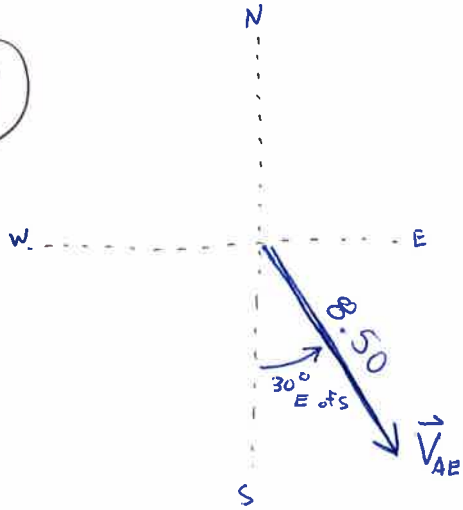
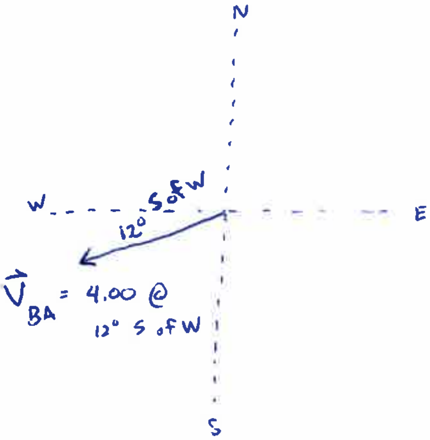
9



$\vec{V}_{AE} = 8.50 @ 30° E of S$



$\vec{V}_{BA} = 4.00 @ 12° S of W$

$$\vec{V}_{AE} = +(8.50 \sin 30.0)\hat{i} - (8.50 \cos 30.0)\hat{j}$$

to the right   down

$$\vec{V}_{BA} = -(4.00 \cos 12.0)\hat{i} - (4.00 \sin 12.0)\hat{j}$$

to the left   down

$$\vec{V}_{AE} = 4.25\hat{i} - 7.361\hat{j}$$

$$\vec{V}_{BA} = -3.913\hat{i} - 0.8316\hat{j}$$

$$\vec{V}_{BE} = \underbrace{\vec{V}_{BA} +}\vec{V}_{AE}$$

ordering is important
for example $\vec{V}_{AB} = -\vec{V}_{BA}$!!!

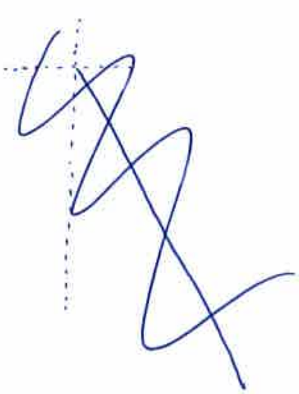
$$\vec{V}_{BE} = \underbrace{(4.25 - 3.913)\hat{i}}_{\text{add } \hat{i} \text{ parts}} + \underbrace{(-7.361 - 0.8316)\hat{j}}_{\text{add } \hat{j} \text{ parts}}$$

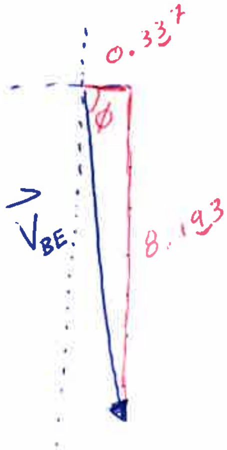
$$\vec{V}_{BE} \quad (+0.337)\hat{i} + (-8.1926)\hat{j}$$

keep right most s.f. when +/-

keep right most column of s.f. when ~~to~~ adding or subtracting

Sketch it





$$\phi = \tan^{-1}\left(\frac{8.193}{0.337}\right) = 87.6 \approx 88° \text{ S of E}$$

(or 2° E of S)

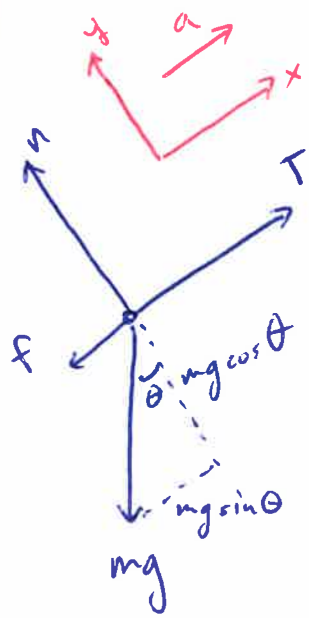
$$V_{BE} = \sqrt{(0.337)^2 + (8.193)^2} = 8.20 \frac{m}{s}$$

