m}$, $v_{i_x} = 2\text{ m/s}$

$v_{f_x} = 0$



$F_x = ?$

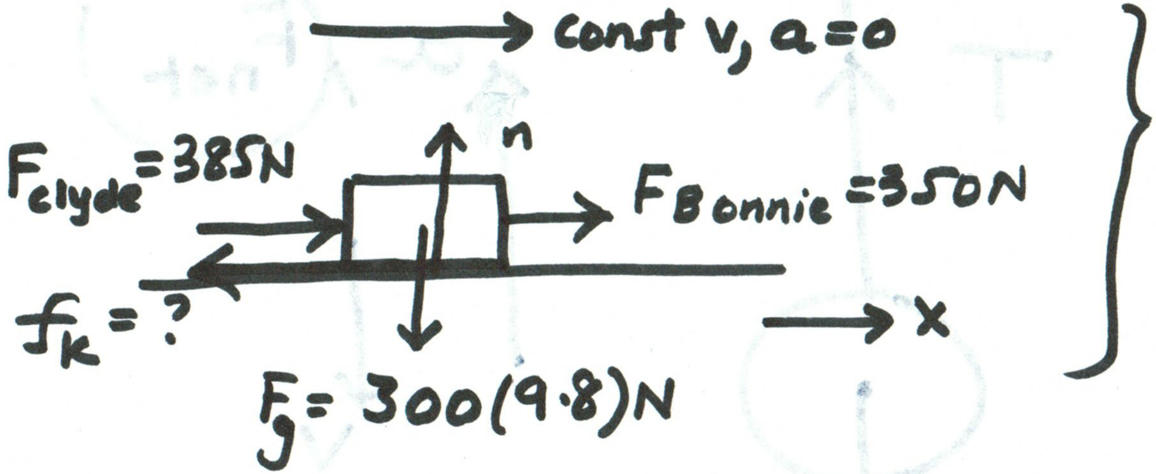
First, find a_x : $v_{f_x}^2 = v_{i_x}^2 + 2a_x\Delta x$

$$0 = 4 + 2a_x(15 \times 10^{-2})$$

$$\Rightarrow a_x = \frac{-4}{2(15 \times 10^{-2})} = -13.33\text{ m/s}^2$$

$\therefore$ average stopping force $= m|a_x| = 16000\text{ N}$

WHITEBOARD 6.8



fbd for safe!

$y: \quad F_g = n = 300(9.8)\,N$
$\qquad\qquad\qquad = 2940\,N$

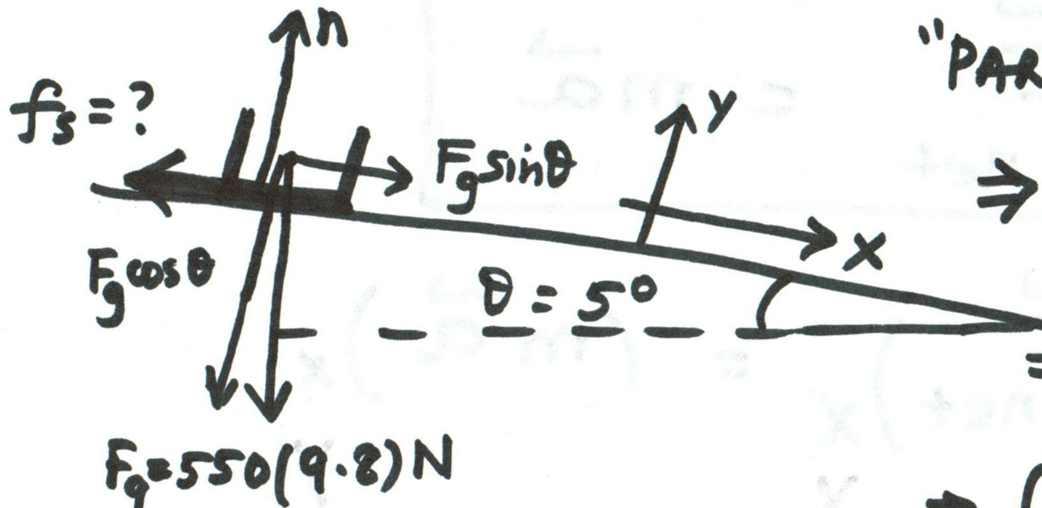
$x: \quad (F_{net})_x = 0$ b/c $a_x = 0$

