24-261 Statics, Fall 2001
Laboratory #5
Due: 1:30 PM, November 15, 2001

## GOALS

The purposes of this laboratory are to (1) have you work with a mechanism based on a four-bar linkage; (2) give you experience analyzing the kinematics (geometry) and statics of this mechanism.

## APPARATUS

The mechanism to be studied is page 3. You will apply a force to a cord, measure the force and motions of the members of the mechanism. The spring constant is 9.72 lb/in and the tension to initiate extension is 6.29 lb. (McMaster part 9654K159). You are to measure the lengths of parts as necessary.

## PROCEDURE

- Apply tension to the cord, maintaining the cord as close to perpendicular to the long lever as possible. The mechanism should cause the spring to stretch. For approximately 2? increments in the orientation of the long lever, perform and record the following measurements twice:
  - The angle of the long lever using the protractor (take the angle to be 0 when the lever is horizontal).
  - The length of the spring using the ruler (you may need to measure the movement of another body which is connected to the upper end of the spring, but which is fully visible).
  - The tension applied to the cord using the spring scale.

- Draw separately each of the members of the mechanism that move. Identify any members which are two-force members. Draw the free body diagrams of each member. By choosing the symbols for the forces carefully, you should make it clear which forces between bodies are equal and opposite pairs. Presume in your analysis that the friction between sliding surfaces can be neglected.

## RESULTS

(i) Present all the raw data in a spreadsheet, with columns labeled, along with averages.

(ii) Using averages, plot the length of the spring as a function of the long lever angle.

(iii) Given the lengths of the members, their initial orientations and the initial length of the spring, use geometry to predict the length of the spring for three values of the long lever angle. The three values of the long lever angle should include the initial angle, the final angle and some angle approximately midway between those angles. **Clearly derive the necessary equations, defining variables and showing all your steps.** You should make use of the analysis in the homework problem dealing with the four-bar linkage. Indicate the three predictions with large dots on the same plot as (i).

(iv) Using the averages, plot the tension applied to the cord as a function of the long lever angle. (The value of tension for the initial long lever angle should be the tension to first cause motion of the mechanism.)

(v) Carry out a statics analysis of each of the members of the mechanism. Free body diagrams of the major parts must be drawn. This analysis will allow you to relate systematically the tension in the cord to the force in the spring. You will need to use both the initial spring tension and the spring constant. Finally, you can use the geometric analysis of part (iii) to relate the tension in the cord to the angle of the long lever. **Show these calculations steps clearly.** You should not expect to find a single relation between the tension and the angle. Rather you will have a series of relations, and a procedure for using the various relations. There are likely to be intermediate results, but in the end, you should have values for angle and values for the corresponding tension. Plot this prediction of tension versus long lever angle for the same three angles as above as large dots on the same plot as (iv).

# Experimental Set Up for Laboratory 5