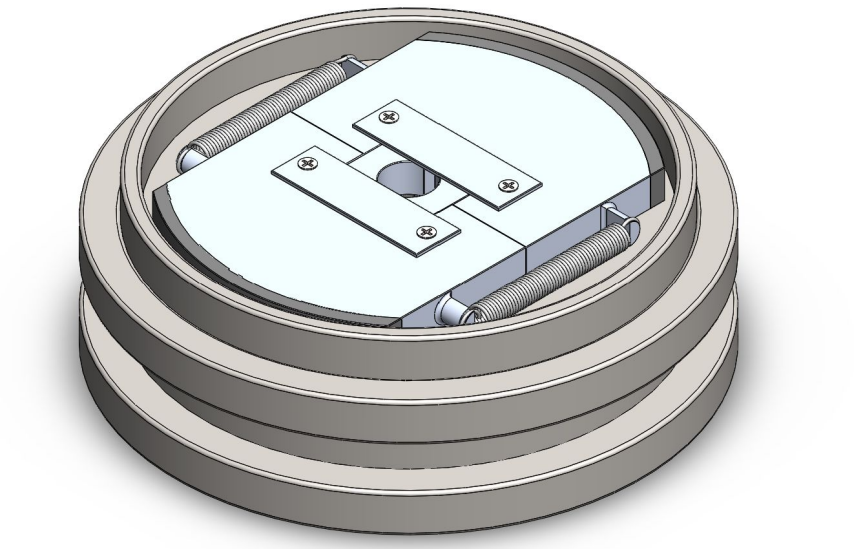
Clutch Assembly

Mech 200

University of Victoria
Fall 2020



Group: 20

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Table of Contents

List of Tables and Figures

1.0 Design Calculations

The following sections will demonstrate the calculations that lead to our determination of clutch shoe geometry, friction lining, shoe/clutch material, and spring coefficient.

At full power:

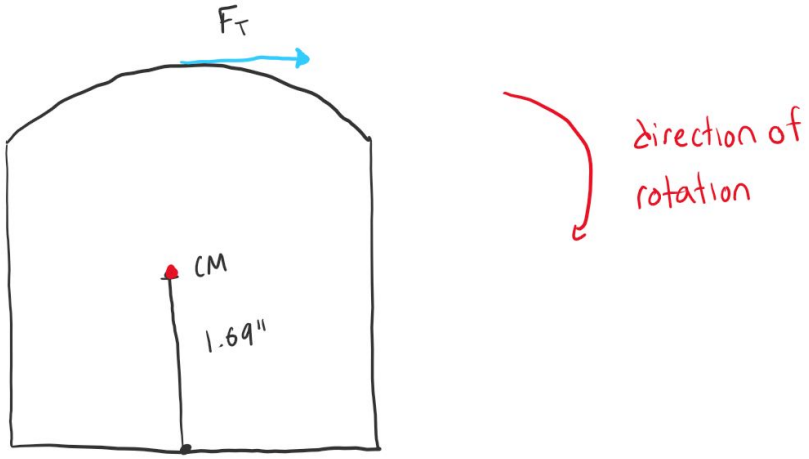
$$\omega_0 = \frac{RPM \times 2\pi}{60} = \frac{710 \times 2\pi}{60} = 74.4 \frac{rad}{s}$$

At 65% power:

$$\omega_1 = 0.65\,\omega_0 = 48.3 \frac{rad}{s}$$

At full speed, Tangential force:

$$F_T = \frac{P}{2r\omega} = \frac{280W}{2(0.0889m)\cdot 74.4\frac{rad}{s}} = 21.1667 \frac{\frac{Nm}{s}}{\frac{m}{s}} = N$$



1.1

Figure 1: FBD Tangential force of clutch shoe.

Step 2

1) Decide on a friction material for lining of the clutch shoe

- Find μ and max pressure

$$V = \frac{RPM \times 2\pi r}{12 \frac{in}{ft}} = \frac{710 RPM \times \pi \times 6.5}{12 \frac{in}{ft}} = 1208.2 \frac{ft}{min}$$

choose a medium friction sheet, $\mu \approx 0.35$

$P_{max} \approx 500$ PSI

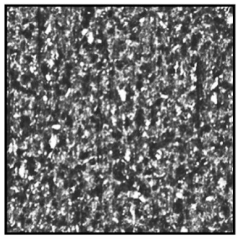
2) Calculate Normal Force such that it is equal to F_T:

$$f_f = F_T$$

$$\mu F_N = F_T$$

$$F_N = \frac{22.8N}{0.35} = 65.14 N$$

* Note:
We chose part number 6090K22 (medium friction clutch & break lining) from McMaster Carr. It has a coefficient of friction of 0.35



Each

In stock
$27.89 Each
6090K22

ADD TO ORDER

Construction	Molded
Thickness	3/16"
Width	7 1/2"
Length	7 1/2"
Maximum Rubbing Speed	5,000 fpm @ 500 psi
Maximum Coefficient of Friction	0.35
Maximum Temperature	550° F
Maximum Pressure	500 psi
RoHS	RoHS 3 (2015/863/EU) Compliant
REACH	REACH (EC 1907/2006) (06/25/2020, 209 SVHC) Compliant
DFARS	Specialty Metals COTS-Exempt
Country of Origin	United States

These sheets provide stable torque at high and low speeds. Also known as friction material, they can be riveted or bonded. They do not contain asbestos.

Figure 2: Friction Brake and Clutch Lining Data Sheet

Step 3

1) Calculate the minimum surface area for the clutch shoes.

$$A_{TOT} = \frac{F_N}{P} = \frac{65.14\,N}{500psi \cdot \frac{6.8948\,kpa}{psi}} = 0.000018913\,m^2$$

$$A_{shoe} = \frac{A_{TOT}}{2} = 0.000009456\,m^2 = 0.01465\,in^2$$

Therefore the minimum area of a shoe is $0.015in^2$

Step 4

1) The normal force obtained from the centripital force. Calculate the value for (mass of shoe) · (radial distance to C.M.) necessary to obtain the centripital force required.

$$F_N = Mr\omega_o^2 - F_s$$

@ 65% operating speed, centripital force equals spring force

$$F_s = Mr\omega_1^2$$

Thus

$$F_N = Mr(\omega_o^2 - \omega_1^2)$$

$$Mr = \frac{F_N}{\omega_o^2 - \omega_1^2} = 0.01021\,kgm$$

Step 5

1) $F_S = Mr\omega_1^2 = (0.01021\,kg \cdot m)\left(48.4\,\frac{rad}{s}\right)^2 = 23.9N$

$F_s = k(x - x_0)$

2) Estimate an r value and find the corresponding M

choose $r = 1.69\,in^2$

So:

$$M = \frac{0.0102\,kg\,m}{1.69 \times 0.0254\,\frac{m}{in}} = 0.2376\,kg$$

3) Pick a material:

Aluminum $\rho = 2710\,\frac{kg}{m^3}$

$$\frac{m}{\rho} = V$$

$$V = \frac{0.2376}{2710\,\frac{kg}{m^3}} = 0.00008765\,m^3 = 5.35\,inches^3$$

Constraints

$SA > 0.01465\,in^2$

$r = 1.69\,in$

$m = 0.2376\,kg$

$\rho = 2710\,\frac{kg}{m^3}$

arc length: 4.37, thickness = 0.5

$SA = 4.37 \times 0.5 = 2.185\,inches^3 > 0.01465\,in^2$

From the choice of r, found volume of the shoe.
In Solidworks we created the shoe where its centre of mass was a distance r from centre of clutch.
and it had volume we calculated using r.

Surface Area

$SA_{min} = 0.01465\,in^2$

Our SA (w values from above) = (arc length)(shoe thickness)

$= (4.37")(0.5")$

$= 2.185"^2 > SA_{min}$

With our values, our minimum surface area is $0.01465in^2$ per shoe.
In solid works, our ACTUAL surface area is $2.185in^2$, which is more than enough.

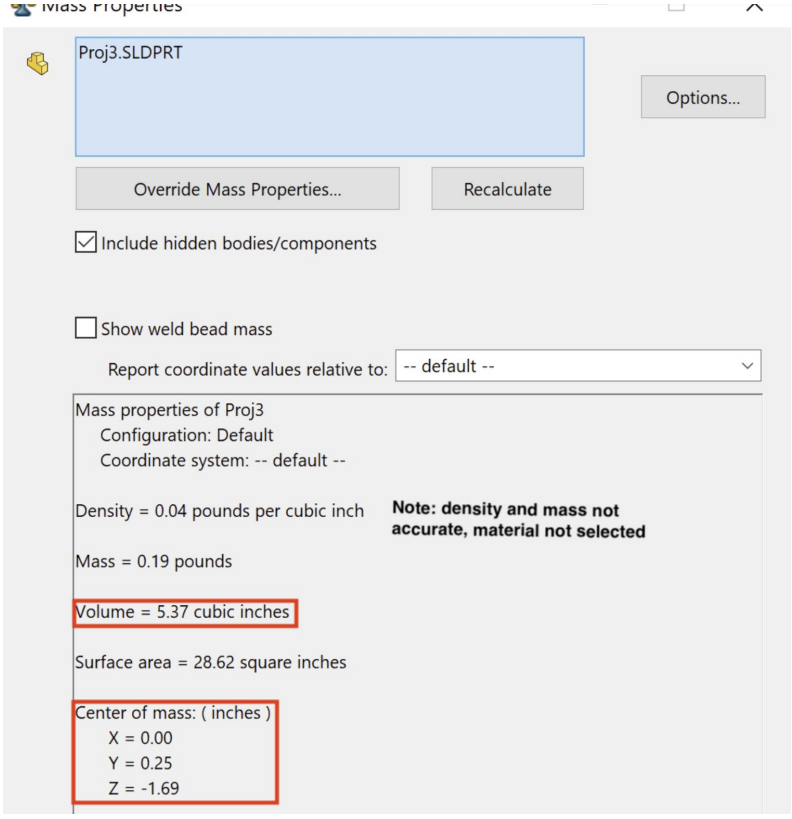
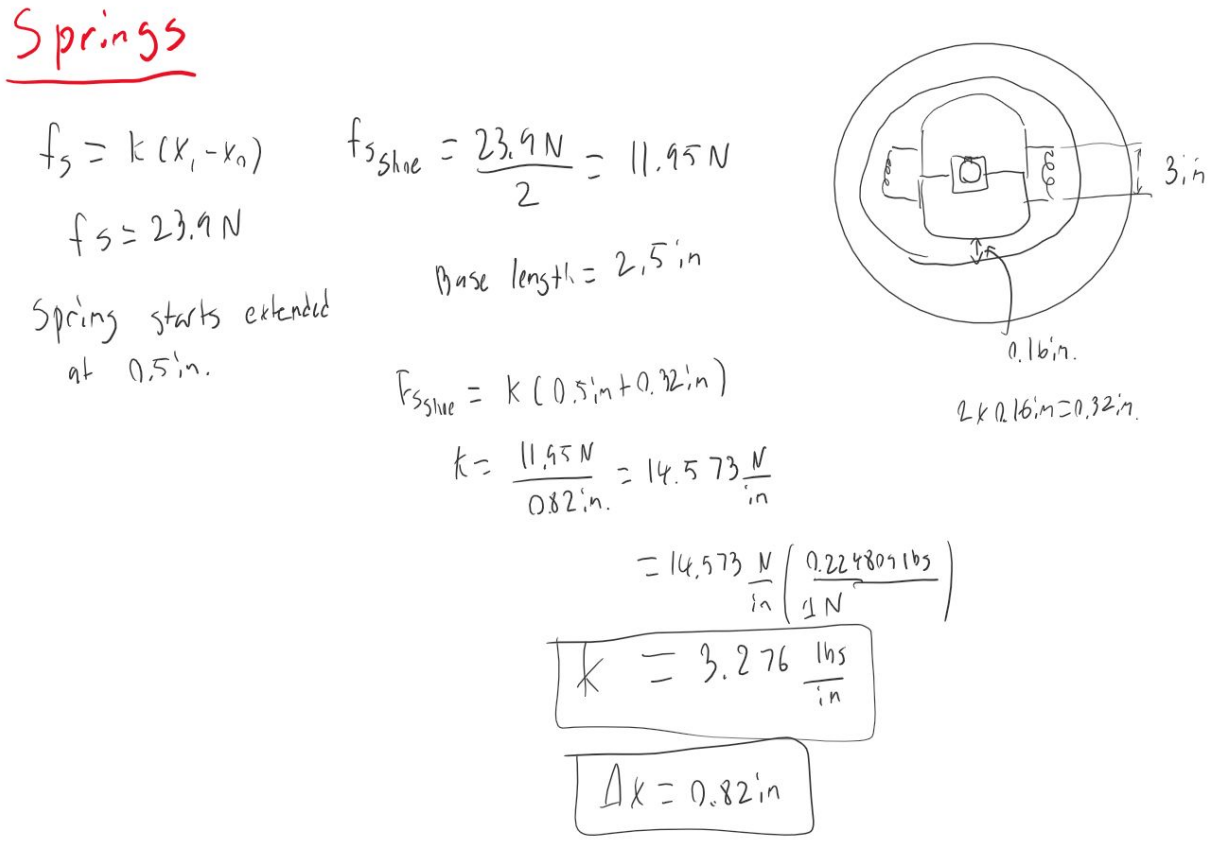
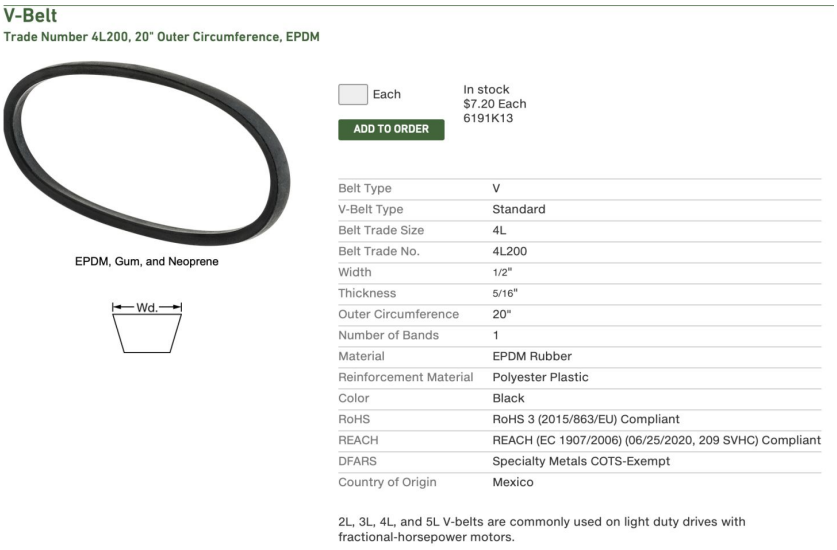


Figure 3: Mass properties of clutch shoe. The center of mass is a distance of r=1.69in.



In order to uphold the constraint of a 4L drive belt, we have selected the following V-belt.



V-Belt

Trade Number 4L200, 20" Outer Circumference, EPDM

EPDM, Gum, and Neoprene

Wd.

Each

In stock
$7.20 Each
6191K13

ADD TO ORDER

Belt Type	V
V-Belt Type	Standard
Belt Trade Size	4L
Belt Trade No.	4L200
Width	1/2"
Thickness	5/16"
Outer Circumference	20"
Number of Bands	1
Material	EPDM Rubber
Reinforcement Material	Polyester Plastic
Color	Black
RoHS	RoHS 3 (2015/863/EU) Compliant
REACH	REACH (EC 1907/2006) (06/25/2020, 209 SVHC) Compliant
DFARS	Specialty Metals COTS-Exempt
Country of Origin	Mexico

2L, 3L, 4L, and 5L V-belts are commonly used on light duty drives with fractional-horsepower motors.

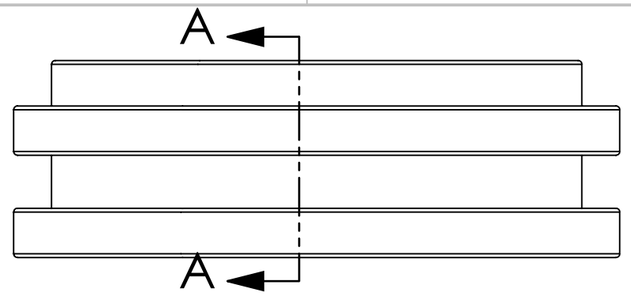
Figure 4: V-belt, to interface clutch with drivetrain.

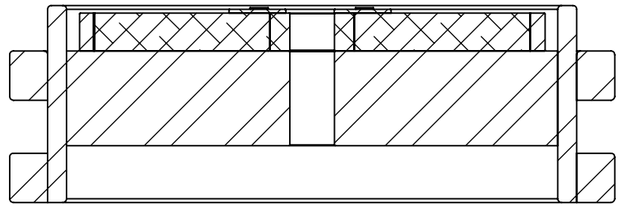
2.0 Bill of Materials

Table 1: Bill of Materials

ITEM NO.	PART NAME	DESCRIPTION	QTY.
1*	Flat Head Screw	A Fastener.	4
2	Plate	Holds *Keyhole Block* in place.	2
3	Keyhole Block	Interfaces with motor drive axle.	1
4	Friction Pad	Interfaces Clutch drum and Clutch shoe.	2
5	Clutch shoe	Applies tangential force to clutch drum when spun.	2
6	Clutch Drum	Interfaces with Clutch shoes, transmitting rotation through belt to drivetrain.	1
7*	Spring	Restricts shoes from interfacing with the drum when spinning slow.	2

*From McMaster-Carr





SECTION A-A

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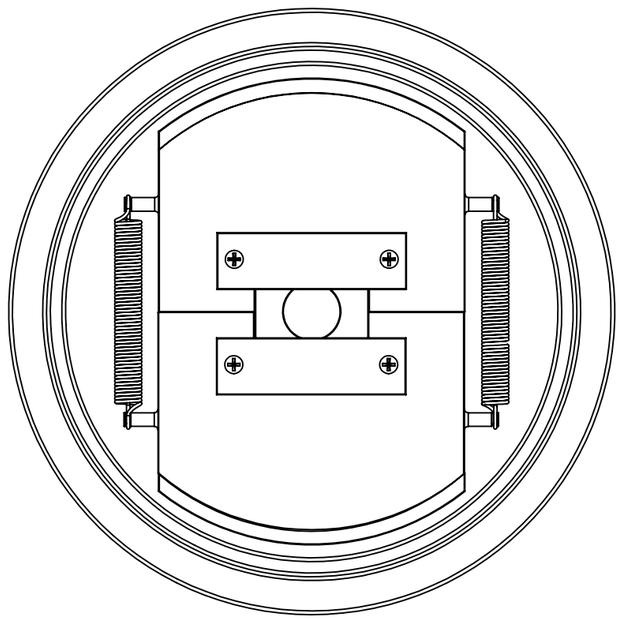

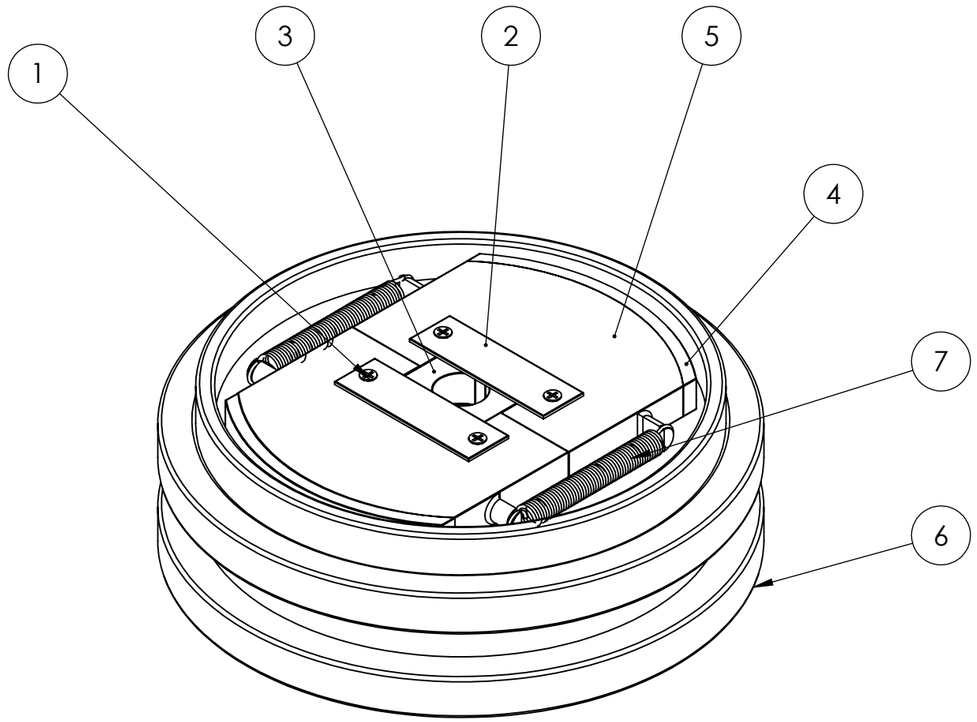

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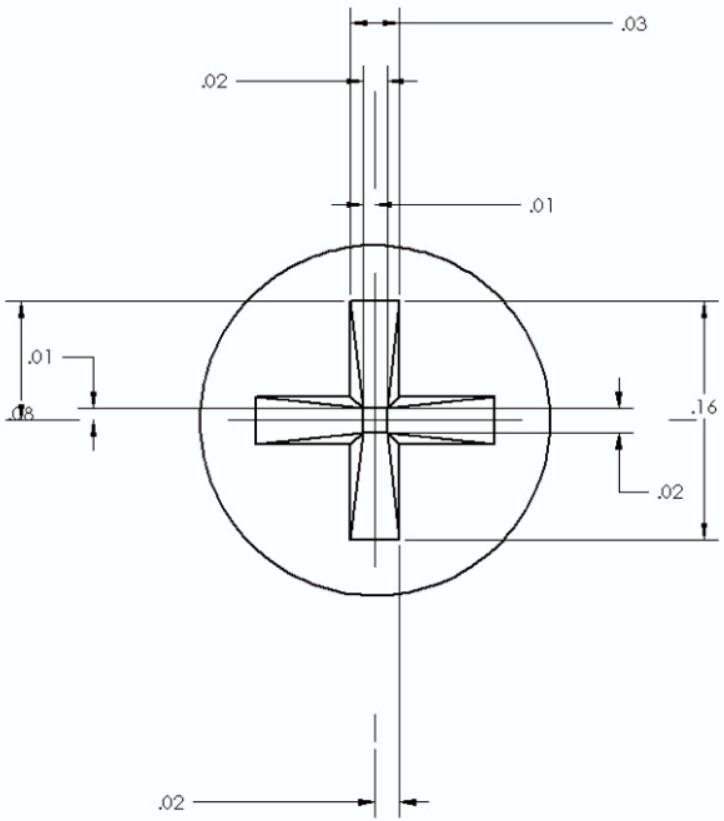
			CHECKED		
			ENG APPR.		
			MFG APPR.		
		INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.		
		MATERIAL	COMMENTS:		
NEXT ASSY	USED ON	FINISH			
APPLICATION		DO NOT SCALE DRAWING			

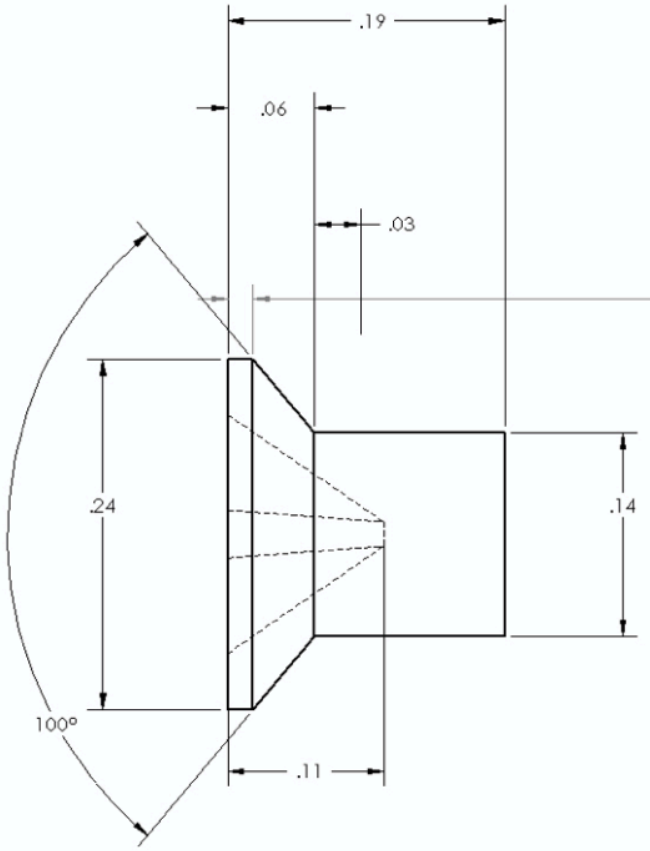
TITLE:

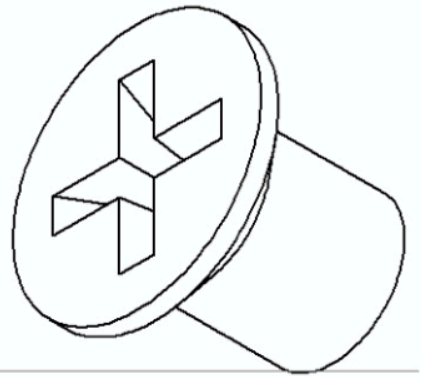
Clutch Assembly

SIZE	DWG. NO.	REV
B	8	

SCALE: 1:5 | WEIGHT: | SHEET 1 OF 1







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			CHECKED		
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			MFG APPR.		
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		MATERIAL	COMMENTS:		
NEXT ASSY	USED ON	FINISH			
APPLICATION		DO NOT SCALE DRAWING			

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Flat Head Screw

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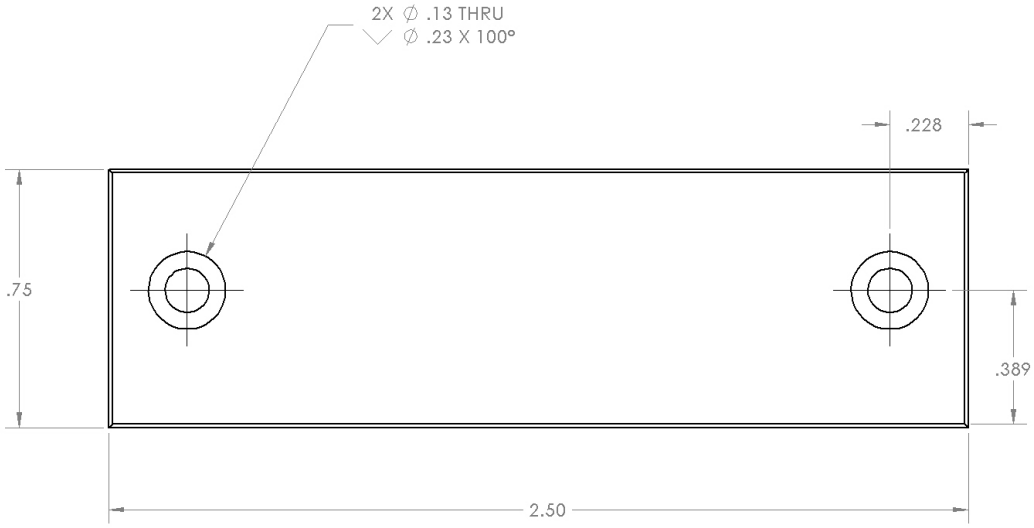

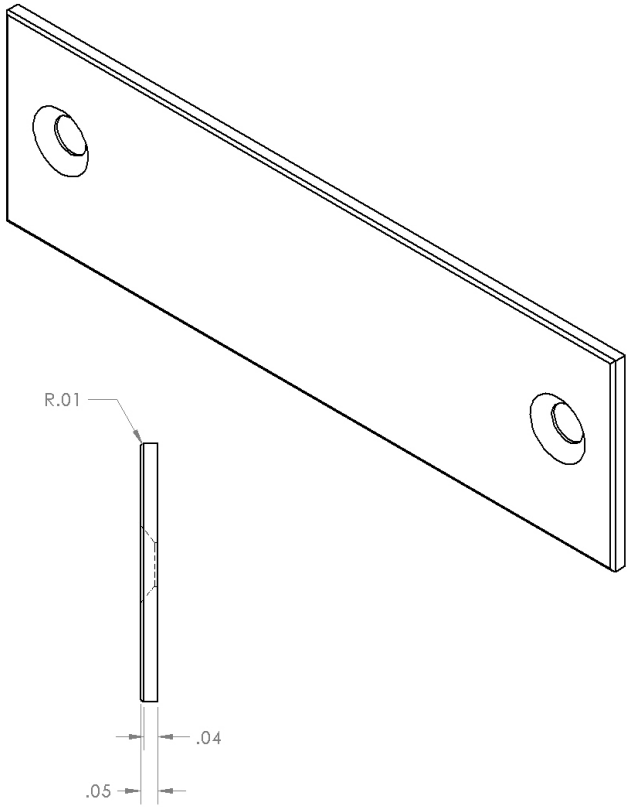

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			CHECKED		
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			MFG APPR.		
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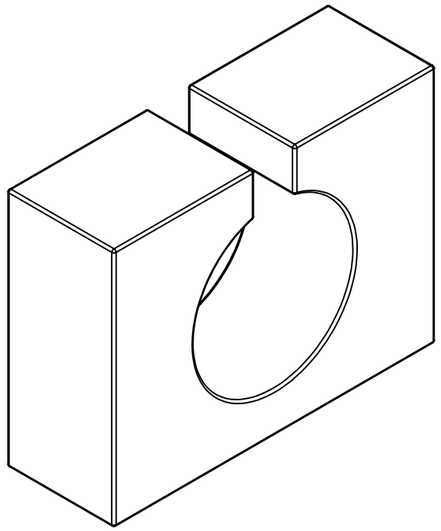
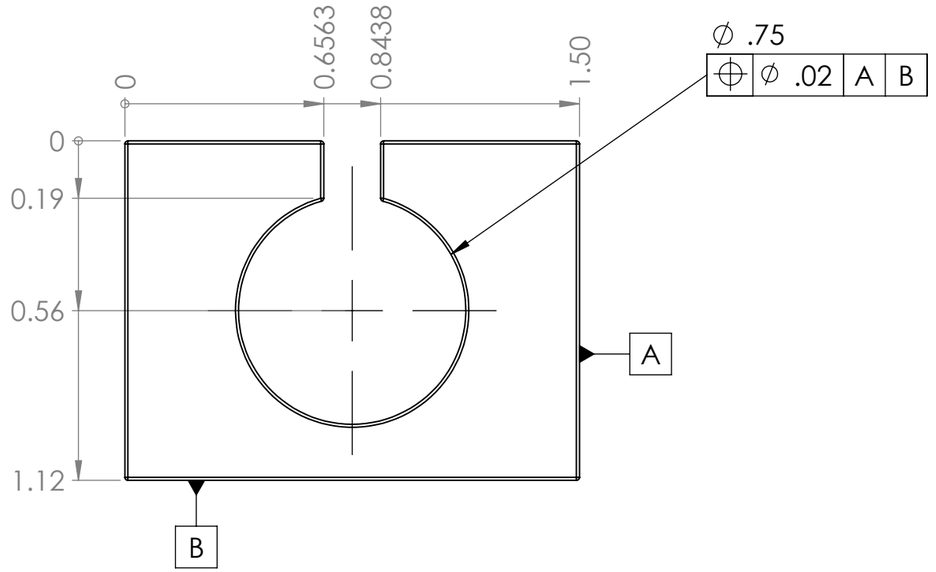
		MATERIAL Aluminum	COMMENTS:		
NEXT ASSY	USED ON	FINISH			
APPLICATION		DO NOT SCALE DRAWING			

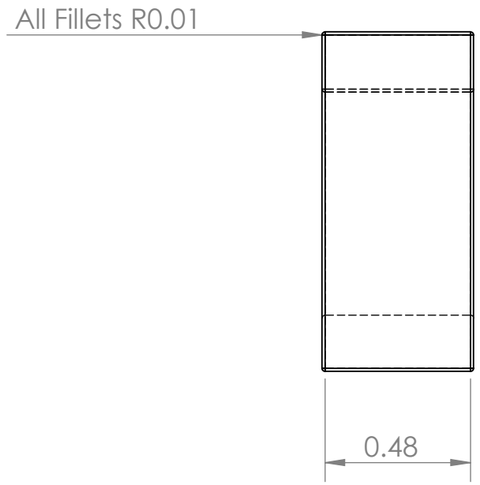
TITLE: Plate

SIZE	DWG. NO.	REV
B	Part Two	

SCALE: 2:1	WEIGHT:	SHEET 1 OF 1







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APPLICATION		DO NOT SCALE DRAWING

	NAME	DATE
DRAWN		
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		
COMMENTS:		

TITLE:

Keyhole Block

SIZE	DWG. NO.	REV
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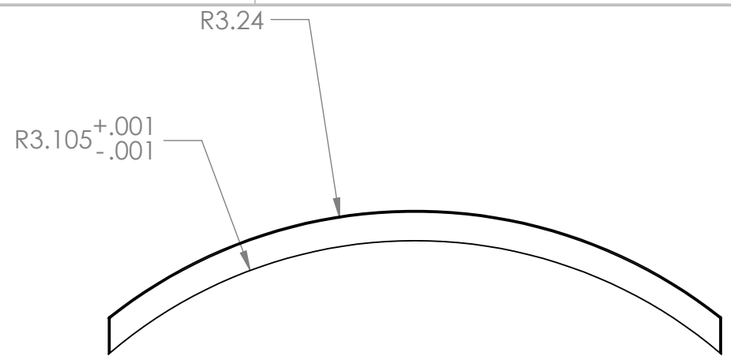

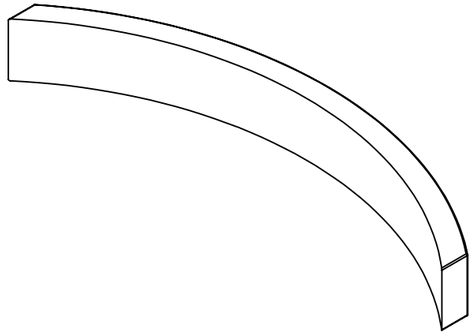

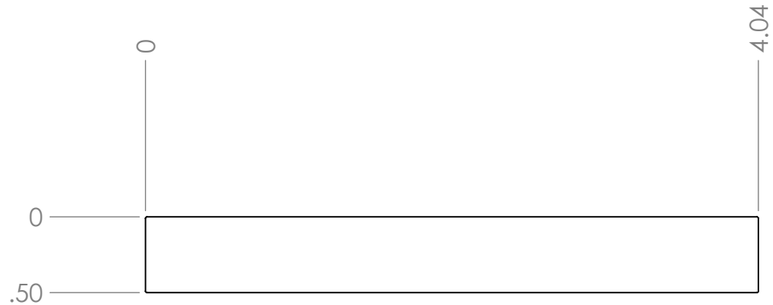

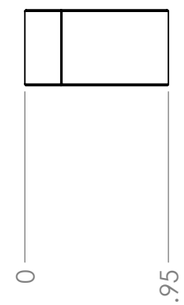

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			CHECKED		
			ENG APPR.		
			MFG APPR.		
		INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.		
		MATERIAL	COMMENTS:		
NEXT ASSY	USED ON	FINISH			
APPLICATION		DO NOT SCALE DRAWING			

TITLE:

Friction pad

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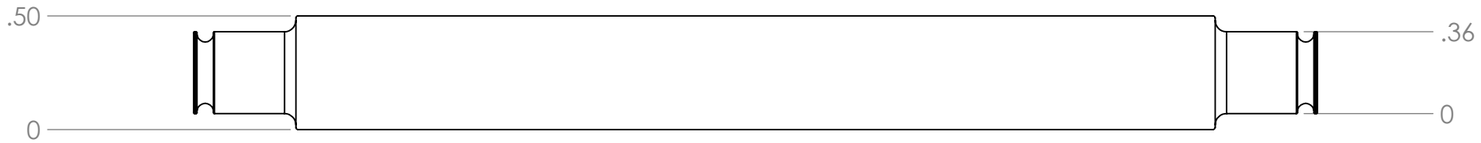

