Practice for Midterm 2:

INTERACTIONS

Physics 203, Profs Yaverbaum, Song, Lu, & Bean

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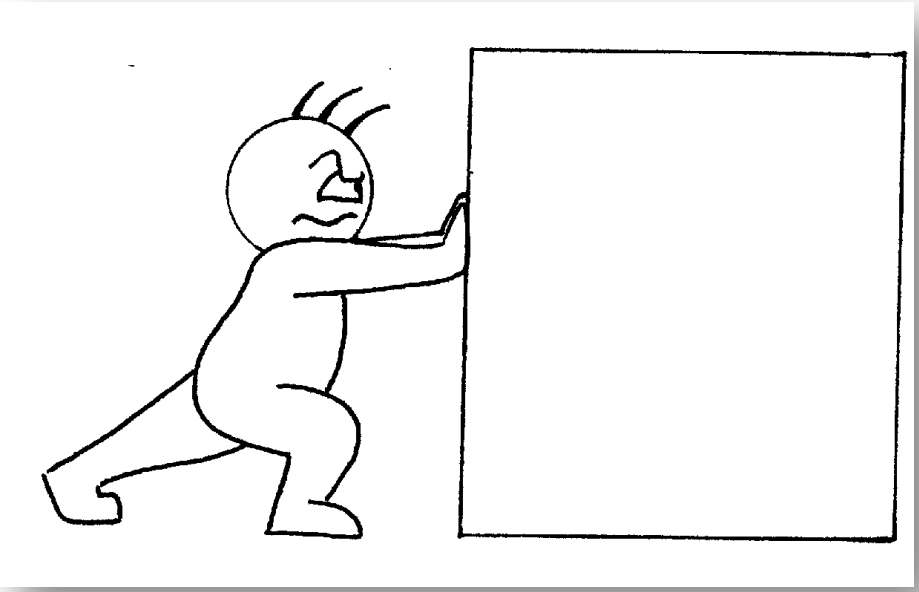


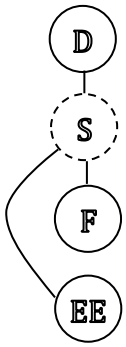
SOLUTIONS Part 1

Part I

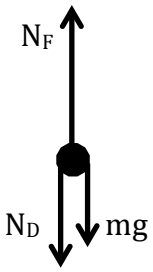
1. A 15 kg dog is sitting on a 5kg stool. The stool is standing on the floor. None of them are moving with respect to each other.
   a. Draw a picture of the situation.
   b. Draw a system schema and an FBD of the stool.
   c. Write out a Newton's 3rd Law pair for each arrow in your FBD.
   d. Draw a system schema and an FBD treating the stool & dog as one system.
   e. Calculate the force with which the floor pushes up on the stool. Show all work.

a.

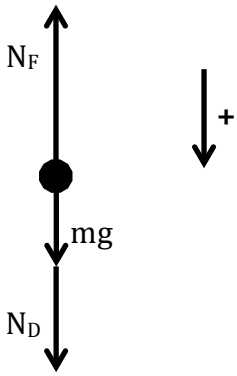
b. S.S. (No motion & no horizontal forces; therefore no friction.)



FBD option 1: adjacent arrows

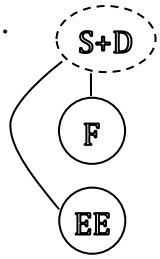


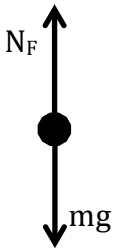
FBD option 2: tip-to-tail arrows



c. Dog pushes down on stool, and stool pushes up on dog.
Earth pulls down on stool, and stool pulls up on earth.
Floor pushes up on stool, and stool pushes down on floor.

d.





e.

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

$-N_F + m_{sys}g = ma_y$

$-N_F + 200 = 0$

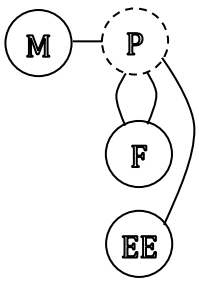
$N_F = 200$ N upwards

m_{sys} = mass of dog-stool system, i.e. 15 + 5 = 20kg

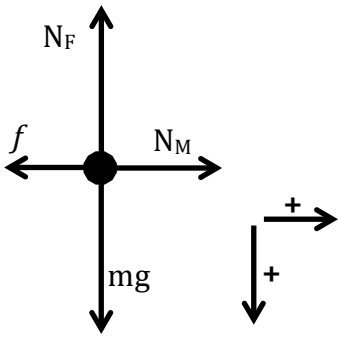
We made up negative. You could make down negative, if you prefer.

