MEC 310 Project #2

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Abstract

The final design is a mechanism that can successfully move a cutting tool through the use of a cam and gear train, run along with a conveyer belt by a hand crank. Our design process contained several constraints. The design must be reasonably sized and compact while also being robust enough to tolerate the oscillatory motion of the knife and input from hand crank source. The conveyer belt, gear train and knife mechanism should also be connected to each other and function as a single mechanism with the knife moving fast enough such that the blade minimally impedes the food feed rate. The pressure angle of the cam should be within 0-30 degrees, with a 0 degree angle being the most desirable. The calculated pressure angle for the final design was 20.66°.

List of Figures/Tables

i. Problem Statement

1.1 The main objective of this project is to design a mechanism utilising a combination of cam, gear train, and or 4-bar mechanism components. The mechanism designed is a cutting board that cuts food at regular intervals. The food must travel along a conveyor belt run by a gear train that is connected to a knife, whose movement is also driven by the master gear train. The final design uses a cam follower to drive the blade. This allows for consistent cuts and can be adjusted depending on the speed of the input gear. The gear train is to have a 1:40 ratio from the crank input to an output on the cam which runs the knife. This means that for every rotation of the crank the knife will slice 40 times, creating thin slices of vegetables. In order to solve this problem one must have knowledge of cam and gear train design. Learning about the SVAJ equations to ensure a 'clean' motion is essential to create a well designed cam. In addition to that, ensuring that the ratio between the gears is reasonable is important to create this mechanism as it can't be too large or complicated for consumer use. The process we used to create this machine was to use MATLAB to calculate the SVAJ equations and the required gear information. Then we created a cad model of the final selected design that we found to be the best out of the three proposed designs.

ii. Design Iterations

2.1: Conceptual Design

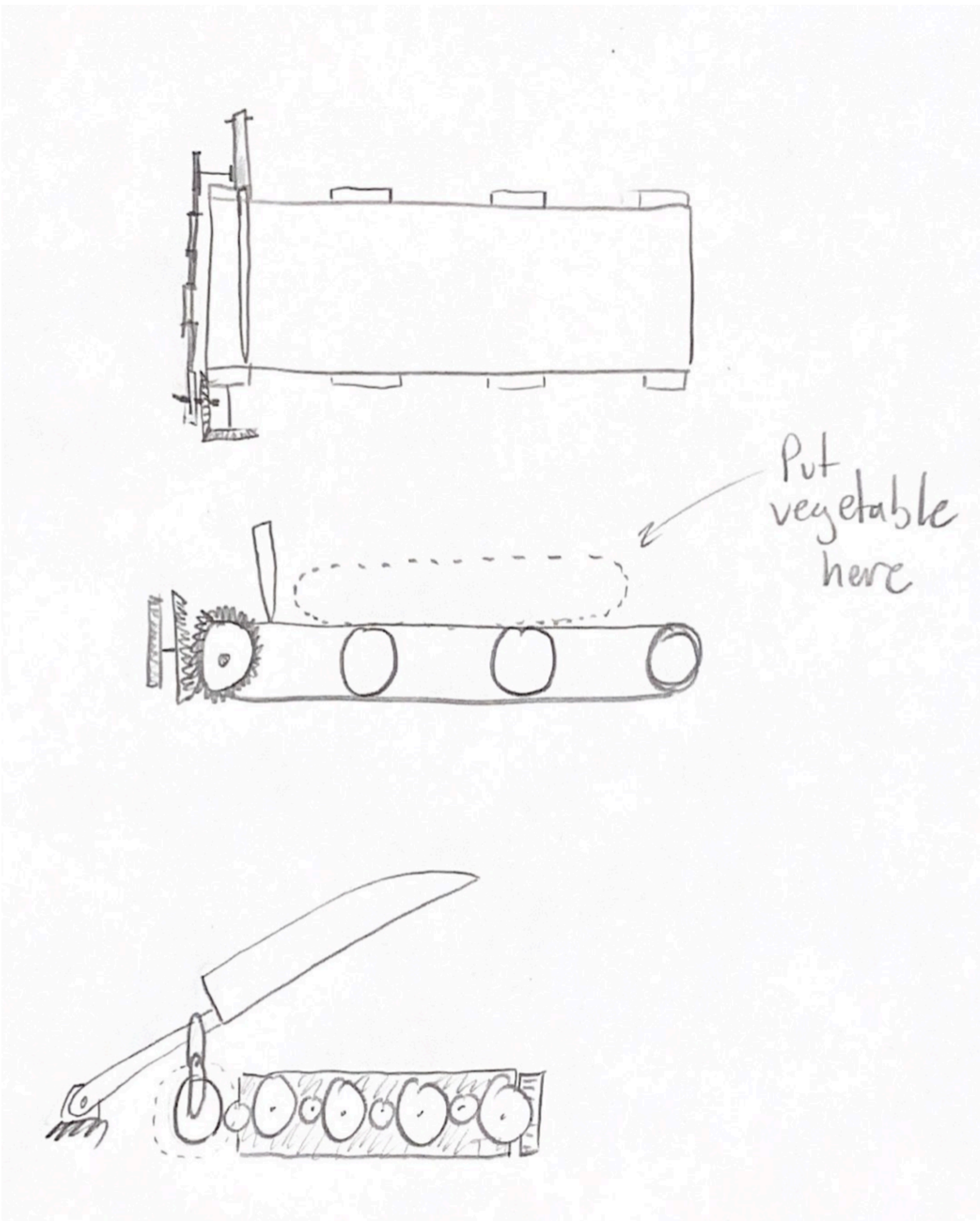
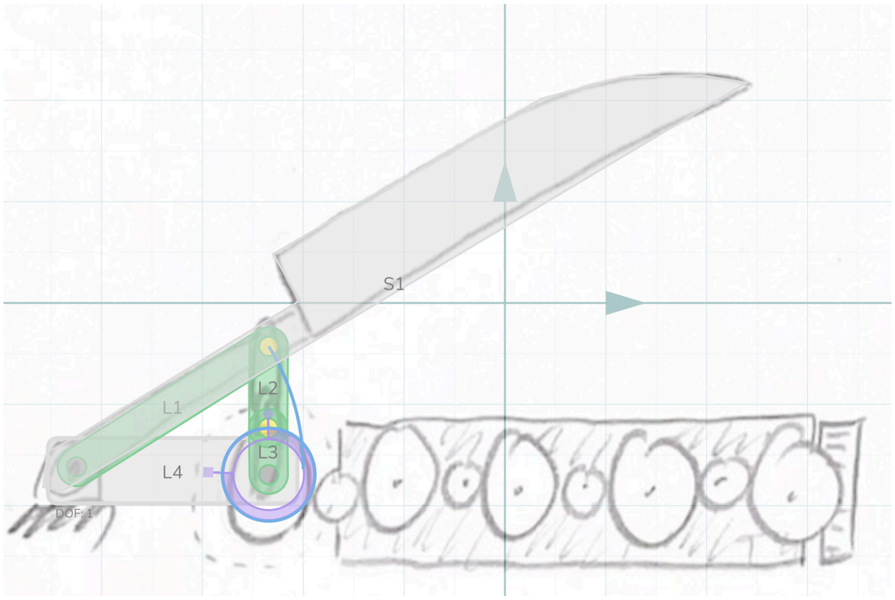