$\Rightarrow 385 + 350 - f_k = 0$

$\Rightarrow f_k = 730\,N$. But $f_k = \mu_k n$

$\Rightarrow \mu_k = \dfrac{f_k}{n} = \dfrac{730}{2940} = 0.25$

WHITEBOARD PROBLEM 6.9



"PARKED" ⇒ STATIONARY

$\Rightarrow (F_{net})_x = ma_x = 0$

$\Rightarrow F_g \sin\theta - f_s = 0$

$\Rightarrow f_s = F_g \sin\theta$

i.e. f_s = static friction force

$= 550(9.8)\sin 5^\circ$

$$\boxed{(F_{net})_y = ma_y = 0 \\ \Rightarrow n = F_g \cos\theta}$$

USE THIS HERE

i.e. $\boxed{f_s = 470\,N}$

CHECK:
MAX. f_s permissible is $(f_s)_{max} = \mu_s n = \mu_s (F_g \cos\theta)$

$= 0.12(550)(9.8)\cos 5^\circ$

$= 644\,N > 470\,N$

i.e. "f_s required" is comfortably less than "max f_s" permissible between sled & snow.

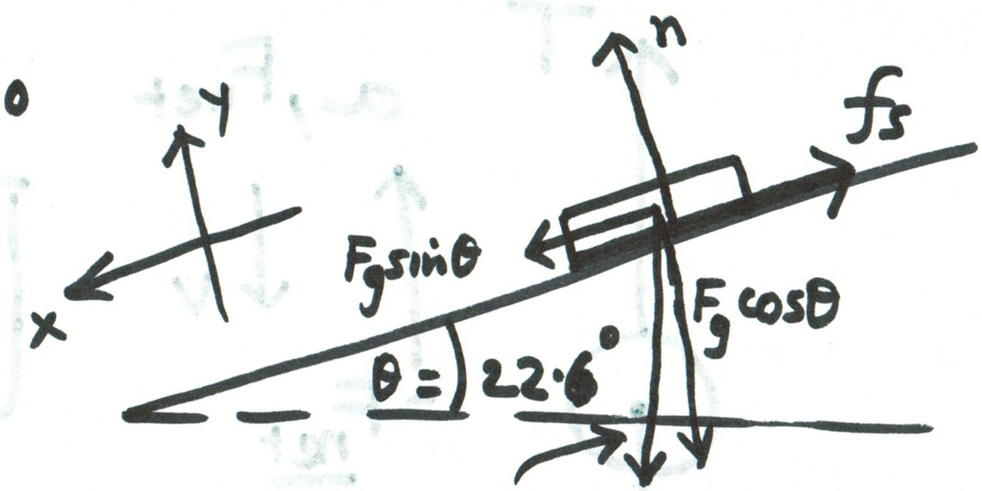
WHITEBOARD PROBLEM 6.10

$y: (F_{net})_y = ma_y = 0$

$\Rightarrow n = F_g \cos\theta$

$= 14.7 \cos 22.6^\circ$

$\Rightarrow n = 13.6\,N$



$F_g = 1.5(9.8) = 14.7\,N$

$x: (F_{net})_x = ma_x$

$a_x \neq 0$ if $F_g \sin\theta - (f_s)_{max} > 0$

$14.7 \sin 22.6^\circ$

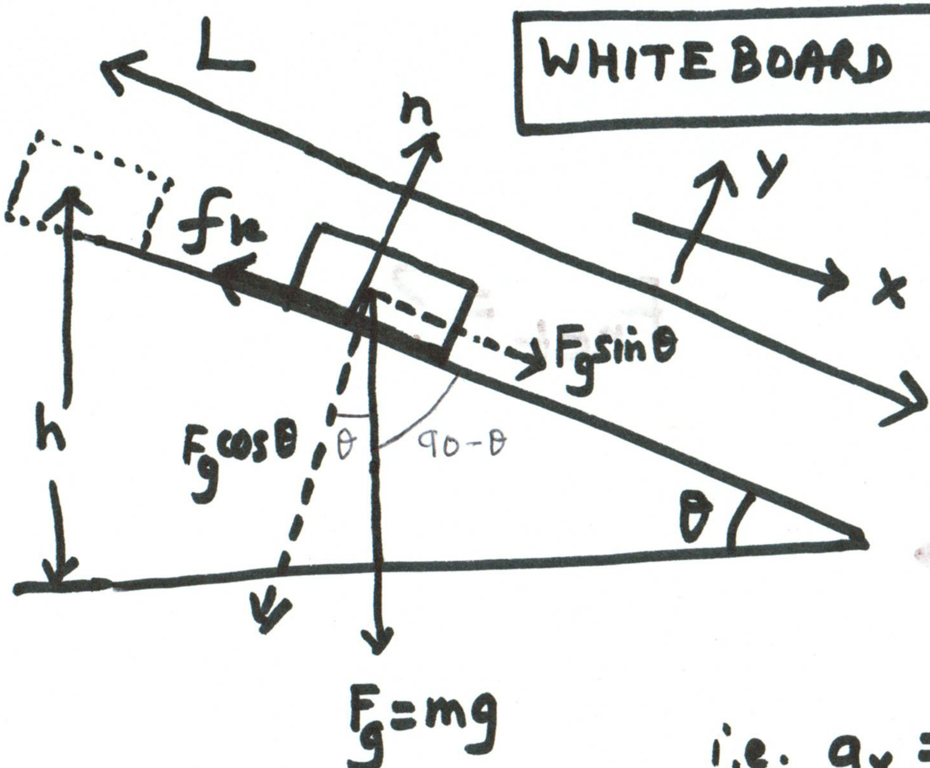
$= 5.6\,N$

$\mu_s n = 0.70(13.6) = 9.5\,N$

THIS SUGGESTS f_s IS MORE THAN CAPABLE OF NEGATING $F_g \sin\theta$

i.e. PIZZA STAYS!

WHITEBOARD PROBLEM 6.11



$y: (F_{net})_y = ma_y = 0$

$\Rightarrow n = mg\cos\theta$ — (i)