2. A mover is trying to push a 120kg piano across a rough floor. The coefficients of friction between the piano and the floor are given as $\mu_s = 0.4$ and $\mu_k = 0.3$.
   a. Draw a picture of the situation.
   b. Draw a system schema and an FBD of the piano.
   c. Write out a Newton's 3rd Law pair for each arrow in your FBD.
   d. Calculate the minimum force the mover must push with if he wants to move the piano at all.

B. Both friction & normal
Between piano & floor;



FBD



Picture not provided.

C. The floor pushes up on the piano & the piano pushes down on the floor.
The earth pulls down on the piano & the piano pulls up on the earth.
The mover pulls the piano to the right & the piano pulls the mover to the left.
The floor drags the piano to the left & the piano drags the floor to the right.

D. This is a question about WHETHER the piano will move, not how fast it will accelerate. Therefore, this is a question about STATIC friction. Minimum force mover must push with is anything greater than max force of static friction.

$|f_s(\text{max})| = \mu_s N$ ⟶ Find F_{NF}: $\sum \vec{F}_y = m\vec{a}_y$

$-N_F + mg = 0$ ← because piano is not going up or down

$-N_F + 1200 = 0$ ← if down is positive.

$N_F = 1200$ N

$|f_s(\text{max})| = 0.4(1200)$

$|f_s(\text{max})| = 480$ N

So, the mover must push with more than 480 N of force in order to move the piano at all.

3. A hand is pushing a flower pot across a table. The coefficients of friction between the pot and the table are given as $\mu_s = 0.4$ and $\mu_k = 0.3$. If the hand pushes with a force of 10N and the flower pot moves with an acceleration of 2 m/s^2, what is the mass of the flower pot?

We're looking for mass of pot, so we'll leave it as a variable in our equations.
The flower pot is MOVING, so we use KINETIC friction

Need N to find f_s in terms of m:

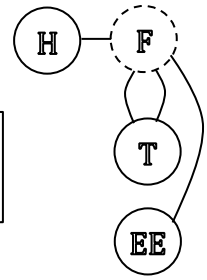
$\sum \vec{F}_y = m\vec{a}_y$

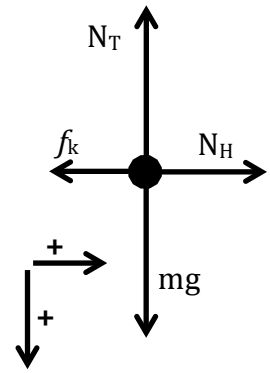
$-N_T + Mg = 0$ ← flwr pot not going up/down

$-N_T = -Mg$

$N_T = 10M$

Picture not provided.





Find f_k in terms of m:

$|f_k| = \mu_k N$

$|f_k| = 0.3(10M)$

$|f_k| = 3M$ n

Use NII to find a in terms of m:

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

$N_H + f_k = ma_x$

$10 - 3M = 2M$ ←

$10 = 5M$ ←

$2 \text{ kg} = M$

Units in here get a little complicated. M is in kg, so that 3 must be in m/s^2; the 2 is also in m/s^2 since it's a_x. So you have:
$2(m/s^2)M(kg) + 3(m/s^2)M(kg) = 5(m/s^2)M(kg)$. And $10N/(5m/s^2) = 2$ kg

4. Someone has shoved a large ceramic plate so that it slides across a cafeteria table. The plate has a mass of 3 kg. It starts out with a velocity of 4 m/s and takes 2 seconds to come to a complete stop.
   a. Draw a picture of the situation.
   b. Draw a system schema & an FBD of plate.
   c. Calculate the acceleration of the plate as it slides.
   d. Calculate the coefficient of kinetic friction between the plate and the table.

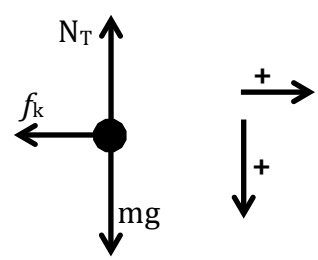
a. (not provided)

c. We have not been given μ_k, so we cannot find ***a*** using Newton's Laws. But we ***have*** been given V_0, ***t***, and V_f, so we can find ***a*** using ***kinematics***. Deja vu!
Right is positive so V_0 is positive & ***a*** (due to friction) will be negative.

$$a = \frac{v - v_0}{t} = \frac{0 - 4}{2} = -2\ m/s^2$$

OR you could figure it out with logic instead of equations.

b. Left-right directions are not given, so we can pick. We'll say V_0 is rightward.



d. $\sum \vec{F}_x = m\vec{a}_x$

$-f_k = (3)(-2) = -6$ n

$|f_k| = \mu_k N$

$6 = \mu_k(30)$

$\mu_k = 6/30 = 0.2$

Find N: $\sum \vec{F}_y = m\vec{a}_y$

$-N_T + mg = 0$

$-N_T = -mg$

$N_T = 30$

Picture & SS not provided.