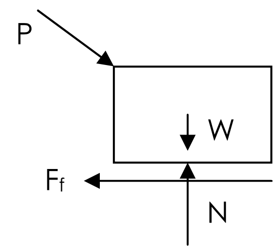
Engineering Statics HW 5 Notes

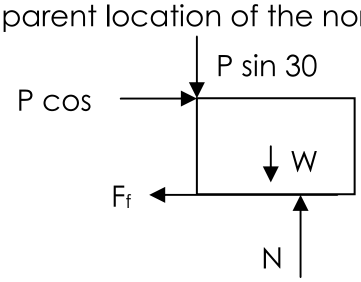
When drawing the free body diagram, draw the direction of the frictional force so that it *opposes* the direction of impending motion. Thus, if we can see that an applied force is pushing to the right, the impending motion is to the left.

1. It will be necessary to draw the free body diagram of this situation:



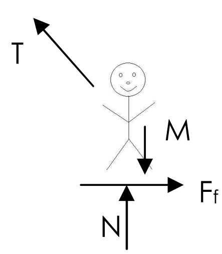
We are looking for the relationship between the frictional force, F_f, and the applied force, P. We know that the frictional force is defined by the normal force, $F_f=\mu N$, and that N is defined as
N = W + Psin30, where W is the weight of the crate(remember W = 50 * 9.81). Thus, $F_f=\mu(W + P \sin 30)$. We are also considering the relationship between the frictional force and the horizontal component of the applied force, $F_f = P \cos 30$. Given two equations and two unknowns we can solve for P.

For the second portion of the problem, we draw another free body diagram where the apparent location of the normal force is to be determined.



Write an equation describing the sum of moments equal to zero about point A. Solve for d_N.

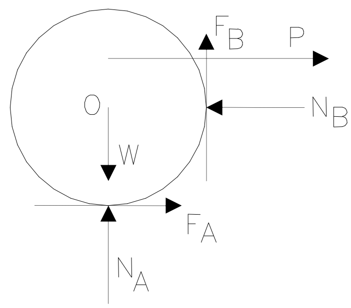
2. Because of the pulley arrangement the tension in the rope is W/3, or T = W/3. The weight of the man, M, is M = 230 (it's already in pounds). We draw a free body diagram:



The relationship between the tension, T, and the frictional force, F_f , is $F_f = T \cos 45$, but also how the tension ,T, effects the normal force, and subsequently the maximum frictional force, or $F_f = \mu N$, where $N = M – T \sin 45$. Thus, $F_f = \mu(M- T \sin 45)$. Two equations, two unknowns, solve for T.

For the second part of this problem notice that the tension, T, is applied horizontally and will have no effect on the normal force, N. Thus, $F_f = \mu M$. Solve for T. (BTW, don't forget to convert the tension, T, back into the weight, W.

3. Draw the free body diagram:



Summing the forces (where frictional force at A uses the notation F_A):

$\Sigma F_x = 0 = F_A + P – N_B$

$\Sigma F_y = 0 = N_A + F_B - W$

Knowing

$F_A = \mu N_A$

$F_B = \mu N_B$

We substitute…

$\Sigma F_x = 0 = \mu N_A – N_B + P$

$\Sigma F_y = 0 = N_A + \mu N_B – W$

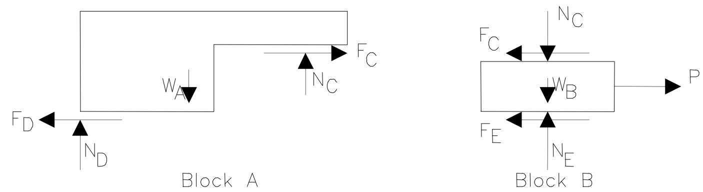
But this is two equations, three unknowns. Fortunately there *is* the sum of moments:

$\Sigma M_o = 0 = F_A(.45m) + F_B(.45m) – P(.25m)$

or $\Sigma M_o = 0 = \mu N_A(.45) + \mu N_B(.45) – P(.25)$

Three equations, three unknowns. Not pretty, but do-able.

4. Draw the free body diagram of each block:



This is a little trickier than it looks. The key is to consider both FC and FD because the pulling of block A depends on the frictional force at point C. Basically, use whicheven one is less. If FD is less than FC, then the frictional force at C, FC, will be enough to pull block A, otherwise block B will move by itself.
Think of it this way… Examining block , what is the minimum frictional force at C needed to move block A? Thanks to the moment equation, we can know the maximum frictional force at C.