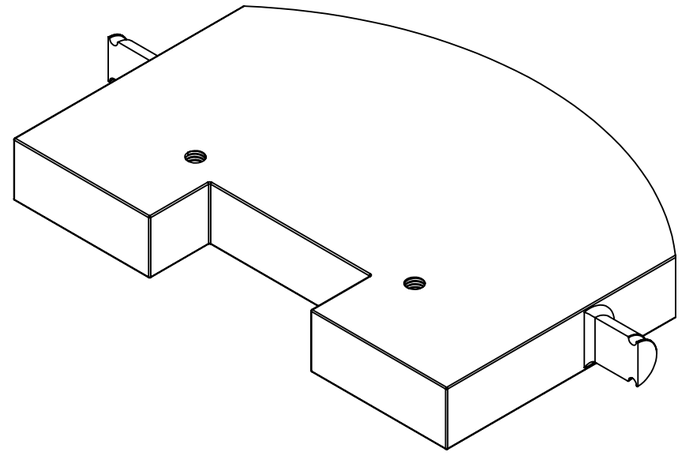

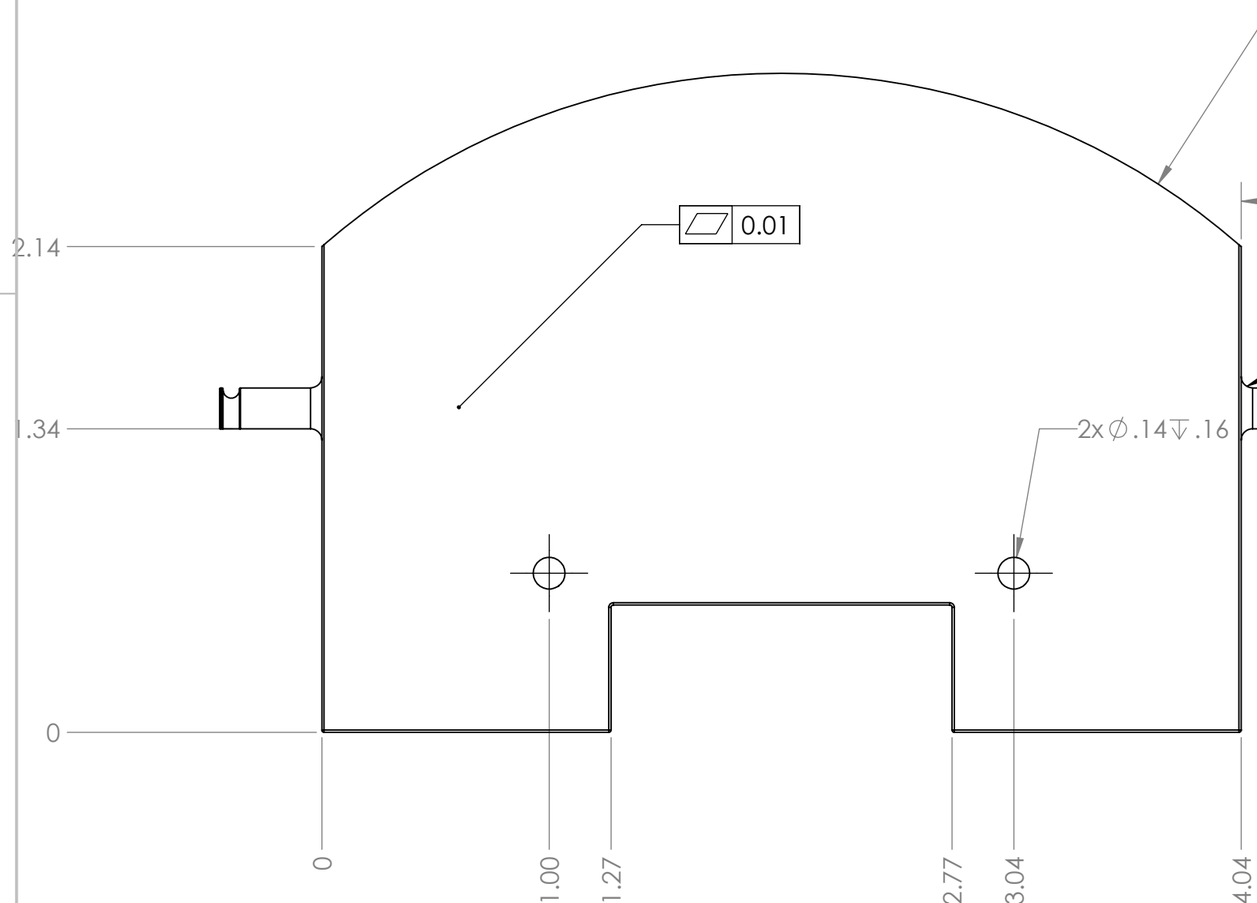

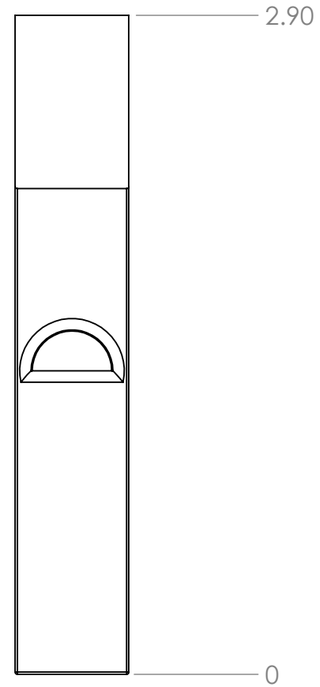

Note: All Fillets are 0.01 inches unless specified otherwise.

NEXT ASSY	USED ON	
APPLICATION		

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DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ± 0.01
THREE PLACE DECIMAL ±0.003

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL

FINISH

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN		
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

TITLE:

Clutch Shoe

SIZE	DWG. NO.	REV
B	5	

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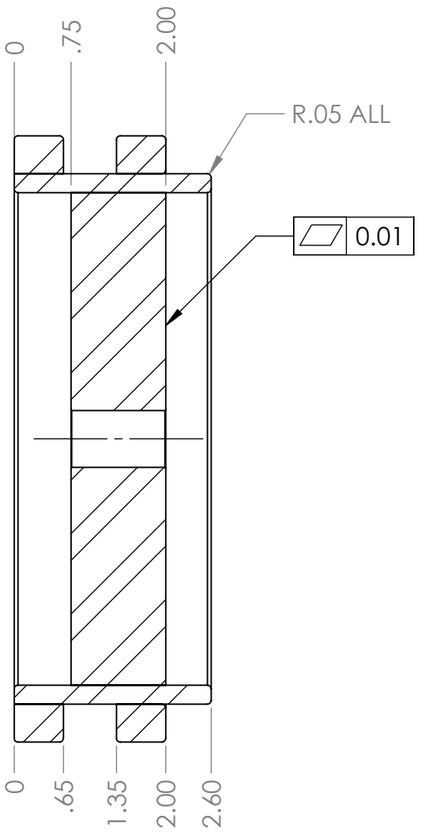

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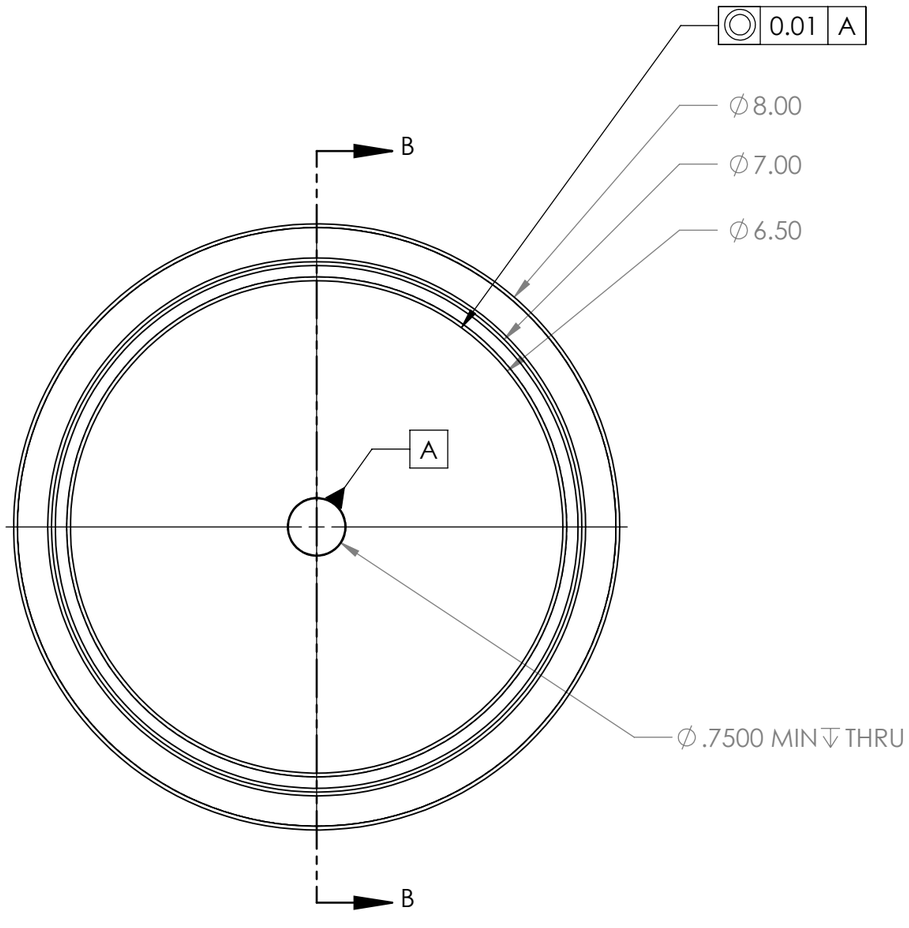

