2.004: MODELING, DYNAMICS, & CONTROL II
Spring Term 2003

Experiment 4: Rockers: Rigid body dynamics II

Introduction:

In this experiment, we will examine another system that its dynamics contains both translation and rotation components. We will experiment on and model the kinematics of rockers with different geometry. One of the rockers is symmetric with respect to a plane through the center of mass while a second rocker is a more complex shape. Looking at both systems will allow us to look at system linearization around a particular equilibrium point.

Learning Goals:

(1) Model system dynamic containing both translation and rotation
(2) Examine "rolling without slipping" geometric constraint.
(3) Linearize around equilibrium point and model dynamics for small perturbation

Experimental procedures:

The experimental design is very simple and involves video recording of the motions of two aluminum rockers. The rockers are anodized black and you are provided with
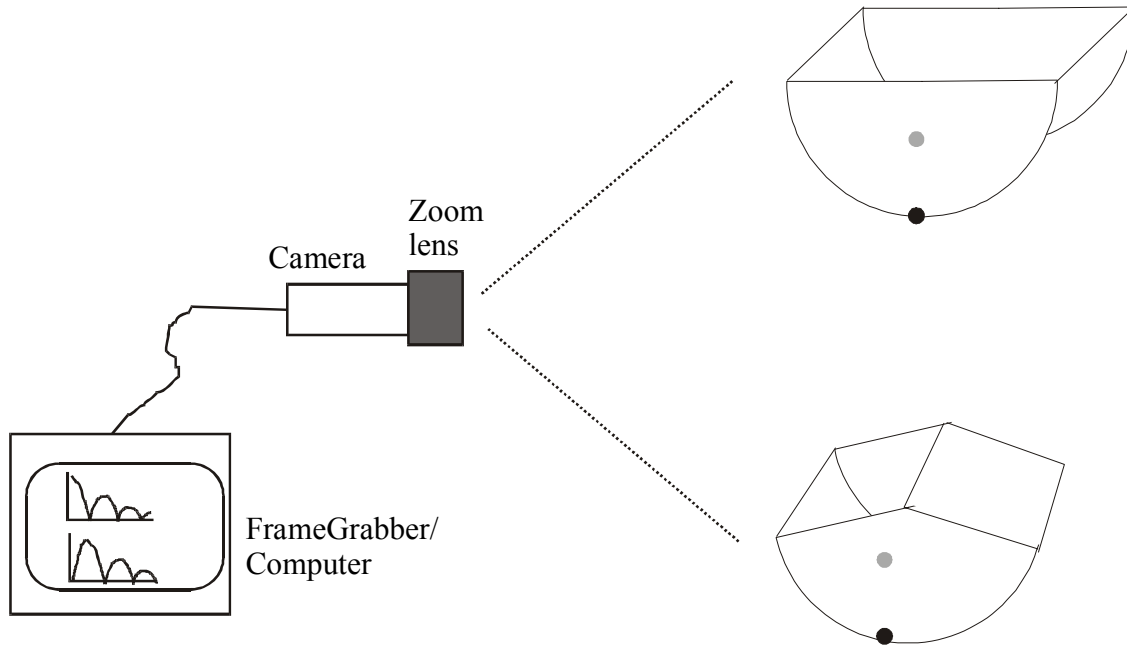
Task 1: We will first study of symmetric rocker. From your prelab exercise, you should be able to identify the center of mass for a rocker of this geometry. Place one visual marker at the center of mass. Also place a marker at the initial contact point between the rocker and the table.

Measure the motions of both markers for two initial angle of deflection. For small angle deflection, the rocker will be deflected by less than 10 degrees. For large angle deflection, the rocker will be deflected by 45 degrees.

Analyze the dynamics and kinematics for both deflection angles:

(a) Calculate the velocity $v_x(t)$, $v_y(t)$ and acceleration $a_x(t)$, $a_y(t)$ at the center of mass. Please compare with theory.
(b) Calculate the force at and the torque reference to the center of mass. Compare with theory.
(c) Calculate the force at and the torque reference to the contact point. Compare with theory.
(d) Deduce the natural frequency of the rocker and compare with experiment.

Task 2: Set up the second rocker in the view of the camera. Measure the motions of both markers again at high and low angle deflection. Repeat the experiment and analysis as in Task 1.

Report content:

(1) Record your results from both tasks.
(2) Please consider three additional questions related to this experiment.

   (a) Compare the deflection experiment at high and low angles. How well are these experiments conforming to theory? Why?
   (b) Is linear or angular momentum conserved in this system? Why?
   (c) There are constraint forces acting on the rigid body? Graphically present the constraint forces. Do these constraint forces relate to the gradual slow down of the rocker.