Design Project #2

Kinematics of a Linkage System

Due: Friday March 12, 2021 uploaded to Blackboard by 11:59pm

Introduction: The purpose of this design project is to give you an opportunity to compute the displacements, velocities, accelerations, of a linkage system. In subsequent projects, you will compute the forces for the system based on given specifications. For this project you will use concepts you have learned in classes (specifically linkage kinematics and position dynamics).

Project Description: Figure 1 shows a schematic of a folding umbrella. The modern folding umbrella is constructed of a linkage system designed to deploy a canopy used to protect against rain or sunlight; the mechanism allows the folded umbrella to be more compact than would be possible with a simpler folding mechanism. Figure 2 shows an umbrella with the membrane cover removed to reveal the mechanisms employed to deploy the membrane. The umbrella is brought from a closed to an open position by moving the slider upward. A schematic of a similar mechanism is illustrated in Figure 3. The slider can move upward with respect to the sliding shaft to move other links of the umbrella upward and outward during use.

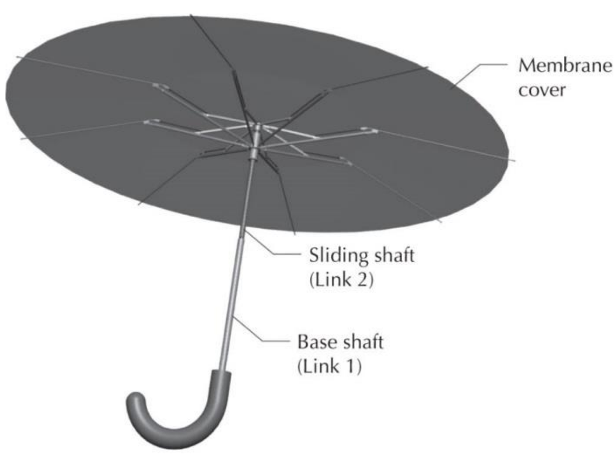

Figure 1: An umbrella device.

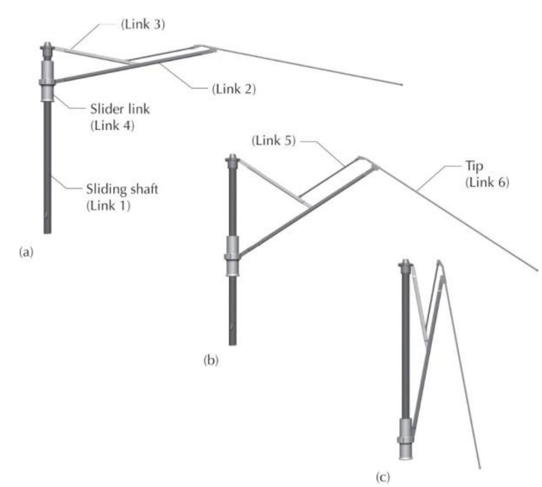

Figure 2: Single linkage of umbrella from fully open to closed: (a) Fully open, (b) partially open (c) fully closed.

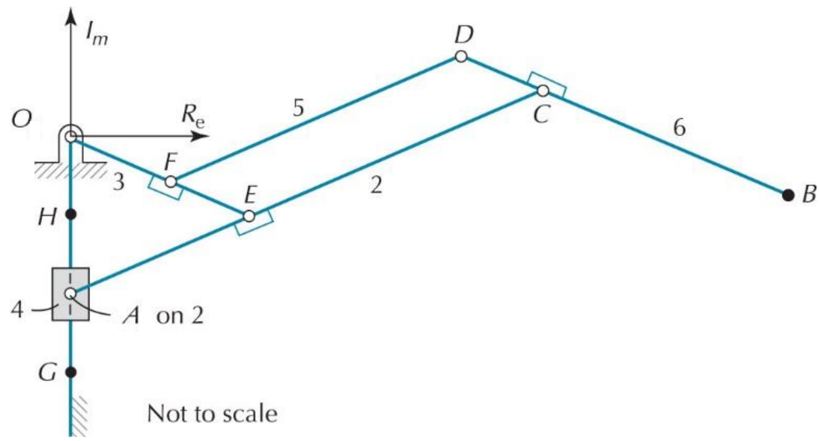

Figure 3: Mechanism used in a folding umbrella

This mechanism is composed of a slider, A, that rides on vertical shaft GAHO. There are four bars: AEC, OFE, DCB, and DF. To start with, use the following lengths:

$$r_{AE} = 16.0\ cm$$
$$r_{AC} = 29.0\ cm$$
$$r_{OF} = 13.0\ cm$$
$$r_{OE} = 16.0\ cm$$
$$r_{DC} = 3.0\ cm$$
$$r_{DB} = 35.0\ cm$$
$$r_{DF} = 13.0\ cm$$

Even though some of the dimensions are the same, you should not expect this to always be the case. You can determine the coordinates of the points of each link as a function of the position of A, which is given as a function of time by:

$$x_A = 0$$
$$y_A = -17.5 - 12.5\cos\left(\frac{\pi t}{\tau}\right) cm$$

where the opening time is $\tau = 2.0\ s$.

Once the positions are found, the velocity and acceleration can be found. (Note: you do not need to use vector loop to solve this system, position dynamics will work as well.)

Laboratory #2 Report Requirements:

Generate a maximum 5 - 8 page write up that contains at least the following:

1. A short introduction to the project (a paragraph is sufficient).
2. An analytical procedure that describes what you did for the solution to the problem.
3. Plots containing:
    a. Trajectory at each joint
    b. Velocity at each joint versus time
    c. Acceleration of each joint versus time

   Make sure the plot is properly labeled (x-axis label, y-axis label, title, and grid).
4. A discussion of your plots: what the various plots show, any observations you have (such as, "The maximum point is at…"), along with how this plot can be utilized by a design engineer (such as "by reading this plot we can see that the trajectory of position B is… because…" or "we can use this plot to understand…")

Project Grading Rubric Guideline

INTRODUCTION (15%)

- Describe the problem that is being studied
- Explain the importance and relevance of the problem
- Must have properly listed citations

ANALYTICAL PROCEDURE (20%)

- Explain steps taken and pertinent equations used to solve the problem (with description of what variables mean)
  - Definition of the problem (include a figure)
  - State the givens
  - Make the appropriate assumptions
  - Explain mathematical models that will be used in the solution
  - Develop a procedure for analysis of the problem
  - Brief explanation of anticipated results

RESULTS (20%)

- Copies of all asked for plots

INTERPRETATION (25%)

- Descriptions of the significant results in the plots
- Engineering observations about utilization of plots

CODE LISTING (10%)

FORMATTING AND CORRECT CITATIONS (10%)

Common mistakes that cost points:

- Project is turned in late
- Incorrect Calculations
- Figures not labeled (with legends if necessary)
- No references
- Incorrect, poorly formatted, or misleading tables and charts
- Grammar mistakes
- Irrelevant results
- Repetition