Figure 2.1.1

Design I



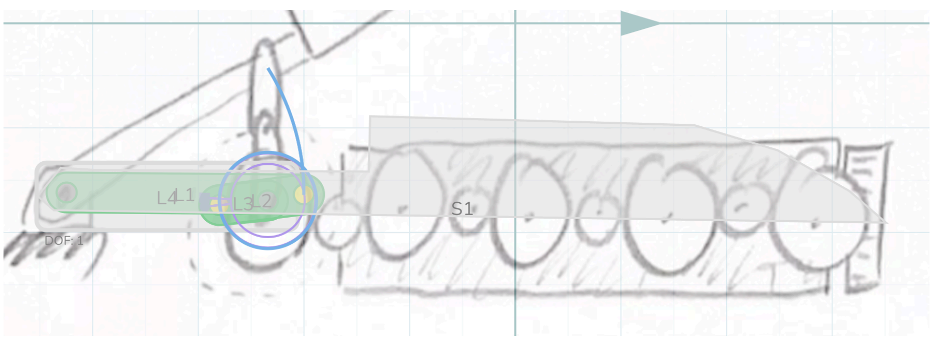


Figure 2.1.2
Design I

2.2: Soroush's Design

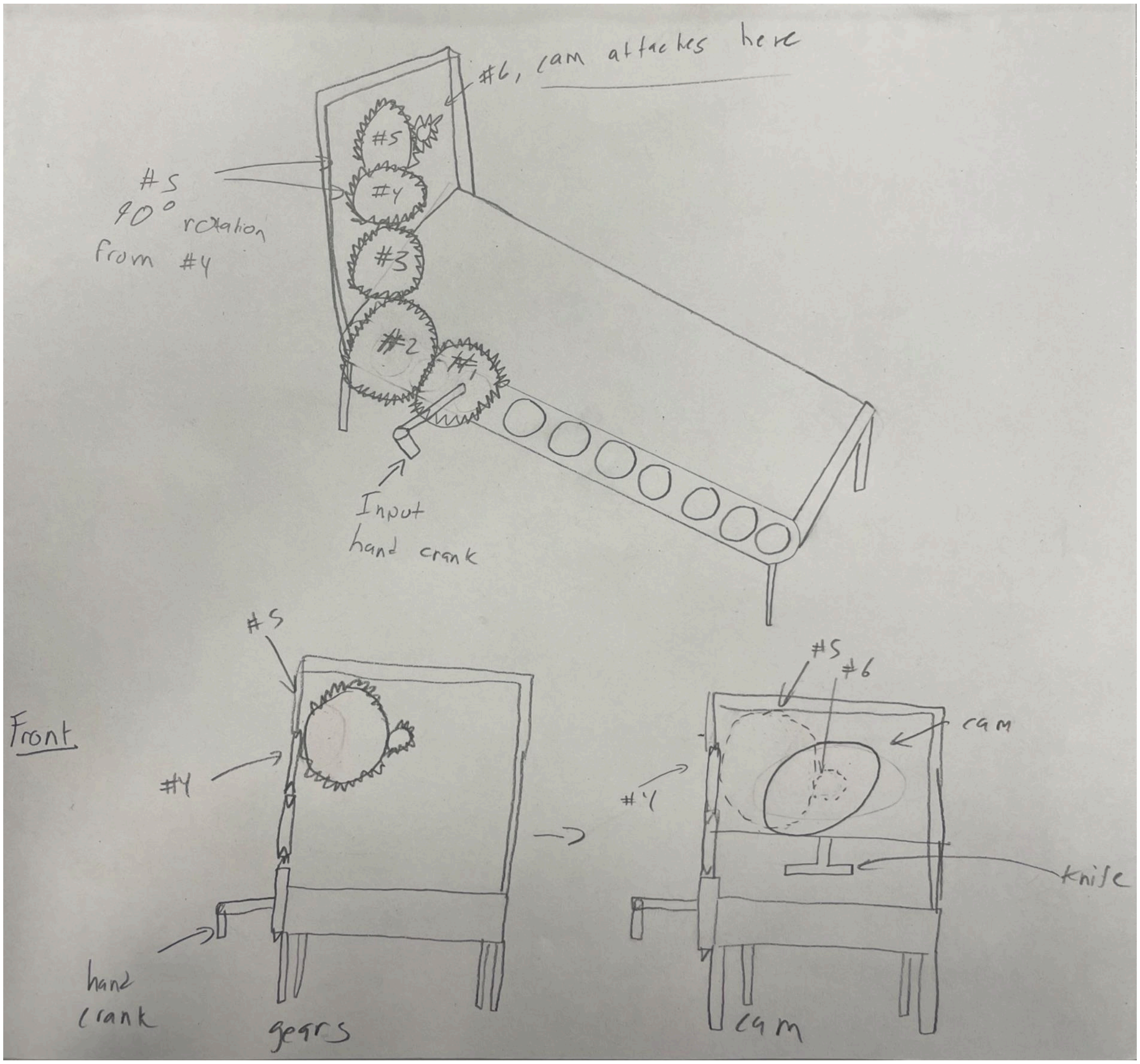
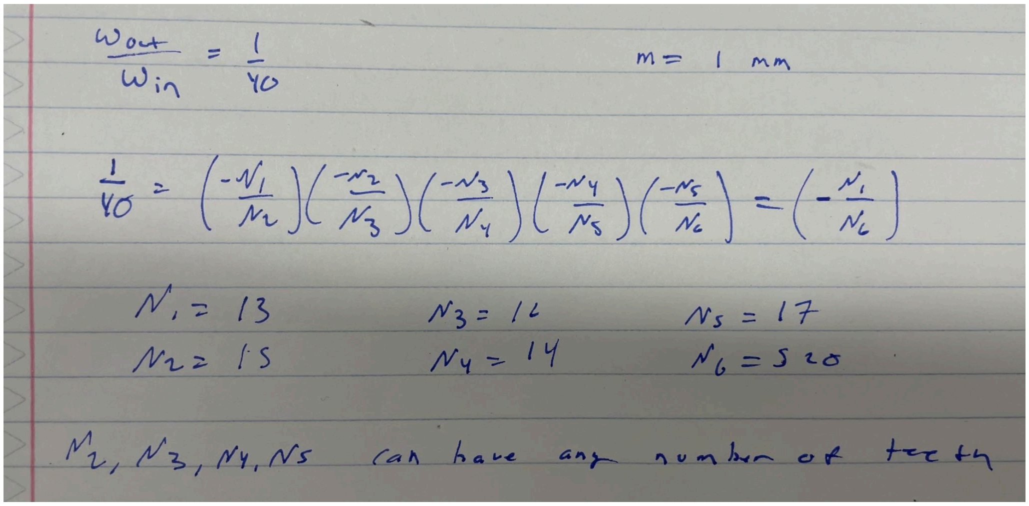


Figure 2.2.1
Soroush's Proposed Design



$$\frac{\omega_{out}}{\omega_{in}} = \frac{1}{40} \qquad m = 1\ \text{mm}$$

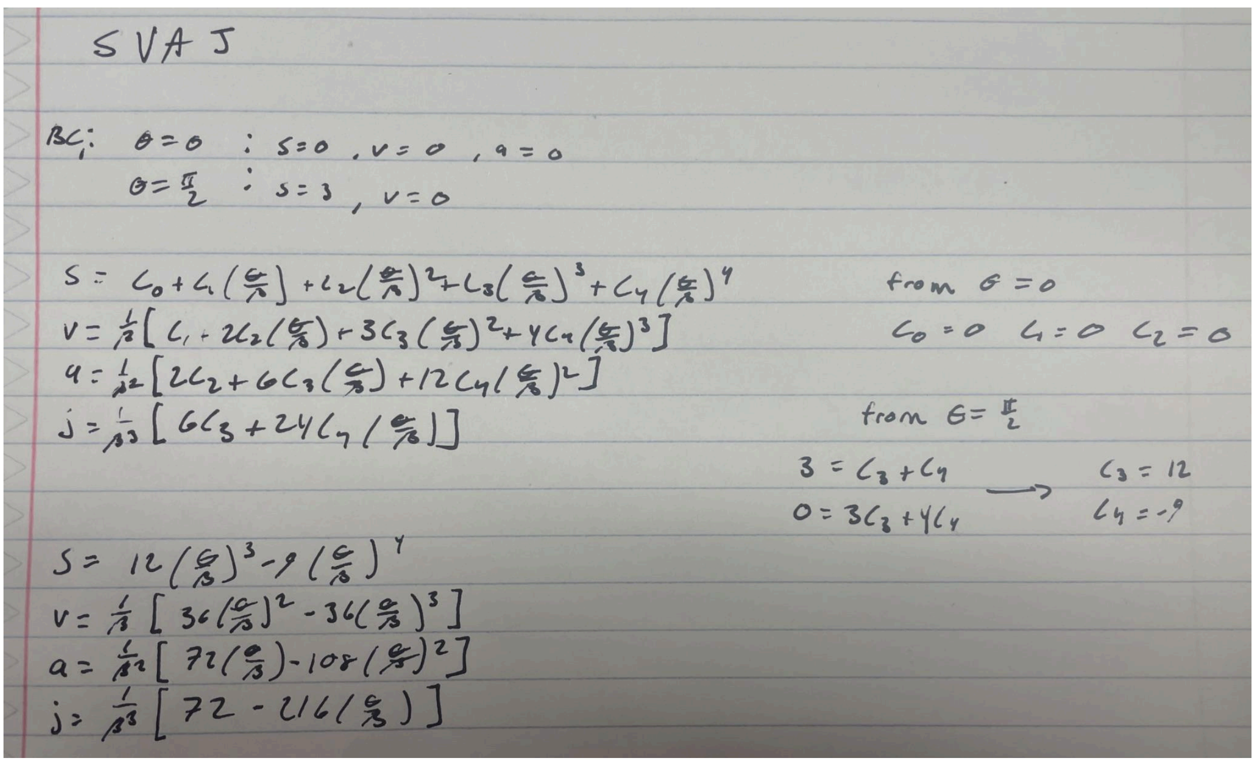
$$\frac{1}{40} = \left(\frac{-N_1}{N_2}\right)\left(\frac{-N_2}{N_3}\right)\left(\frac{-N_3}{N_4}\right)\left(\frac{-N_4}{N_5}\right)\left(\frac{-N_5}{N_6}\right) = \left(-\frac{N_1}{N_6}\right)$$

