NAME : ....

Massachusetts Institute of Technology

16.07 Dynamics

Problem Set 8

Out date: Nov 3, 2004

Due date: Nov 10, 2004

	Time Spent [minutes]
Problem 1 - A	
Problem 1 - B (OPTIONAL)	
Problem 2	
Problem 3	
Problem 4	
Study Time	

Turn in **each problem** *on* **separate sheets** *so that grading can be done in parallel*

Problem 1 - Kater's Pendulum

In this assignment you are asked to make an experimental measurements of the period of a pendulum. You should review lecture $D21$ for a description of the theory. The pendulum is set up the the hangar of building 33. It consists of a steel bar with two knife edges (approximately 1 m apart) and two brass bobs – one large and one small –. The small bob can be moved. Next to the pendulum, you will find a measuring tape and a stop watch.

Part A

In the first part of this assignment, you will remove the small bob. You will consider the compound pendulum made up of the steel bar and the large bob suspended from the knife edge at the opposite end of the (large) bob. The mass of the steel bar is 2.905 kg and the mass of the large bob is 1.397 kg. Use the measuring tape to make necessary measurements to calculate the moment of inertia and the center of mass of the pendulum (the mass of the triangular knife edges can be neglected). Using these values, determine analytically the period of the pendulum. Next, you will suspend the pendulum and measure the period experimentally. Verify your predicted value.

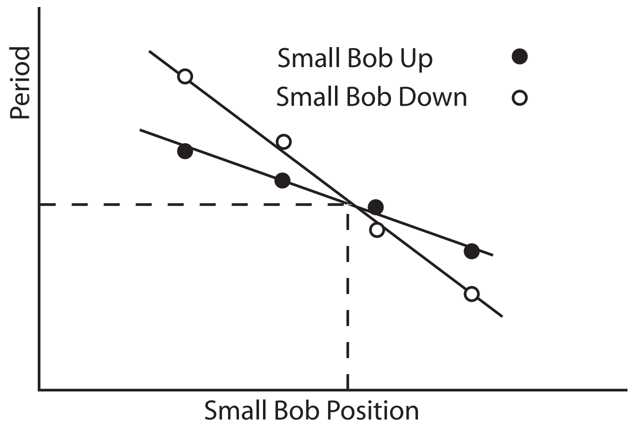
Part B

THIS PART IS OPTIONAL. STUDENTS WHO COMPLETE IT SUCCESSFULLY WILL OBTAIN EXTRA CREDIT EQUIVALENT TO ONE HOMEWORK PROBLEM. THE MEASUREMENTS, FOR THIS PART ONLY, CAN BE MADE IN GROUPS OF UP TO FIVE STUDENTS, BUT YOU SHOULD TURN IN SEPARATE SOLUTIONS AND IDENTIFY WHO WAS IN YOUR GROUP. THIS PART CAN BE TURNED IN WITH PROBLEM SET 9 ON NOVEMBER 19.

Here you are asked to measure the acceleration of gravity using a Kater Reversible Pendulum. For many years this was the the most accurate way to measure the value of g. When very careful measurements are made, typical errors in the value of g are less than ± 0.0003 m/s^2. You are certainly not expected to get this level of accuracy, but with some care you should be able to obtain reasonable accuracy.

Here, you will need to use the small bob. You will need to find out the position of the small bob such that the period of the pendulum is the same when the pendulum is swung from either end. Once this is accomplished, you will have reversible pendulum. Using the period of this pendulum and the distance between the knife edges, you should be able to determine the value of g.