Each block has its own set of equilibrium equations. Write them out:

Block A:

$\Sigma F_x = 0 = F_C - F_D$

$\Sigma F_y = 0 = N_D + N_C - W_A$

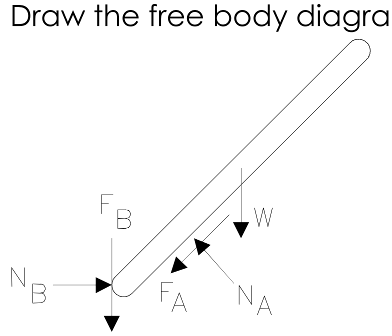
$\Sigma M_D = 0 = N_C(22) - W_A(8)$

Block B:

$\Sigma F_x = 0 = P - F_C - F_E$

$\Sigma F_y = 0 = N_E - N_C - W_B$

5. Draw the free body diagram:



Write the equations of equilibrium in terms of the angle θ (note that θ is along an unusual axis):

$\Sigma F_x = 0 = N_B - N_A \sin\theta - F_A \cos\theta$

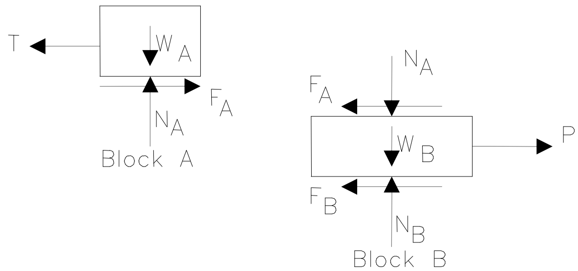
$\Sigma F_y = 0 = -F_A \cos\theta - F_B - W + N_A \sin\theta$

Detailed examination shows us that we have three unknowns, but only two equations. (Actually it is more like four unknowns because the trig functions are *almost* independent of each other. Fortunately they are not.) So we need a moment equation. I'm choosing point B because *most* of the forces pass through this point, meaning I don't have to write them out.

$\Sigma M_B = 0 = N_A(1\text{m}) - W(2.3\text{m} \sin\theta)$

At first this looks particularly ugly because θ is buried in *sin* and *cos* functions. A technique commonly used is to

6. Draw the free body diagrams:



Block A:

$\Sigma F_x = 0 = F_A - T$

$\Sigma F_y = 0 = N_A - W$

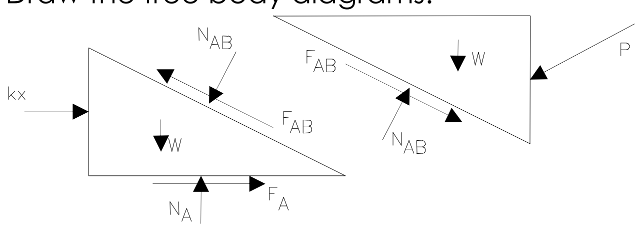
Block B:

$\Sigma F_x = 0 = P - F_A - F_B$

$\Sigma F_y = 0 = N_B - N_A - W$

More than enough information here to solve for P.

7. Draw the free body diagrams:



Write the equations of equilibrium for each block:

Block A:

$\Sigma F_x = 0 = kx + F_A - (13/13)F_{AB} - (5/13)N_{AB}$

$\Sigma F_y = 0 = N_A - (12/13)N_{AB} + (5/13)FAB - W$

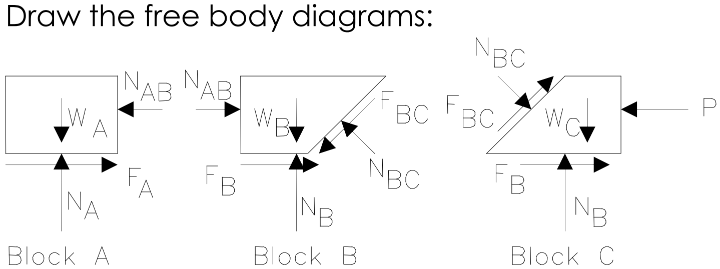
Block B:

$\Sigma F_x = 0 = (12/13)F_{AB} + (5/13)N_{AB} - P\cos 30$

$\Sigma F_y = 0 = (5/13)N_{AB} + (12/13)F_{AB} - W - P\sin 30$

There is enough information here to solve for x.

8. Draw the free body diagrams:



9. Draw the free body diagram: