

MECH 200

Design Project #3

Centrifugal Clutch

Group 16

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# 1.0 Design Calculations

## Motor Speed and Tangential Force

Max speed of motor:

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

65% speed of motor:

$$\omega_1 = \frac{RPM \times 2\pi}{60} = 0.65 \frac{710 \times 2\pi}{60} = 48.3 \text{ rad/s}$$

Tangential force from the motor at max speed:

$$F_T = \frac{Power}{2r\omega} = \frac{280 \text{ W}}{2(3.25 \times 0.0254)74.4} = 22.8 \text{ N}$$

## Clutch Lining Specifications

Linear speed the clutch lining will see:

$$v = \frac{RPM \times 2\pi D}{12} = \frac{710 \text{ RPM} \times \pi \times 6.5 \text{ in}}{12 \frac{\text{in}}{\text{ft}}} = 1208 \frac{\text{ft}}{\text{min}}$$

McMaster-Carr part:

- Name - Medium friction clutch lining
- McMaster-Carr # - 6090K21
- Friction coefficient - 0.35
- Thickness -  $\frac{1}{8}$ "
- Max. pressure - 500 psi

Normal force required for zero slippage:

$$F_N = \frac{F_T}{\mu} = \frac{22.8}{0.35} = 65.2 \text{ N}$$

Minimum surface area for each shoe/lining:

$$A = \frac{F_N}{P} = \frac{65.2/2 \text{ N}}{500 \text{ psi} \times 6894.757 \text{ pa/psi}} = 9.45e-6 \text{ m}^2 = 0.015 \text{ in}^2$$

## Clutch Shoe Specifications:

Theoretical M (mass of shoe) x r (radial distance of the CM of the moving part):

$$Mr = \frac{F_N}{(\omega_0^2 - \omega_1^2)} = \frac{\frac{65.2}{2}}{(74.4^2 - 48.4^2)} = 0.0102 \text{ kg} \cdot \text{m}$$

Shoe + clutch lining mass using estimate r (radial distance of the CG of the moving part):

$$M = \frac{0.0102 \text{ kg} \cdot \text{m}}{1.4 \text{ in} \times 0.0254 \text{ m/in}} = 0.2868 \text{ kg}$$

Shoe material: Aluminum

Density:  $2700 \text{ kg/m}^3$

Shoe + clutch lining volume:

$$V = \frac{0.2858 \text{ kg}}{2700 \text{ kg/m}^3 \times 1.64 \times 10^{-5} \text{ m}^3/\text{in}^3} = 6.48 \text{ in}^3$$

Actual  $M \times r$  of clutch shoe + lining:

$$M = 0.2858$$

$$r = 1.408$$

$$Mr = 0.2858 \times 1.408 \times 0.0254 \text{ m/in} = 0.0102 \text{ kg} \cdot \text{m}$$

### Spring Specifications:

Required spring force:

$$F_s = Mr\omega_1^2 = (0.0102 \text{ kg} \cdot \text{m}) \left(48.4 \frac{\text{rad}}{\text{s}}\right)^2 = 23.8 \text{ N}$$

