Warsaw University of Technology

Faculty of Mechatronics

Theory of Machines and Devices

Project 04

Report

Cam mechanism with roller follower

Made by:

Harshit Verma (302601)

1. Mechanism Synthesis

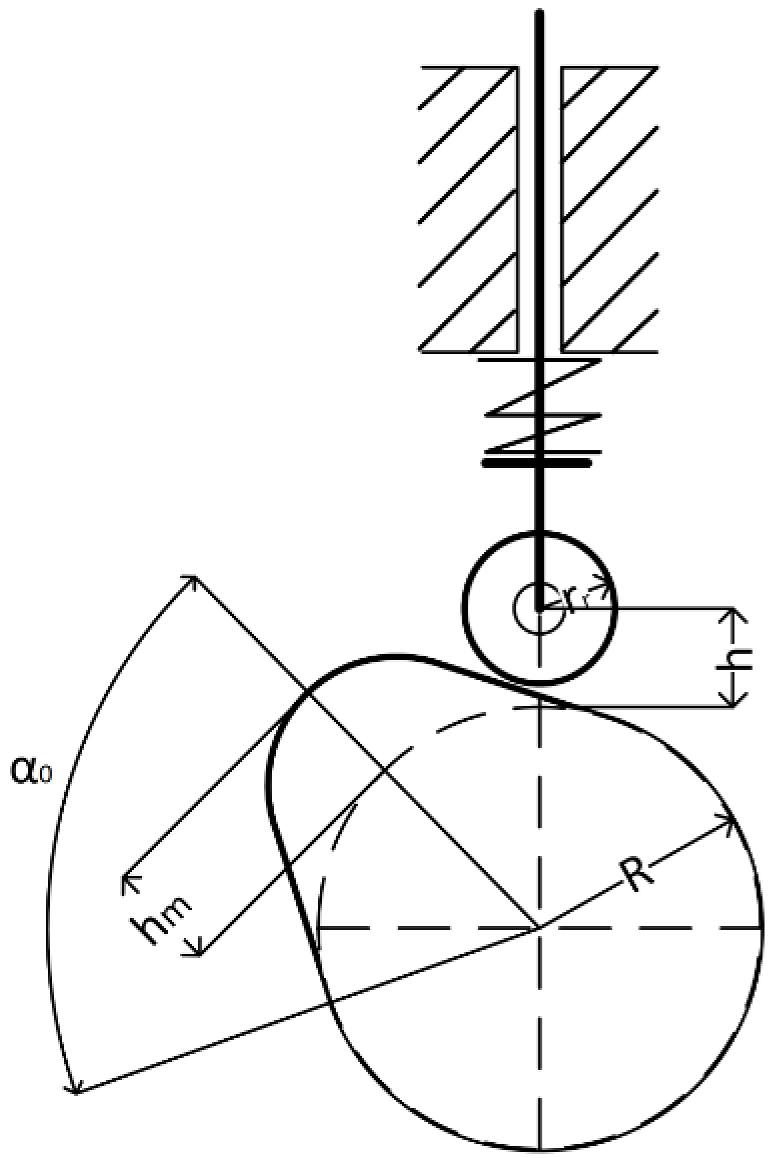


Figure-1.1 Schematic of a Cam Mechanism.

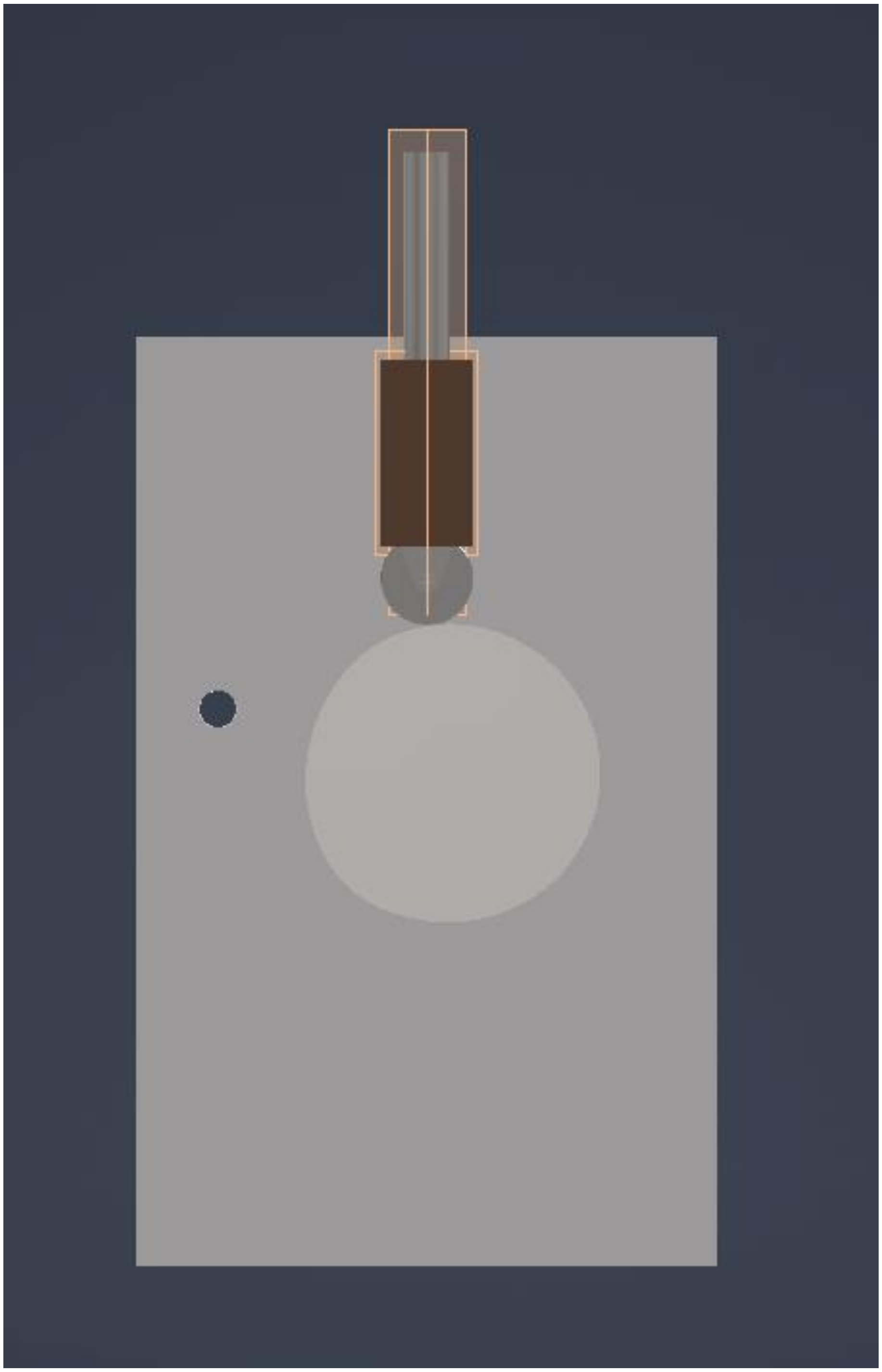
2. Course of the exercise

In this exercise, we are going to prepare a Disc Mechanism. We must prepare disc cams using two methods, Harmonic (Sinusoidal) motion an done with our own choice (Parabolic Motion).

Values assigned						
No.	αo	αop	αpd	hm	ω	m
15	160	160	40	15	80	0.15

3.1 Harmonic (Sinusodial) Motion

Inventor Model:



Results:

Guide

Path Type - Inner

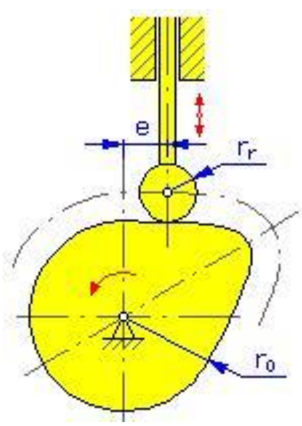
Follower Type - Translating

Follower Shape - Cylinder

Direction - Left

Cam

Type of model		Component
Cam Basic Radius	r0	25.000 mm
Cam Width	bc	12.000 mm
Calculation Points		720 ul
Model Points		60 ul



Follower

Roller Radius	rr	12.000 mm
Roller Width	br	12.000 mm
Eccentricity	e	0.000 mm

Cam Segments

Segment 1

Motion		Harmonic (sinusoidal)
Motion Start Position	l0	0.00 deg

Motion End Position	l	160.00 deg
Lift at Start	h0	0.000 mm
Lift at End	h	15.000 mm
Max. Speed	vmax	0.675 mps
Max. Acceleration	amax	60.749 m/s^2
Min. Acceleration	amin	-60.749 m/s^2
Max. Pulse	jmax	0.000 m/s^3
Min. Pulse	jmin	-5467.420 m/s^3
Max. Pressure Angle	γmax	10.89 deg
Max. Follower Force	Fmax	18.812 N
Max. Normal Force	Fnmax	18.812 N
Max. Torque	Tmax	0.074 N m
Min. Curvature Radius (+)	Rcmin	-37.768 mm
Min. Curvature Radius (-)	Rcmin2	-31.888 mm
Max. Specific Pressure	pmax	78.889 MPa

