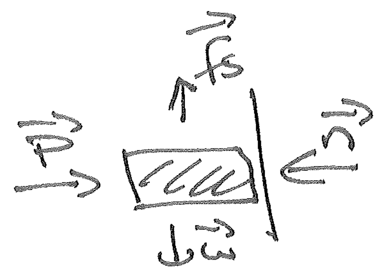
Physics 160
Extra Credit #14

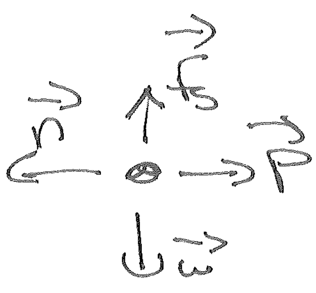
NORMAL & FRICTIONAL Forces

FOR A BOX AGAINST A WALL:



NORMAL force to left since vertical wall

Also $\vec{w}$ DOWN. WITH NO FRICTION BOX would slide DOWN $\Rightarrow$ FRICTION is upward



NO MOTION $\Rightarrow$ $\sum F_x = 0$, $\sum F_y = 0$

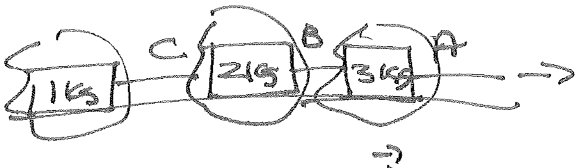
$\sum F_x = 0 \Rightarrow P - n = 0 \Rightarrow n = P$

$\sum F_y = 0 \Rightarrow f_s - w = 0 \Rightarrow f_s = w$

a) RANK BASED ON P SINCE $n = P$

b) $f_s = w \Rightarrow$ RANK BASED ON MASS VALUES ($w = mg$)

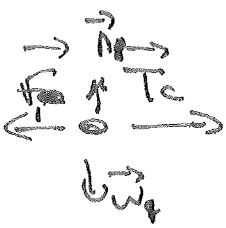
Kinetic Friction Ranking Task



Constant speed $\Rightarrow \sum F_x = 0$

No motion in $y \Rightarrow \sum F_y = 0$

forces on 1kg:



T_C = Tension in Rope C

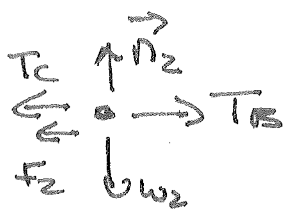
$\vec{f}^1$ = Kinetic friction on 1

$\sum F_y = 0 \Rightarrow n_1 - w_1 = 0 \Rightarrow n_1 = w_1 = (1kg)g$

$\& \ f^1 = \mu_K n_1 = \mu_K (1kg) g$

$\sum F_x = 0 \Rightarrow T_C - f^1 = 0 \Rightarrow T_C = f^1 = \mu_K (1kg) g$

forces on 2kg:



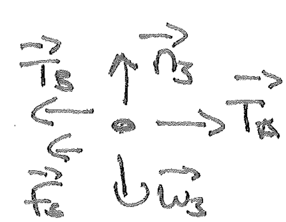
$\sum F_y = 0 \Rightarrow n_2 = w_2 = (2kg)g$

so $f_2 = \mu_K (2kg) g$

$\sum F_x = 0 \Rightarrow T_B - T_C - f_2 = 0$

$\Rightarrow T_B = T_C + f_2 = \mu_K (1kg) g + \mu_K (2kg) g = \mu_K (3kg) g$

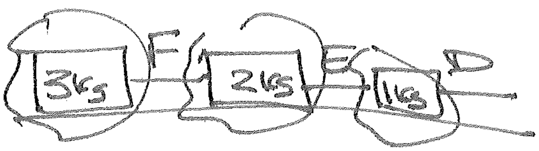
forces on 3kg:



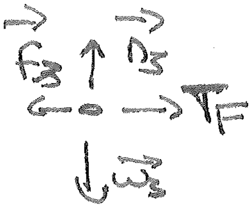
$\sum F_y = 0 \Rightarrow n_3 = w_3 = (3kg) g \Rightarrow f_3 = \mu_K (3kg) g$

$\sum F_x = 0 \Rightarrow T_A - T_B - f_3 = 0$

$\Rightarrow T_A = T_B + f_3 = \mu_K (3kg) g + \mu_K (3kg) g = \mu_K (6kg) g$



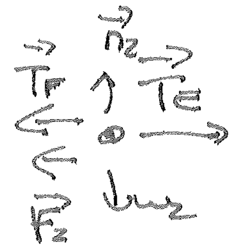
on 3kg:



From previous work: $f_3 = \mu_k (3kg) g$

$\sum F_x = 0 \Rightarrow T_F - f_3 = 0 \Rightarrow T_F = f_3 = \mu_k (3kg) g$

on 2kg:

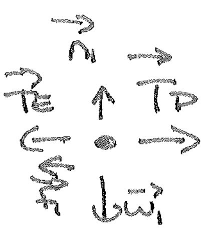


From previous: $f_2 = \mu_k (2kg) g$

$\sum F_x = 0 \Rightarrow T_E - T_F - f_2 = 0$

$\Rightarrow T_E = T_F + f_2 = \mu_k (3kg) g + \mu_k (2kg) g = \mu_k (5kg) g$

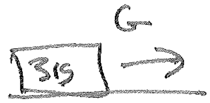
on 1kg:



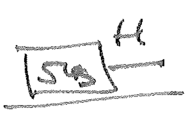
$f_1 = \mu_k (1kg) g$

$\sum F_x = 0 \Rightarrow T_D - T_E - f_1 = 0 \Rightarrow T_D = T_E + f_1$

$\Rightarrow T_D = \mu_k (5kg) g + \mu_k (1kg) g = \mu_k (6kg) g$



From previous $T_G = \mu_k (3kg) g$



$T_H = \mu_k (5kg) g$

So All together:

$T_C = \mu_K (1\,kg) g$

$T_F = \mu_K (3\,kg) g$

$T_B = \mu_K (3\,kg) g$

$T_E = \mu_K (5\,kg) g$

$T_A = \mu_K (6\,kg) g$

$T_D = \mu_K (6\,kg) g$

$T_G = \mu_K (3\,kg) g$

$T_H = \mu_K (5\,kg) g$

largest

smallest

$$T_A, T_D > T_E, T_H > T_B, T_F, T_G > T_C$$

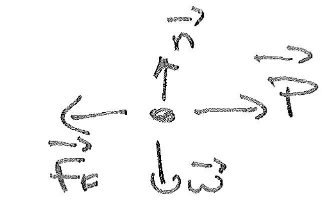
5.27

Crate:

$m = 11.7\,kg$, Constant speed $V_0 = 3\,m/s$

$\mu_K = 0.18$

To MAINTAIN MOTION?



Constant speed $\Rightarrow a_x = 0$

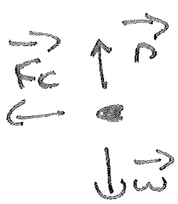
NO MOTION IN $y \Rightarrow a_y = 0$

$\sum F_y = 0 \Rightarrow n - w = 0 \Rightarrow n = w = mg = (11.7\,kg)(9.8\,m/s^2) = 114.66\,N$

$f_K = \mu_K n = 0.18(114.66\,N) = 20.6388\,N$

$\sum F_x = 0 \Rightarrow P - f_K = 0 \Rightarrow P = f_K = 20.6388\,N$

b) Without P, How far to stop?