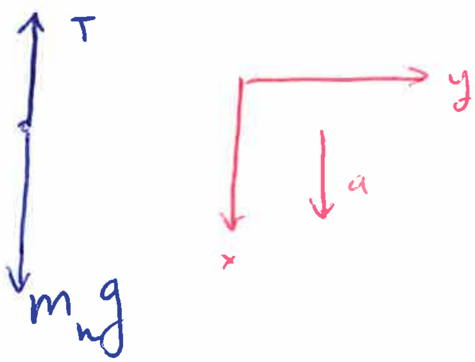
$$= \sqrt{0.113 + 67.13}$$

$$= \sqrt{67.23}$$

3 s.f.

(10)





m_h = mass hanging

(x:) $T - mg\sin\theta - f = ma$

(x:) $m_h g - T = m_h a$

(y:) $n = mg\cos\theta$

Notice
- T drops out cuz internal force
- get $m_{total}\, a$ on RHS.

addin the two x: eq'ns

$$(T - mg\sin\theta - f = ma)$$
$$+ \quad (m_h g - T = m_h a)$$

forgot f!

$$\cancel{(m_h - m\sin\theta)\, g = (m_h + m)\, a}$$

$$m_h g - mg\sin\theta - f = (m_h + m)\, a$$

Guess assume $f = \mu_k n$ ... if $a \le 0$ must redo problem assuming either 1) blocks move other way 2) blocks @ rest

$$m_h g - mg\sin\theta - \mu_k mg\cos\theta = (m_h + m)\, a$$

letting $m_h = 3m$

$$3m g - mg\sin\theta - \mu_k mg\cos\theta = 4ma$$

$$a = g\,\frac{3\cancel{m} - \cancel{m}\sin\theta - \mu_k \cancel{m}\cos\theta}{4\cancel{m}} = g\,\frac{3 - \sin 30.0 - 0.2\cos 30}{4}$$

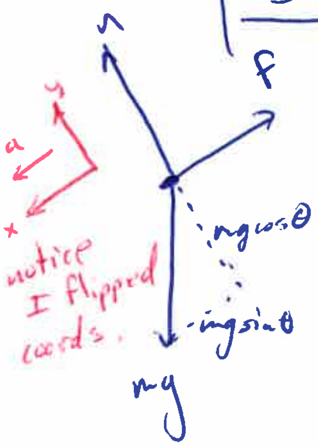
0.5817g=5.70 m/s²

problem 10 continued

- if hanging mass removed, no longer have tension
- friction now points other way!!!

will Block m slide?

Step 1 compute max possible f



$$f_{max} = \mu_s n = \mu_s mg\cos\theta = (0.3)mg(\cos 30) = 0.2598\,mg$$

step 2 compute force acting down the plane

$$\swarrow mg_{\parallel \text{ to plane}} = mg\sin\theta = 0.5mg$$

θ: 30.0°

step 3 THink: Because (force down plane) > ($f_{max \text{ possible}}$) block will slide.

If Block will slide, must use $f = \mu_k n$

Step 4 compute a using force eq'n

$$\cancel{m}g\sin\theta - \mu_k \underbrace{mg\cos\theta}_{n} = \cancel{m}a$$

m cancels since in all terms

$$\boxed{a = g(\sin\theta - \mu_k\cos\theta)} = 3.20\ \text{m/s}^2$$

if hanging mass removed

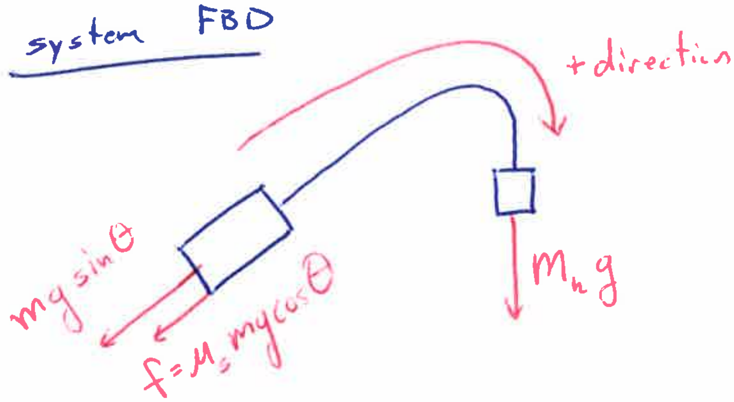
more problem 10

what range of m_h keeps system stationary

Case 1 $\quad m$ is about to slide <u>up</u> the plane

assume
1) friction points <u>down</u> plane
2) $a \approx 0$ @ onset of slipping
3) $f = \underline{\underline{\mu_s}}\, n$