$N_1 = 13$ $\quad N_3 = 16$ $\quad N_5 = 17$

$N_2 = 15$ $\quad N_4 = 14$ $\quad N_6 = 520$

N_2, N_3, N_4, N_5 can have any number of teeth

Figure 2.2.2
Gear Train Ratio Calculation



SVAJ

BC: $\theta = 0$: $s = 0$, $v = 0$, $a = 0$

$\theta = \frac{\pi}{2}$: $s = 3$, $v = 0$

$$s = C_0 + C_1\left(\frac{\theta}{\beta}\right) + C_2\left(\frac{\theta}{\beta}\right)^2 + C_3\left(\frac{\theta}{\beta}\right)^3 + C_4\left(\frac{\theta}{\beta}\right)^4$$

$$v = \frac{1}{\beta}\left[C_1 + 2C_2\left(\frac{\theta}{\beta}\right) + 3C_3\left(\frac{\theta}{\beta}\right)^2 + 4C_4\left(\frac{\theta}{\beta}\right)^3\right]$$

$$a = \frac{1}{\beta^2}\left[2C_2 + 6C_3\left(\frac{\theta}{\beta}\right) + 12C_4\left(\frac{\theta}{\beta}\right)^2\right]$$

$$j = \frac{1}{\beta^3}\left[6C_3 + 24C_4\left(\frac{\theta}{\beta}\right)\right]$$

from $\theta = 0$

$C_0 = 0$ $\quad C_1 = 0$ $\quad C_2 = 0$

from $\theta = \frac{\pi}{2}$

$3 = C_3 + C_4$

$0 = 3C_3 + 4C_4$ $\longrightarrow$ $C_3 = 12$, $C_4 = -9$

$$s = 12\left(\frac{\theta}{\beta}\right)^3 - 9\left(\frac{\theta}{\beta}\right)^4$$

$$v = \frac{1}{\beta}\left[36\left(\frac{\theta}{\beta}\right)^2 - 36\left(\frac{\theta}{\beta}\right)^3\right]$$

$$a = \frac{1}{\beta^2}\left[72\left(\frac{\theta}{\beta}\right) - 108\left(\frac{\theta}{\beta}\right)^2\right]$$

$$j = \frac{1}{\beta^3}\left[72 - 216\left(\frac{\theta}{\beta}\right)\right]$$

Figure 2.2.3
Cam Equations: Segment I

SVAJ

$$\beta = \frac{\pi}{2}$$

BC: $\theta = \frac{\pi}{2}$: $s = 3$, $v = 0$, $a = -14.59$

$\theta = \pi$: $s = 0$, $v = 0$, $a = 0$

$$s = C_0 + C_1\left(\frac{\theta}{\beta}\right) + C_2\left(\frac{\theta}{\beta}\right)^2 + C_3\left(\frac{\theta}{\beta}\right)^3 + C_4\left(\frac{\theta}{\beta}\right)^4 + C_5\left(\frac{\theta}{\beta}\right)^5$$

$$v = \frac{1}{\beta}\left[C_1 + 2C_2\left(\frac{\theta}{\beta}\right) + 3C_3\left(\frac{\theta}{\beta}\right)^2 + 4C_4\left(\frac{\theta}{\beta}\right)^3 + 5C_5\left(\frac{\theta}{\beta}\right)^4\right]$$

$$a = \frac{1}{\beta^2}\left[2C_2 + 6C_3\left(\frac{\theta}{\beta}\right) + 12C_4\left(\frac{\theta}{\beta}\right)^2 + 20C_5\left(\frac{\theta}{\beta}\right)^3\right]$$

$$j = \frac{1}{\beta^3}\left[6C_3 + 24C_4\left(\frac{\theta}{\beta}\right) + 60C_5\left(\frac{\theta}{\beta}\right)^2\right]$$

when $\theta = \pi \longrightarrow C_0 = 0 \quad C_1 = 0 \quad C_2 = 0$

when $\theta = \pi/2$

$3 = C_3 + C_4 + C_5 \longrightarrow C_3 = 22.7$

$0 = 3C_3 + 4C_4 + 5C_5 \longrightarrow C_4 = -30.4$

$-14.59 = 6C_3 + 12C_4 + 20C_5 \longrightarrow C_5 = 10.7$

$S =$

$$V = \frac{1}{\beta}\left[22.7\left(\frac{\theta}{\beta}\right)^3 - 30.4\left(\frac{\theta}{\beta}\right)^4 + 10.7\left(\frac{\theta}{\beta}\right)^5\right]$$

$$a = \frac{1}{\beta^2}\left[68.1\left(\frac{\theta}{\beta}\right)^2 - 121.6\left(\frac{\theta}{\beta}\right)^3 + 53.5\left(\frac{\theta}{\beta}\right)^2\right]$$

$$j = \frac{1}{\beta^3}\left[136.2\left(\frac{\theta}{\beta}\right) - 364.8\left(\frac{\theta}{\beta}\right)^2 + 214\left(\frac{\theta}{\beta}\right)^3\right]$$

Figure 2.2.4
Cam Equations: Segment II

2.3: Alexander's Design

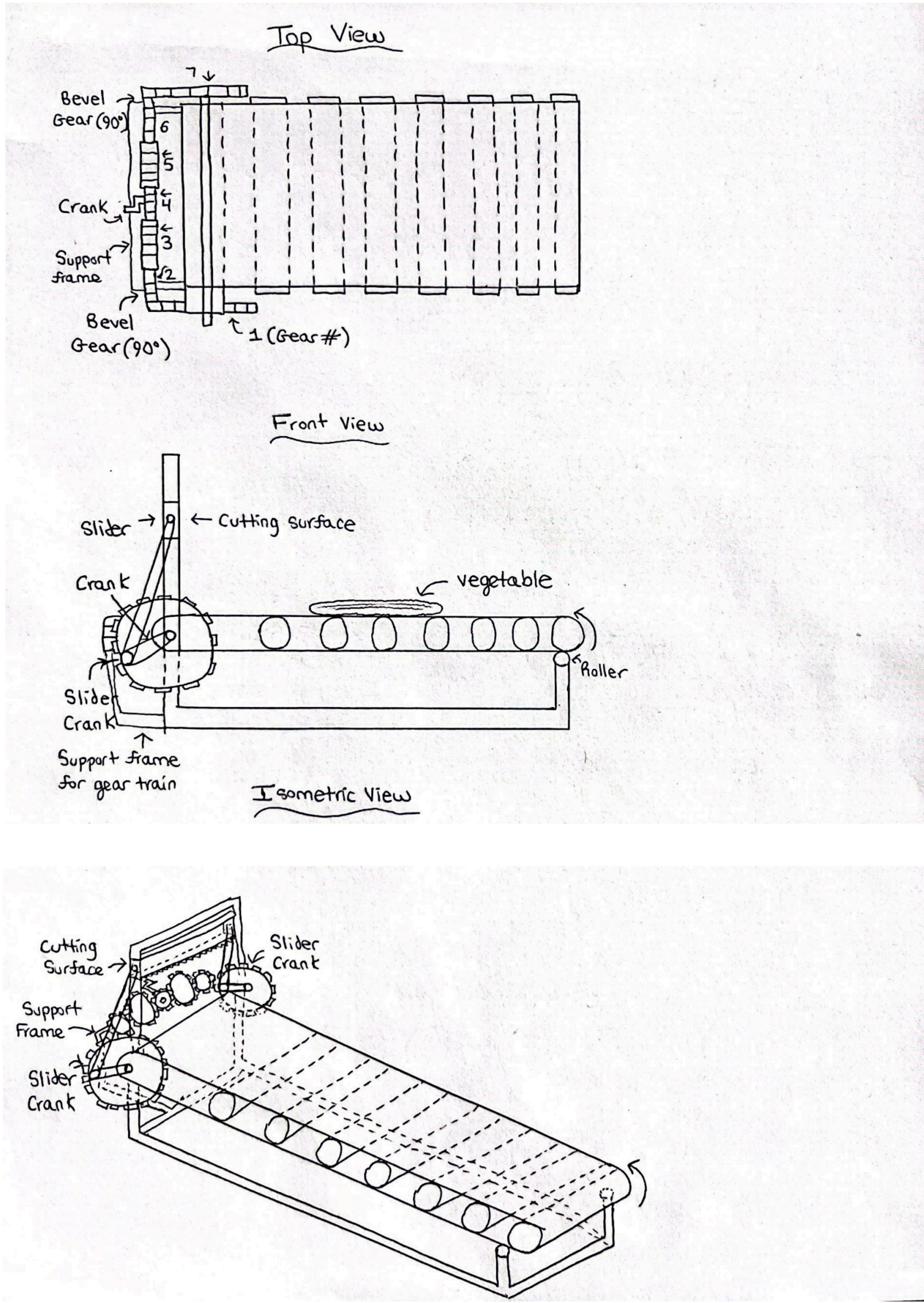


Figure 2.3.1
Alexander's Proposed Design

$$\frac{\omega_{out}}{\omega_{in}} = \frac{1}{40}$$

$$\frac{\omega_{out}}{\omega_{in}} = \left(-\frac{N_1}{N_2}\right)\left(-\frac{N_2}{N_3}\right)\left(-\frac{N_3}{N_4}\right)\left(-\frac{N_4}{N_5}\right)\left(-\frac{N_5}{N_6}\right)\left(-\frac{N_6}{N_7}\right) = -\frac{N_1}{N_7}$$

$$\Rightarrow \frac{1}{40} = -\frac{N_1}{N_7} \quad \text{where } N_1 = 12,\ N_7 = 480$$

$$N_2 = 14,\ N_3 = 18,\ N_4 = 15,\ N_5 = 18,\ N_6 = 14$$

Figure 2.3.2
Gear Train Ratio Calculation

SVAJ Equations

1st Segment:

BC's: At $\theta = 0$: $s = 0$, $v = 0$, $a = 0$ 5 BC's $\Rightarrow$ 4th degree polynomial

At $\theta = \frac{\pi}{2}$: $s = 5$, $v = 0$

$$s = C_0 + C_1\left(\frac{\theta}{\beta}\right) + C_2\left(\frac{\theta}{\beta}\right)^2 + C_3\left(\frac{\theta}{\beta}\right)^3 + C_4\left(\frac{\theta}{\beta}\right)^4$$

$$v = \frac{1}{\beta}\left(C_1 + 2C_2\left(\frac{\theta}{\beta}\right) + 3C_3\left(\frac{\theta}{\beta}\right)^2 + 4C_4\left(\frac{\theta}{\beta}\right)^3\right)$$

$$a = \frac{1}{\beta^2}\left(2C_2 + 6C_3\left(\frac{\theta}{\beta}\right) + 12C_4\left(\frac{\theta}{\beta}\right)^2\right)$$

$$j = \frac{1}{\beta^3}\left(6C_3 + 24C_4\left(\frac{\theta}{\beta}\right)\right)$$

At $\theta = 0$: $s = 0 \Rightarrow C_0 = 0$; $v = 0 \Rightarrow C_1 = 0$; $a = 0 \Rightarrow C_2 = 0$

At $\theta = \frac{\pi}{2}$: $s = 5 \Rightarrow 5 = C_3 + C_4$ (1); $v = 0 \Rightarrow 0 = 3C_3 + 4C_4$ (2)

$\Rightarrow$ (1) $C_3 = 5 - C_4$

(2) $3(5 - C_4) + 4C_4 = 0$

$15 - 3C_4 + 4C_4 = 0$

$15 = -C_4$

$\Rightarrow C_4 = -15$

$\Rightarrow C_3 = 20$

$$s = 20\left(\frac{\theta}{\beta}\right)^3 - 15\left(\frac{\theta}{\beta}\right)^4$$

$$v = \frac{1}{\beta}\left(60\left(\frac{\theta}{\beta}\right)^2 - 60\left(\frac{\theta}{\beta}\right)^3\right)$$

$$a = \frac{1}{\beta^2}\left(120\left(\frac{\theta}{\beta}\right) - 180\left(\frac{\theta}{\beta}\right)^2\right)$$

$$j = \frac{1}{\beta^3}\left(120 - 360\left(\frac{\theta}{\beta}\right)\right)$$

Figure 2.3.3
Cam Equations: Segment I

$\underline{2^{nd}\ \text{Segment:}}$ $\quad$ $\underline{\text{BC's:}}$ At $\theta = \frac{\pi}{2}$: $s = 5$, $v = 0$, $a = -61.92$ $\quad$ 6 BC's $\Rightarrow$ 5^{th} degree Polyno.

At $\theta = \pi$: $s = 0$, $v = 0$, $a = 0$

$$s = C_0 + C_1\left(\frac{\theta}{\beta}\right) + C_2\left(\frac{\theta}{\beta}\right)^2 + C_3\left(\frac{\theta}{\beta}\right)^3 + C_4\left(\frac{\theta}{\beta}\right)^4 + C_5\left(\frac{\theta}{\beta}\right)^5$$

$$v = \frac{1}{\beta}\left(C_1 + C_2\left(\frac{\theta}{\beta}\right) + 3C_3\left(\frac{\theta}{\beta}\right)^2 + 4C_4\left(\frac{\theta}{\beta}\right)^3 + 5C_5\left(\frac{\theta}{\beta}\right)^4\right)$$

$$a = \frac{1}{\beta^2}\left(C_2 + 6C_3\left(\frac{\theta}{\beta}\right) + 12C_4\left(\frac{\theta}{\beta}\right)^2 + 20C_5\left(\frac{\theta}{\beta}\right)^3\right)$$

$$j = \frac{1}{\beta^3}\left(6C_3 + 24C_4\left(\frac{\theta}{\beta}\right) + 60C_5\left(\frac{\theta}{\beta}\right)^2\right)$$

$\underline{\text{At } \theta = \pi:}$ $\quad$ $s = 0 \Rightarrow C_0 = 0$

$v = 0 \Rightarrow C_1 = 0$

$a = 0 \Rightarrow C_2 = 0$

$\underline{\text{At } \theta = \frac{\pi}{2}:}$ $\quad$ $s = 5 \Rightarrow 5 = C_3 + C_4 + C_5$

$v = 0 \Rightarrow 0 = 3C_3 + 4C_4 + 5C_5$

$a = -61.92 \Rightarrow -61.92 = 6C_3 + 12C_4 + 20C_5$

$\Rightarrow C_3 = 19.04$

$\Rightarrow C_4 = -13.08$

$\Rightarrow C_5 = -0.96$

$$s = 19.04\left(\frac{\theta}{\beta}\right)^3 - 13.08\left(\frac{\theta}{\beta}\right)^4 - .96\left(\frac{\theta}{\beta}\right)^5$$

$$v = \frac{1}{\beta}\left(57.12\left(\frac{\theta}{\beta}\right)^2 - 52.32\left(\frac{\theta}{\beta}\right)^3 - 4.8\left(\frac{\theta}{\beta}\right)^4\right)$$

$$a = \frac{1}{\beta^2}\left(114.24\left(\frac{\theta}{\beta}\right) - 156.96\left(\frac{\theta}{\beta}\right)^2 - 19.2\left(\frac{\theta}{\beta}\right)^3\right)$$

$$j = \frac{1}{\beta^3}\left(114.24 - 313.92\left(\frac{\theta}{\beta}\right) - 57.6\left(\frac{\theta}{\beta}\right)^2\right)$$

