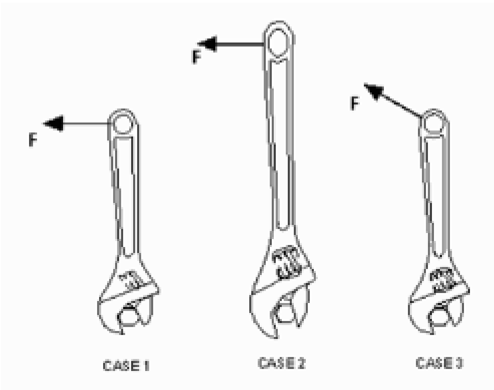
Name & Date: ____

Torque Problems

#1) The picture shows three different ways of using a wrench to loosen a stuck bolt. Assume the applied force F is the same in each case.

a. In which of the cases is the torque on the bolt the biggest?

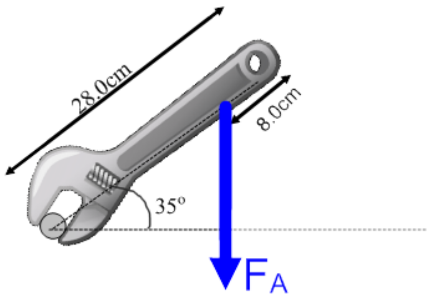
b. In which case is the torque on the bolt the smallest?



#2) You pull straight down 8.00cm from the END of a 1.50 kg, 28.0 cm wrench as shown:

a. It will take 50.6Nm of torque to turn the bolt. How much force do you need to exert? Assume the centre of mass of the wrench is located 12.0cm from the bolt (why not halfway?) [3.00×10^2N]

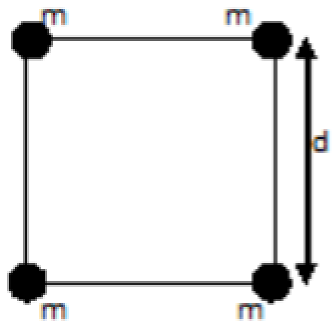
b. What can you change to reduce the force needed to create this torque?



#3) Four point masses (mass=m) are connected in a square formation (sides of length d) by massless rods. What is the moment of inertia of the system if it rotates around

a. its centre? [$I=2md^2$]

b. any one of its corners? [$I=4md^2$]

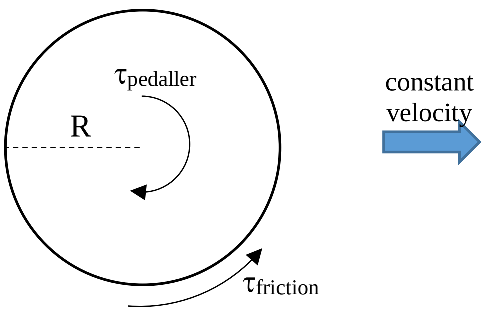


#4) A bike with 75.0cm diameter wheels is moving to the right at constant speed. The force from the person pedaling results in 59.3Nm of torque on the back wheel (by turning the back sprocket which exerts a force on the back wheel, which causes torque on the back wheel).

a. How much static friction from the ground must be exerted on the back wheel for it to roll forward without slipping?

b. If the bike + rider have a combined mass of 98.9kg, and the coefficient of friction between the asphalt and the tires is 0.78, will the bike slip or roll forward without slipping?

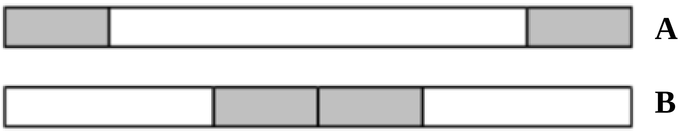
c. What if the bike is on ice so the coefficient of static friction is only 0.08?



#5) Two batons at rest have equal mass and length.

a. Which will be *easier* to start spinning about its centre? Choose the best response from the options provided and briefly justify your choice.

i) A
ii) B
iii) Neither has any resistance to changes in its rotational motion.
iv) They are the same in how much they resist changes to their rotational motion.
v) More information is needed.



