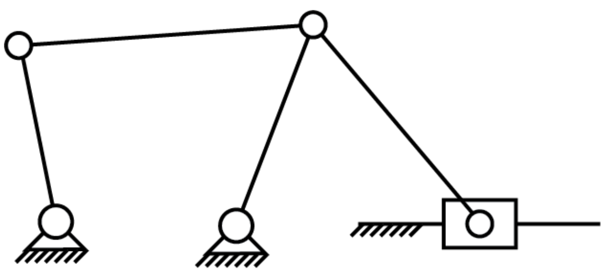
MAE 292 Spring 2020 Homework 4

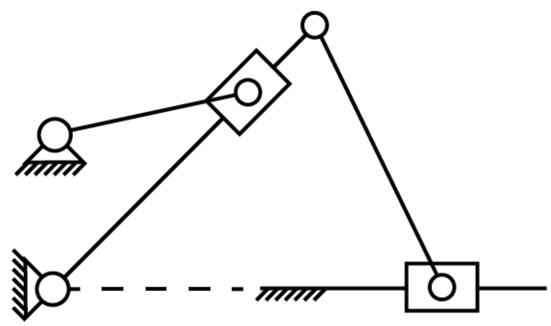
Due on May 14, 2020, at 11:59 PM

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

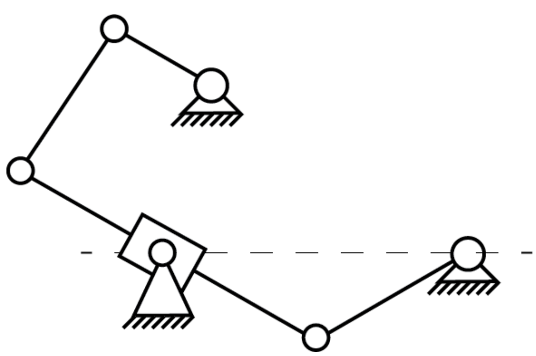
Part a



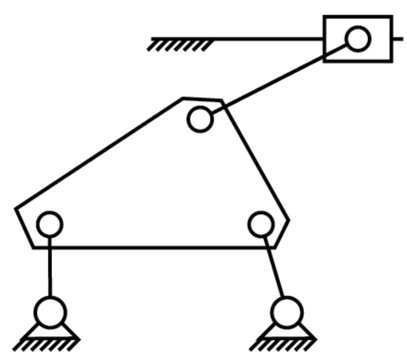
Part b



Part c

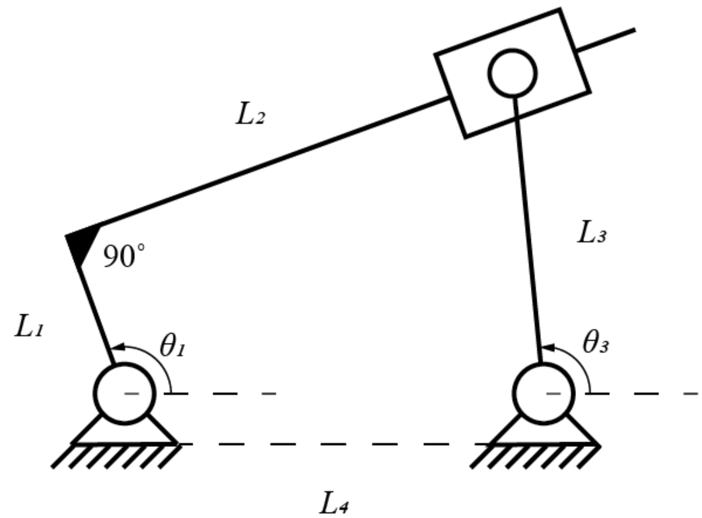


Part d



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

L_1	L_2	L_3	L_4
4	Variable	[1, 2, 3, 4, 5]	10

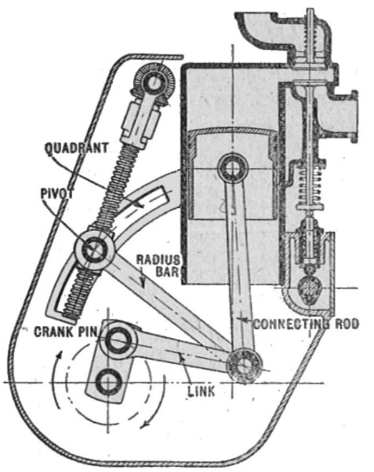


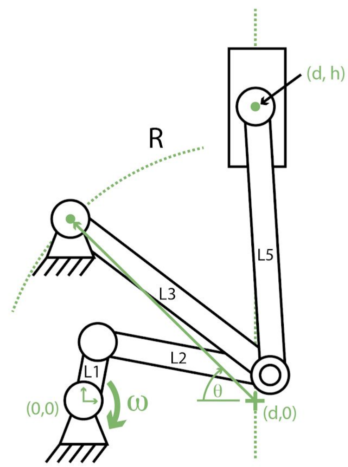
a. How many joints and links are there? Compute the mobility of the mechanism.
b. Write out the loop-closure constraint equation for this system, f(x) = 0.
c. Implement a matlab function that returns f(x).