Figure 2.3.4

Cam Equations: Segment II

2.4: Cole's Design/Final Design

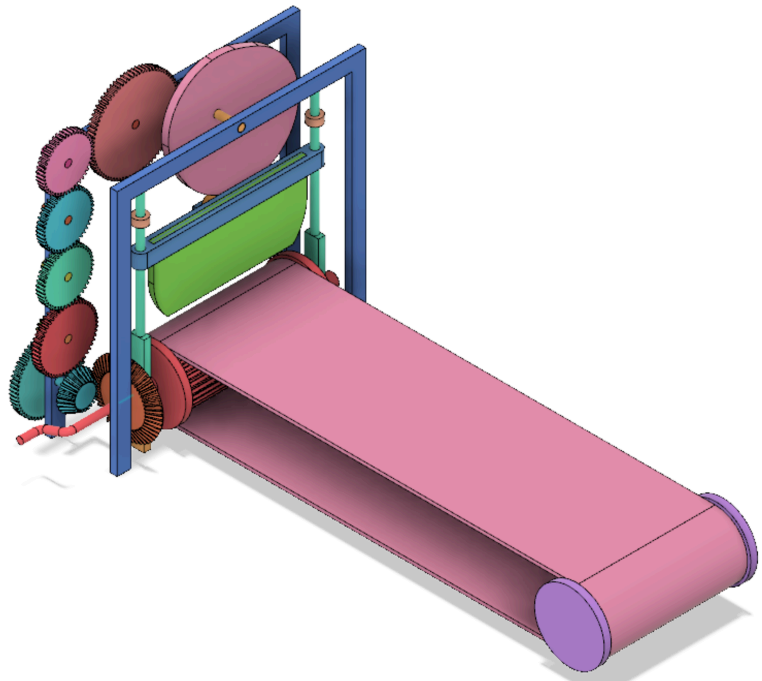


Figure 2.4.1
Cole's/Final Proposed Design ¾ angle

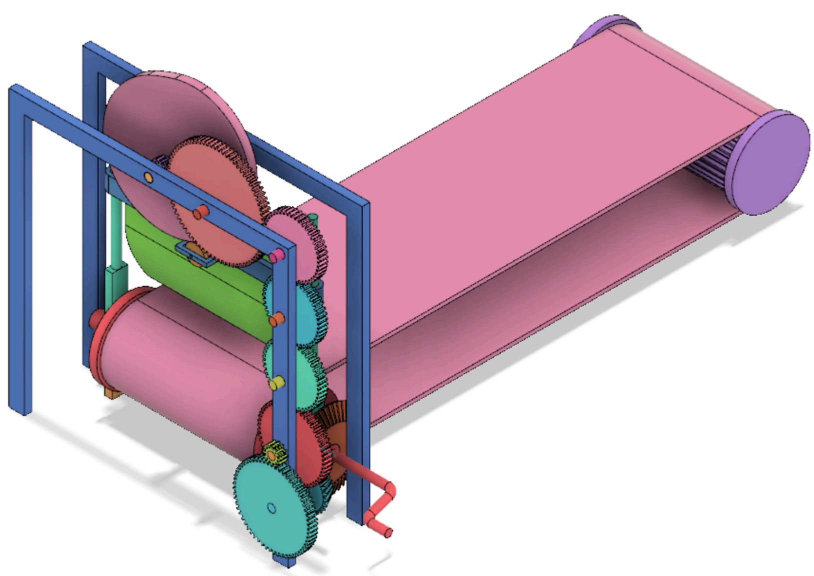


Figure 2.4.2
Final design ¾ rear angle

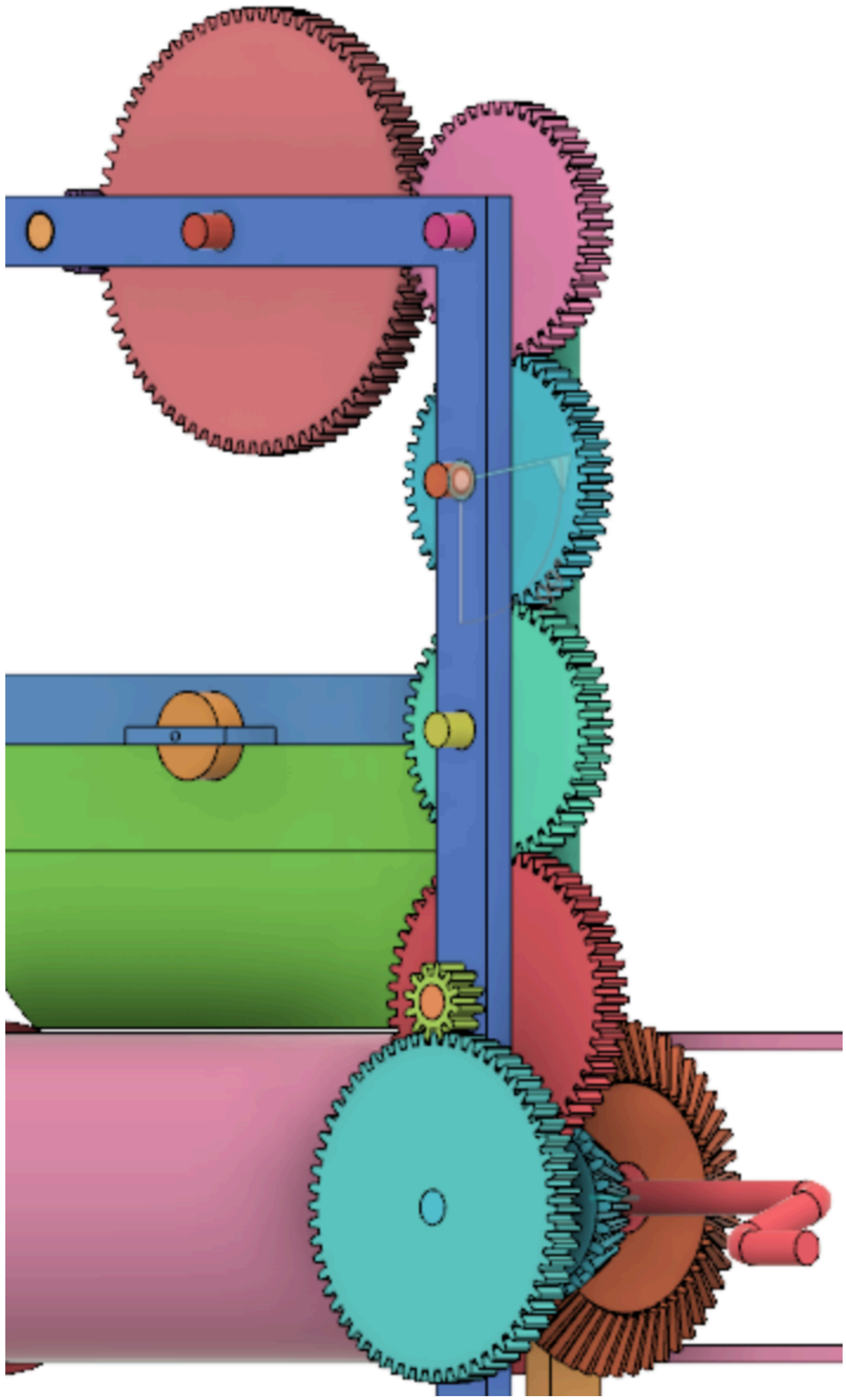


Figure 2.4.3
Side View of Gear Train

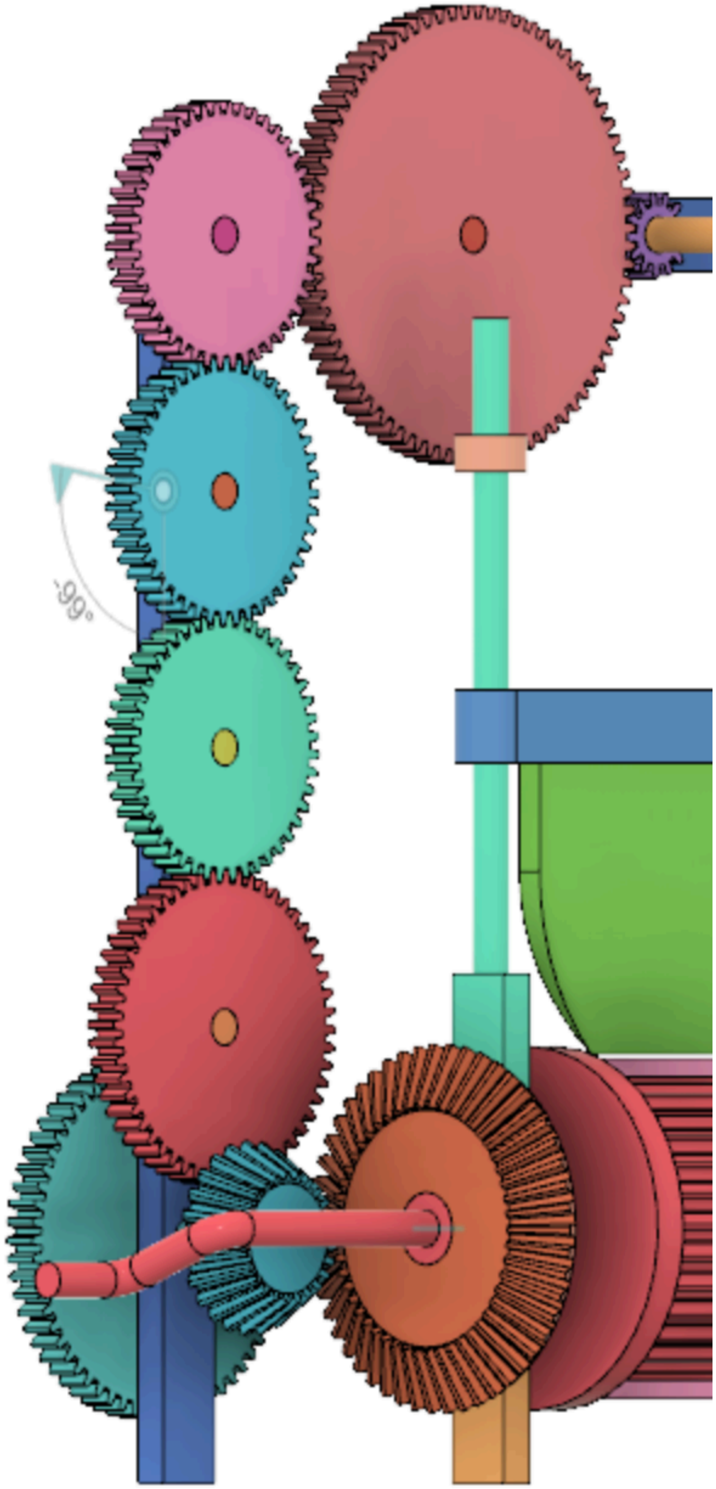


Figure 2.4.4
View of Crank and Gear Train Mechanism