(The grey areas represents the heavy parts of the baton, while the white represents the light parts)

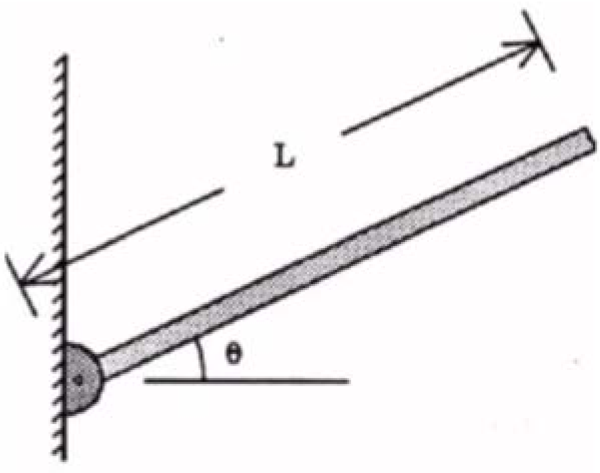
b. Which will be *easier* to start spinning about one end? (this is a more complicated analysis… consider it carefully, no calculations needed, but try to think about how much mass is contributing to the moment of inertia and how far that mass is from the end of the rod. Then think about what has a greater effect on I: m or r?)

i) A
ii) B
iii) Neither has any resistance to changes in its rotational motion.
iv) They are the same in how much they resist changes to their rotational motion.
v) More information is needed.

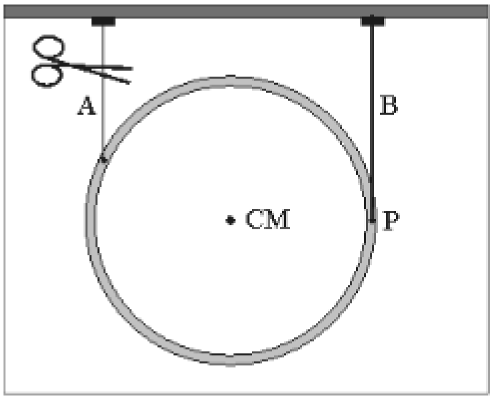
#6) An 8.0m, 12.0kg seesaw is pivoted 3.0m from the left end. A 67.0 kg person sits 0.50m from the left end. Where should an 80.0kg person sit to prevent the seesaw from rotating? [3.1m from the right end]

#7) Now the pivot is in the middle of the seesaw but instead of balancing themselves, both people sit at the far ends of the seesaw. What is the initial angular acceleration of the system? Approximate the system to be a thin rod with a point mass (person) at each end. [0.21rads/s^2]

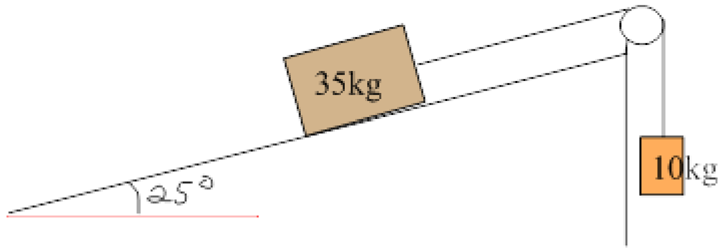
#8) Consider a beam of Length L, mass m, and moment of inertia about one end of $1/3mL^2$. It is pinned to a hinge on one end. Determine the beam's angular acceleration. [$\alpha=3g\cos\theta/2L$] hint: Start by finding the net torque on the beam. Where does F_g act on the beam?



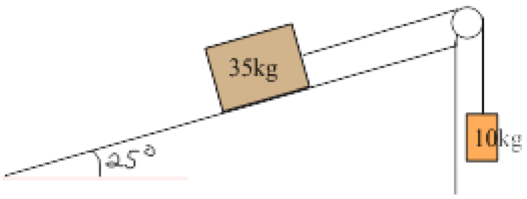
#9) A thin circular hoop with radius *r* and mass *m* is suspended vertically by two thin strings, A and B as shown in the figure. The center of the mass of the hoop is at the same height as the point P where string B is attached. Find an equation for the angular acceleration of the hoop at the instant the string is cut. ($I_{hoop\ rotating\ around\ edge} = 2MR^2$) [$\alpha$=g/2R] Hint: Around which point would the hoop rotate when string A is cut?