The position of the small bob will be measured from the end of the bar to the edge of the bob. For every position of the small bob, you will need to measure the periods of the pendulum with the small bob up and with the small bob down. You will then move the small bob and measure them again. You should plot the bob position vs period for the pendulum with the small bob up and for the pendulum with the small bob down. You should consider at least three bob positions. Your graph should look approximately like this,



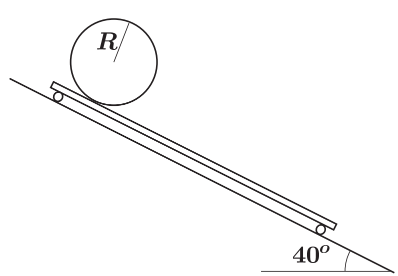
Identify the position for the small bob that results in a reversible pendulum and its period. You will notice that in a certain region the period changes very little and measurements need to be very accurate (large number of periods) in order to be able to tell the difference. Try your best and see what you get!

Note: When taking period measurements, you should make sure that the amplitude of the pendulum is small $\approx 10 - 15^o$***. Also, your measurements will be more accurate if you let the pendulum settle, after it has been set in motion, and start timing after*** $5 - 10$ ***oscillations. In any event, you should always measure the time it takes for the pendulum to do a large number of swings (at the very least*** 100***, and many more for Part B), and then divide the total time by the number of swings to obtain the period. The more swings you consider the smaller the error will be.***

Problem 2

Part A

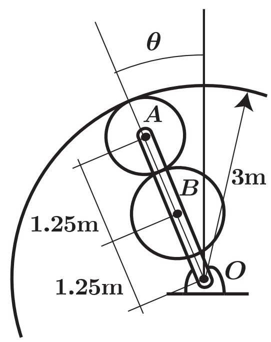
The 10 kg cylinder of radius R rests on a 5 kg cart. If the system is released from rest, determine the angular velocity of the cylinder after 2 s. The coefficient of friction is $\mu = 0.3$.



Hint : First, solve the problem assuming that the cylinder does not slip on the cart

Part B

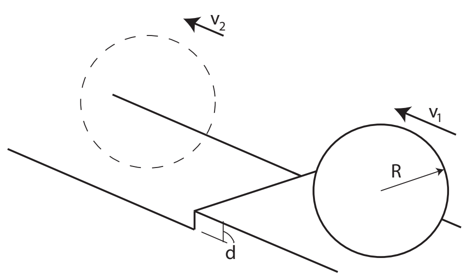
Gear A has a mass of 50kg, a radius of 0.5m and a radius of gyration of 0.4m, and gear B has a mass of 80kg, radius of 0.75m and a radius of gyration of 0.55m. The link is pinned at O and has a mass of 35kg. If the link can be treated as a slender rod, determine the angular velocity of the link after the assembly is released from rest when $\theta = 0$ and falls to $\theta = 90^o$. Assume that between any two surfaces, there is only rolling without slipping.



Problem 3

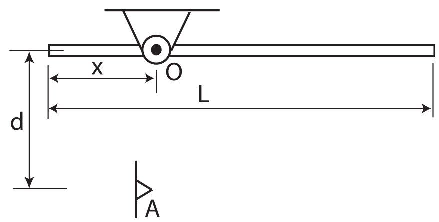
Part A

A ball of radius $R = 125$ mm having a mass of 8 kg and initial speed of $v_1 = 0.2$ m/s rolls over a step which is $d = 10$ mm deep. Assuming that the ball rolls off the edge determine the velocity v_2 when it reaches the other side.



Part B

For the pivoted rod of length L and mass M, determine the distance x for which the angular velocity will be a maximum as the bar becomes vertical after being released in the horizontal position as shown. For the x determined, calculate the distance d at which the stop, A, must be placed so that when the bar impacts the stop the horizontal reaction at O is zero. Calculate also the impulse from the stop assuming that the bar bounces elastically after impacting A.



Problem 4

The rectangular steel plate of mass 120 kg is welded to the shaft with its plane tilted 35^o from the $(y - z)$ plane normal to the shaft axis. The shaft and plane are rotating about the fixed x-axis at a rate $\omega = 100$ rev/min. Determine the angular momentum $\boldsymbol{H}_O$ of the plate about O.