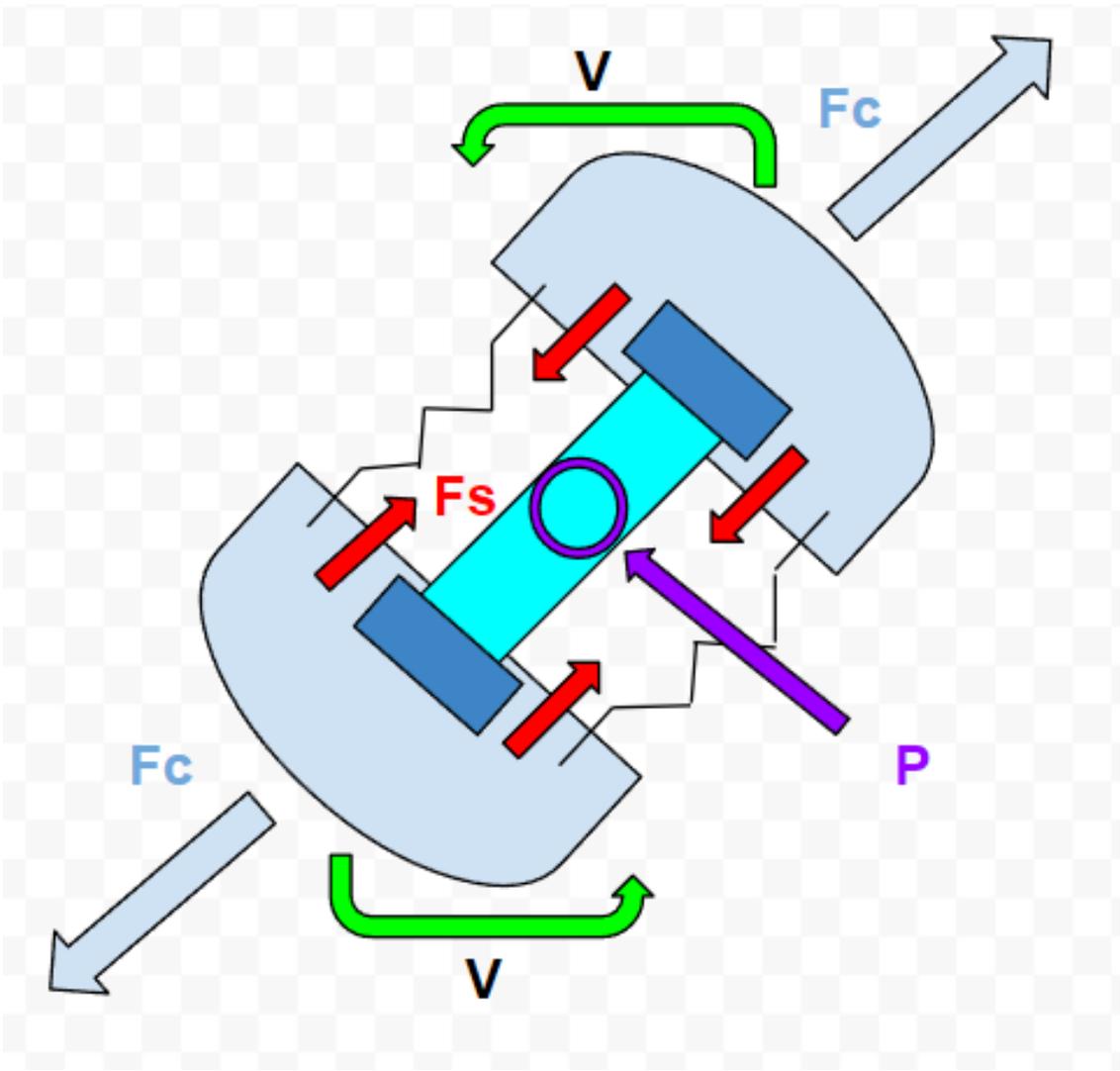
McMaster-Carr part:

- Name - Extension Spring with Loop Ends
- McMaster-Carr # - 9044K347
- OD - 0.5"
- Length with no load - 2.5" = 63.5 mm
- Extended length at max load - 4.82"
- Spring rate - 5.1 lbs/in. = 0.89301 N/mm

Extended spring length using McMaster-Carr extension spring 9044K347:

$$F_s = k(x - x_0) \rightarrow x = \frac{F_s}{k} + x_0 = \frac{23.8 \text{ N}}{0.89301 \text{ N/mm}} + 63.5 \text{ mm} = 90.15 \text{ mm} = 3.55 \text{ in}$$