#10)If the pulley has a radius of 8.00 cm and a mass of 3.00 kg, what is the acceleration of the system below? The system is frictionless, and you can consider the pulley to be a disk. [1.01m/s^2 but in what direction?]



#11) A pulley of radius 8.00cm and mass 3.00kg supports a string connected to two blocks as shown. The system is initially at rest. The heavy block and the inclined plane have $\mu_s = 0.30$ and $\mu_k = 0.20$. Will the system accelerate? If so, at what rate and in which direction? [it stays at rest]



#12) A massive pulley is suspended from the ceiling. Two masses are connected by a massless string which loops over the pulley. m_1 is heavier than m_2.

a. What can you say about *a*, the magnitude of the acceleration of the masses.

i. $a > 9.81$ m/s^2.

ii. $a = 9.81$ m/s^2.

iii. $a < 9.81$ m/s^2.

iv. $a = 0$ m/s^2.

v. It depends on the difference in the two masses.

#13) How does *a* compare to what the acceleration would be if the pulley's mass was negligible ($a_{massless}$)?

i. $a > a_{massless}$.

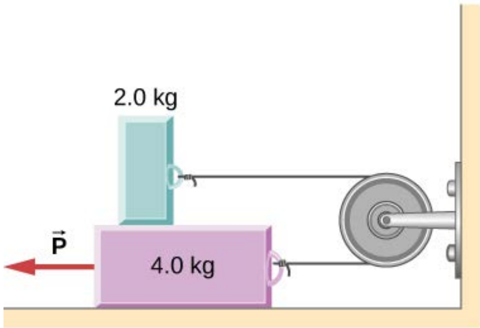
ii. $a = a_{massless}$.

iii. $a < a_{massless}$.

iv. It depends on the difference in the two masses.

#14) Explain, using relevant physics, the answer to the previous question.

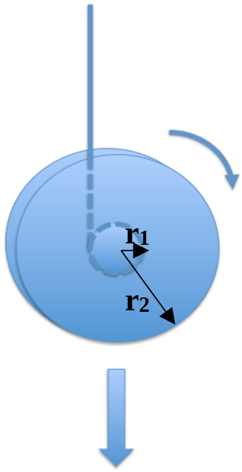
#15) A 2.00 kg block is stacked on top of a 4.00 kg block as shown. They are connected by a string that loops over a disk shaped pulley with mass 10.0kg as shown. A person pulls on the bottom block with a constant force of 62.0N force to the left (labelled P in the diagram). The coefficient of friction between all surfaces is 0.400.



a. What is the acceleration of the top block? [2.1m/s^2]

b. If the system starts at rest and the pulley has a radius of 15.0cm, find the angular velocity of the pulley after 1.70s. [23.6 rads/s.]

#16) A person is holding the top of a 80.0g yoyo string steady while the yoyo unrolls and accelerates downwards, as shown. The radius of the axle around which the string is wrapped is r_1, while the radius of the full yoyo is r_2.



a. Where is the axis of rotation of the yoyo?

b. There are two forces acting on the yoyo. Which one exerts a torque and which one doesn't? Why?

c. The downwards acceleration of the yoyo (a) and the angular acceleration of the yoyo (α) are related through $a = \alpha r$. But which radius, r_1 or r_2? Why? [hint, what is controlling how fast the yoyo accelerates downwards?]

d. Find the downwards acceleration of the yoyo (you'll need more space). $r_1 = 1.50$cm and r_2=4.00cm. Approximate the shape of the yoyo as a disk. Here's some help:

- In previous situations involving blocks on pulleys, we drew FBD's for the translating masses (moving up & down) and applied Newton's 2nd Law. We also drew a torque diagram for the rotating object and applied Newton's 2nd Law of rotation. We then solved the resulting relationships together since a and α were related through $a = \alpha R$.
- In this new situation, there is only one object: The yoyo. It is both translating and rotating. So we need to both forms of analysis on the yoyo: translational and rotational! Draw a FBD of the yoyo and a torque diagram.

e. How does this compare to the acceleration of the yoyo if the yoyo's mass was negligible?

#17) More challenging moment of inertia problem: What are the moments of inertia of this three particle system about each of the three axes A, B and C, where C goes in and out of the page, passing through the centre of the triangle. [I_A = 0.688kgm^2, I_B=0.439kgm^2, I_C=1.13kgm^2]