Segment 2

Motion		Harmonic (sinusoidal)
Motion Start Position	l0	160.00 deg
Motion End Position	l	320.00 deg
Lift at Start	h0	15.000 mm
Lift at End	h	0.000 mm
Max. Speed	vmax	-0.675 mps
Max. Acceleration	amax	60.749 m/s^2
Min. Acceleration	amin	-60.749 m/s^2
Max. Pulse	jmax	5467.420 m/s^3

Min. Pulse	jmin	0.000 m/s^3
Max. Pressure Angle	γmax	-10.89 deg
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Max. Torque	Tmax	0.000 N m
Min. Curvature Radius (+)	Rcmin	-37.768 mm
Min. Curvature Radius (-)	Rcmin2	-31.888 mm
Max. Specific Pressure	pmax	78.889 MPa

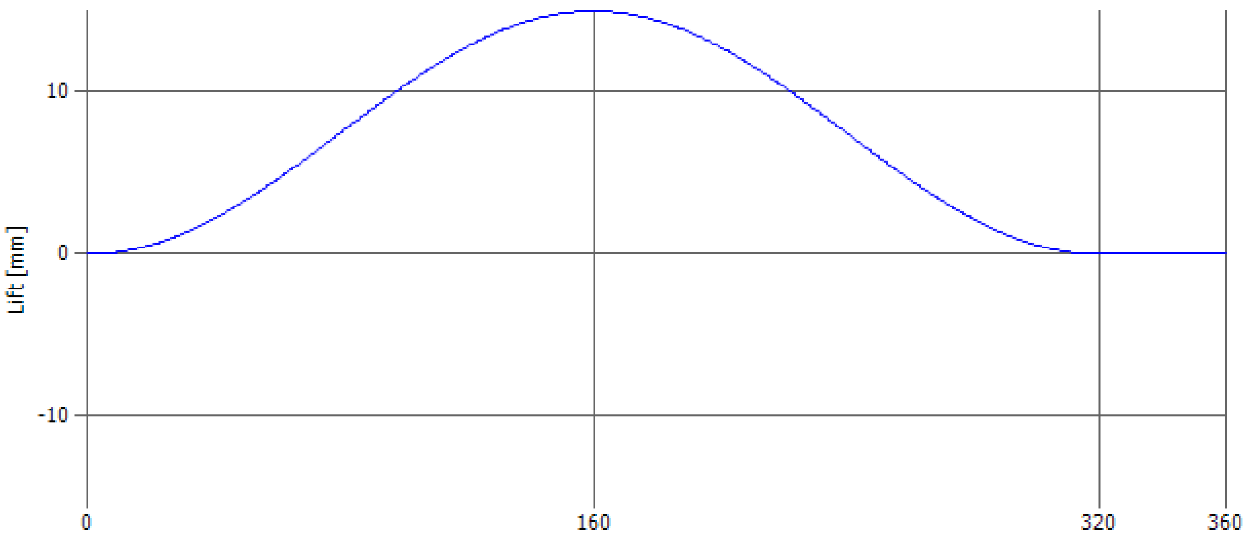
Segment 3

Motion		Harmonic (sinusoidal)
Motion Start Position	l0	320.00 deg
Motion End Position	l	360.00 deg
Lift at Start	h0	0.000 mm
Lift at End	h	0.000 mm
Max. Speed	vmax	0.000 mps
Max. Acceleration	amax	0.000 m/s^2
Min. Acceleration	amin	0.000 m/s^2
Max. Pulse	jmax	0.000 m/s^3
Min. Pulse	jmin	0.000 m/s^3
Max. Pressure Angle	γmax	0.00 deg
Max. Follower Force	Fmax	9.700 N
Max. Normal Force	Fnmax	9.700 N
Max. Torque	Tmax	0.000 N m
Min. Curvature Radius (+)	Rcmin	-25.000 mm
Min. Curvature Radius (-)	Rcmin2	-25.000 mm