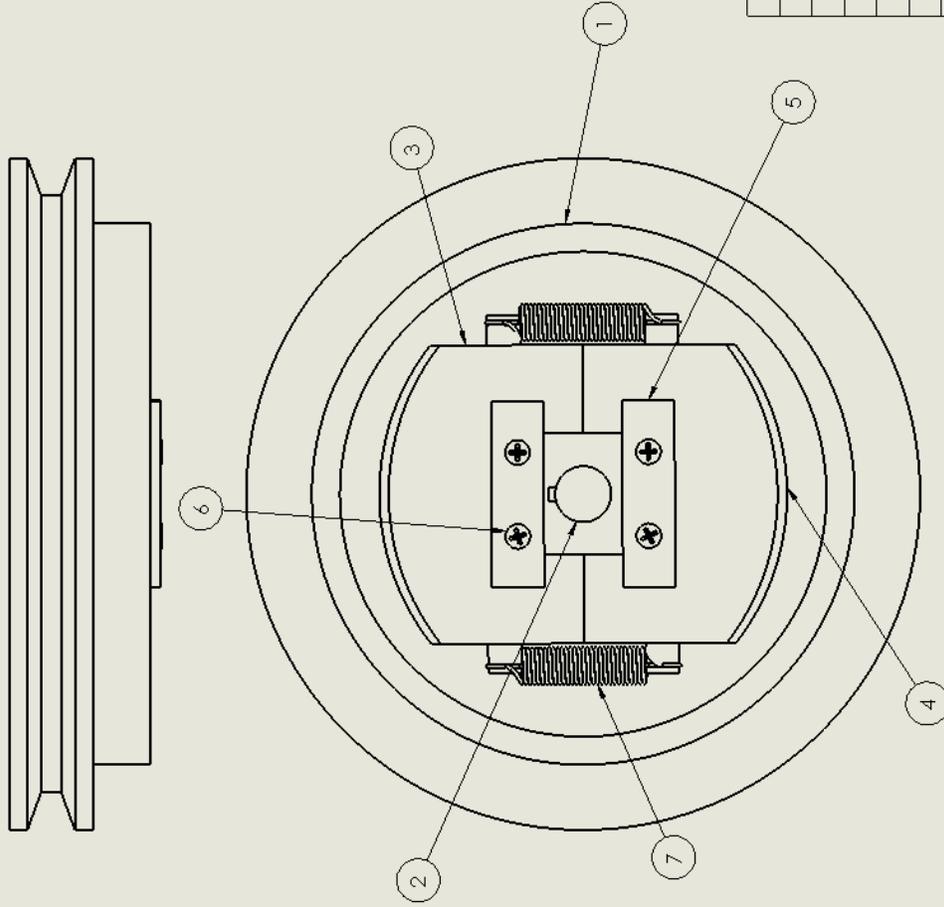
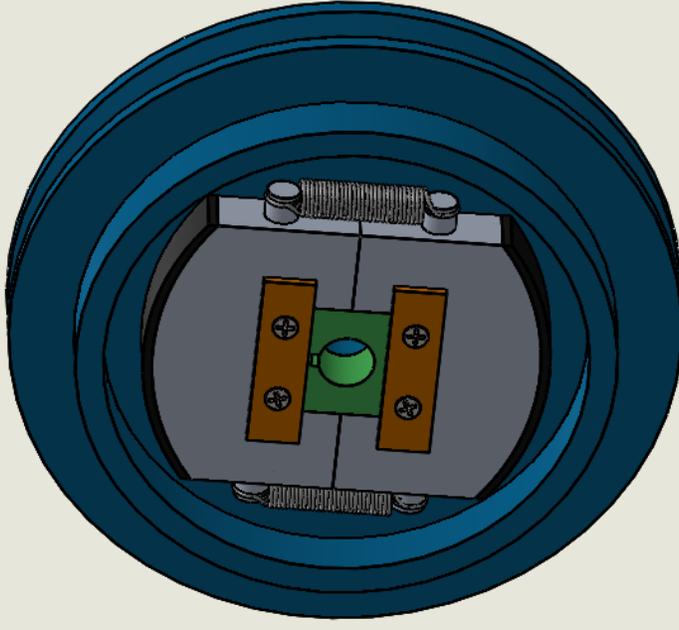
1.1 Free-Body Diagram of Forces:



## 2.0 Engineering Bill of Materials:

Part No.	Description	Quantity	Unit Cost (\$)	Total Cost (\$)	McMaster Carr Part ID
1	Clutch Drum	1	180.00	180.00	Custom
2	Center Bearing with 3/16 Square Keyway	1	36.07	36.07	Custom
3	Clutch Shoe	2	75.00	150.00	Custom
4	Medium-grade Friction Clutch Lining	1	29.41	29.41	6090K21
5	Guide Plate	2	19.67	39.34	Custom
6	18-8 Stainless Steel Phillips Flat Head Screws	4 (minimum order 50)	7.96	7.96	91771A963
7	Extension Spring	2 (minimum order 3)	5.83	5.83	9044K347
<b>TOTAL</b>				<b>448.61</b>	

### 3.0 Assembly Drawing



ITEM NO.	PART NUMBER	QTY.
1	Clutch Drum	1
2	Center Bearing with 3/16 Keyway	1
3	Clutch Shoe	2
4	Clutch Lining	2
5	Guide Plate	2
6	CR-FHM1 0.19-32x0.375x0.375-N	4
7	Extension Spring	2

TITLE:

Centrifugal  
Clutch

SIZE DWG. NO.

