ME224 – ASSIGNMENT 2

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Sec. – B

Q1.

Q) 1) Analysis:- Given:-

Translating flat face follower

a) $0^\circ \rightarrow 80^\circ$ => Dwell (Clockwise Rotation)

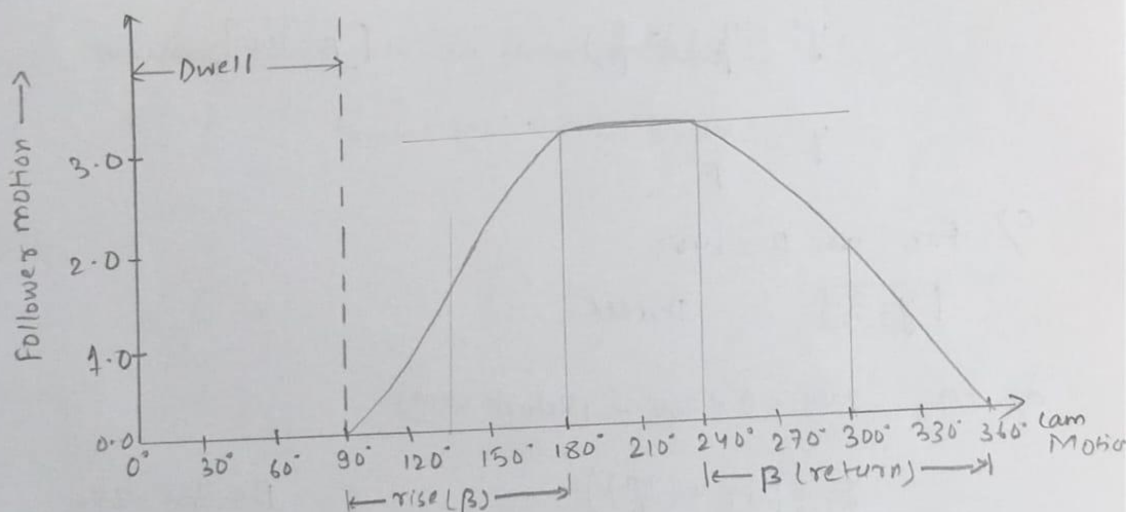
b) $80^\circ \rightarrow 180^\circ$ => rise (parabolic)

c) $180^\circ \rightarrow 240^\circ$ => Dwell

d) $240^\circ \rightarrow 360^\circ$ => Return (SHM)

amplitude => 3cm (h)

base circle radius (r_{bmin}) = ?



a) For $0^\circ \leq \theta \leq 80^\circ$;

$\boxed{y = 0}$ Dwell

$\boxed{y' = 0}$; $\boxed{y'' = 0}$

b) For $80^\circ \le \theta \le 180^\circ$ (Parabolic rise)

i) First part of rise; ($80^\circ \le \theta \le 130^\circ$)

$$y = 2L\left(\frac{\theta}{\beta}\right)^2 \qquad \beta = 180^\circ - 80^\circ$$

$$\boxed{\beta = 100^\circ}$$

$$\Rightarrow y' = \frac{4L}{\beta}\left(\frac{\theta}{\beta}\right)$$

$$\Rightarrow y'' = \frac{4L}{\beta^2}$$

ii) For the second part of rise; ($130^\circ \le \theta \le 180^\circ$)

$$y = L\left(1 - 2\left(1 - \frac{\theta}{\beta}\right)^2\right)$$

$$y' = \frac{4L}{\beta}\left(1 - \frac{\theta}{\beta}\right) \qquad \boxed{\beta = 100^\circ}$$

$$y'' = -\frac{4L}{\beta^2}$$

c) For, $180^\circ \le \theta \le 240^\circ$;

$\boxed{y = 3}$ Dwell

d) For, $240^\circ \le \theta \le 360^\circ$ - (Return stroke)

$$y = \frac{L}{2}\left(1 + \cos\left(\frac{\pi\theta}{\beta}\right)\right) \qquad \beta = 360^\circ - 240^\circ$$

$$\boxed{\beta = 120^\circ}$$

$$\Rightarrow y' = \frac{\pi}{2\beta} L \sin\left(\frac{\pi\theta}{\beta}\right)$$

$$\Rightarrow y'' = -\frac{L}{2}\left(\frac{\pi}{\beta}\right)^2 \cos\left(\frac{\pi\theta}{\beta}\right)$$

c) For $180° \le \theta < 240°$

$\boxed{y = 4 \text{ cm}}$ Dwell

d) For, $240° \le \theta < 360°$; (SHM Descent)

$\beta = 360° - 240°$

$\boxed{\beta = 120°}$

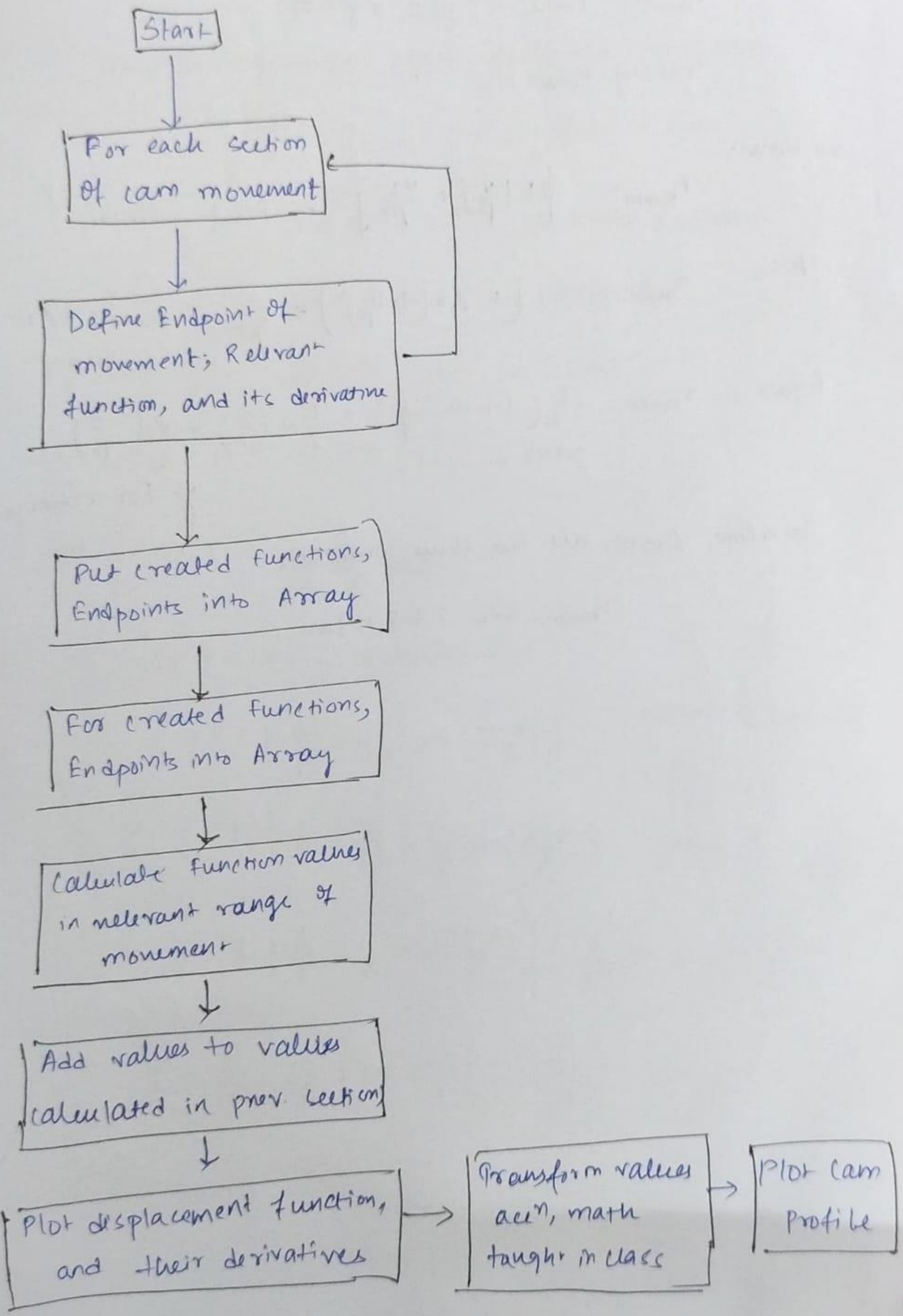
$\boxed{\theta \rightarrow \theta - 240°}$

$\Rightarrow y = \frac{L}{2}\left(1 + \cos\frac{\pi\theta}{\beta}\right)$

$\Rightarrow y' = \frac{L\pi}{2\beta}\left(-\sin\frac{\pi\theta}{\beta}\right) = -\frac{\pi L}{2\beta}\sin\left(\frac{\pi\theta}{\beta}\right)$

$\Rightarrow y'' = -\frac{\pi^2 L}{2\beta^2}\cos\left(\frac{\pi\theta}{\beta}\right)$

2) Flowchart (Pseudocode) of Computations:-

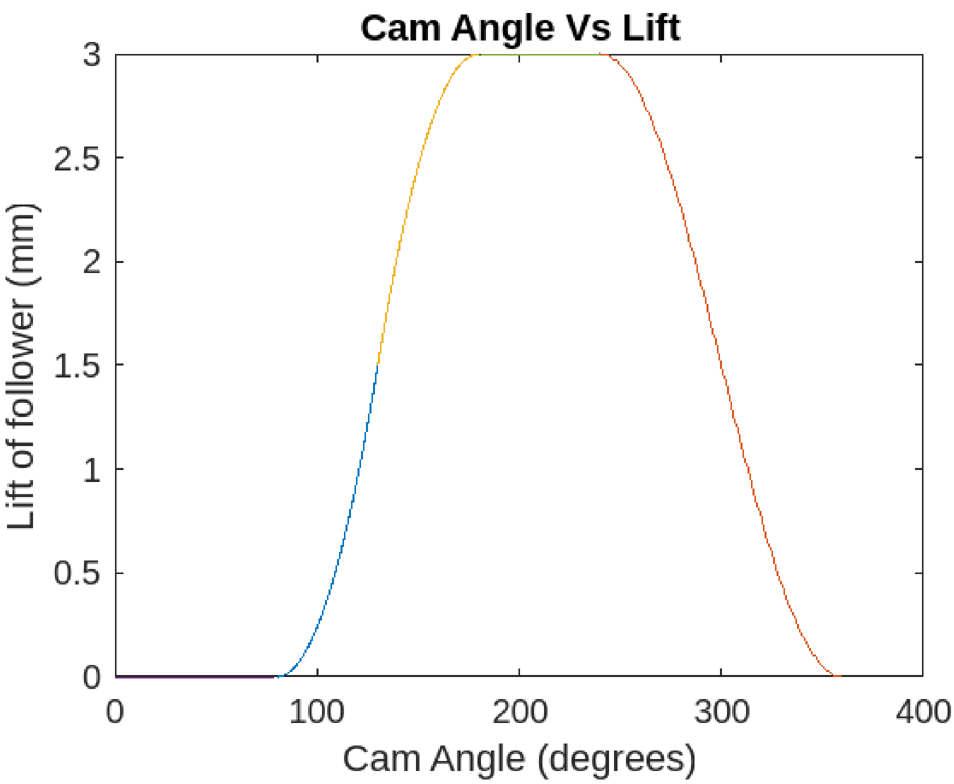


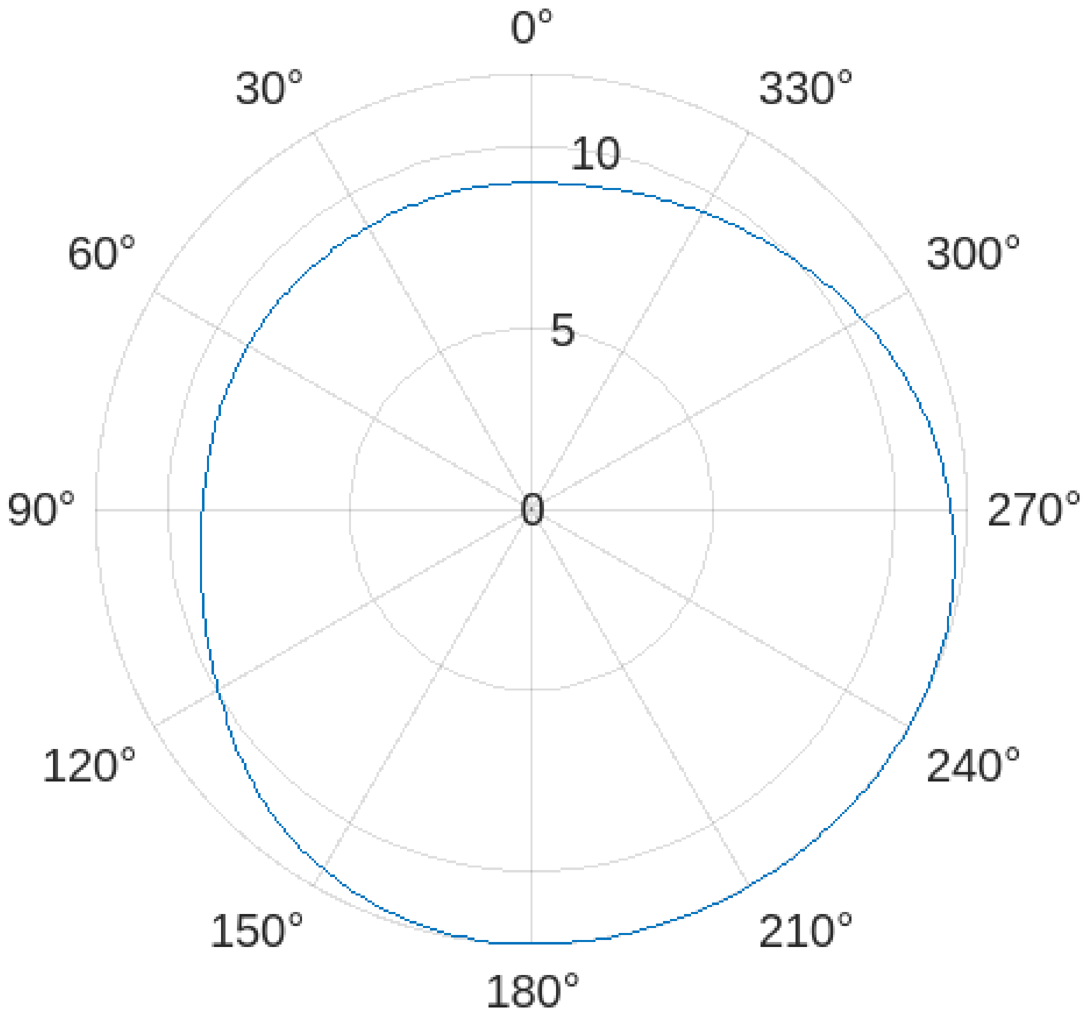
MATLAB CODE

```
clc
clear all
h=3;
r=9;
%Ascent and Descent Angles
dwell_1 = 80;
ascent  = 100;
dwell_2 = 60;
descent = 360 -(ascent + dwell_1 + dwell_2);
%Additional Angles
after_dwell_1 = dwell_1 + ascent/2;
after_half_ascent = after_dwell_1 + ascent/2;
after_dwell_2 = after_half_ascent + dwell_2;
final = after_dwell_2 + descent;
%Cam Angle
theta = linspace(0,360,361);
%Ascent Motion Conditions
h_half_ascent = (2*h).*(((theta(theta<=ascent/2))/ascent).^2);
h__Ahalf_ascent = h.*(1-2*(1-(theta(theta>=ascent/2 &
theta<=100)/ascent)).^2);
%Descent Motion Conditions
h_descent = h-((0.5*h).*(1 - cosd((180/descent).*theta(theta<=descent))));
%Lift during Dwell
h_dwell1 = zeros(1,dwell_1);
h_dwell2 = ones(1,dwell_2).*h;
%Plotting Cam Angle Vs Lift
plot(theta(theta>=dwell_1 & theta<=after_dwell_1),h_half_ascent,
theta(theta>=after_dwell_2 & theta<=final),h_descent);
hold on
plot(theta(theta>=after_dwell_1 & theta<=after_half_ascent),
h__Ahalf_ascent);
hold on
plot(theta(theta<dwell_1), h_dwell1 , theta(theta>after_half_ascent &
theta<=after_dwell_2),h_dwell2);
title('Cam Angle Vs Lift')
xlabel('Cam Angle (degrees)');
ylabel('Lift of follower (mm)');
%Defining radii during different phases of Cam
r1 = r + h_dwell1;
r2 = r + h_half_ascent(h_half_ascent<1.5);
r3 = r + h__Ahalf_ascent(h__Ahalf_ascent<3);
r4 = r + h_dwell2;
r5 = r + h_descent;
%Joining all radii
r = [r1 r2 r3 r4 r5];
%Convert theta to radians
theta_radians = deg2rad(theta);
%Plotting Cam Profile
figure
polarplot(theta_radians,r);
set(gca,'ThetaZeroLocation','top')
%Converting Polar to Cartesian Coordinate System
[x,y] = pol2cart(theta_radians,r);
x_cord = transpose(x);
y_cord = transpose(y);
```

```
z_cord = zeros(361,1);
cam_profile = [x_cord y_cord z_cord];
```

%end of code




0°
330°
300°
270°
240°
210°
180°
150°
120°
90°
60°
30°
10
5
0

Q2.

Q) 2) Analysis:- We have :-

Given:-

Translating knife edged follower translation,

$h = 4\,cm$; $r_{b\,min} = 5\,cm$; offset $= 0.5\,cm$,

a) Dwell $\Rightarrow$ $0 \leq \theta < 80°$ - clockwise Rotation

b) Rise $\Rightarrow$ $80° \leq \theta < 180°$ - Cycloidal

c) Dwell $\Rightarrow$ $180° \leq \theta < 240°$ - Dwell

d) Descent $\Rightarrow$ $240° \leq \theta \leq 360°$ $\rightarrow$ SHM

a) For $0 < \theta < 80°$: $\boxed{y = 0}$ Dwell

b) For $80° \leq \theta \leq 180°$; cycloidal rise

$$y = L\left(\frac{\theta}{\beta} - \frac{1}{2\pi}\cdot \sin\left(\frac{2\pi\theta}{\beta}\right)\right)$$

where, $\beta = 180° - 80°$

$\boxed{\beta = 100°}$

$$\Rightarrow y' = L\left(\frac{1}{\beta} - \frac{1}{2\pi} \times \frac{2\pi}{\beta}\cos\left(\frac{2\pi\theta}{\beta}\right)\right)$$

Also; $\boxed{\theta \rightarrow \theta - 80°}$

$$\Rightarrow y' = L\left(\frac{1}{\beta} - \frac{1}{\beta}\cos\left(\frac{2\pi\theta}{\beta}\right)\right) = \frac{L}{\beta}\left(1 - \cos\frac{2\pi\theta}{\beta}\right)$$

Also, $$y'' = \frac{L}{\beta} \times \frac{2\pi}{\beta}\left(\sin\frac{2\pi\theta}{\beta}\right) = \frac{2\pi L}{\beta^2}\cdot\sin\left(\frac{2\pi\theta}{\beta}\right)$$

Also, we know that:

$r_{bmin} = P_{min} - (y(\theta) + y''(\theta))$

Taking $P_{min} = 0$;

we have:-

$r_{bmin} = -\left\{2L\left(\frac{\theta}{\beta}\right)^2 + \frac{4L}{\beta^2}\right\}$ => first part rise.

Also, $r_{bmin} = -L\left(1-2\times\left(1-\frac{\theta}{\beta}\right)^2\right) + \frac{4L}{\beta^2}$ => second part rise

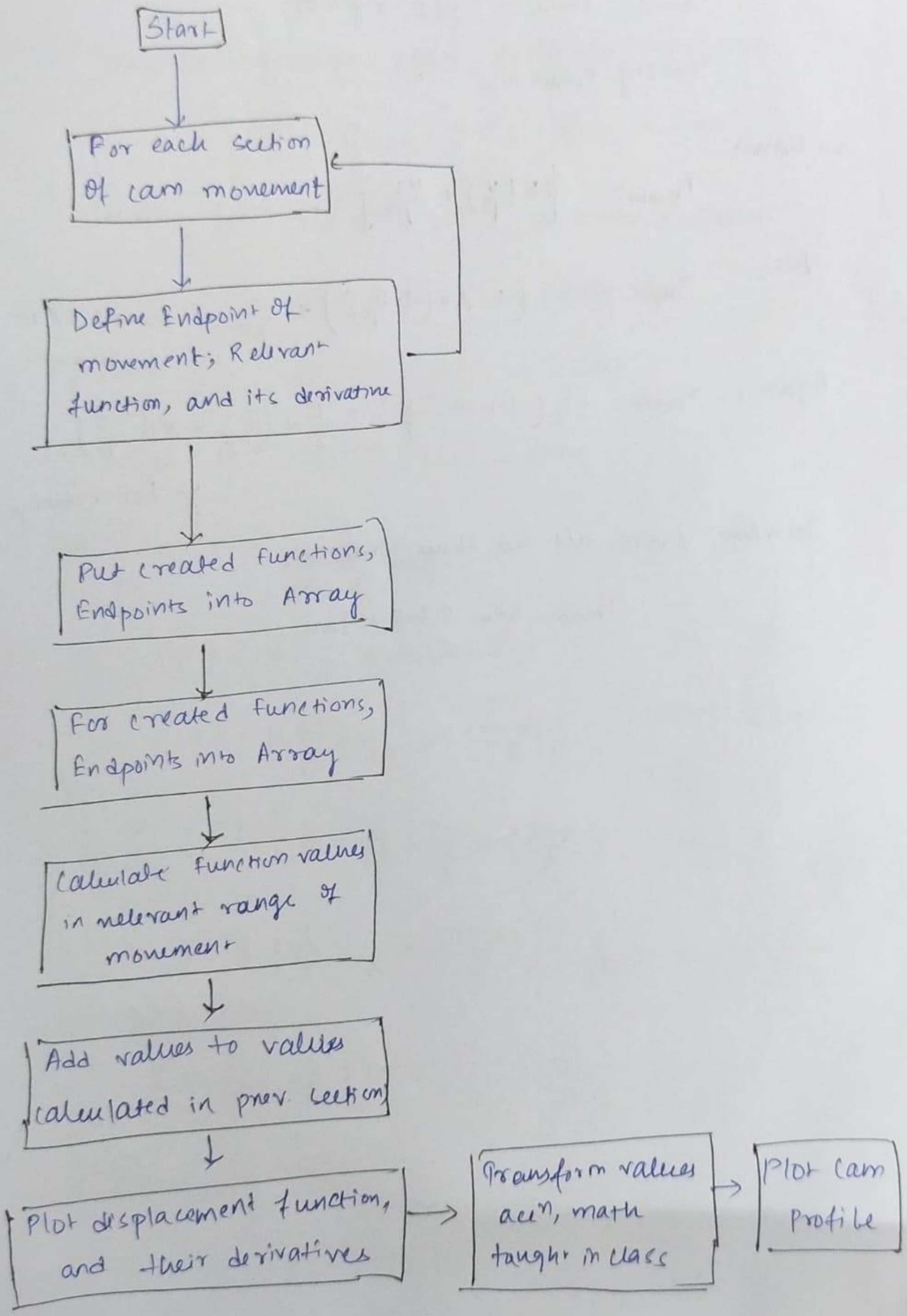
Again, $r_{bmin} = -\frac{L}{2}\left(1+\cos\frac{\pi\theta}{\beta}\right) + \frac{L}{2}\times\left(\frac{\pi}{2}\right)^2\times\cos\left(\frac{\pi\theta}{\beta}\right)$

=> for return.

Therefore, from all the three conditions;

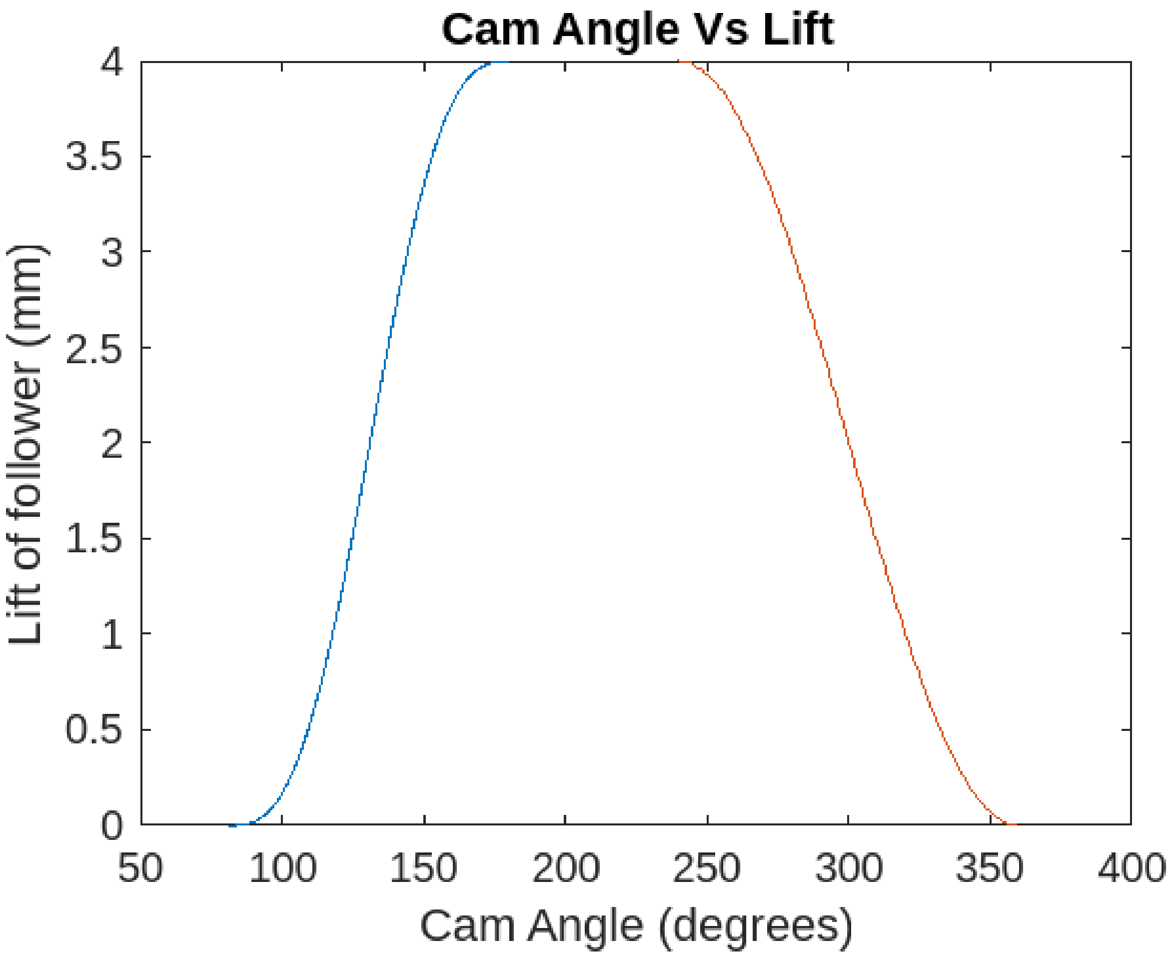
$r_{bmin} = 3\times L = 3\times 3 = 9 cm$

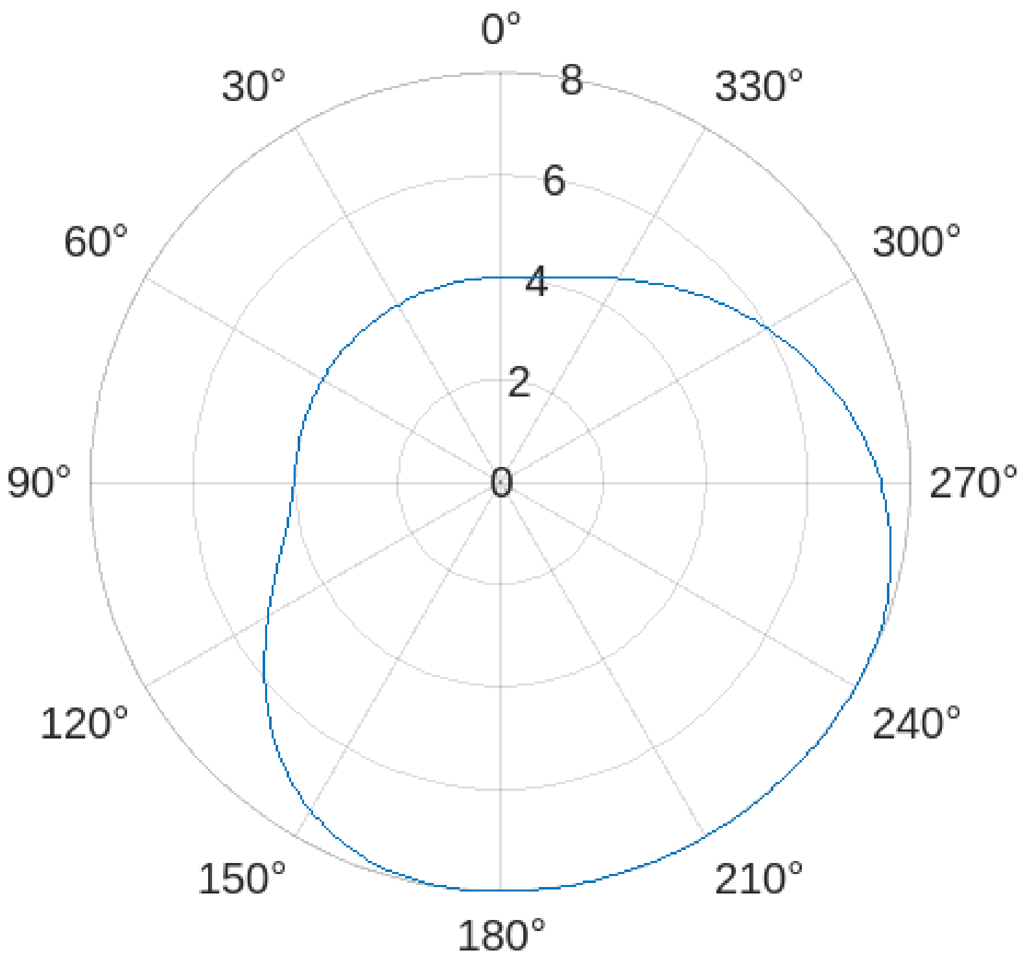
2) Flowchart (Pseudocode) of Computations:-