d. Use fsolve and the constraint equation to solve for the mechanism configuration with θ_3 as the input.
e. Compute the value of θ_1 for $\theta_3 = [0:0.1:2\pi]$ for $L_3 = [1:5]$ and plot θ_1 versus θ_3 for all L_3 lengths in one plot.
f. Estimate numerically the max and min values of θ_1 for each L_3. Plot max(θ_1) and min(θ_1) verse L_3.
g. **Extra credit:** solve by hand the maximum and minimum values of θ_1 for the range of L_3 given in part f. Plot the exact solution with the estimated data.

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.

L_1	L_2	L_3	R	L5	d	θ (deg.)
3	7	9	12.5	10	7	[35 - 70]



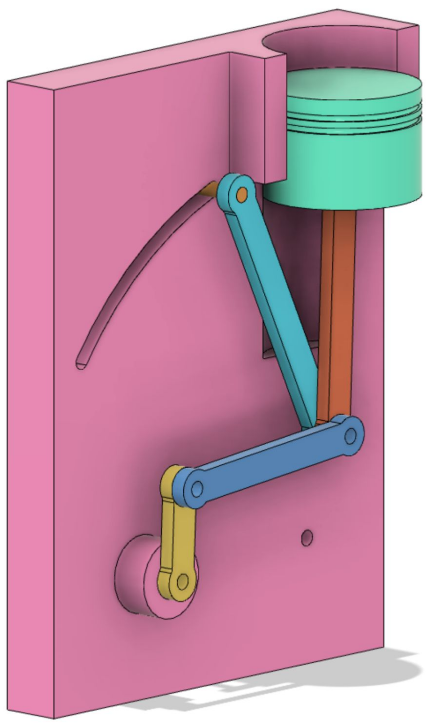


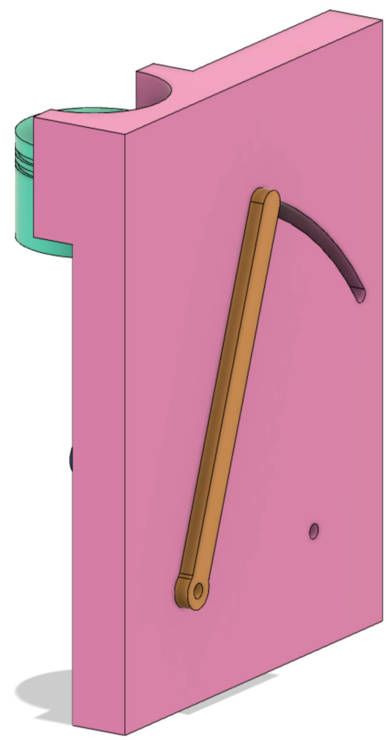
1. Plot the relationship between input angle and piston height for a range of stroke adjustment angles (θ), choose a reasonable range.

