

Problem 3: (~~Torque and Conservation of Angular Momentum~~) A bowling ball of mass m and radius R is thrown down an alley with an initial velocity v_0 and no initial angular velocity. The moment of inertia of the ball about the center of mass is $I = \frac{2}{5} mR^2$. The coefficient of friction between the ball and the alley is μ .

- a) ~~What is the angular velocity of the ball when the ball just starts to roll without slipping down the alley?~~
- b) ~~What is the kinetic energy of the ball when the ball just starts to roll without slipping down the alley?~~
- c) ~~What is the change in kinetic energy?~~

Problem 4: (~~Torque and angular acceleration~~) A pulley of mass m , radius R , and moment of inertia $I = \frac{1}{2} mR^2$ about the center of mass is hung from a ceiling with a massless string that winds around the rim of the pulley. At time $t = 0$ the pulley is released from rest.

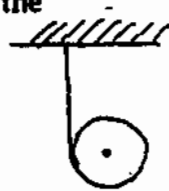
- (a) Draw the free body diagram on the pulley.
- (b) Write down the equation describing the motion of the center of mass.
- (c) Write down the rotational equation of motion.
- (d) Find the direction and magnitude of the translational acceleration of the pulley.
- (e) How long does it take for the pulley to fall a distance L ?
- (f) What is the tension on the string?

Problem 5: (~~Conservation of angular momentum~~) A long stick of length L and mass m lies motionless on a frictionless surface. A putty of the same mass m moves without friction on the floor with a speed of v_0 toward the stick, hits one of the ends of the stick perpendicularly and is stuck to the end.

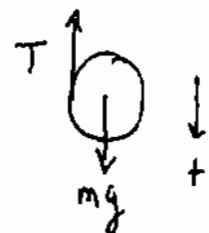
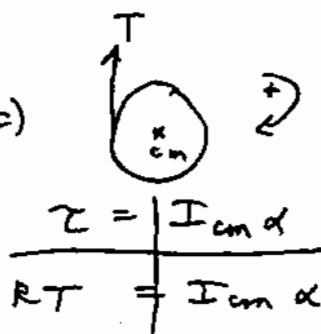
- (a) ~~How far from the midpoint of the stick is the center of mass of the stick plus the putty at the time of the collision?~~
- (b) ~~What is the momentum of the stick plus putty after the collision?~~
- (c) ~~What is the angular velocity of the stick plus putty after the collision?~~
- (d) ~~How far does the stick's center of mass move during one rotation of the stick?~~

Problem 4: (Torque and angular acceleration)

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- Draw the free body diagram on the pulley.
- Write down the equation describing the motion of the center of mass.
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a)  , b) $mg - T = ma$ c) 

d) $T = \frac{I_{cm} \alpha}{R}$, $\alpha = \frac{a}{R} \Rightarrow T = \frac{1}{2} \frac{mR^2}{R} \frac{a}{R} = \frac{1}{2} ma$
 Then $mg - T = ma \Rightarrow mg - \frac{1}{2} ma = ma \Rightarrow$
 $mg = \frac{3}{2} ma \Rightarrow a = \frac{2}{3} g$

e) $L = \frac{1}{2} a t^2 \Rightarrow t = \left(\frac{2L}{a} \right)^{1/2} = \left(\frac{2L}{\frac{2}{3}g} \right)^{1/2} = \left(\frac{3L}{g} \right)^{1/2}$

f) $T = \frac{1}{2} ma = \frac{1}{2} m \left(\frac{2}{3} g \right) = \frac{1}{3} mg$