<u>system FBD</u>

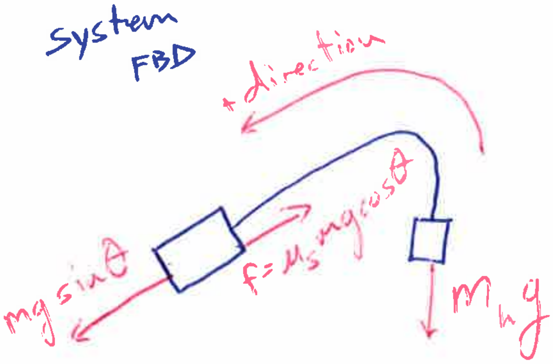


$$m_h g = mg\sin\theta + \mu_s mg\cos\theta$$

$$m_h = m(\sin\theta + \mu_s\cos\theta) = 0.759\underline{9}\, m$$

Case 2 $\quad m$ about to slide <u>down</u> plane
1) f points up the plane
2) $a \approx 0$
3) $f = \underline{\underline{\mu_s}}\, n$

system FBD



$$mg\sin\theta = \mu_s mg\cos\theta + m_h g$$

$$m_h = m(\sin\theta - \mu_s\cos\theta)$$

$$m_h = 0.24\underline{0}2\, m$$

---

for all m_h <u>between</u> $0.760\,m$ and $0.240\,m$ the system is @ rest!

(11) Convert

$$\frac{33\ \text{cents}}{in^2} \quad \text{to} \quad \frac{\$}{km^2}$$

100 cents = 1 \$

2.54 cm = 1 in

100 cm = 1 m

1000 m = 1 km

$$33\ \frac{\text{cents}}{in^2} \cdot \frac{1\ \$}{100\ \text{cents}} \frac{(1\ in)^2}{(2.54\ cm)^2} \frac{(100\ cm)^2}{(1\ m)^2} \frac{(1000\ m)^2}{(1\ km)^2} = 5.\cancel{115\ \frac{\$}{km^2} \times 10^8}$$

units are squared
must square all parts of conversion factors

$$5.115 \times 10^8\ \frac{\$}{km}$$

$$= 0.51\ \frac{G\$}{km^2}$$

$$\text{or} = 510\ \frac{M\$}{km^2}$$

preferred format for engineering

this has minimum # of leading/trailing zeros

(12)

$$a = 6.29 \frac{mi}{day^2} \left| \frac{1609\,m}{1\,mi} \right| \left(\frac{1\,day}{24\,h}\right)^2 \left| \left(\frac{1\,h}{3600\,s}\right)^2 = 1.356 \times 10^{-6} \frac{m}{s}\right.$$

unit is squared, must square conversion factors!!!

$$a = 1.36 \frac{\mu m}{s}$$

note: what does it mean to write down accel. in "g's"?

Think 60 eggs = 5 dozen eggs

$$\underset{\times 12}{\uparrow}$$

$$19.6 \frac{m}{s^2} = 2\,g \quad \times 9.8 \frac{m}{s^2}$$

in general

$$\frac{a}{g} = \#\text{ of } g\text{'s}$$

$$\Rightarrow \boxed{\text{(a)}\ a = 1.38 \times 10^{-7}\,g}$$

(b) $v_i = 0$ $\quad \Delta x = 10000\,m$

$10.0\,km \frac{1000\,m}{1\,km}$

$$\Delta x = \frac{1}{2} a_x t^2 + \cancel{v_{ix} t}^{\,0} \Rightarrow t = \sqrt{\frac{2\Delta x}{a}} = 1.21 \times 10^5\,s$$

this number is too big to be meaningful

convert to hrs? days?

$$1.21 \times 10^5\,s \; \frac{1\,hr}{3600\,s} = 33.7\,hrs \text{ (or } 1.41\,days)$$

*assuming special relativity corrections are small

(c) $v_f = 0.01c = 0.01(3\times10^8 \frac{m}{s}) = 3\times10^6 \frac{m}{s}$

$$v_{fx}^2 = \cancel{v_{ix}^2}^{\,0} + 2a_x \Delta x \Rightarrow \Delta x = \frac{v_{fx}^2}{2a_x} = \frac{(3\times10^6 \frac{m}{s})^2}{2(1.36\times10^{-6}\frac{m}{s})} \approx 3.31 \times 10^{6}\,m$$

Hockey puck

13a 2nd picture from Left

note: this is very different from rocket with thruster from PHYS 110 Fall 16 Test 3 Problem 6.