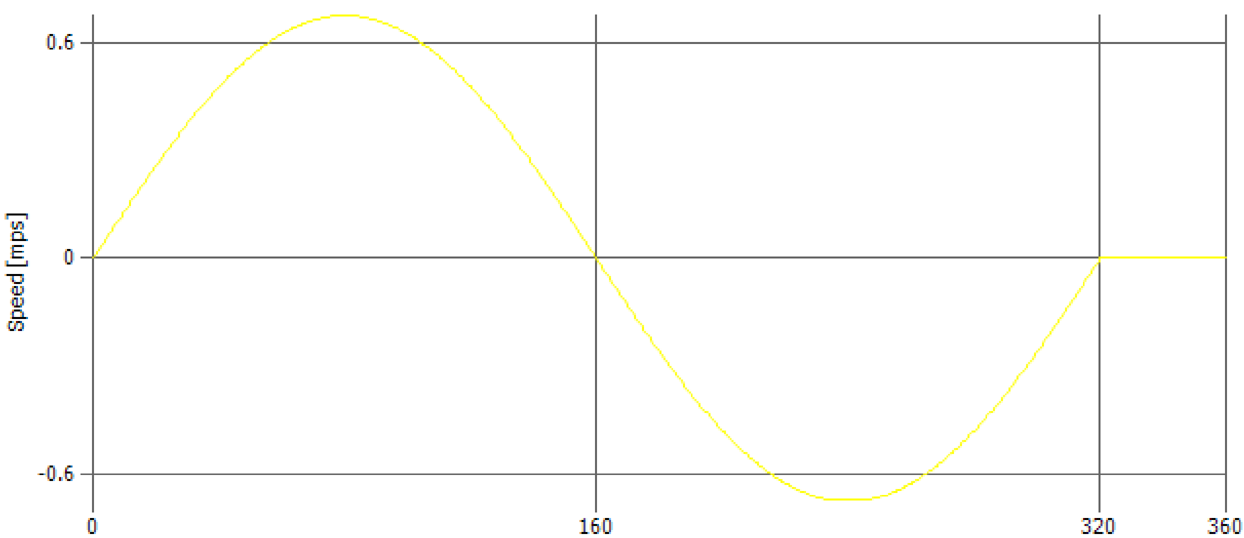
Max. Specific Pressure	pmax	60.034 MPa

Graphs

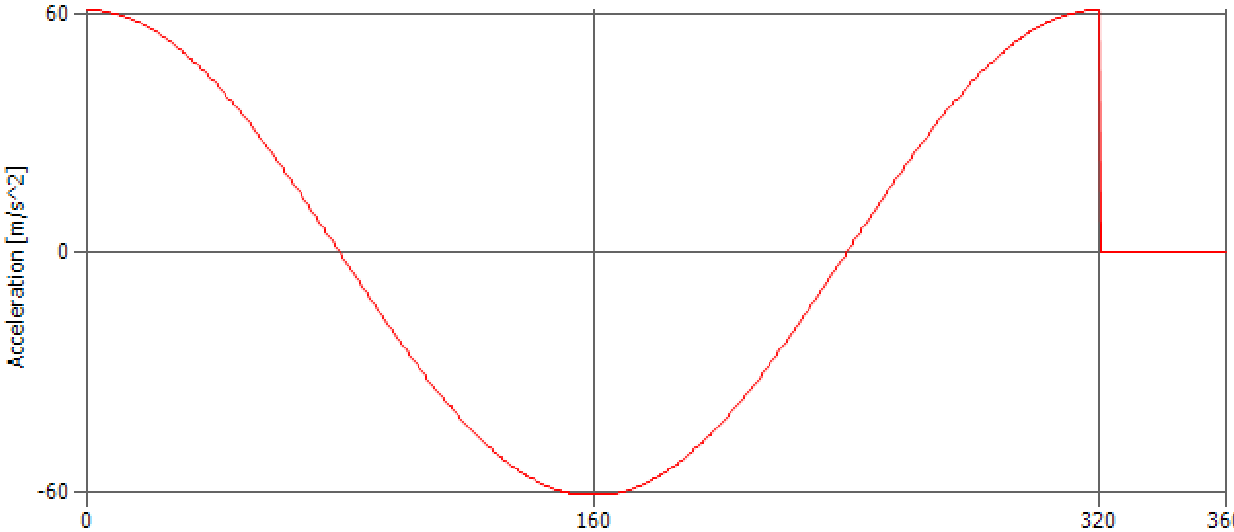
Lift



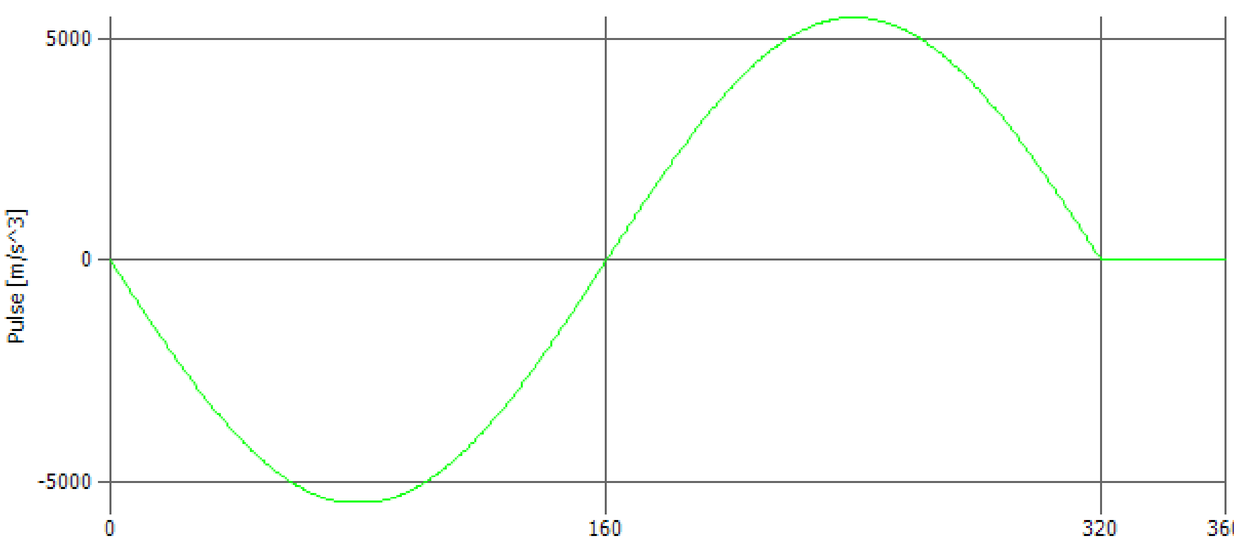
Speed



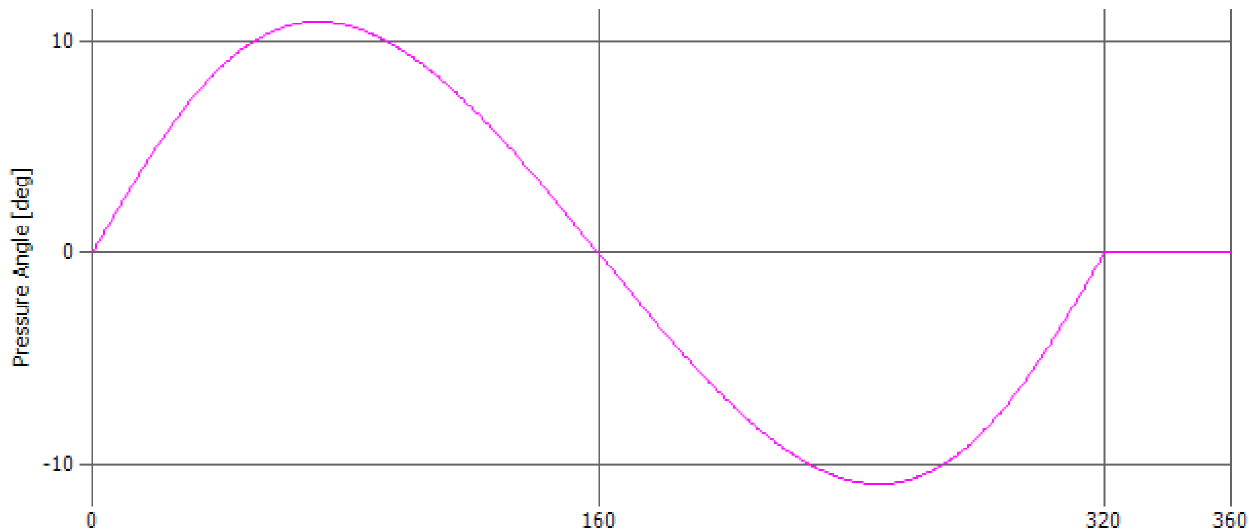
Acceleration



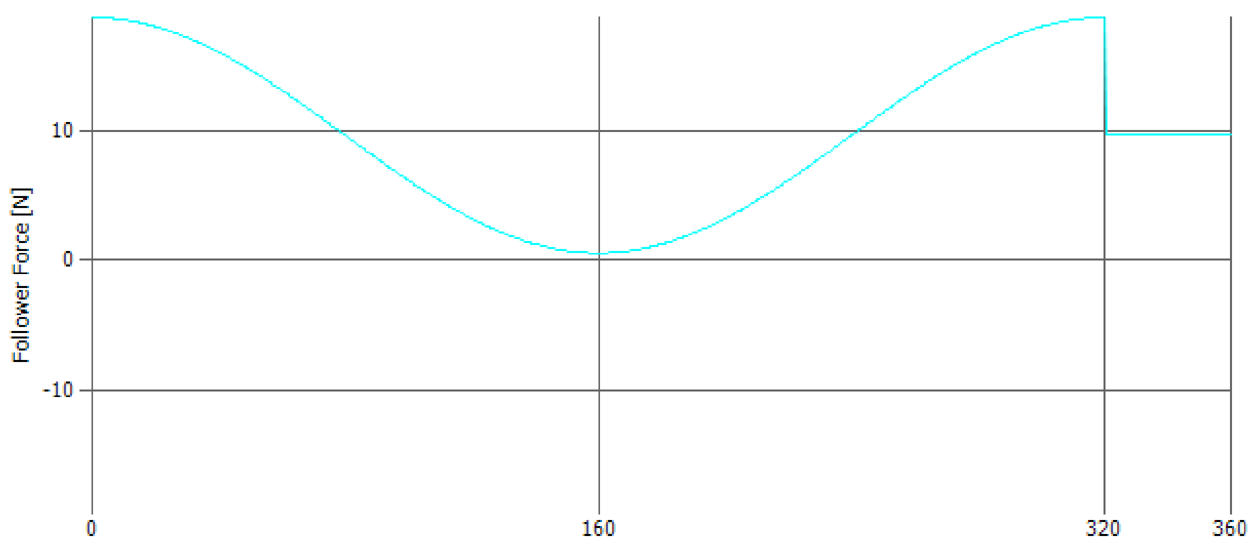
Pulse



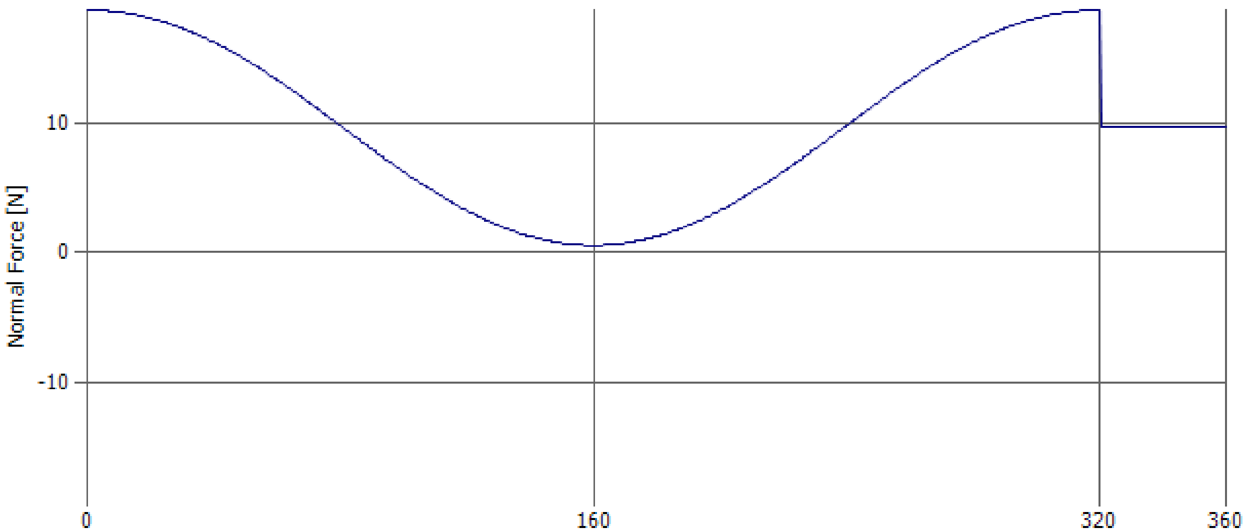
Pressure Angle



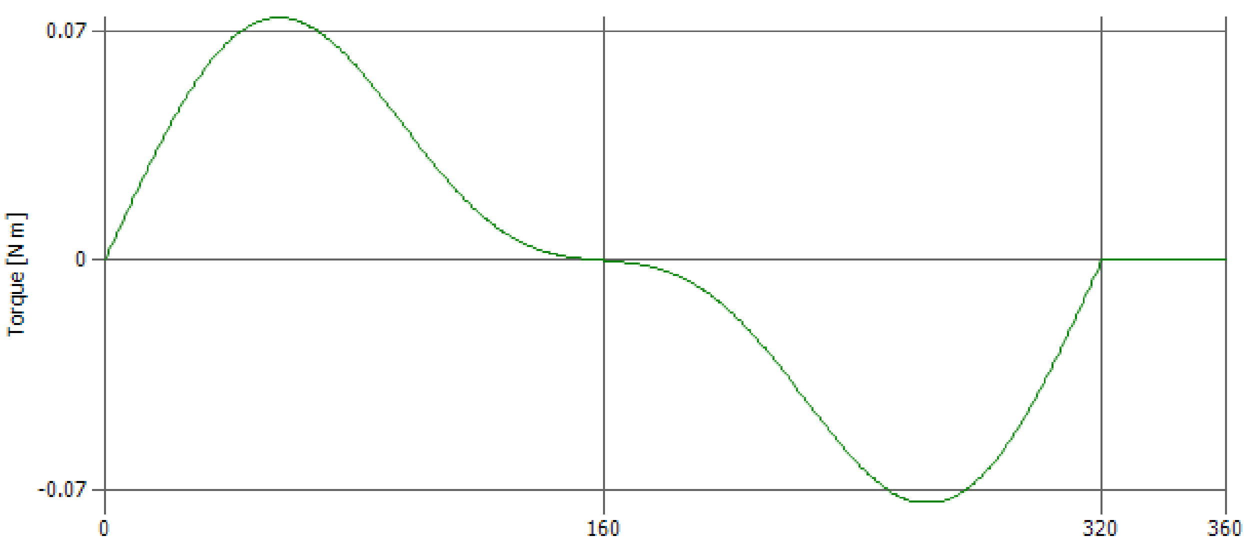
Follower Force



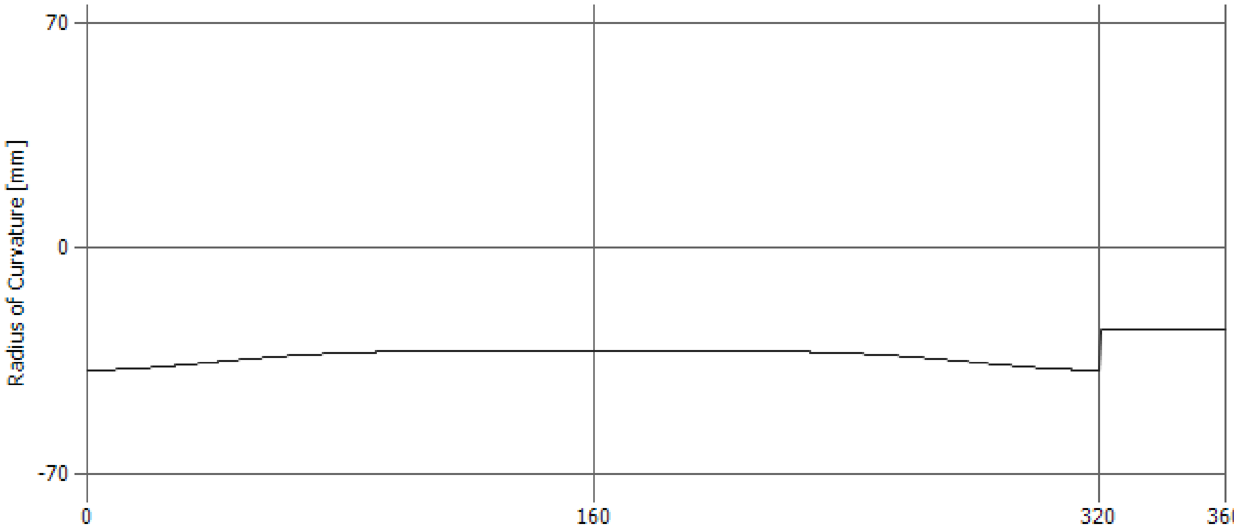
Normal Force



