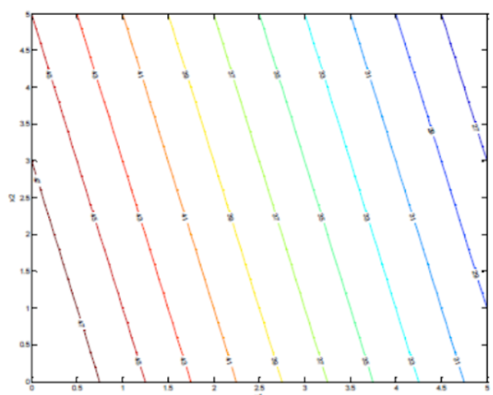
NC STATE UNIVERSITY

MAE-208, Section 204
Engineering Dynamics
Project 2 Written in Matlab
(Individual submission)

Optimization of a Slider-Crank

Written By: Grady Fort
https://drive.google.com/drive/folders/1QuqTKF5MmFdNi7ZiElbpFE2_fJLLDHXw?usp=sharing



Date Report Submitted: March 3, 2022

1 Diagram

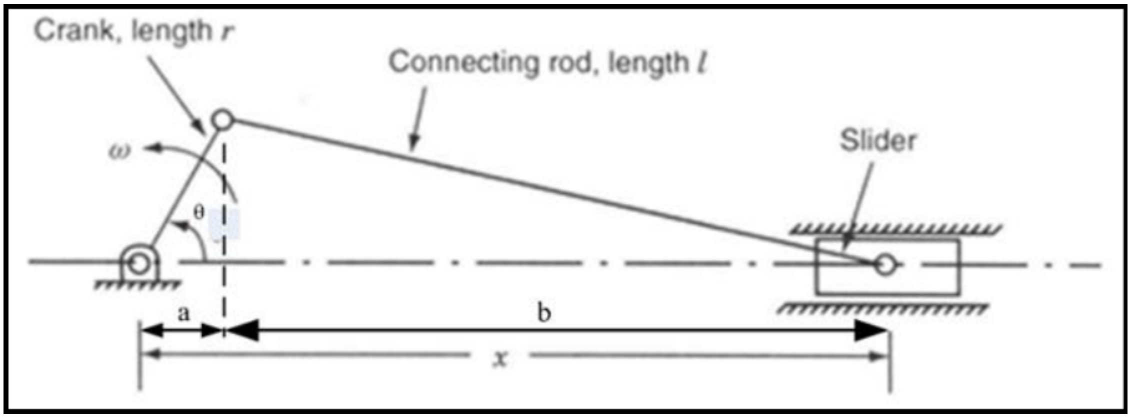


Figure 1: Diagram of the Crank Assembly From Handout

2 Calculating x

$$a = rcos(\theta) \tag{1}$$

$$L^2 = b^2 + (sin\theta(r))^2 \tag{2}$$

$$\begin{aligned} x &= a + b \\ &= rcos\theta + \sqrt{L^2 - (sin\theta(r))^2} \end{aligned} \tag{3}$$

3 Solving for L

$$L = \sqrt{(H - r * cos(\theta))^2 + (r * sin(\theta))^2} \tag{4}$$

4 Calculating v

$$\begin{aligned} v &= \frac{dx}{dt} \\ &= -r\omega\theta sin\theta - \frac{r^2\theta sin\theta cos\theta}{\sqrt{L^2-(sin\theta(r))^2}} \\ &= -r(70)sin(40) - \frac{r^2(40)sin(40)cos(40)}{\sqrt{L^2-(sin(40)(r))^2}} \end{aligned} \tag{5}$$

5 Constraints Calculations

Constrain Within Channel

$$\begin{aligned} 10 &\leq x \leq 20 \\ x &= \\ &= rcos\theta + \sqrt{L^2-(sin\theta(r))^2} \\ &= rcos(40) + \sqrt{L^2-(sin(40)(r))^2} \end{aligned} \tag{6}$$

