MAE 292 Spring 2020 Homework 4

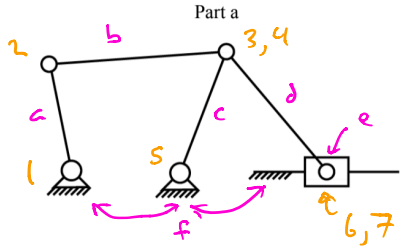
Due on May 14, 2020, at 11:59 PM

Problem 1: Analyze the mobility of following mechanisms (20 points)

joints = 1, 2, 3...
links = a, b, c...

$m = 3(l-1) - 2j$

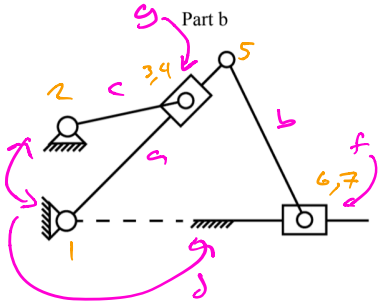
Part a



$m = 3\cdot(6-1) - 2\cdot 7$

$\boxed{m = 1}$

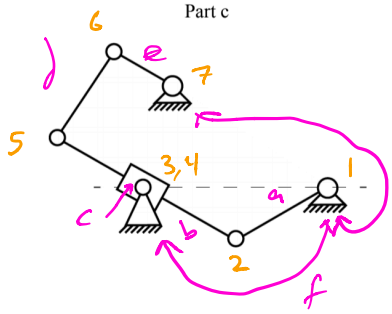
Part b



$m = 3\cdot(6-1) - 2\cdot 7$

$\boxed{m = 1}$

Part c

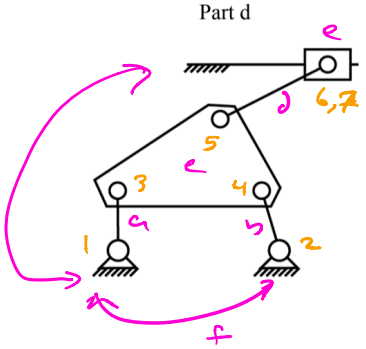


$m = 3\cdot(6-1) - 2\cdot 7$

$= 15 - 14$

$\boxed{m = 1}$

Part d



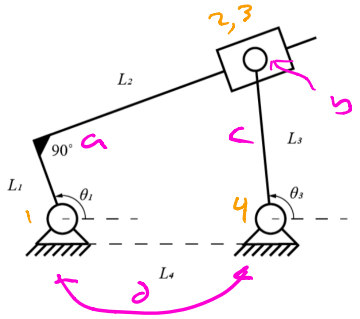
$m = 3\cdot(6-1) - 2\cdot 7$

$= 15 - 14$

$\boxed{m = 1}$

Problem 2: Mechanism modeling in matlab (40 points)
Consider the following mechanism. The link lengths are given in the table

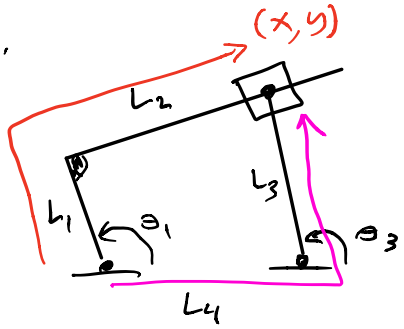
L1	L2	L3	L4
4	Variable	[1, 2, 3, 4, 5]	10



a. How many joints and links are there? Compute the mobility of the mechanism.
b. Write out the loop-closure constraint equation for this system, f(x) = 0.
c. Implement a matlab function that returns f(x).
d. Use fsolve and the constraint equation to solve for the mechanism configuration with θ_3 as the input.
e. Compute the value of θ_1 for $\theta_3 = [0:0.1:2\pi]$ for L3 = [1:5] and plot θ_1 versus θ_3 for all L3 lengths in one plot.
f. Estimate numerically the max and min values of θ_1 for each L3. Plot max(θ_1) and min(θ_1) verse L3.
g. **Extra credit:** solve by hand the maximum and minimum values of θ_1 for the range of L3 given in part f. Plot the exact solution with the estimated data.

a. 4 joints and 4 links. $m = 1$

b.



$$\begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} \cos\theta_1 & -\sin\theta_1 \\ \sin\theta_1 & \cos\theta_1 \end{bmatrix} \begin{bmatrix} L_1 \\ -L_2 \end{bmatrix}$$

$$\begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} \cos\theta_3 & -\sin\theta_3 \\ \sin\theta_3 & \cos\theta_3 \end{bmatrix} \begin{bmatrix} L_3 \\ 0 \end{bmatrix} + \begin{bmatrix} L_4 \\ 0 \end{bmatrix}$$

$$\begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} x \\ y \end{bmatrix}$$

$$\begin{bmatrix} x \\ y \end{bmatrix} - \begin{bmatrix} x \\ y \end{bmatrix} = 0$$

$$L_1\cos\theta_1 + L_2\sin\theta_1 - L_3\cos\theta + L_4 = 0$$

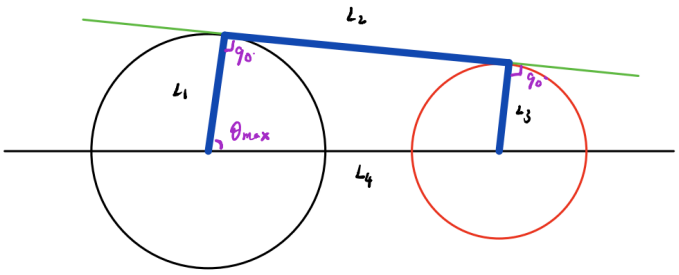
$$L_1\sin\theta_1 - L_2\cos\theta_1 + L_3\sin\theta_3 = 0$$

