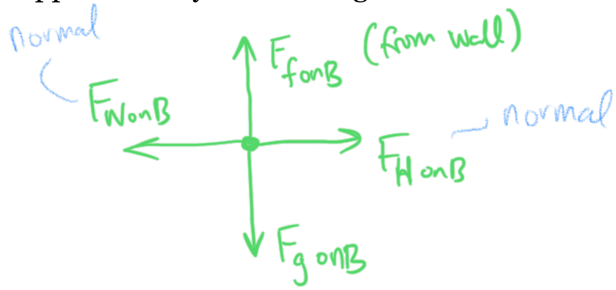
Name ______________________________

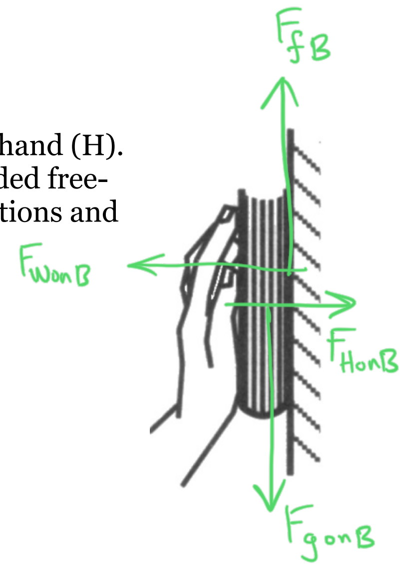
ASU ID#: ______________________________

PHY121 (Jacobs) Recitation 4

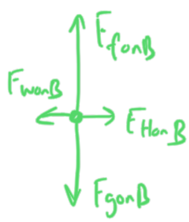
1. Suppose you successfully press a book (B) against a wall (W) with your hand (H).

a. Identify all the forces acting on the book and draw a clear extended free-body diagram (FBD) showing each force with their correct directions and approximately correct magnitudes.





b. Suppose that you now decrease size of your pushing force, but not enough for the book to slip. What happens to each of the two normal force components and to each of the two frictional force components in your FBD; do they increase in magnitude, decrease, or not change? Explain, using Newton's 1st or 3rd Law where appropriate.



Both normal forces must decrease to maintain equilibrium in the x-direction. But since F_{gonB} does not change, F_{fonB} also cannot change. This is consistent w/ the fact that static friction is only "as big as it needs to be")

c. For the situation in **b.**, what happens to the maximum force of static friction on each side of the book? Explain.

$0 \leq F_{f,s} \leq max$

This also decreases b/c $F_{f,max} = \mu_s F_N$, and F_N has decreased.

d. Now suppose the side of the book on which you are pushing is very slick so that the only frictional force is between the wall and the book. If the coefficient of static friction (μ_s) between wall and book is known, as well as the book's mass m_B, then at least how hard must you push to keep the book at rest? Is this likely to be more or less than the weight of the book?

Here we assume $F_{fonB} = F_{f,max} = \mu_s F_N$, $F_N = F_{WonB} = F_{HonB}$

N2L$_y$: $F_{fonB} - F_{gonB} = m_{book} a_y = 0$

↪ $\mu_s F_{HonB} = F_{gonB} = m_{book} g$

↪ $F_{HonB} = \frac{m_{book} g}{\mu_s} > m_{book} g$ if $\mu_s < 1$ & it usually is.

2. Consider a box (B) riding in the back of a flatbed truck (T).
   a. If the truck accelerates gently, the box moves with the truck without slipping. Draw a free-body diagram (FBD) of the box as it accelerates, to the right, without slipping.

F_N

$F_{f,s}$

$F_{g,B} = m_B g$

   b. If the truck's acceleration is too large, the box will begin to slip. Draw a FBD for the box while still touching the truck, but while the truck is slipping out from under the box. Explain how you might be able to predict the acceleration OF THE BOX in this situation. What would you need to know?

F_N

$F_{f,k}$ sliding/kinetic friction

$F_{g,B}$

Model: $F_{f,k} = \mu_k F_N$

& $\underbrace{N2L_y: \; F_N - F_{g,B} = 0}$

$F_{f,k} = \mu_k F_{g,B} = \mu_k m_B g$

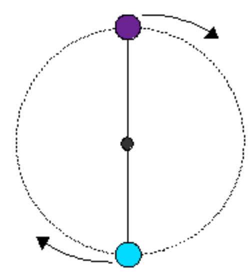
N2Lx: $F_{f,k} = m_B a$

$\mu_k \cancel{m_B} g = \cancel{m_B} a$

$\mu_k g = a$

Only need μ_k

3. With enough speed, a ball on a string can travel in a VERTICAL circle.



   a. Draw two FBD's of the ball at the top of the circle. On the left, show the ball when it is traveling very fast. On the right, show the ball successfully passing the top of the circle, but traveling more slowly.

Very fast

$F_{g,b}$

F_T

Could be bigger or smaller than $F_{g,b}$

Slower

$F_{g,b}$

F_T

Just a smaller arrow than before

   b. Suppose the ball (of mass m) has the smallest top-of-circle speed that allows it to stay in a circular path. What is the tension in the string when the ball is passing the top of the circle? Explain. (Hint: use Newton's 2nd law and explore what happens when the speed gets *too* small).

UCM

$a_c = \frac{v^2}{r}$

N2Ly: $-F_T - mg = m a_y$ b/c points downward

$= m\left(-\frac{v^2}{r}\right)$

$F_T + mg = \frac{mv^2}{r} \longrightarrow F_T = \frac{mv^2}{r} - mg$

- In this convention $F_T > 0$ by definition
- Note that if v gets too small, $F_T < 0$, which is unphysical.

$F_T = 0$ is the lowest