In that problem the force was applied for a significant amount of time causing acceleration + parabolic trajectory.

In this case the force has already been applied. The force caused the puck to accelerate + change direction of motion. HOWEVER, after the kick no force is applied anymore, ~~[illegible]~~ The puck again travels in straight line in the absence of any net external force.

Note: the normal force from floor and mg from gravity are both the external forces on puck. In this case these forces balance causing no NET external force.

~~14a~~ ~~[illegible]~~ 15a no longer ~~have~~ applied force AFTER kick $\Rightarrow a = 0$ ~~[illegible]~~ speed remains constant

switch order... my bad

~~15a~~ 14a during kick acceleration occured, $V_f > V_i$

16a only A + ~~B~~ C ... momentum is not a force
velocity is not a force
only Forces ~~are~~ are Forces

#18 Clock hand velocity?

1) I assume we are talking about the tip of each hand

2) assume big hand $\approx$ 8 inches $\approx$ 20cm

3) small hand $\approx$ 4 inches $\approx$ 10 cm

4) big hand travels $2\pi r_B$ in 1 hr $= 3600\,s$

5) small hand travels $2\pi r_S$ in ~~24~~ 12 hrs $= 12 \cdot 3600\,s$

$$V_{Big} = \frac{2\pi(0.20\,m)}{3600} = 3.49 \times 10^{-4} \approx \overset{350}{\cancel{3.5}} \times 10^{-6}\,\frac{m}{s}$$

$$V_{big} \approx 400\,\frac{\mu m}{s}$$

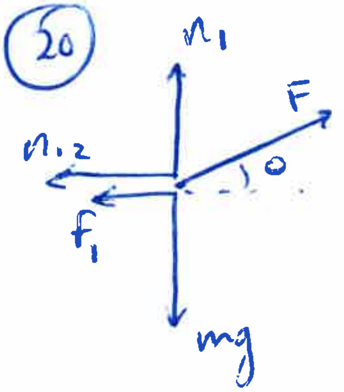
round to 1 s.f. for estimations

$$V_{small} = \frac{2\pi(0.\overset{10}{\cancel{14}})}{12 \cdot 3600} = \frac{1}{24} V_{big} \approx 14.5\,\frac{\mu m}{s} \approx \overset{15}{\cancel{14}}\,\frac{\mu m}{s}$$

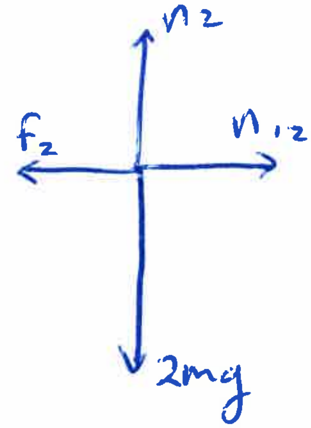
if leading digit is 1 consider using 2 s.f.'s even though this is only an estimation

FBD m

20



FBD 2m



assuming $a \approx 0$ cuz applying min force to start motion. Also, @ onset of slipping

$$f = \mu_s n \quad \begin{cases} f_1 = \mu_s n_1 \\ f_2 = \mu_s n_2 \end{cases}$$

FBD m eq'ns

y: $F\sin\theta + n_1 - mg = 0$

$n_1 = mg - F\sin\theta$

x: $F\cos\theta - n_{12} - f_1 = m\cancel{a}^{\approx 0}$

$F\cos\theta - n_{12} - \mu_s(mg - F\sin\theta) = 0$

FBD 2m eq'ns

y: $n_2 - 2mg = 0$

x: $n_{12} - f_2 = (2m)\cancel{a}^{0}$

↑ * remember if Doing 2m block use (2m)a

$F\cos\theta - 2\mu_s mg - \mu_s mg + \mu_s F\sin\theta = 0$ notice $n_{12} = f_2 = \mu_s(2mg)$

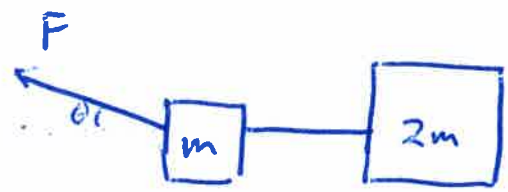
b

$$\Rightarrow \boxed{F_{min} = \frac{3\mu_s mg}{\cos\theta + \mu_s\sin\theta}}$$

c

$$\boxed{n_{12} = 2\mu_s mg}$$

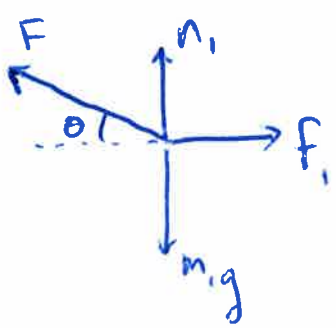
~~Pg~~ #21



In this case there is no tension until m is on the verge of slipping. If the applied force gradually increases we expect f_1 to initially build from $0 \to f_{1max} = \mu_s n_1$. Then f_2 will "turn on" and gradually build from $0 \to f_{2max} = \mu_s n_2$.