**B** Assembly

REV

SCALE: 2:3 WEIGHT:

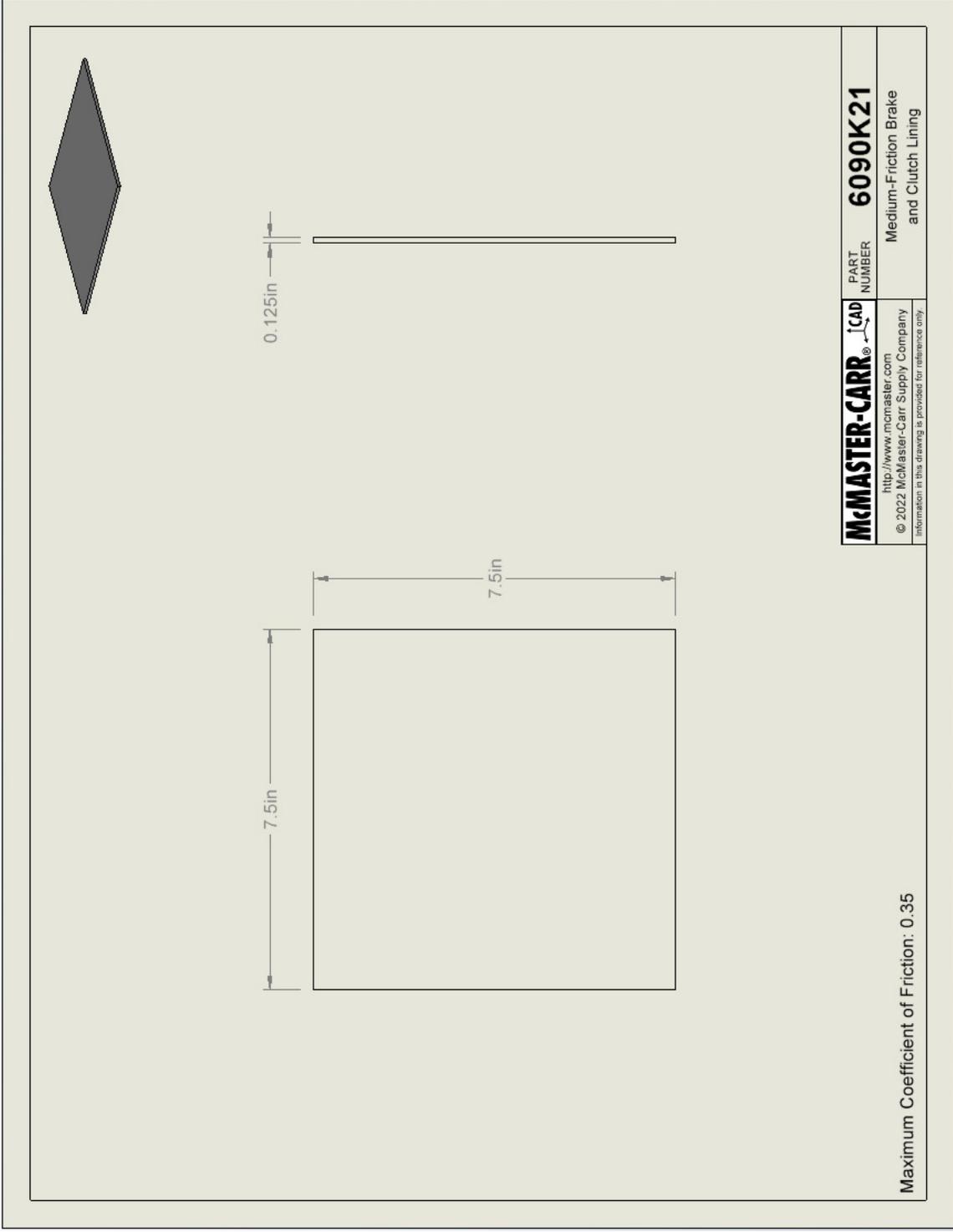