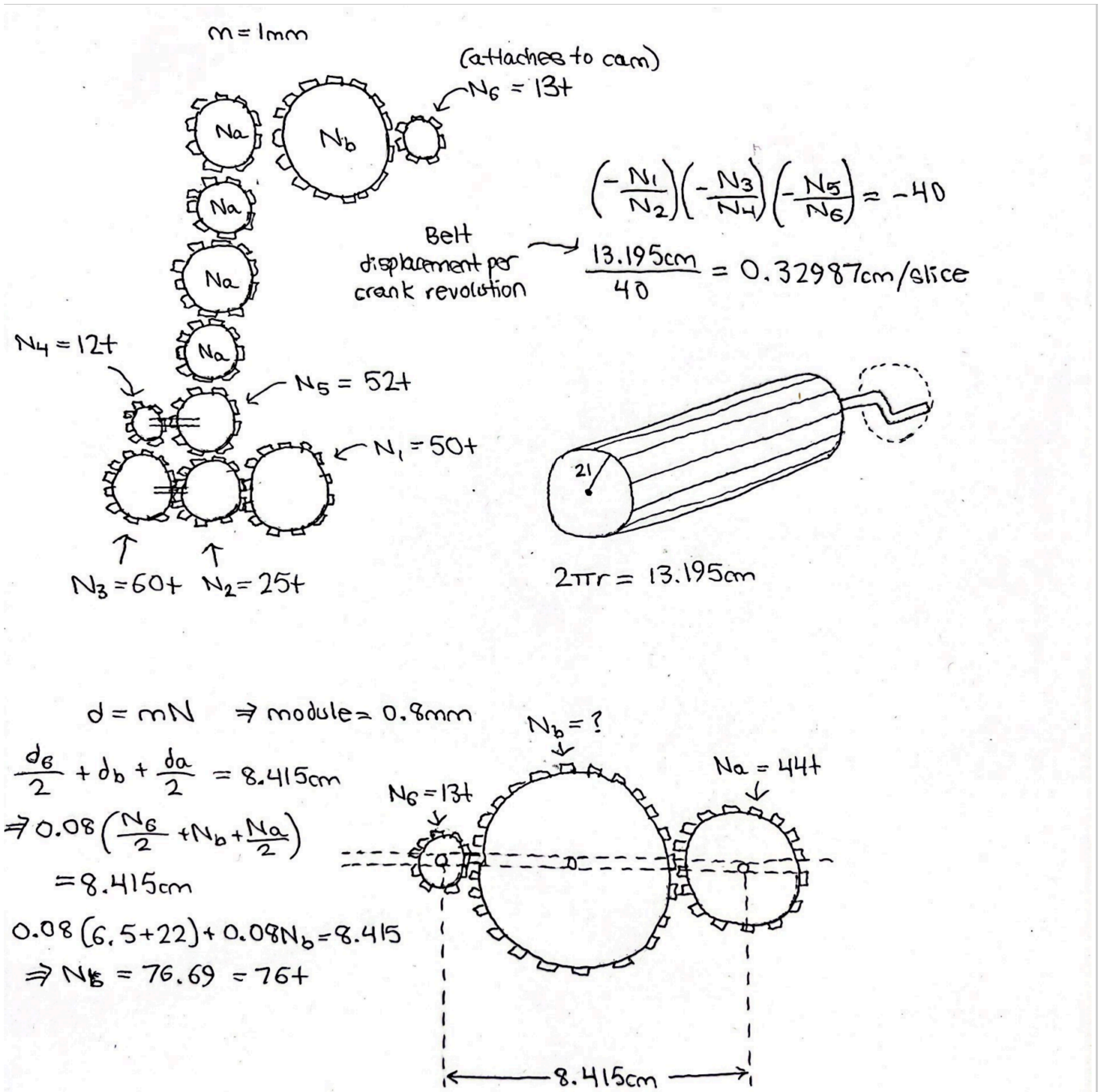


Figure 2.4.5
Final Gear Train Calculations

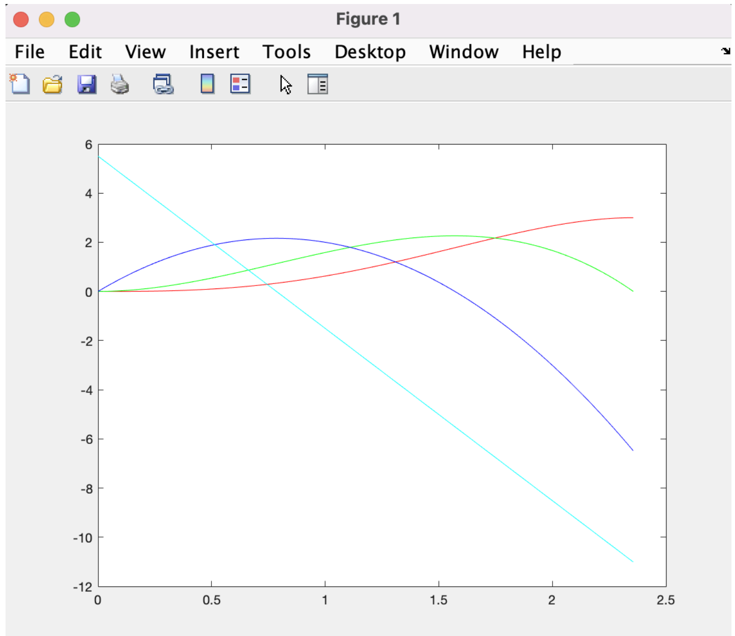


Figure 2.4.6
SVAJ Graph Segment I

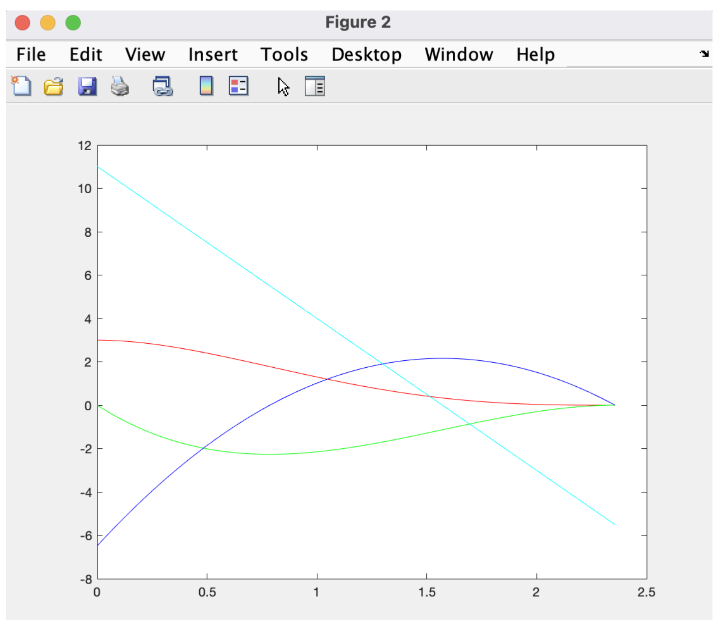
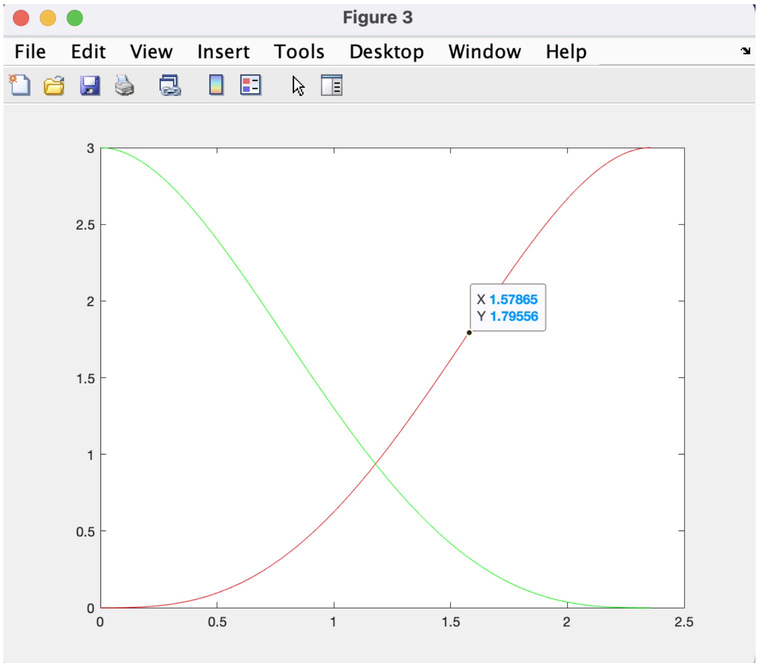


Figure 2.4.7
SVAJ Graph Segment II



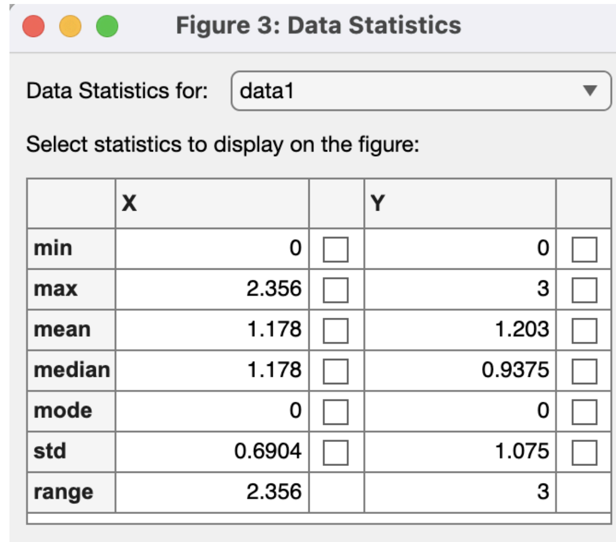


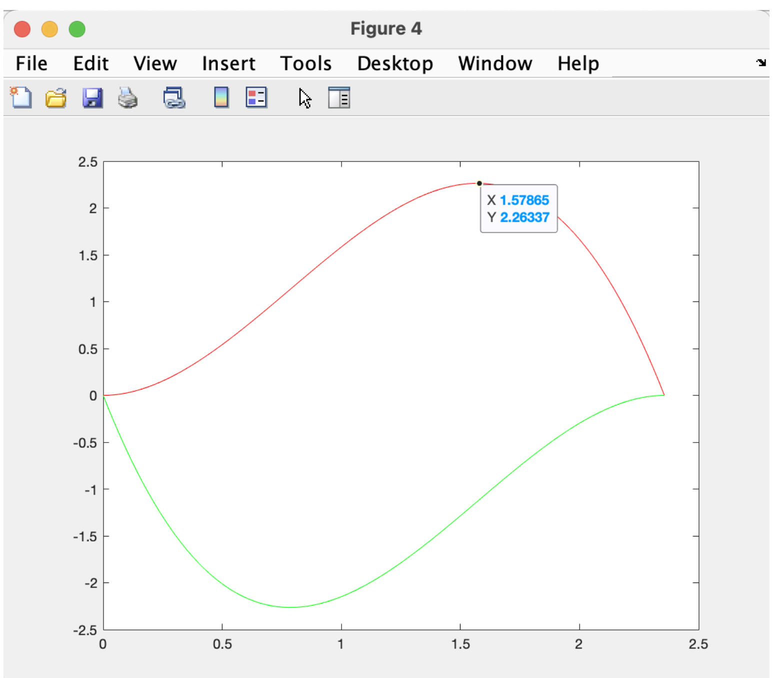
Figure 3: Data Statistics

Data Statistics for: data1

Select statistics to display on the figure:

	X		Y	
min	0	☐	0	☐
max	2.356	☐	3	☐
mean	1.178	☐	1.203	☐
median	1.178	☐	0.9375	☐
mode	0	☐	0	☐
std	0.6904	☐	1.075	☐
range	2.356		3	

Figure 2.4.8
Displacement Segment I and II & Associated Data Statistics



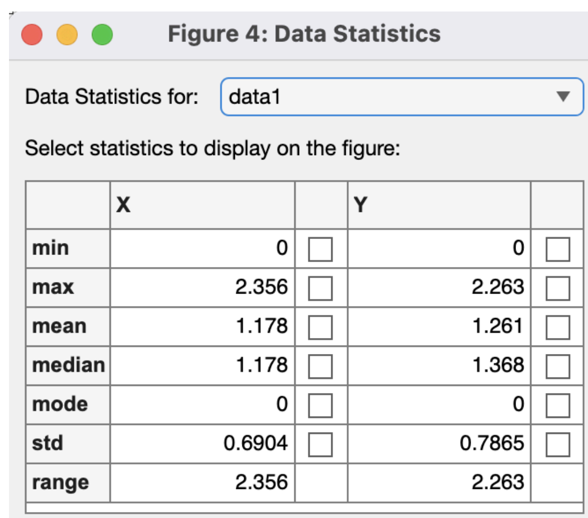


Figure 4: Data Statistics

Data Statistics for: data1

Select statistics to display on the figure:

	X		Y	
min	0	☐	0	☐
max	2.356	☐	2.263	☐
mean	1.178	☐	1.261	☐
median	1.178	☐	1.368	☐
mode	0	☐	0	☐
std	0.6904	☐	0.7865	☐
range	2.356		2.263	

Figure 2.4.9
Velocity Segment I and II & Associated Data Statistics

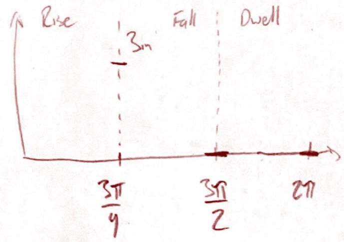
camProfile.m

```
C_31 = 12;          %from handwork
C_41 = -9;          %from handwork
B = (3*pi)/4;          %beta P_one
x = 0:(((3*pi)/4)/100):((3*pi)/4);         %x scale for plotting

S1 = C_31*(x/B).^3+C_41*(x/B).^4;
V1 = (1/B)*(C_31*3*(x/B).^2+C_41*4*(x/B).^3);
A1 = (1/B^2)*(C_31*6*(x/B)+C_41*12*(x/B).^2);
J1 = (1/B^3)*(C_31*6+C_41*24*(x/B));
figure(1);
plot(x,S1,"r",x,V1,"g",x,A1,"b",x,J1,"c")  %SVAJ curves segment 1

for x = (3*pi)/4
    A_B1 = (1/B^2)*(C_31*6*(x/B)+C_41*12*(x/B).^2) %Acceleration into P_2
end

C_02 = 3;          %from handwork
C_22 = -18;          %from handwork
linequ2 = [1,1,1; 3,4,5; 6,12,20];  %from handwork:(C_3+C_4+C_5)
linsolu2 = [-1*(C_02+C_22); -1*(2*C_22); -1*(2*C_22)];  %from handwork:(Solutions to lin. equ.)
C__2 = linsolve(linequ2,linsolu2);
C_32 = C__2(1,1);       %Allocationg solutions to variables
C_42 = C__2(2,1);
C_52 = C__2(3,1);

x = 0:(((3*pi)/4)/100):((3*pi)/4);

S2 = C_02+C_22*(x/B).^2+C_32*(x/B).^3+C_42*(x/B).^4+C_52*(x/B).^5;
V2 = (1/B)*(C_22*2*(x/B)+C_32*3*(x/B).^2+C_42*4*(x/B).^3)+C_52*5*(x/B).^4;
A2 = (1/B^2)*(C_22*2+C_32*6*(x/B)+C_42*12*(x/B).^2+C_52*20*(x/B).^3);
J2 = (1/B^3)*(C_32*6+C_42*24*(x/B))+C_52*60*(x/B).^2;
figure(2)
plot(x,S2,"r",x,V2,"g",x,A2,"b",x,J2,"c")   %SVAJ curves segment 2
figure(3)
plot(x,S1,"r",x,S2,"g")   %plot comparing both position curves
figure(4)
plot(x,V1,"r",x,V2,"g")   %plot comparing both velocity curves

S1_ = [];
S2_ = [];
x_ = [];
for x = 0:(((3*pi)/4)/5):((3*pi)/4)   %0-3pi/4 in 5 steps
    s1_ = C_31*(x/B).^3+C_41*(x/B).^4;
    s2_ = C_02+C_22*(x/B).^2+C_32*(x/B).^3+C_42*(x/B).^4+C_52*(x/B).^5;
    x_ = [x_,x];   %make list
    S1_ = [S1_, s1_];   %make list
    S2_ = [S2_, s2_];   %make list
end
PosData = [x_*(180/pi),((((3*pi)/4))+x_)*(180/pi);S1_,S2_]   %organize data from for loop
```

Command Window

```
A_B1 =

   -6.4846


PosData =

         0   27.0000   54.0000   81.0000  108.0000  135.0000  135.0000  162.0000  189.0000  216.0000  243.0000  270.0000
         0    0.0816    0.5376    1.4256    2.4576    3.0000    3.0000    2.7598    1.9356    0.8776    0.1572         0

>>
```

Figure 2.4.10
MATLAB Code for SVAJ



$\theta = 0 : S = 0,\ V = 0,\ a = 0$

$\theta = \beta : S = 3,\ V = 0$

$$s(\theta) = C_0 + C_1\left(\tfrac{\theta}{\beta}\right) + C_2\left(\tfrac{\theta}{\beta}\right)^2 + C_3\left(\tfrac{\theta}{\beta}\right)^3 + C_4\left(\tfrac{\theta}{\beta}\right)^4$$

$$v(\theta) = \tfrac{1}{\beta}\left[C_1 + 2C_2\left(\tfrac{\theta}{\beta}\right) + 3C_3\left(\tfrac{\theta}{\beta}\right)^2 + 4C_4\left(\tfrac{\theta}{\beta}\right)^3\right]$$

$$a(\theta) = \tfrac{1}{\beta^2}\left[2C_2 + 6C_3\left(\tfrac{\theta}{\beta}\right) + 12C_4\left(\tfrac{\theta}{\beta}\right)^2\right]$$

$$j(\theta) = \tfrac{1}{\beta^3}\left[6C_3 + 24C_4\left(\tfrac{\theta}{\beta}\right)\right]$$

$s(0) = 0 \quad C_0 = 0 \quad s(\beta): C_3 + C_4 = 3 \quad C_3 = 12$

$v(0) = 0 \quad C_1 = 0 \quad v(\beta): 3C_3 + 4C_4 = 0 \quad C_4 = -9$

$a(0) = 0 \quad C_2 = 0 \quad a(\beta) = \frac{1}{\left(\frac{3\pi}{4}\right)^2}\left[6(12) + 12(-9)\right] = -6.4846$

$\bar{\theta} = 0 \quad s = 3 \quad v = 0 \quad a = -6.4846$ (B.C. for segment 2)

$\bar{\theta} = \beta \quad s = 0 \quad v = 0 \quad a = 0$

$$s(\bar{\theta}) = C_0 + C_1\left(\tfrac{\bar{\theta}}{\beta}\right) + C_2\left(\tfrac{\bar{\theta}}{\beta}\right)^2 + C_3\left(\tfrac{\bar{\theta}}{\beta}\right)^3 + C_4\left(\tfrac{\bar{\theta}}{\beta}\right)^4 + C_5\left(\tfrac{\bar{\theta}}{\beta}\right)^5$$

$$v(\bar{\theta}) = \tfrac{1}{\beta}\left[C_1 + 2C_2\left(\tfrac{\bar{\theta}}{\beta}\right) + 3C_3\left(\tfrac{\bar{\theta}}{\beta}\right)^2 + 4C_4\left(\tfrac{\bar{\theta}}{\beta}\right)^3 + 5C_5\left(\tfrac{\bar{\theta}}{\beta}\right)^4\right]$$

$$a(\bar{\theta}) = \tfrac{1}{\beta^2}\left[2C_2 + 6C_3\left(\tfrac{\bar{\theta}}{\beta}\right) + 12C_4\left(\tfrac{\bar{\theta}}{\beta}\right)^2 + 20C_5\left(\tfrac{\bar{\theta}}{\beta}\right)^3\right]$$

$$j(\bar{\theta}) = \tfrac{1}{\beta^3}\left[6C_3 + 24C_4\left(\tfrac{\bar{\theta}}{\beta}\right) + 60C_5\left(\tfrac{\bar{\theta}}{\beta}\right)^2\right]$$