Note: while f_1 builds to f_{1max} there is <u>no</u> <u>tension</u> in string.

~~FBM~~ FBD m *(while T = 0)



@ ~~onset~~ onset of tension expect
1) $f_1 = f_{1max} = \mu_s n_1$
2) $a = 0$

$\boxed{\Sigma F_y}$: $n_1 = m_1 g - F\sin\theta$

$f = \mu_s n$: $f_1 = \mu_s (m_1 g - F\sin\theta)$

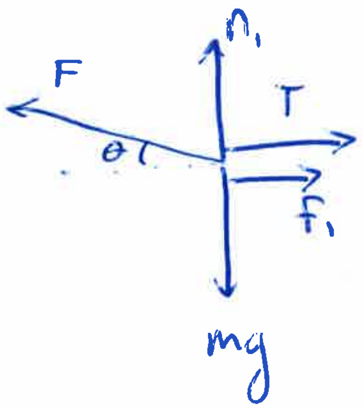
ΣF_x: $F\cos\theta - f_1 = m\cancel{a}^{\,0}$

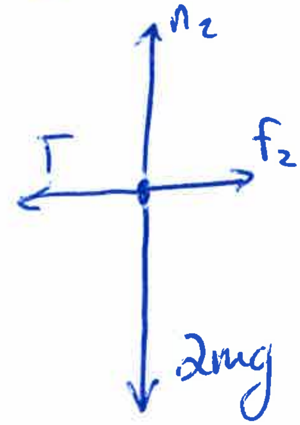
$F\cos\theta - \mu_s mg + \mu_s F\sin\theta = 0$

$$\Rightarrow F_{pizza} = \frac{\mu_s mg}{\cos\theta + \mu_s \sin\theta} =$$ minimum force to cause tension in string

similar ~~same~~ FBDs as to problem 20 ... only difference

Blocks are now about to move ~~moving~~ left instead of right.





~~Fo~~ * I will assume left is + direction.

x: $F\cos\theta - T - f_1 = m\cancel{a}$ ≈0 @ onset of slipping

y: $n_2 = 2mg$

x: $T - f_2 = (2m)\cancel{a}$ ≈0 @ onset of slipping

~~$n_1 - mg = 0$~~

y: $n_1 - mg + F\sin\theta = 0$

$n_1 = mg - F\sin\theta$

exactly the same eq'ns from problem 20!

note: ** I find it convenient to align +direction of coordinates with direction of acceleration... even if $a \approx 0$!.

Again find $F_{min} = \dfrac{3\mu_s mg}{\cos\theta + \mu_s \sin\theta}$ and $T = 2\mu_s mg$

Bonus for for #2$\frac{1}{2}$ what if I apply $F = 2F_{min}$ ... what is acceleration?

suppose $F = 2F_{min} = \dfrac{6\mu_s mg}{\cos\theta + \mu_s \sin\theta}$

think: $a \neq 0$ anymore!

also $f_1 = \mu_k n_1$ and $f_2 = \mu n_2$

from x: of FBD m

should've used T

$$F\cos\theta - n_{12} - \mu_k(mg - F\sin\theta) = ma$$

* note: in these eq'ns I should've used T instead of n_{12} ...

from x: of FBD 2m

should've used T

$$n_{12} - \mu_k(2mg) = (2m)a$$

adding eq'ns n_{12} drops out (it is internal force!)

$$F\cos\theta - \mu_k(2mg) - \mu_k mg + \mu_k F\sin\theta = ma$$

$$F(\cos\theta + \mu_k\sin\theta) - 3\mu_k mg = ma$$

now, remember, we are using $F = 2F_{min}$ ... $\underline{\underline{\text{not}}}$ F_{min}

$$\frac{6\mu_s \cancel{m}g}{\cos\theta + \mu_s\sin\theta}(\cos\theta + \mu_k\sin\theta) - 3\mu_k \cancel{m}g = \cancel{m}a$$

m's drop!!

these don't cancel!!!

$$g\left[\frac{6\mu_s(\cos\theta + \mu_k\sin\theta)}{\cos\theta + \mu_s\sin\theta} - 3\mu_k\right] = a$$