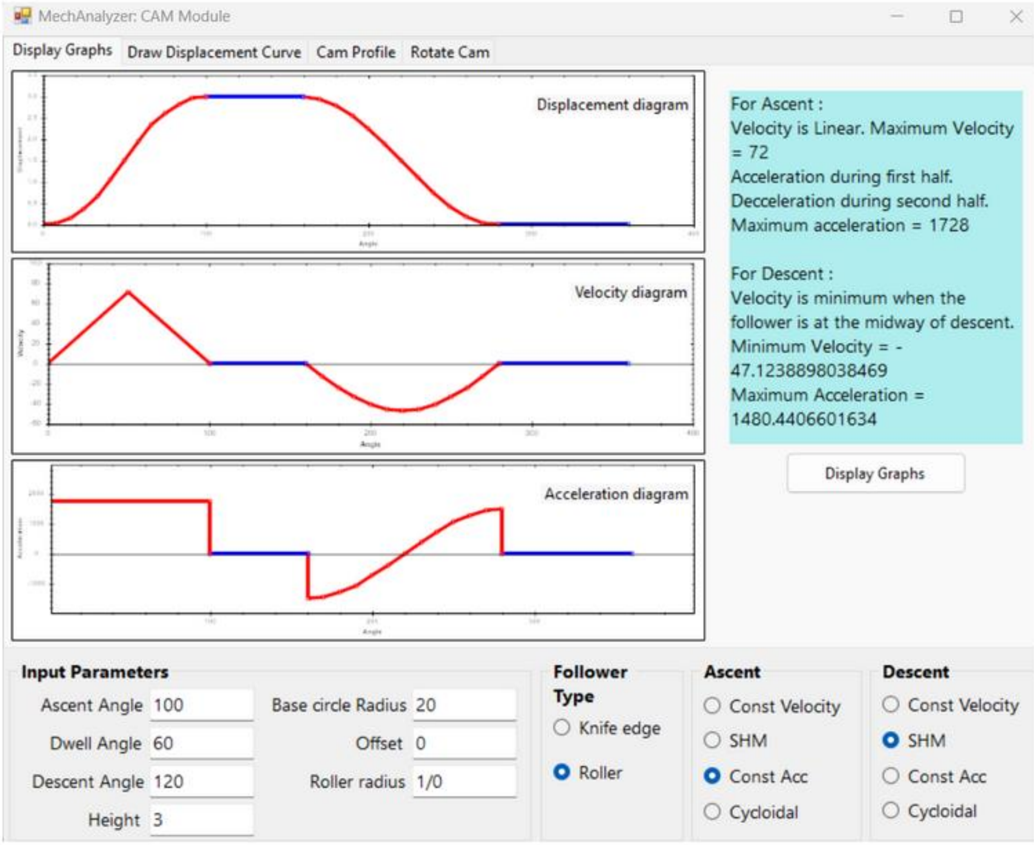
```
clc
clear all
h=4;
r=4;
%Ascent and Descent Angles
dwell_1 = 80;
ascent  = 100;
dwell_2 = 60;
descent = 360 -(ascent + dwell_1 + dwell_2);
%Additional Angles
after_dwell_1 = dwell_1 + ascent;
after_dwell_2 = after_dwell_1 + dwell_2;
%Cam Angle
theta = linspace(0,360,361);
%Ascent Motion Conditions
h_ascent = (h/pi)*(((pi/ascent).*theta(theta<ascent)) -
0.5*sind((2*180/ascent).*theta(theta<ascent)));
%Descent Motion Conditions
h_descent = h-((0.5*h).*(1 - cosd((180/descent).*theta(theta<=descent))));
%Lift during Dwell
h_dwell1 = zeros(1,dwell_1);
h_dwell2 = ones(1,dwell_2).*h;
%Plotting Cam Angle Vs Lift
plot(theta(theta>dwell_1 & theta<=after_dwell_1),h_ascent,
theta(theta>=after_dwell_2 & theta<=360),h_descent);
title('Cam Angle Vs Lift')
xlabel('Cam Angle (degrees)');
ylabel('Lift of follower (mm)');
%Defining radii during different phases of Cam
r1 = r + h_dwell1;
r2 = r + h_ascent;
r3 = r + h_dwell2;
r4 = r + h_descent;
%Joining all radii
r = [r1 r2 r3 r4];
%Convert theta to radians
theta_radians = deg2rad(theta);
%Plotting Cam Profile
figure
polarplot(theta_radians,r);
set(gca,'ThetaZeroLocation','top')
%Converting Polar to Cartesian Coordinate System
[x,y] = pol2cart(theta_radians,r);
x_cord = transpose(x);
y_cord = transpose(y);
z_cord = zeros(361,1);
cam_profile = [x_cord y_cord z_cord];

%END OF CODE
```

