

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Experimental Study Group

Physics 8.012, Fall 2010

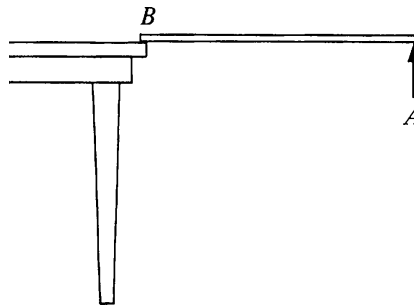
Problem Set 9

Due: Friday, November 19

Reading: Kleppner and Kolenkow, *An Introduction to Mechanics*, Chapter Six
Problems: Chapter 6: 14, 18, 24, 29, 30, 37, 41

Problem 1: K&K 6.14

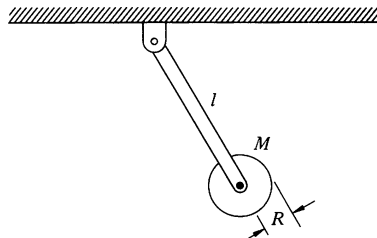
A uniform stick of mass m and length l is suspended horizontally with end B at the edge of a table and the other end A is held by hand. Point A is suddenly released. At the instant after release:



- What is the torque about the end B on the table?
- What is the angular acceleration about the end B on the table?
- What is the vertical acceleration of the center of mass?
- What is the vertical component of the hinge force at B ? Does the hinge force have a horizontal component at the instant after release?

Problem 2: K&K 6.18

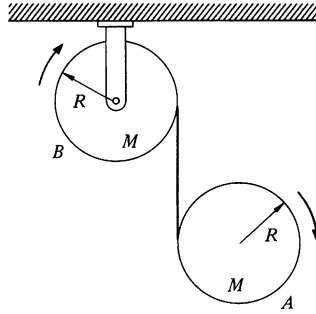
A physical pendulum consists of a disc of radius R and mass m_d fixed at the end of a rod of mass m_r and length l .



- Find the period of the pendulum.
- How does the period change if the disk is mounted to the rod by a frictionless bearing so that it is perfectly free to spin?

Problem 3: K&K 6.24

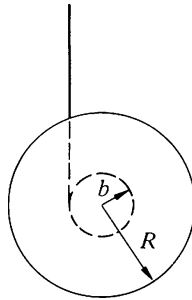
A drum A of mass m and radius R is suspended from a drum B also of mass m and radius R , which is free to rotate about its axis. The suspension is in the form of a massless metal tape wound around the outside of each drum, and free to unwind. Gravity is directed downwards. Both drums are initially at rest. Find the initial acceleration of drum A , assuming that it moves straight down.



Problem 4: K&K 6.29

A Yo-Yo of mass m has an axle of radius b and a spool of radius R . Its moment of inertia can be taken to be $I = (1/2)mR^2$ and the thickness of the string can be neglected.

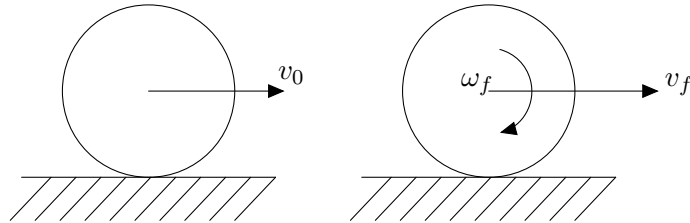
The Yo-Yo is released from rest.



- What is the tension in the cord as the Yo-Yo descends and as it ascends?
- The center of the Yo-Yo descends a distance h before the string is fully unwound. Use conservation of energy to find the angular velocity of the Yo-Yo when it reaches its lowest point.
- What happens to the Yo-Yo at the bottom of the string?
- Assuming it reverses direction with uniform angular velocity, find the average force on the string while the Yo-Yo turns around.

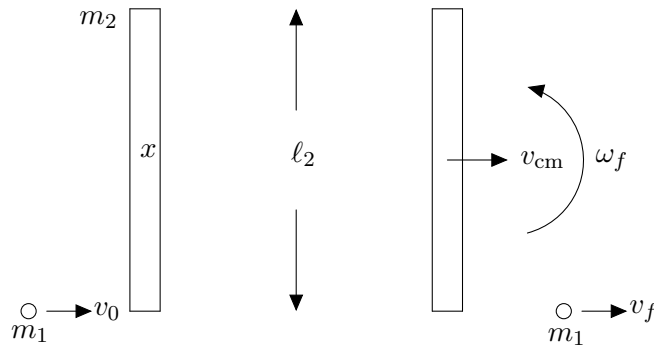
Problem 5: K&K 6.30

A bowling ball of mass m and radius R is initially thrown down an alley with an initial velocity v_0 and it slides without rolling but due to friction it begins to roll. The moment of inertia of the ball about its center of mass is $I_{\text{cm}} = (2/5)mR^2$. What is the velocity of the bowling ball when it just start to roll without slipping.



Problem 6: K&K 6.37

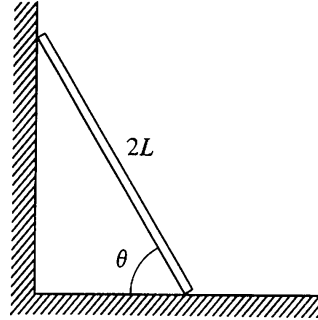
A hockey puck of mass m_1 slides along ice with a velocity v_0 and strikes one end of a stick lying on the ice of length l_2 and mass m_2 . The center of mass of the stick moves with an unknown magnitude v_{cm} . The stick also rotates about the center of mass with unknown angular velocity ω_f . The puck continues to move in the same straight line as before it hit the stick with velocity v_f . Assume the ice is frictionless and there is no loss of mechanical energy during the collision.



- Write down the equation for conservation of momentum.
- Write down the equation for conservation of energy.
- Is there any external torques acting on the system consisting of the puck and the stick? Write down the equation for conservation of angular momentum about a convenient point.
- Find the velocity of the center of mass of the stick.
- Find the velocity of the puck after the collision.
- Find the angular velocity of the stick after the collision.

Problem 7: K&K 6.41

A plank of length $2l$ leans against a wall. The mass of the plank is m which is uniformly distributed. The plank is initially inclined at an angle θ with respect to the horizontal. It starts to slip downward without friction.



- Draw a force diagrams showing all the forces acting on the plank. What is the condition that the plank just starts to slip from the wall.
- Is the mechanical energy of the plank conserved as it slips down the wall?
- What equations arise from the conditions for static equilibrium for both forces and torque? Think about which point to compute the torque about.
- Show that the top of the plank loses contact with the wall when it is two-thirds of its initial height against the wall. Hint: only a single variable and its derivatives are needed to describe the motion of the system. Consider the motion of the center of mass of the plank.