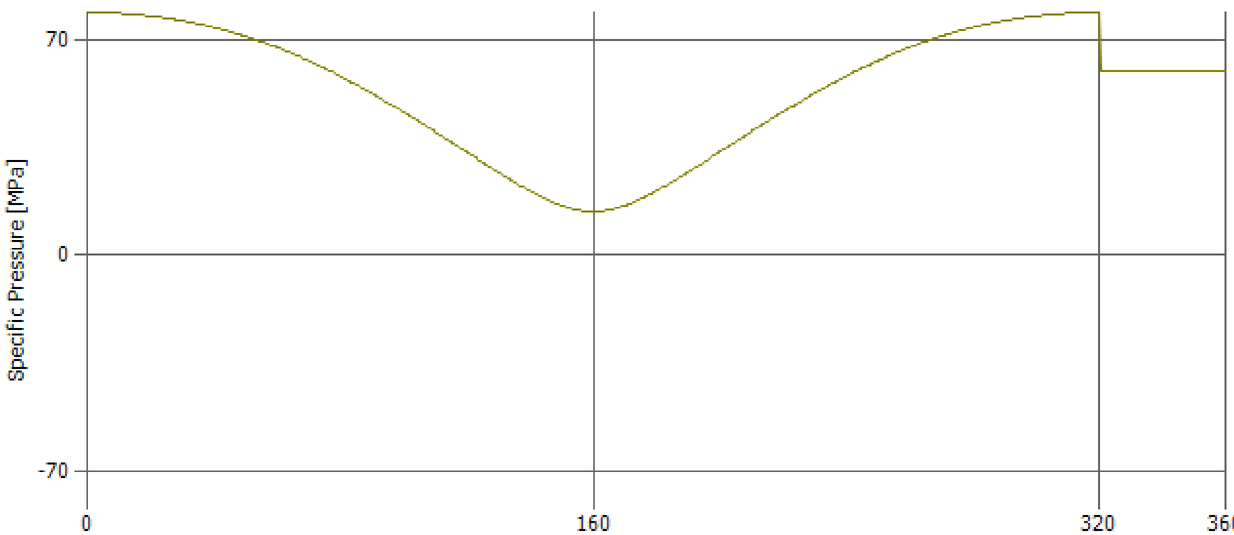
Torque



Radius of Curvature



Specific Pressure



Loads

Cycle Time	t	0.0785 s
Speed	ω	763.940 rpm
Force on Roller	F	9.700 N

Weight of Accelerated Elements	m	0.150 kg
Spring Ratio	c	0.000 N/mm

Material

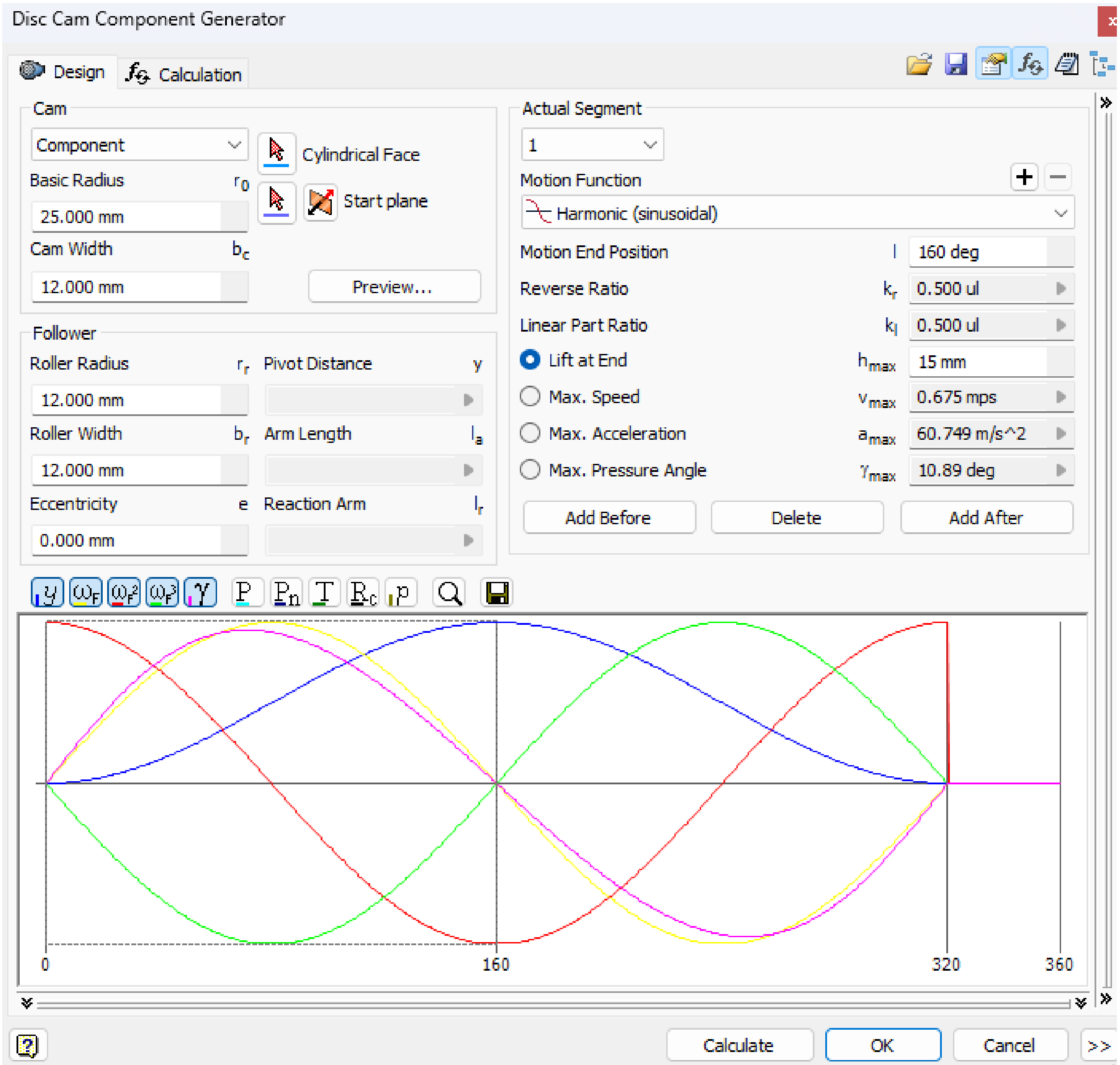
		Cam	Follower
		User material	User material
Allowable Pressure	pA	500.000 MPa	500.000 MPa
Modulus of Elasticity	E	206700 MPa	206700 MPa
Poisson's Ratio	µ	0.300 ul	0.300 ul

Strength Calculation

Results

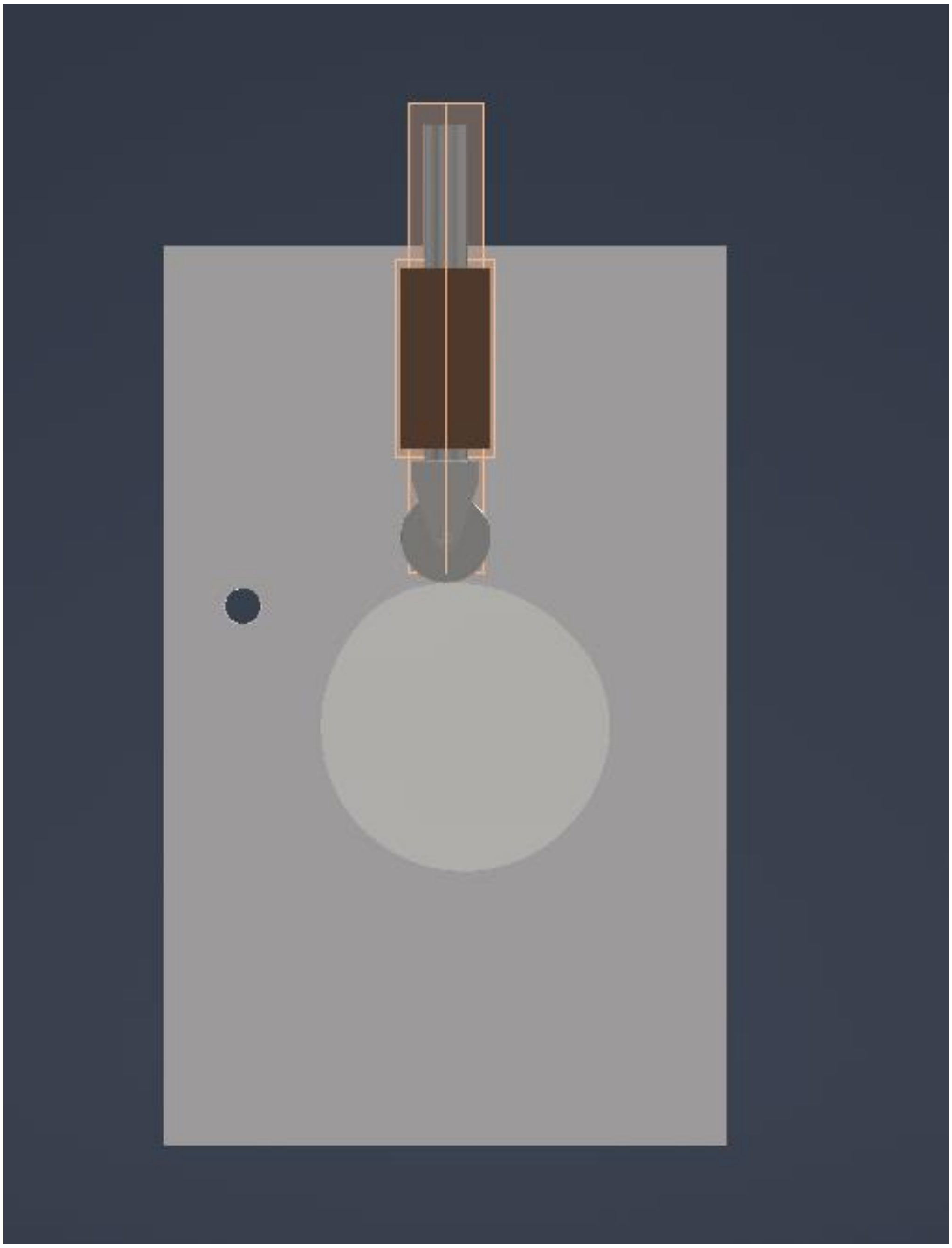
Max. Lift	hmax	15.000 mm
Min. Lift	hmin	0.000 mm
Max. Speed	vmax	0.675 mps
Min. Speed	vmin	-0.675 mps
Max. Pressure Angle	γmax	10.89 deg
Min. Pressure Angle	γmin	-10.89 deg
Max. Acceleration	amax	60.749 m/s^2
Min. Acceleration	amin	-60.749 m/s^2
Max. Pulse	jmax	5467.420 m/s^3
Min. Pulse	jmin	-5467.420 m/s^3
Max. Follower Force	Fmax	18.812 N
Min. Follower Force	Fmin	0.588 N
Max. Normal Force	Fnmax	18.812 N
Min. Normal Force	Fnmin	0.588 N
Max. Torque	Tmax	0.074 N m

Min. Curvature Radius (+)	Rcmin	-37.768 mm
Min. Curvature Radius (-)	Rcmin2	-25.000 mm
Max. Specific Pressure	pmax	78.889 MPa
Check Calculation		**Positive**



3.2 Parabolic Motion

Inventor Model:



1) **Results:**

Guide

Path Type - Inner

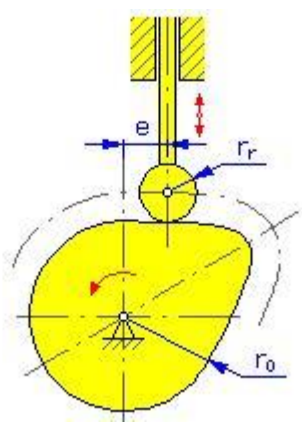
Follower Type - Translating

Follower Shape - Cylinder

Direction - Left

Cam

Type of model		Component
Cam Basic Radius	r0	25.000 mm
Cam Width	bc	12.000 mm
Calculation Points		720 ul
Model Points		60 ul



Follower

Roller Radius	rr	12.000 mm
Roller Width	br	12.000 mm
Eccentricity	e	0.000 mm

Cam Segments

Segment 1

Motion		Parabolic (Polynomial of 2nd degree)
Motion Start Position	l0	0.00 deg

Motion End Position	l	160.00 deg
Lift at Start	h0	0.000 mm
Lift at End	h	15.000 mm
Max. Speed	vmax	0.859 mps
Max. Acceleration	amax	49.242 m/s^2
Min. Acceleration	amin	-49.242 m/s^2
Max. Pulse	jmax	0.000 m/s^3
Min. Pulse	jmin	0.000 m/s^3
Max. Pressure Angle	γmax	13.57 deg
Max. Follower Force	Fmax	17.086 N
Max. Normal Force	Fnmax	17.577 N
Max. Torque	Tmax	0.136 N m
Min. Curvature Radius (+)	Rcmin	-41.802 mm
Min. Curvature Radius (-)	Rcmin2	-26.032 mm
Max. Specific Pressure	pmax	75.975 MPa

Segment 2

Motion		Harmonic (sinusoidal)
Motion Start Position	l0	160.00 deg
Motion End Position	l	320.00 deg
Lift at Start	h0	15.000 mm
Lift at End	h	0.000 mm
Max. Speed	vmax	-0.675 mps
Max. Acceleration	amax	60.749 m/s^2
Min. Acceleration	amin	-60.749 m/s^2
Max. Pulse	jmax	5467.420 m/s^3

Min. Pulse	jmin	0.000 m/s^3
Max. Pressure Angle	γmax	-10.89 deg
Max. Follower Force	Fmax	18.812 N
Max. Normal Force	Fnmax	18.812 N
Max. Torque	Tmax	0.000 N m
Min. Curvature Radius (+)	Rcmin	-37.768 mm
Min. Curvature Radius (-)	Rcmin2	-31.888 mm
Max. Specific Pressure	pmax	78.889 MPa

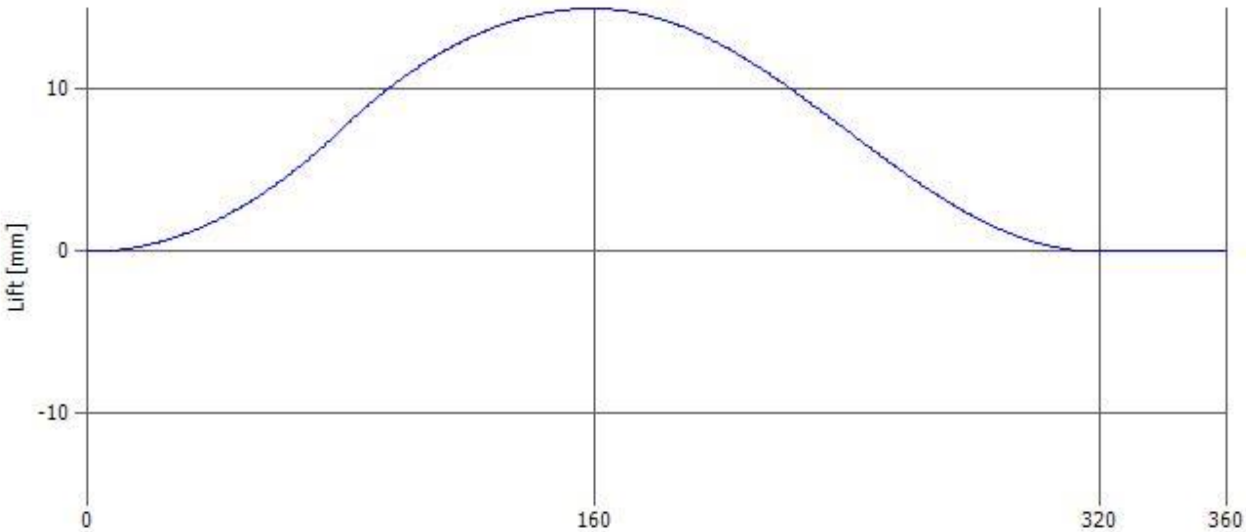
Segment 3

Motion		Harmonic (sinusoidal)
Motion Start Position	l0	320.00 deg
Motion End Position	l	360.00 deg
Lift at Start	h0	0.000 mm
Lift at End	h	0.000 mm
Max. Speed	vmax	0.000 mps
Max. Acceleration	amax	0.000 m/s^2
Min. Acceleration	amin	0.000 m/s^2
Max. Pulse	jmax	0.000 m/s^3
Min. Pulse	jmin	0.000 m/s^3
Max. Pressure Angle	γmax	0.00 deg
Max. Follower Force	Fmax	9.700 N
Max. Normal Force	Fnmax	9.700 N
Max. Torque	Tmax	0.000 N m
Min. Curvature Radius (+)	Rcmin	-25.000 mm
Min. Curvature Radius (-)	Rcmin2	-25.000 mm

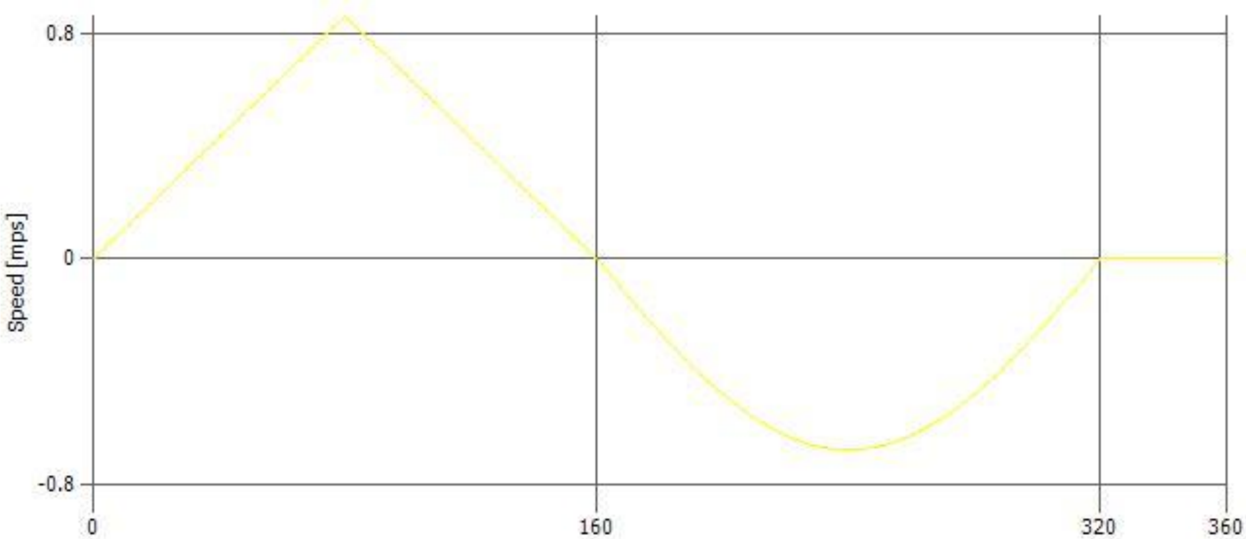
Max. Specific Pressure	pmax	60.034 MPa

Graphs

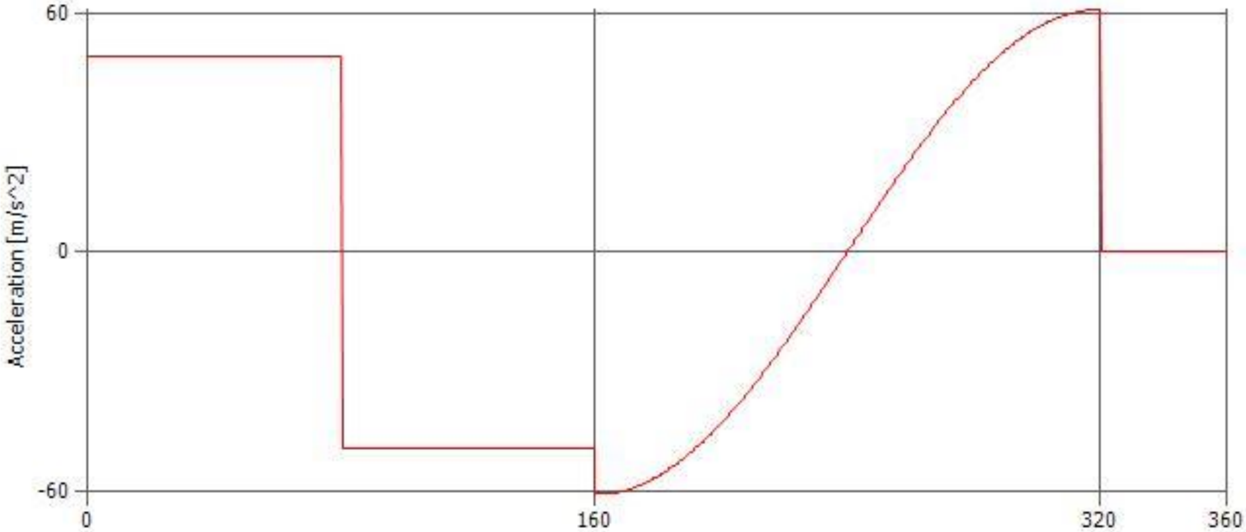
Lift



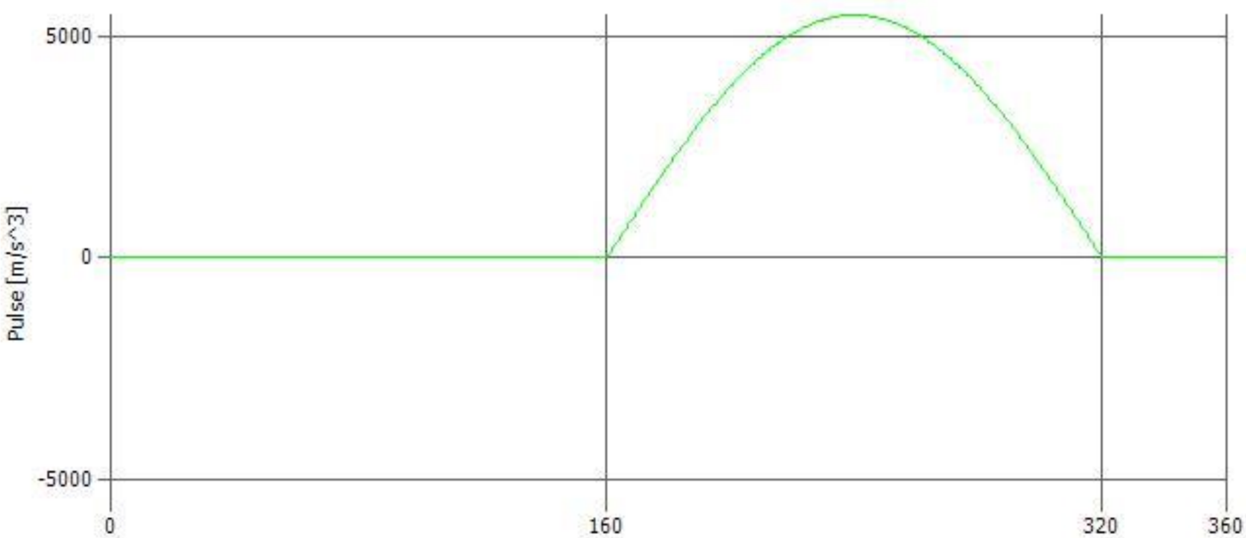
Speed



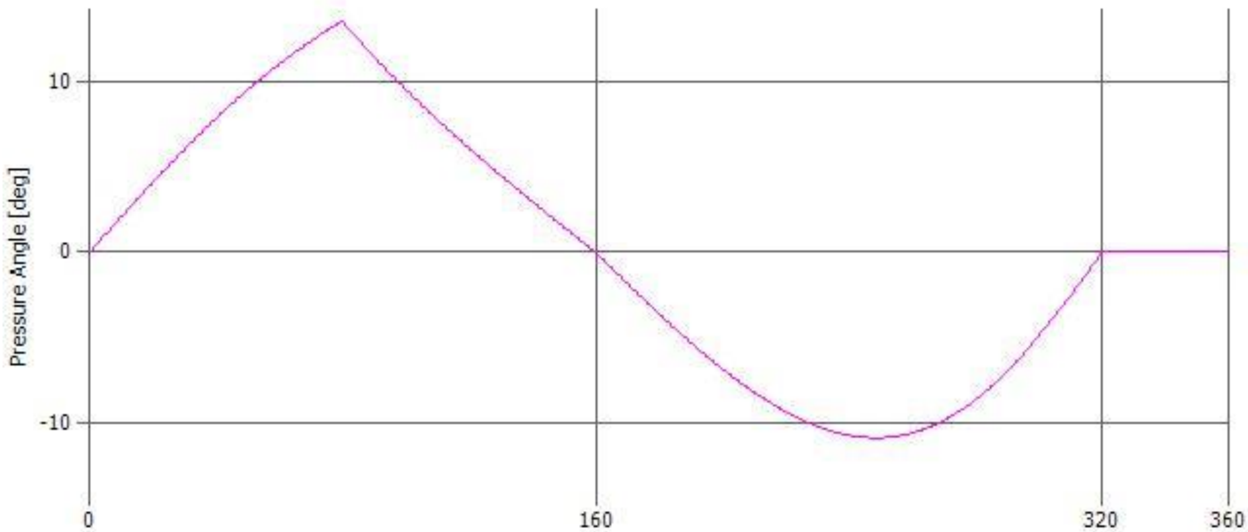
Acceleration



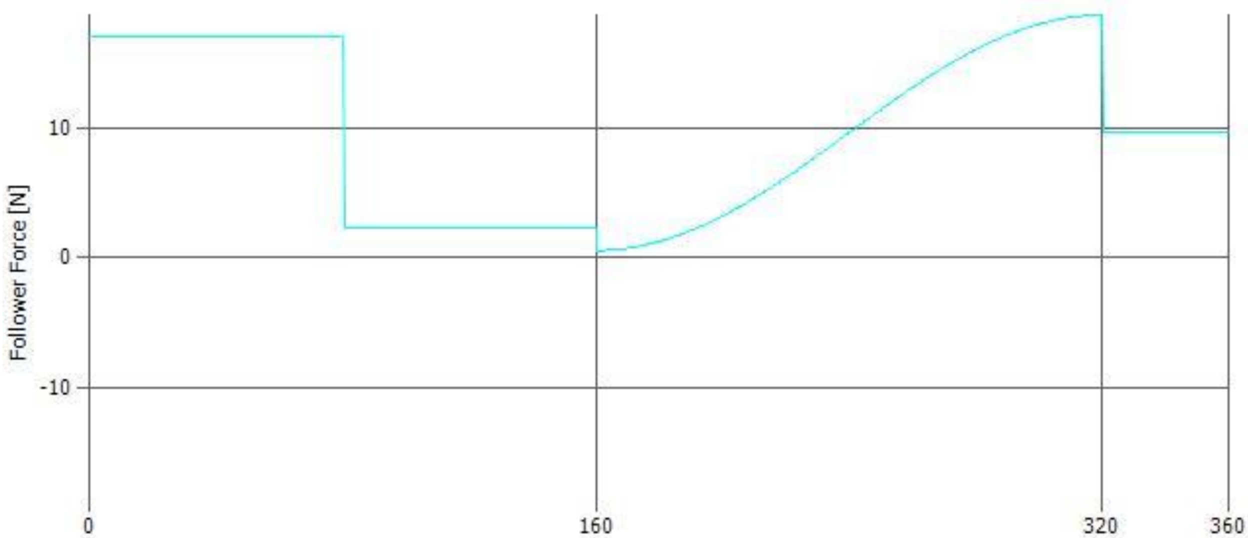
Pulse



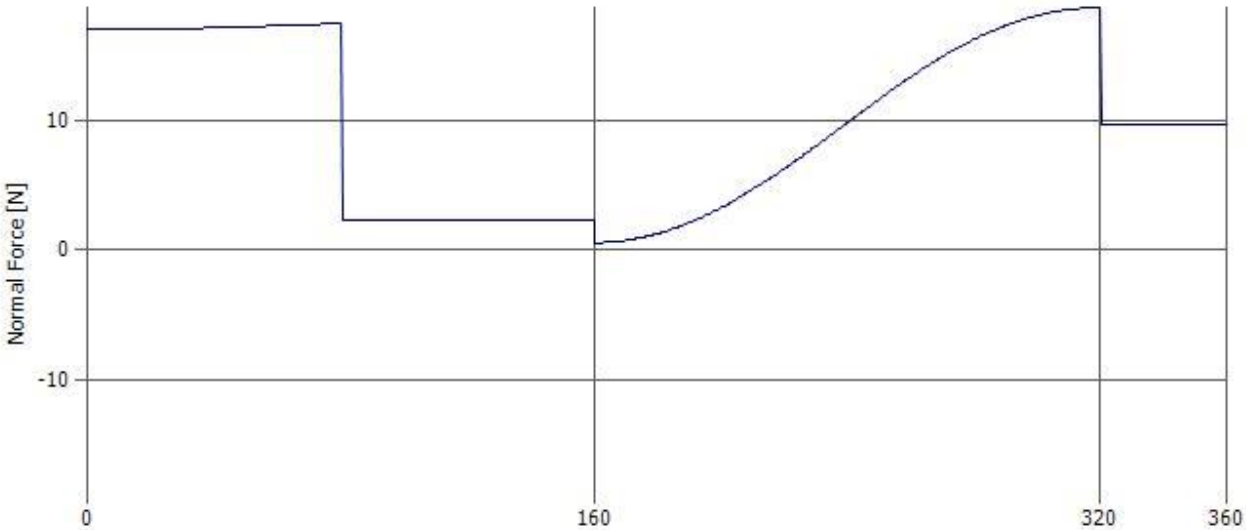
Pressure Angle



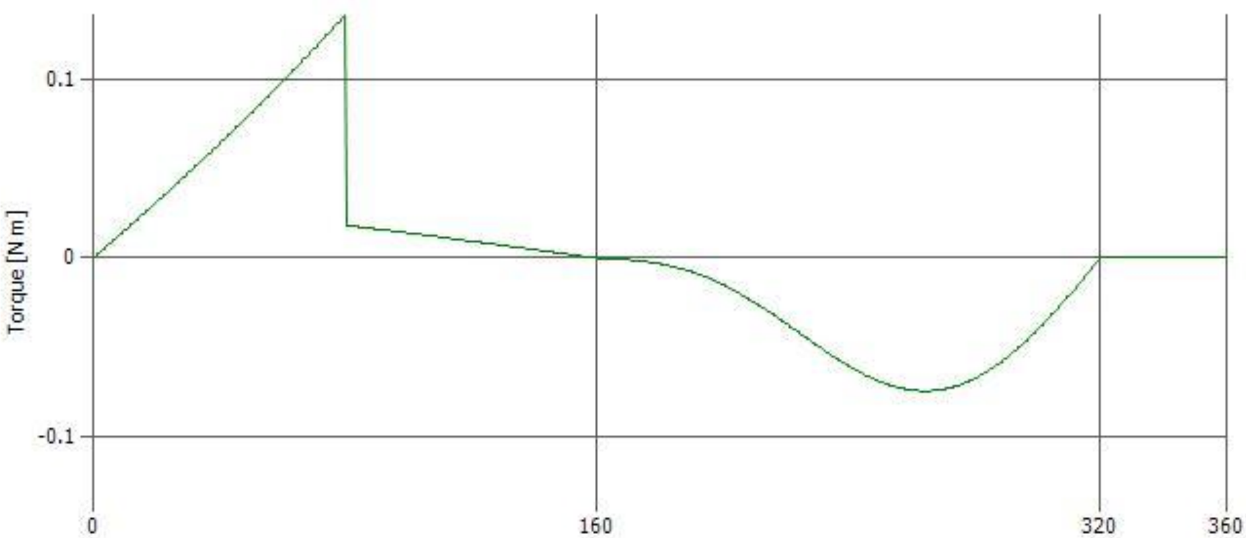
Follower Force



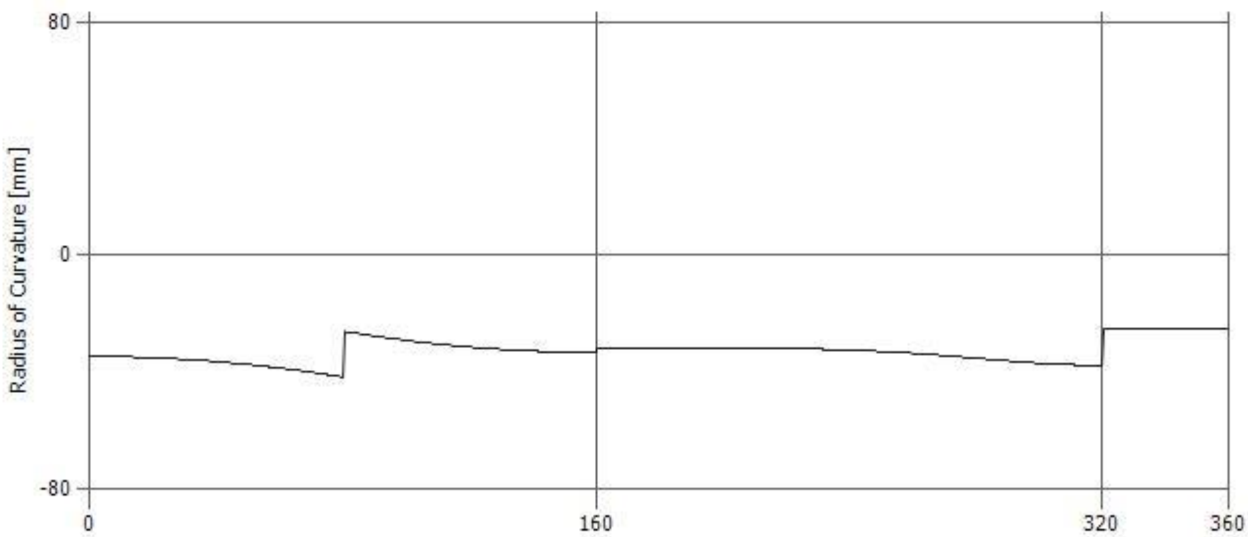
Normal Force



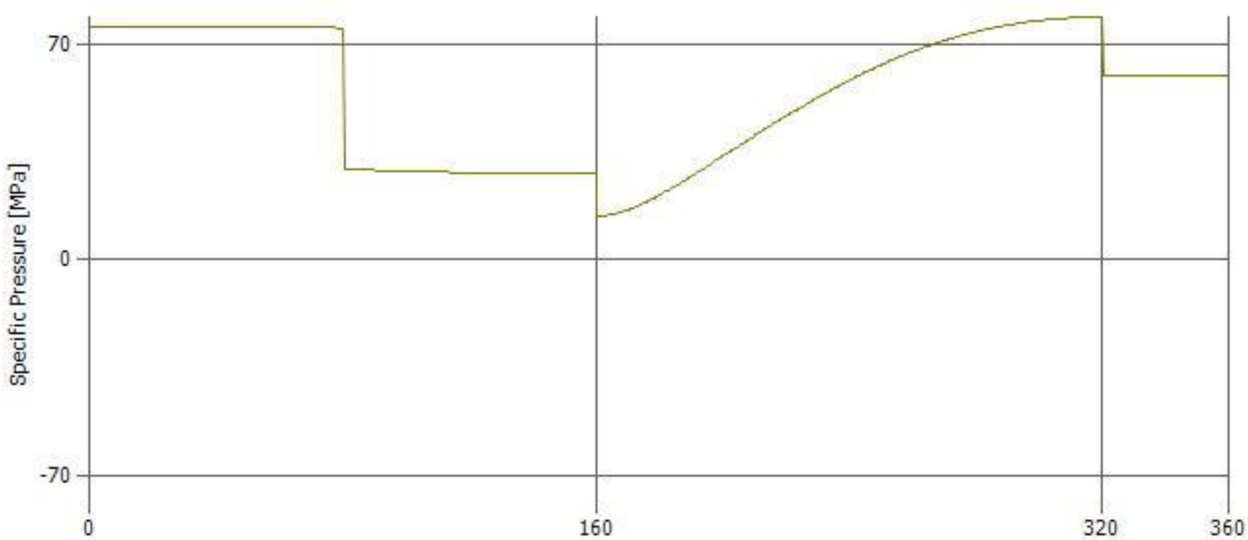
Torque



Radius of Curvature



Specific Pressure



Loads

Cycle Time	t	0.0785 s
Speed	ω	763.940 rpm

Force on Roller	F	9.700 N
Weight of Accelerated Elements	m	0.150 kg
Spring Ratio	c	0.000 N/mm

Material

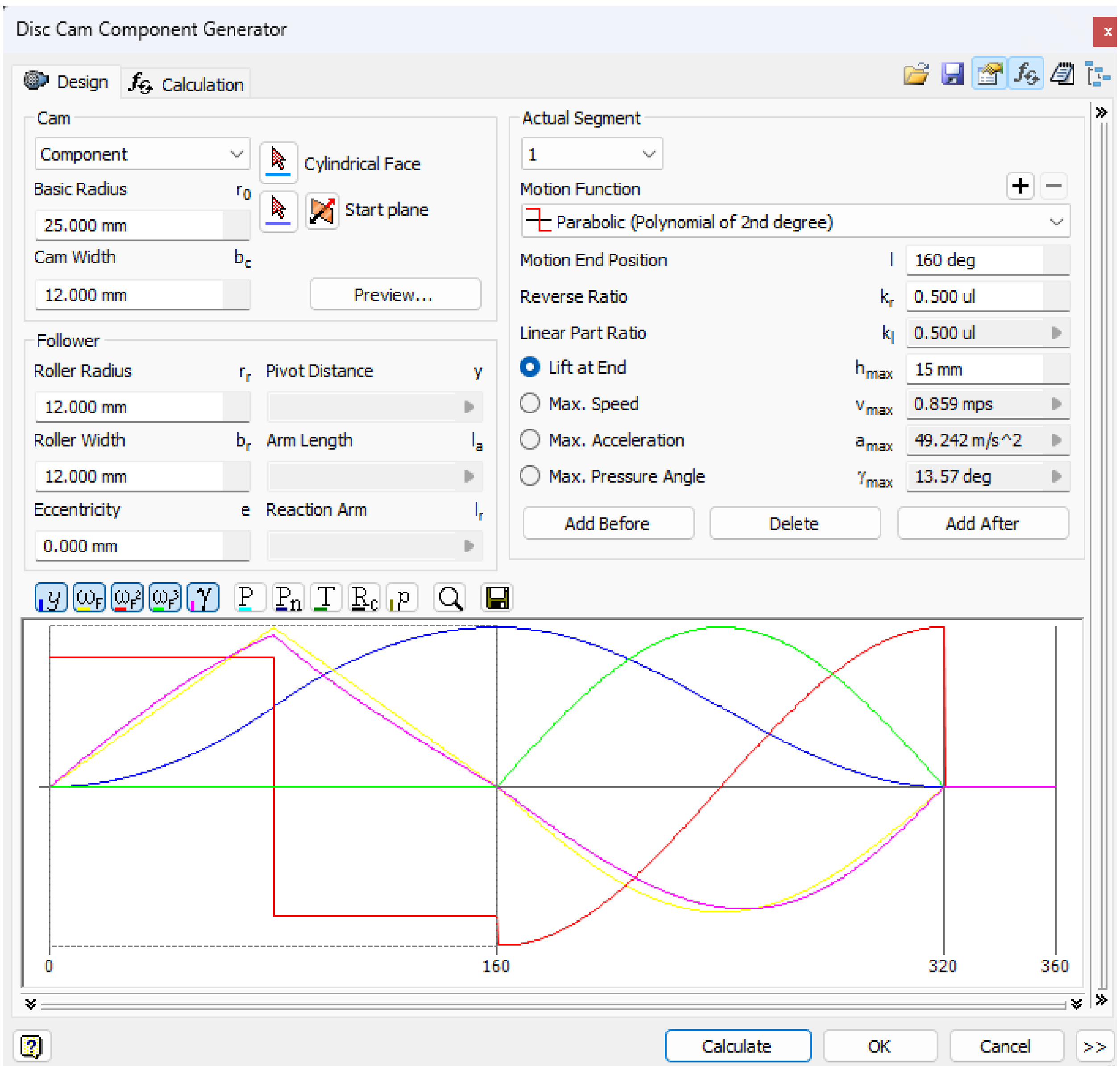
		Cam	Follower
		User material	User material
Allowable Pressure	pA	500.000 MPa	500.000 MPa
Modulus of Elasticity	E	206700 MPa	206700 MPa
Poisson's Ratio	μ	0.300 ul	0.300 ul

Strength Calculation

Results

Max. Lift	hmax	15.000 mm
Min. Lift	hmin	0.000 mm
Max. Speed	vmax	0.859 mps
Min. Speed	vmin	-0.675 mps
Max. Pressure Angle	γmax	13.57 deg
Min. Pressure Angle	γmin	-10.89 deg
Max. Acceleration	amax	60.749 m/s^2
Min. Acceleration	amin	-60.749 m/s^2
Max. Pulse	jmax	5467.420 m/s^3
Min. Pulse	jmin	0.000 m/s^3
Max. Follower Force	Fmax	18.812 N
Min. Follower Force	Fmin	0.588 N