$s(0) \Rightarrow C_0 = 3 \qquad a(0) = \tfrac{1}{\beta^2}[2C_2] = -6.4846$

$v(0) \Rightarrow C_1 = 0 \qquad C_2 = -18.00$

Figure 2.4.11
SVAJ Calculation Handwork

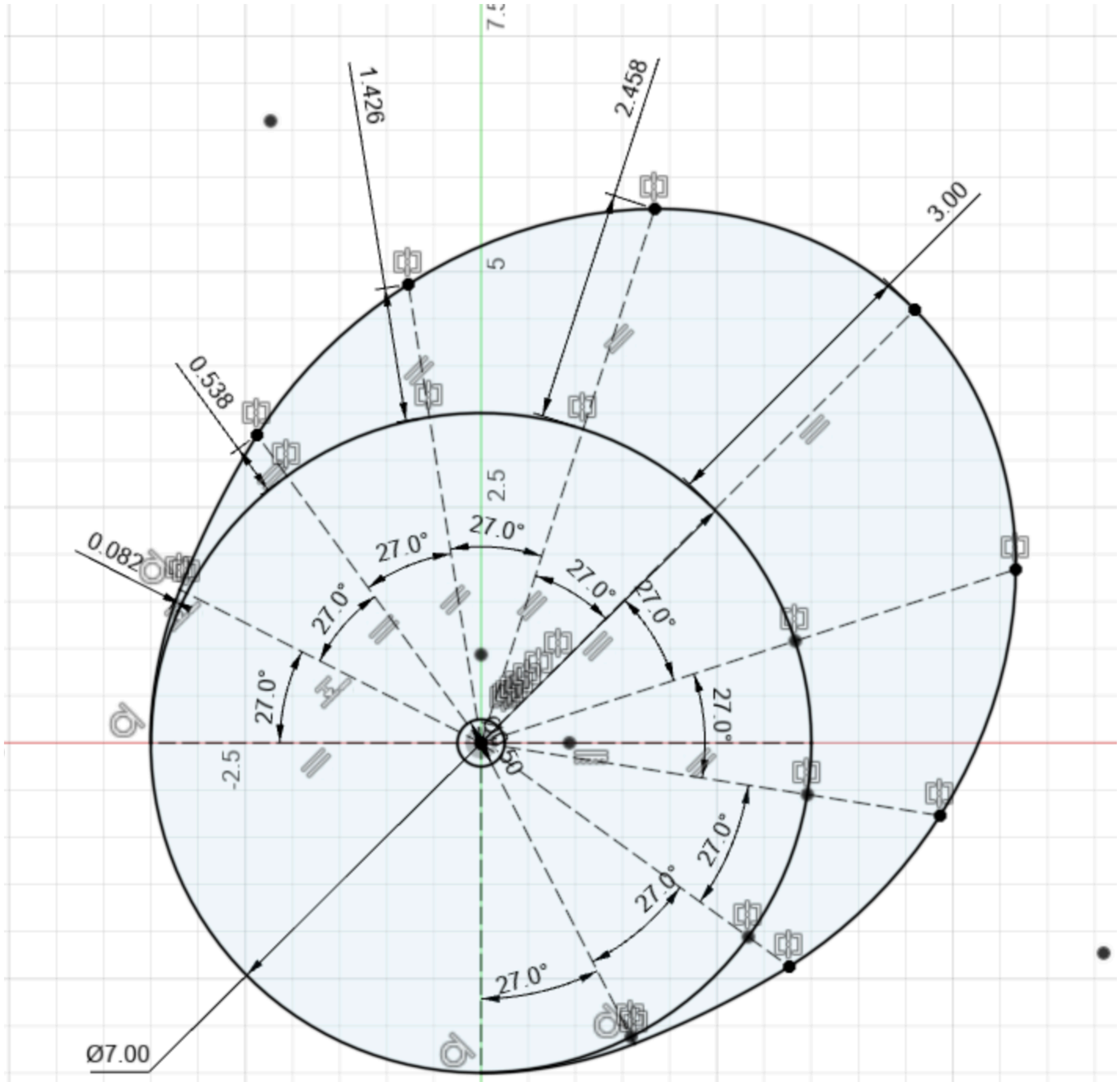


Figure 2.4.12
Cam Profile

iii. Design Analysis and Simulation

3.1 NOTES FOR EACH FIGURE

2.1.(1,2) - Design I. The group's initial design idea. The issue is that the coupler, crank and rocker approach collinearity, meaning the transmission angle nears zero. This results in a lack of cutting force. Also, if the crank is provided a constant angular velocity from the drive gears, the cutting blade spends a large amount of time at the bottom of the stroke, as visualised in MotionGen. This would be undesirable for a constant vegetable feed speed.

2.2.1 - Soroush's Design Proposal Sketch. Consists of a simple gear train that controls a cam. The gear train is run by an external hand crank. The gears run the conveyor belt that feeds the vegetables into the cutter. There is a ratio of 1:40 which means that for every rotation of the crank, the cutter will cut 40 times allowing for fine slices of vegetables. The cam is also run by a gear train that connects to the conveyor belt.

2.2.2 - The gear train has a ratio of 1:40 and has an input of 13 teeth to an output of 520 teeth. This design was not selected because of this large range of teeth, and therefore a compound gear train seen in Cole's proposal was selected for the final design. Also the cam design had a higher pressure angle and increased jerk when compared to Cole's design.

2.2.3 - Segment I SVAJ equations.

2.2.4 - Segment II SVAJ equations.

2.3.1 - Alexander's Proposed Design. The gear ratio of 1:40 with an input of 12 teeth and an output of 480 teeth is not ideal considering the large range of teeth. This design requires a compound gear train in order to have a more consistent teeth ratio.

Additionally, when the slider crank mechanism is run in MotionGen, the range of the coupler link does not extend to both ends of the cutting frame. Therefore, the crank link length would need to be increased.

2.4.1 - *Cole's/Final Proposed Design* (**Discussed in Section iv**) ¾ angle

2.4.2 - Final design ¾ rear angle

2.4.3 - Side View of Gear Train

2.4.4 - View of Crank and Gear Train Mechanism

2.4.5 - Final Gear Train Calculations

2.4.6 - SVAJ Graph Segment I

2.4.7 - SVAJ Graph Segment II

2.4.8 - Displacement Segment I and II & Associated Data Statistics

2.4.9 - Velocity Segment I and II & Associated Data Statistics

2.4.10 - MATLAB Code for SVAJ

2.4.11 - SVAJ Calculation Handwork

2.4.12 - Cam Profile

iv. Discussions and Conclusions

4.1 Reasons for Selecting the Final Design

The final design meets all the criteria required for this project. The design is compact and as the cad model demonstrates the mechanism functions as a whole, there are no issues when it runs. We wanted a ratio of 1:40 for all the designs and Cole's design has a compound gear train that allows for the number of gears to be within a reasonable range of teeth. The radius of the prime circle for the cam was designed purposefully large to reduce the pressure angle as much as possible. The pressure angle is calculated using the formula:

$$\phi = arctan\frac{v-\epsilon}{s+\sqrt{R_p^2-\epsilon^2}}$$

where $v = velocity\ of\ follower,\ \epsilon = offset\ of\ follower$

$s = displacement\ of\ follower, and\ R_p = radius\ of\ prime\ circle.$

From the SVAJ diagrams (Figure 2.4.8, 2.4.9) we get a values of

$s = 3,\ v = 2.263,\ and\ R_p = 3.$ There is no offset for our design, and the resulting pressure angle is 20.66°, which is less than the maximum desired angle of 30°. The calculated slice thickness was found to be 3.3mm (Figure 2.4.5), which is ideal for cucumbers in an artisanal salad.

4.2 Possible Improvements

If we had more time, we could have designed the gear train to be stronger. The smallest pinion gear is 12 tooth, when considering strictly from a transmission of motion standpoint, this is fine. Instead, if the pinion was larger and the gear train had more compound components, the design would be more capable of handling high forces. The second concern is the simple gear train across the top. These gears have the closest possible number of teeth possible to match the span from the edge of the frame to the centre, however due to the necessity of matching modules and integer number of teeth, the teeth do not mesh perfectly (illustration and calculations in figure 2.4.5). These two shortcomings could lead to stripping teeth under large loads.

v. Contribution of each group member:

5.1 All group members contributed equally to arrive at our functioning design. Everyone provided a handful of mechanism proposals. From this pool of ideas, we inspected the highlights and weaknesses of each configuration. The designs were collectively refined and the best design was selected, as shown above. The majority of the report was written by all members with certain tasks such as inserting figures being delegated to the member with access to the files. Each member was tasked with designing an individual mechanism. The final design was selected as a group based on whether or not it met the requirements best.

vi. Acknowledgements

6.1 Professor Chakraborty for teaching us the methods to create a 4/6-bar, gear train, and cam mechanisms and Professor Purwar for providing us with motion gen software to design mechanisms.