$$LL = \sqrt{(10-r*cos(40))^2+(r*sin(40))^2} \tag{7}$$

$$LU = \sqrt{(20-r*cos(40))^2+(r*sin(40))^2} \tag{8}$$

6 Contour Plots

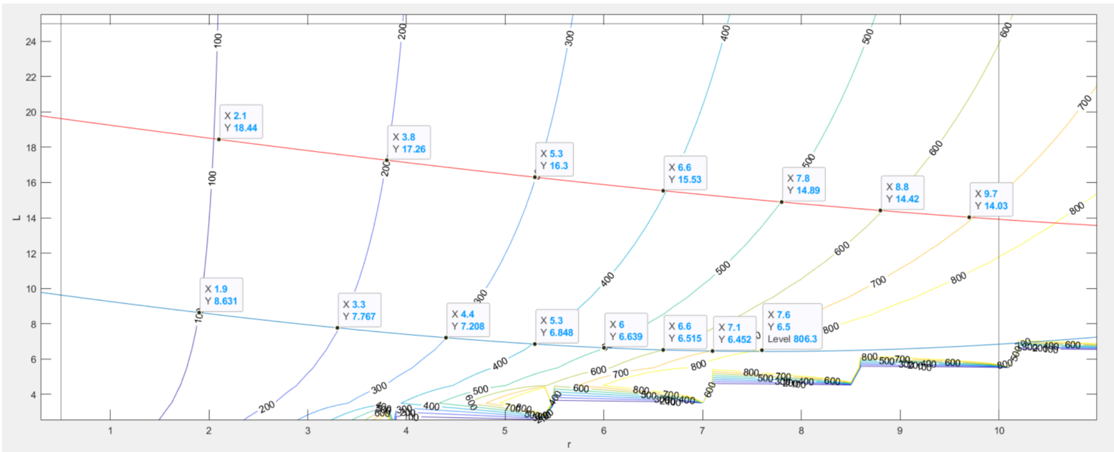


Figure 2: Contour plot showing slider speeds

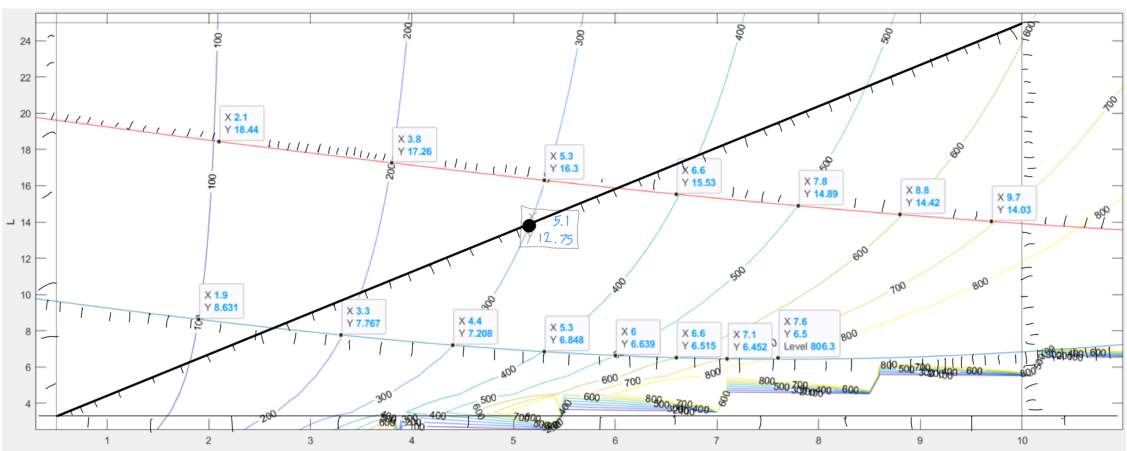


Figure 3: Contour plot with constraints and bounds

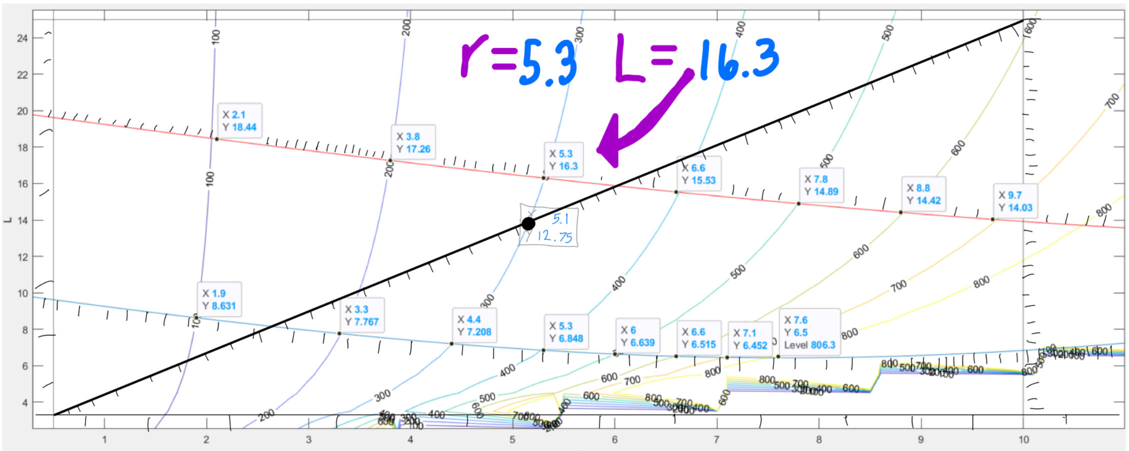


Figure 4: Contour plot with optimal solution identified

7 Calculated Triangle

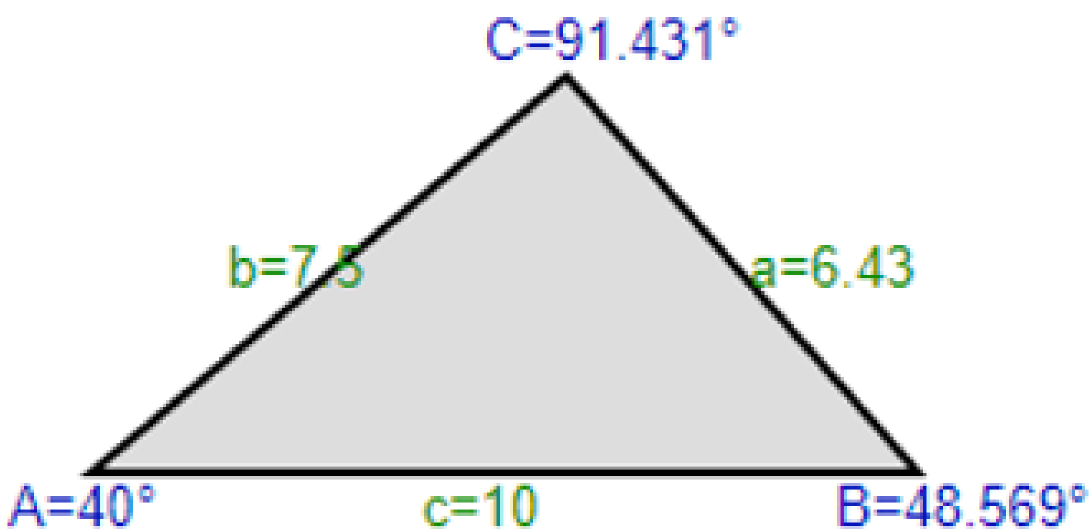


Figure 5: Triangle formed by r=5.3 and L=16.3

8 Justification

- Criteria

- The black line is the Groshof's criterion
- The blue line is the minimum (L) can be according to equation (7)
- The red line is the maximum that the connecting rod (r) can be according to equation (8)

- Constraints
  - The length of the crank (r) is constrained by $0.5 \leq r \leq 10$
    - defined by vertical lines
  - The length of the connecting rod (L) is constrained by $2.5 \leq L \leq 25$
    - defined by horizontal lines
- Optimization
  - The goal is to maximize the speed of the slider. Speed is the absolute value of velocity. Velocity was found to be equation (5) by deriving the position x of the slider. The speed is maximized when the length (r) is as large as possible within the feasible design space.
- Optimal Solution
  - r = 5.3 & L = 16.3

9 Appendix Matlab Code

```
% % 22-03-30-1745
% MAE 208 (004)
% Project-2-Individual-Crank_Grady_Fort.M
% 22-03-31
% Grady Fort
% gefort@ncsu.edu
% x steps
% old: .3:.1:11
% new: .5:.1:11
clc; clear; %%%%%%%%%%%%%%%%%%%%
% This code maximizes the speed of a slider crank system when \theta is 40 \degrees