Max. Normal Force	Fnmax	18.812 N
Min. Normal Force	Fnmin	0.588 N

Max. Torque	Tmax	0.136 N m
Min. Curvature Radius (+)	Rcmin	-41.802 mm
Min. Curvature Radius (-)	Rcmin2	-25.000 mm
Max. Specific Pressure	pmax	78.889 MPa
Check Calculation		**Positive**



4. Summary:

In this report, two methods were employed to design a cam mechanism with a roller follower: the harmonic sinusoidal method and the parabolic method. The harmonic sinusoidal method generates a cam profile based on sinusoidal motion, providing smooth acceleration and deceleration phases. The parabolic method, on the other hand, uses parabolic curves to define the follower's motion, offering a different balance of velocity and acceleration characteristics. Both methods were analyzed to understand their impact on the cam mechanism's performance, focusing on the smoothness of motion, stress distribution, and overall efficiency.

5. Conclusions:

1) **Harmonic Sinusoidal Method**:

- **Smooth Motion**: This method produces a cam profile that ensures smooth acceleration and deceleration, minimizing jerk and resulting in a more fluid motion of the roller follower.
- **Reduced Wear and Tear**: The gradual changes in acceleration help in reducing wear and tear on the cam and follower, potentially increasing the lifespan of the mechanism.
- **Application Suitability**: Ideal for applications where smooth and continuous motion is critical, such as in precision machinery and instruments.

2) **Parabolic Method**:

- **Distinct Motion Characteristics**: The parabolic method provides a distinct acceleration and deceleration pattern, which may result in slightly higher peak accelerations compared to the harmonic sinusoidal method.
- **Stress Distribution**: While this method can handle varying loads effectively, the peak stresses might be higher, necessitating more robust materials and design considerations.
- **Efficiency and Performance**: Suitable for applications where the specific motion profile generated by parabolic curves is required, offering a different balance of speed and force.

3) **Comparative Analysis**:

- **Motion Smoothness**: The harmonic sinusoidal method generally offers smoother motion, making it preferable for high-precision and high-speed applications.
- **Design Complexity**: Both methods require careful design and analysis, but the harmonic sinusoidal method may be slightly more complex due to the need to accurately model sinusoidal functions.

- **Material Considerations**: The choice of method impacts material selection and durability, with the harmonic sinusoidal method potentially allowing for lighter materials due to reduced peak stresses.