c - f. See r files

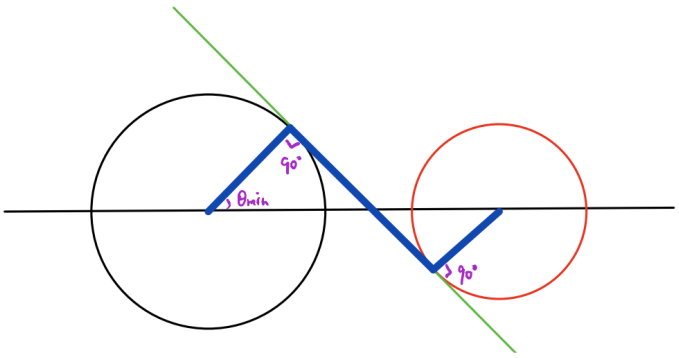
g. $L_3 = [1 \; -5]$ $L_1 = 4$

θ_1 is max when L_3 is $\perp$ to L_2

This happens when



$$\theta_{max} = \cos\left(\frac{L_1 - L_3}{L_4}\right)$$

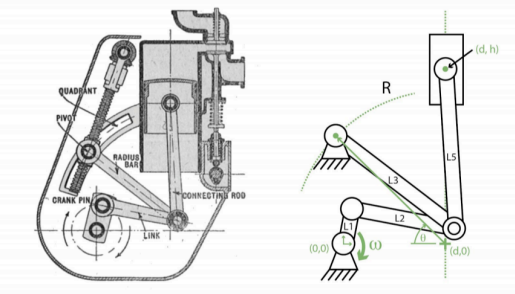


$$\theta_{min} = \cos\left(\frac{L_1 + L_3}{L_4}\right)$$

Problem 3: CAD and Simscape multibody (40 points)

Part 1: A variable stroke engine is shown to the left below and a schematic of the system is shown to the right below. Using the following parameters (dimensions are all in inches) construct a model of this system using simscape multibody or fsolve in matlab.

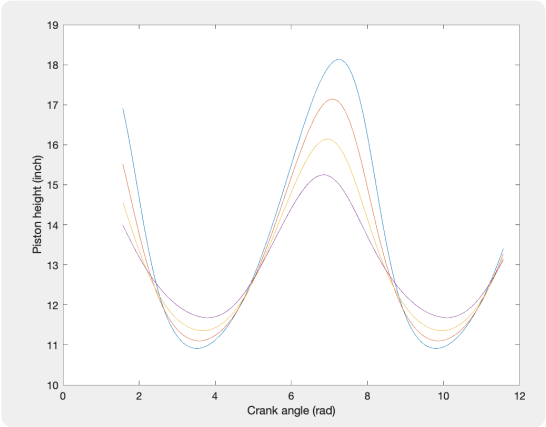
L1	L2	L3	R	L5	d	θ (deg.)
3	7	9	12.5	10	7	[35 - 70]

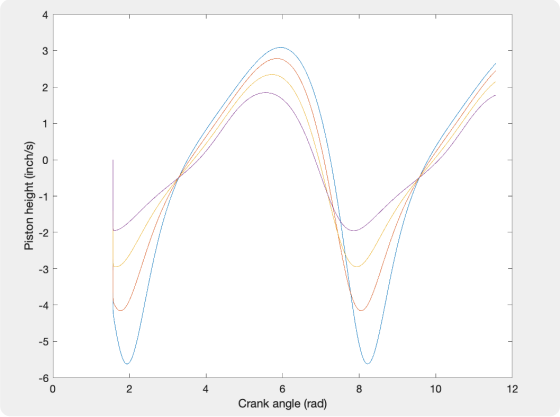


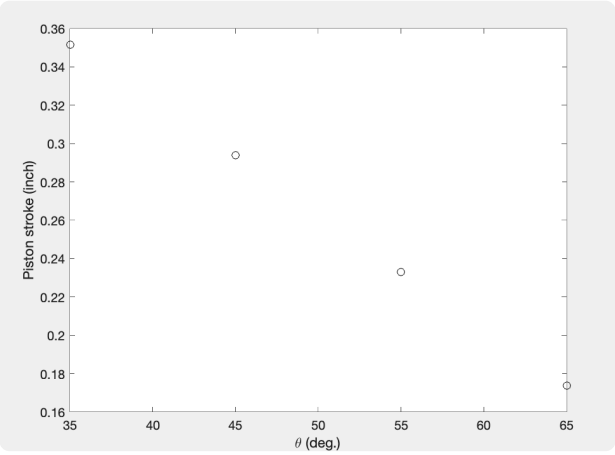
1. Plot the relationship between input angle and piston height for a range of stroke adjustment angles (θ), choose a reasonable range.

2. Plot the vertical speed of the piston as a function of time, for a constant input angular speed $\omega = 1$.

3. Plot the total stroke length of the piston (max(h) - min(h)) as a function of θ.






Piston stroke (inch)
0.36
0.34
0.32
0.3
0.28
0.26
0.24
0.22
0.2
0.18
0.16
35
40
45
50
55
60
65
θ (deg.)