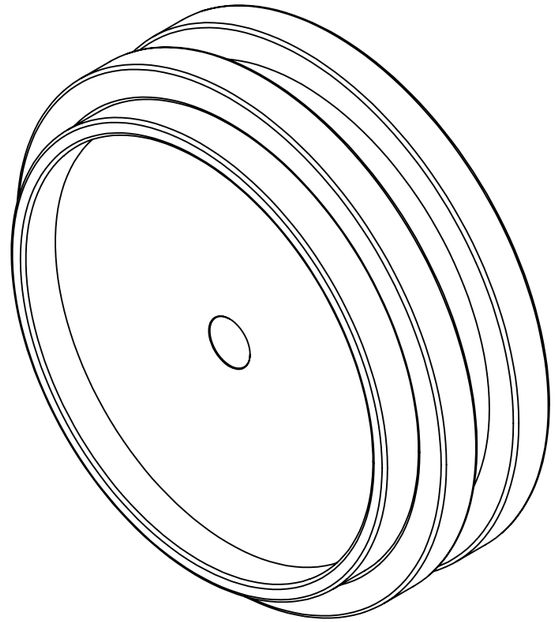

NEXT ASSY	USED ON	
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UNLESS OTHERWISE SPECIFIED:

DIMENSIONS ARE IN INCHES
TOLERANCES:

TWO PLACE DECIMAL ±0.010
THREE PLACE DECIMAL ±0.003

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL

FINISH

	NAME	DATE
DRAWN		
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

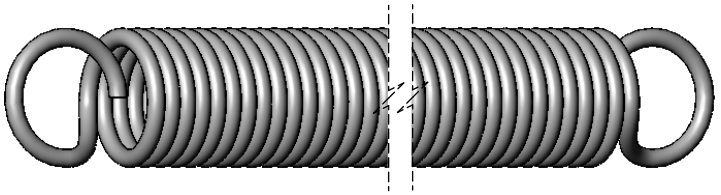
COMMENTS:

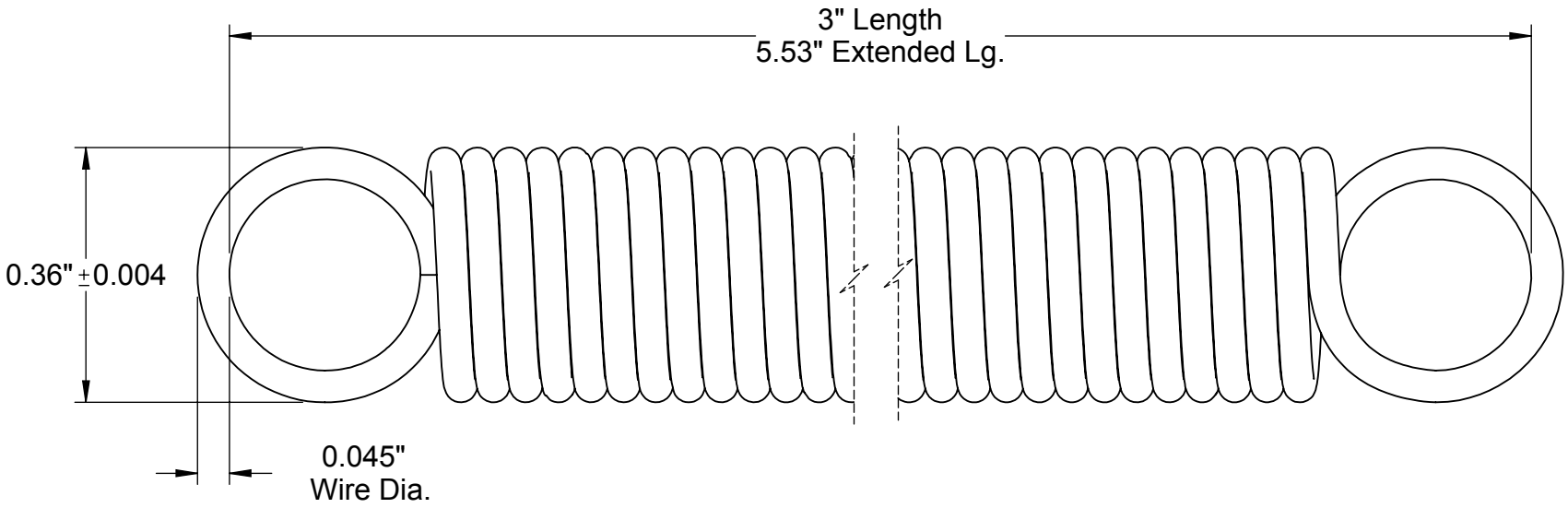
TITLE:

Clutch

SIZE	DWG. NO.	REV
B	6	

SCALE: 1:2 | WEIGHT: | SHEET 1 OF 1





McMASTER-CARR® CAD	PART NUMBER 9044K265
http://www.mcmaster.com © 2019 McMaster-Carr Supply Company Information in this drawing is provided for reference only.	Extension Spring

4.0 References

[1] “McMaster-Carr,” *McMaster*. [Online]. Available: https://www.mcmaster.com/. [Accessed: 14-Nov-2020].

[2] “3D CAD Design Software,” *Solidworks*. [Online]. Available: https://www.solidworks.com/. [Accessed: 14-Nov-2020].

[3]*University of Victoria - Mech 240*. [Online]. Available: https://bright.uvic.ca/d2l/home/53503. [Accessed: 14-Nov-2020].