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.

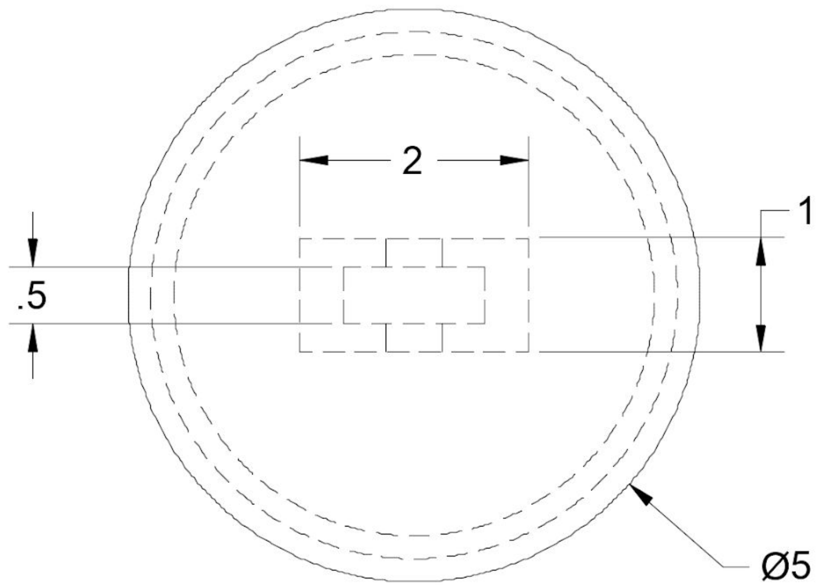
Part 2: Create a CAD model of the engine assembly. There are 7 components in the assembly, 4 links, 1 piston, one stroke adjuster, and the frame. The assembly is shown below and the dimensioned components are given after. Use revolute joint constraints for all rotation joints, and use a slider joint for the piston in the chamber. Constrain the joint limits of the shaft adjuster so that the pin remains in the slot. You will have to lock the joint of the shaft adjuster angle (the joint shown on the bottom right) to make the assembly be 1-DOF.
(Example of finished assembly https://a360.co/35HFnAj)