Now $\sum F_x = ma_x \Rightarrow -f_K = ma_x$

$\Rightarrow -\mu_K n = ma_x$, $n = w = mg \Rightarrow -\mu_K mg = ma_x$

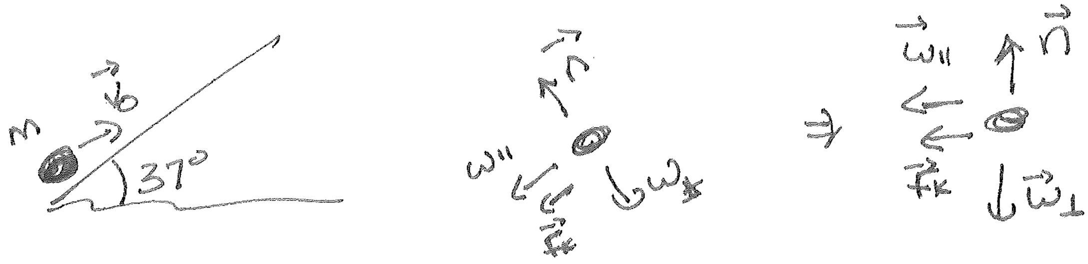
$\Rightarrow a_x = -\mu_K g$ (Didn't NEED MASS to DO this part!)

$a_x = -0.18(9.8\,m/s^2) = -1.764\,m/s^2$ ← constant so $V^2 = V_0^2 + 2a_x(X - X_0)$

$\Rightarrow 0 = (3\,m/s)^2 + 2(-1.764\,m/s^2)(X - 0) \Rightarrow X = \dfrac{-(3\,m/s)^2}{2(-1.764\,m/s^2)} = 2.551\,m$

5.30

$V_0 = 14\,m/s$, $\mu_K = 0.35$, $\mu_S = .59$



NO Acceleration perpendicular to incline $\Rightarrow \sum F_\perp = 0$

$\Rightarrow n - \omega_\perp = 0 \Rightarrow n = \omega_\perp = mg\cos\alpha$

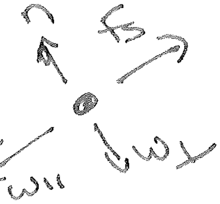
so $f_K = \mu_K n = \mu_K mg\cos\alpha$

$\sum F_\parallel = m a_\parallel$. $a_\parallel = a = ?$

$\Rightarrow -\omega_\parallel - f_K = ma \Rightarrow -mg\sin\alpha - \mu_K mg\cos\alpha = ma$

$\Rightarrow a = -g(\sin\alpha + \mu_K\cos\alpha) = -9.8\,m/s^2(\sin 37° + .35\cos 37°) = -8.637\,m/s^2$

b) will it stay at top. AT TOP, static friction tries to prevent motion BACK DOWN.



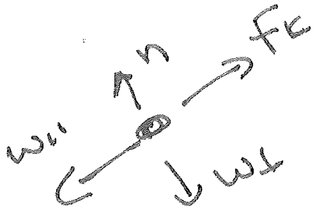
so if $f_{S,MAX} \geq \omega_\parallel$, it will stay

$f_{S,MAX} = \mu_S n \Rightarrow \mu_S n \geq \omega_\parallel$. $n = \omega_\perp = mg\cos\alpha$

$\Rightarrow \mu_S mg\cos\alpha \leq mg\sin\alpha \Rightarrow 0.59\cos 37° \leq \sin 37°$

$\Rightarrow 0.471 \leq 0.602$ so $f_{S,MAX}$ Not big enough

c) BACK DOWN: $\vec{f}_k$ opposite to $w_{\parallel}$



$n = w_\perp = mg\cos\alpha$ still

$\sum F_\parallel = ma_\parallel \Rightarrow f_k - w_\parallel = ma$

$\Rightarrow \mu_k mg\cos\alpha - mg\sin\alpha = ma$

$\Rightarrow a = (\mu_k\cos\alpha - \sin\alpha)g = (.35\cos 37^\circ - \sin 37^\circ)(9.8\,m/s^2)$

$= -3.15846\,m/s^2$