$x: (F_{net})_x = ma_x$

$\Rightarrow a_x = \dfrac{F_g\sin\theta - f_k}{m}$

i.e. $a_x = \dfrac{mg\sin\theta - \mu_k n}{m}$

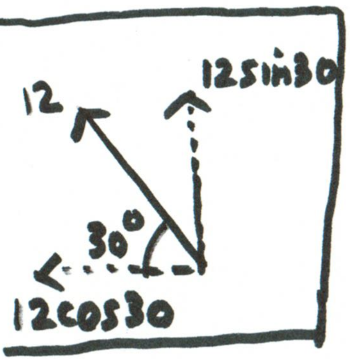
i.e. $a_x = \dfrac{mg\sin\theta - \mu_k mg\cos\theta}{m}$ $\Rightarrow a_x = g\sin\theta - \mu_k g\cos\theta$ — (ii)

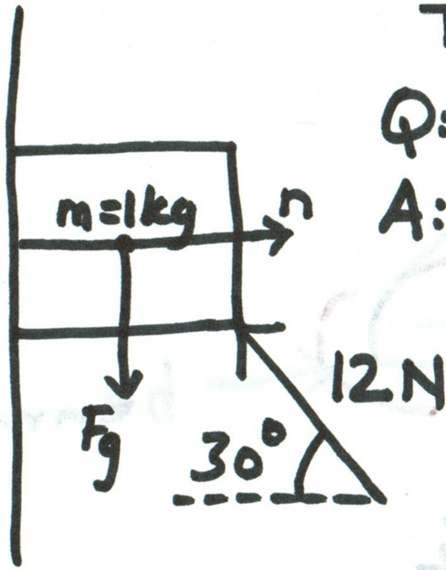
Use a_x in Eqn. (ii) in the KINEMATICS Equation $v_{f_x}^2 = v_{i_x}^2 + 2a_x\Delta x$

We find $v_{f_x} = \sqrt{0 + 2(g\sin\theta - \mu_k g\cos\theta)L}$

i.e. $\boxed{v_{f_x} = \sqrt{2gL(\sin\theta - \mu_k\cos\theta)}}$

WHITEBOARD PROBLEM 6-12





To complete the fbd I must also draw f_s!

Q: But which way should f_s point?

A: OPPOSITE TO the direction of "$\underbrace{\text{impending}}$ motion"!

i.e. the direction in which the block will tend to move!

THIS DIRECTION IS DETERMINED BY THE RELATIVE MAGNITUDES OF THE FORCE UP (i.e. 12 sin30 = 6N) AND THE FORCE DOWN (i.e. $F_g = 1(9.8) = 9.8N$). SINCE $F_g > 12\sin 30$, THE BLOCK IS TENDING TO MOVE DOWN $\Rightarrow$ f_s WILL OPPOSE THIS IMPENDING MOTION AND WILL POINT UP.

Q: CAN f_s AND THE "12 sin 30" force acting UPWARD negate THE force down (i.e. F_g)?

A: $(f_s)_{max} = \mu_s n = 0.5(12\cos 30) = 5.2N$, which exceeds ($F_g - 12\sin 30 = 3.8N$)

TABLE 6.1 in book (wood on wood)

∴ BLOCK STAYS PUT!