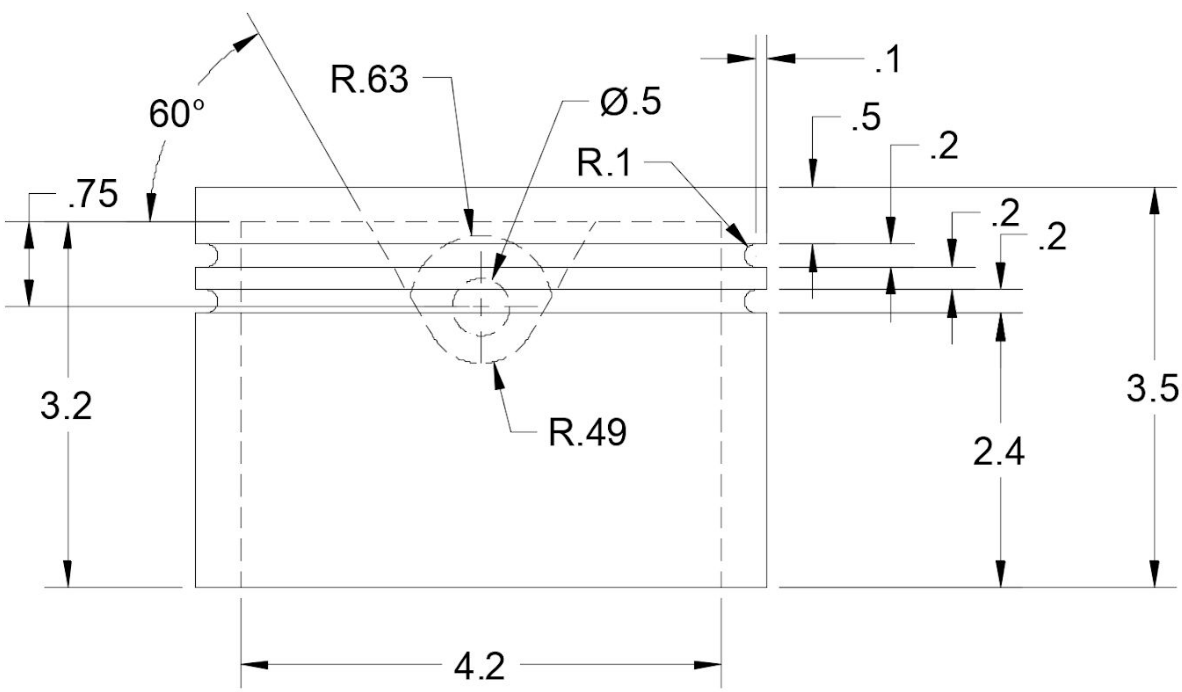




Piston

I had to add a couple dimensions to the depth of the piston cavity, and the location of the o-ring seals running around the piston.

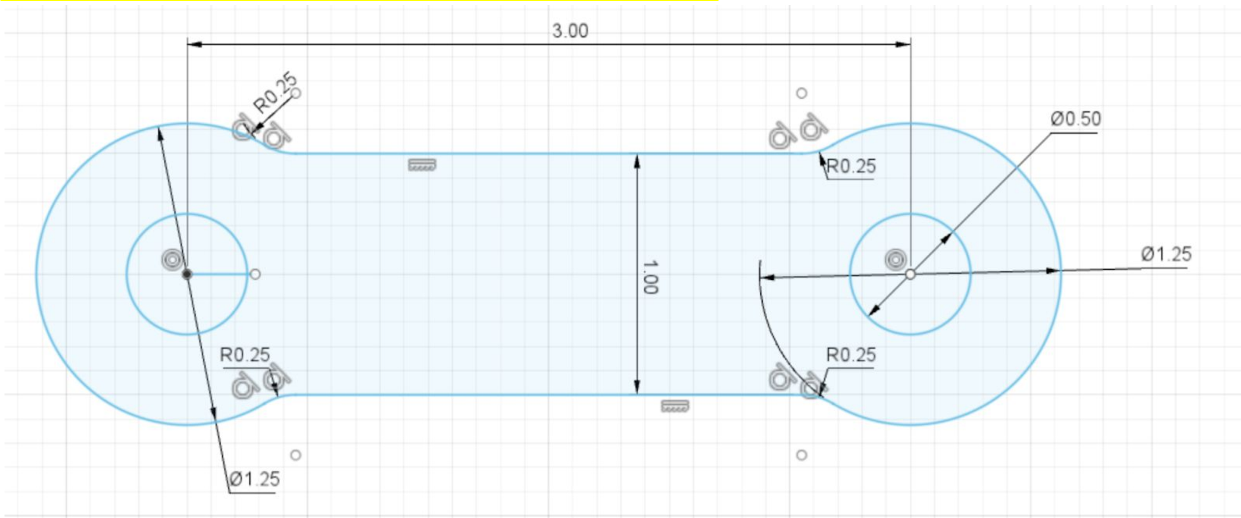




Links and stroke adjuster

All links have the same shape at the ends with the pinhole to pinhole length given in the table above. All links are 0.5” thickness. The stroke adjuster has a 0.5” diameter pin extending from one end a distance of 3.25”.

Note: I have added a missing dimension, the width of the link is 1” shown in the dimension below. As noted in the above description all links are extruded 0.5” in thickness. The 1.25” rounded ends and the 0.5” through-holes are concentric.



Chamber