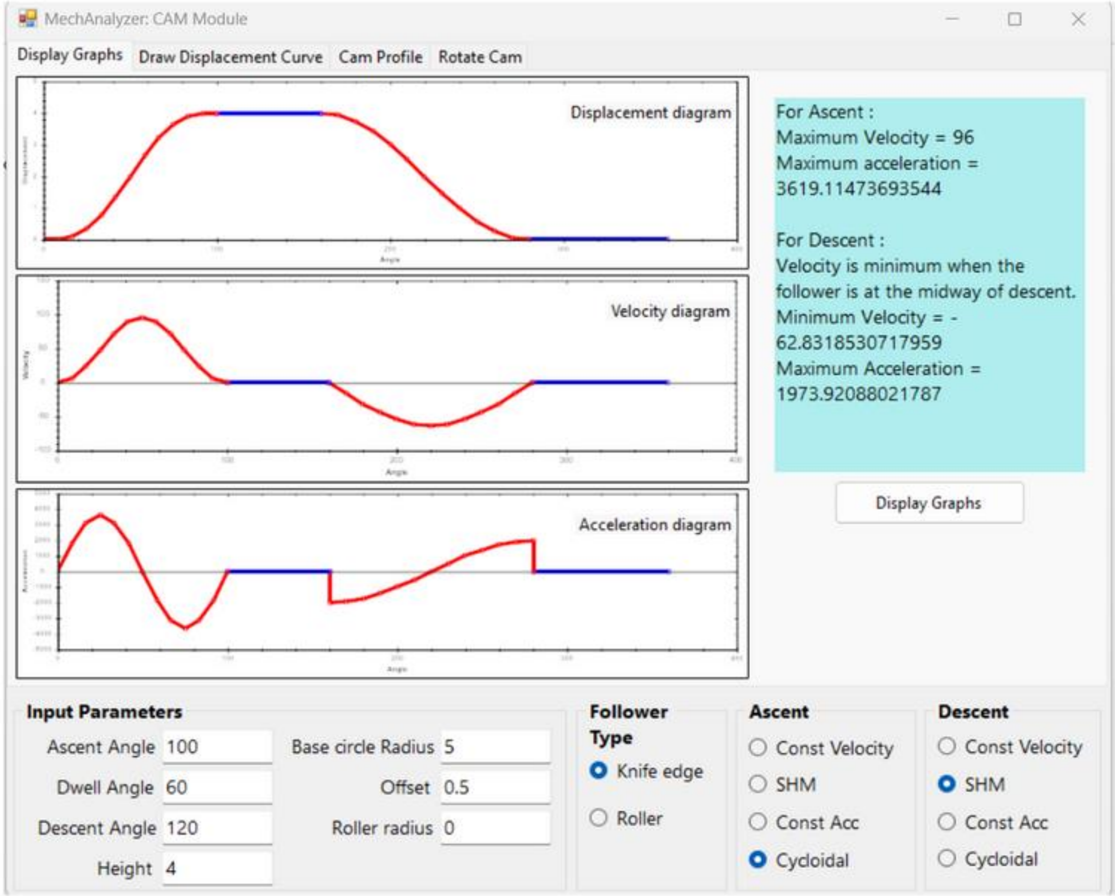

Cam Angle Vs Lift
Lift of follower (mm)
Cam Angle (degrees)
0
0.5
1
1.5
2
2.5
3
3.5
4
50
100
150
200
250
300
350
400

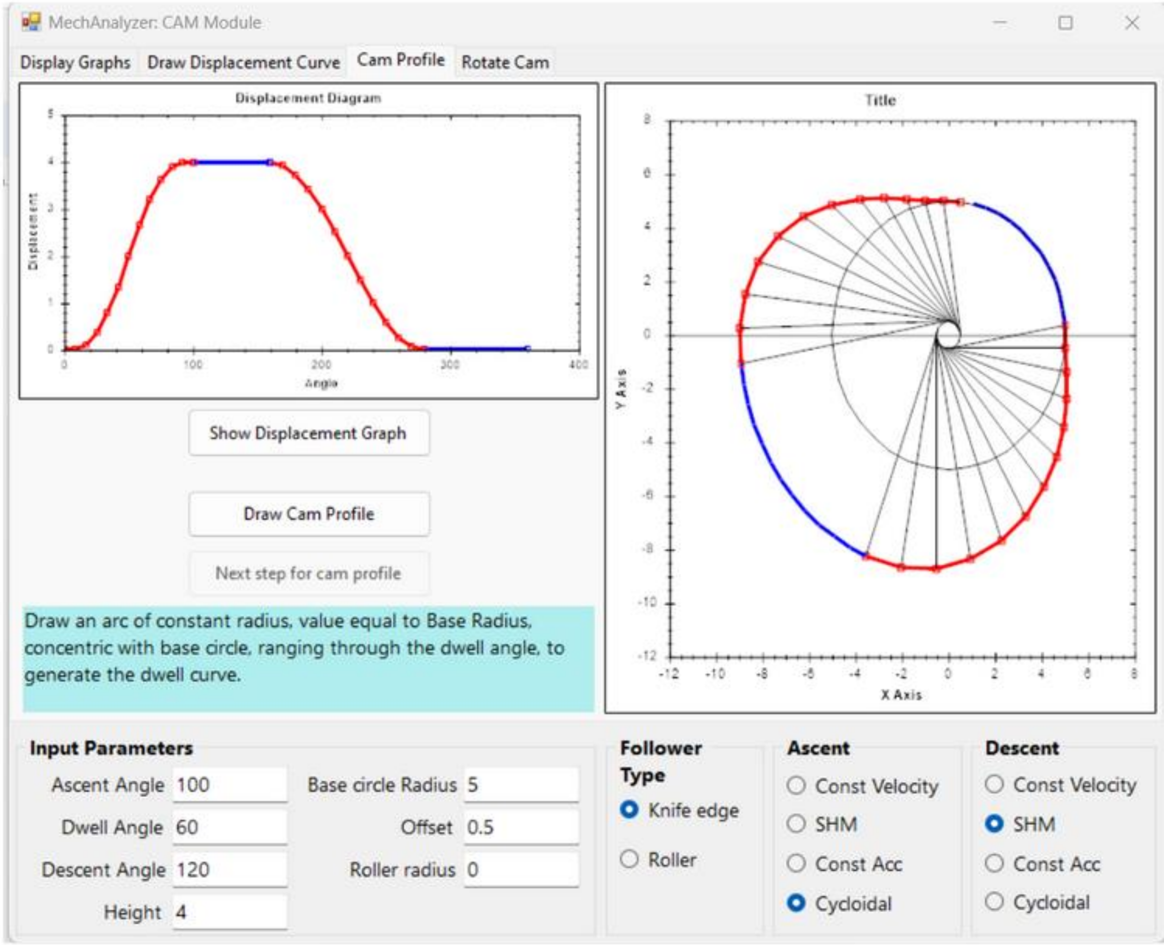

0°
330°
300°
270°
240°
210°
180°
150°
120°
90°
60°
30°
8
6
4
2
0

ADDITIONAL PLOT1



Additional PLOT2




MechAnalyzer: CAM Module
Display Graphs
Draw Displacement Curve
Cam Profile
Rotate Cam
Displacement Diagram
Displacement
Angle
Title
Y Axis
X Axis
Show Displacement Graph
Draw Cam Profile
Next step for cam profile
Draw an arc of constant radius, value equal to Base Radius, concentric with base circle, ranging through the dwell angle, to generate the dwell curve.
Input Parameters
Ascent Angle 100
Dwell Angle 60
Descent Angle 120
Height 4
Base circle Radius 5
Offset 0.5
Roller radius 0
Follower Type
Knife edge
Roller
Ascent
Const Velocity
SHM
Const Acc
Cycloidal
Descent
Const Velocity
SHM
Const Acc
Cycloidal

THANK YOU!