% code based on contour_example.m written by Professor Scott Fergusson
%%%%%%%%%%%%%%%%%%%%
%%
```

```
% The meshgrid command returns a set of 2-D grid coordinates that become
% the foundation of the contour plot.
% [X,Y] = meshgrid(x,y)
% x, y represent the bounds on each variable for the plot
% format - lower bound : step size : upper bound
% use 'help meshgrid' for more
%[r,L] = meshgrid(.5:.1:11,2.5:1:26);
[r,L] = meshgrid(.3:.1:11,2.5:1:26);
%%
% This command determines how many rows and columns are in the design
% variable r.
% m is the number of rows
% n is the number of columns
[m,n] = size(r);
%%
% For each element of the 2-D grid, we evaluate the objective function
% Store it in F(row,column)
for i = 1:m
for j = 1:n
% F(i,j) = -((r(i,j))^2*theta*cos(theta)*sin(theta))/...
% sqrt((l(i,j))^2-r^2*sin(theta)^2)-omega*r(i,j)*theta*sin(theta);
f = -r(i,j)*70*sind(40) - (r(i,j)*sind(40).*r(i,j)*70*cosd(40))/...
(sqrt(L(i,j).^2 - (r(i,j)*sind(40)).^2));
if isreal(f)
F(i,j) = f;
end
end
end
%%
% Now, we can make the contour plot
% The 10 in the last element of the function tells it to plot that many
% different contour levels
%
% use 'help contour' for more information
% [c1,h1] = contour(r,l,F,10);
```

```
%%

% clabel puts contour labels on the graph

% xlabel labels the x-axis %%

% Now, lets say that we want to define specific contours to plot

% We will show the contours when F = [31, 35, 39, 43, 47]

z = [100 200 300 400 500 600 700 800];

figure

[c2,h2] = contour(r,L,abs(F),z);

clabel(c2,h2);

xlabel('r')

ylabel('L')
```