SHEET 1 OF 1



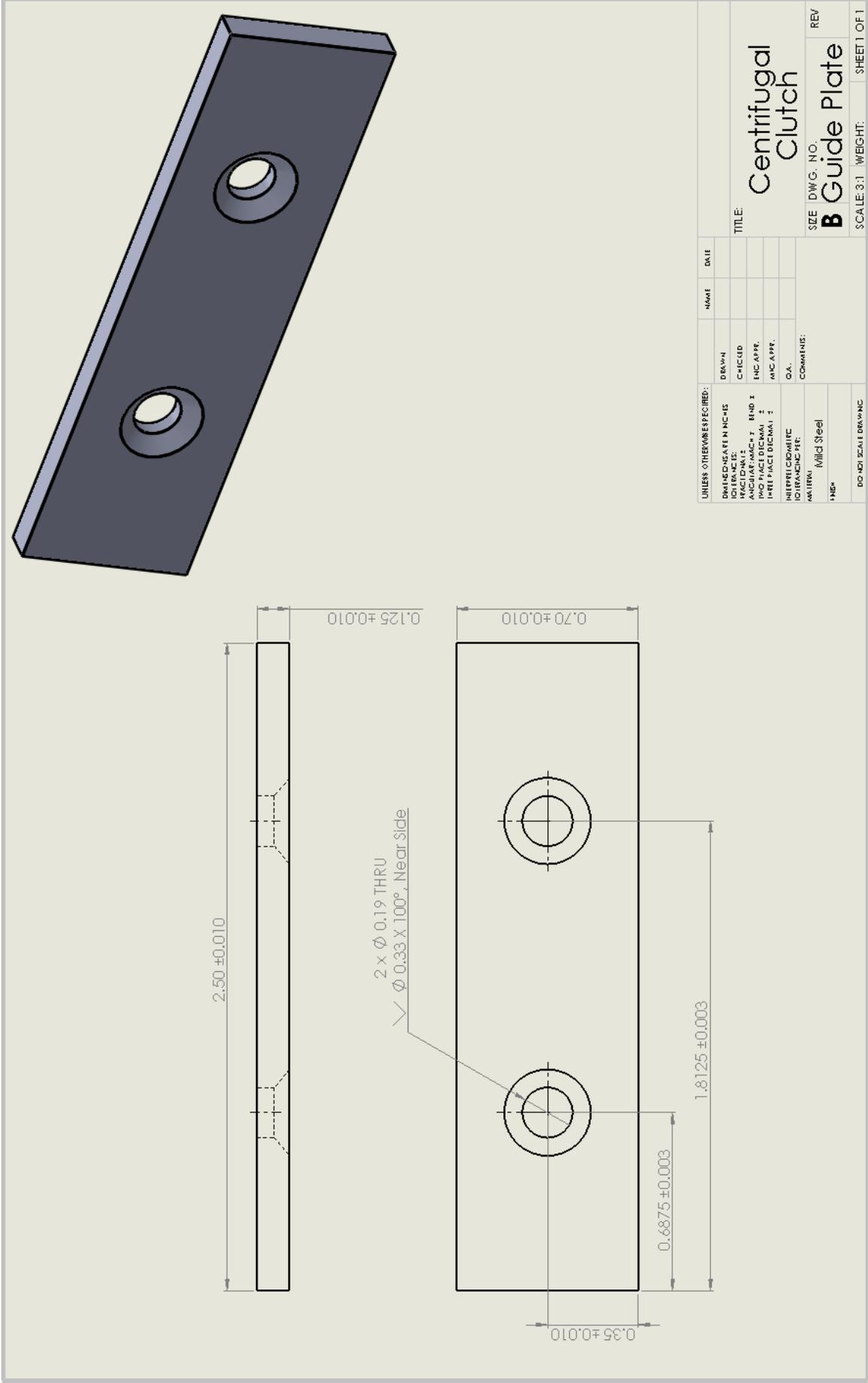




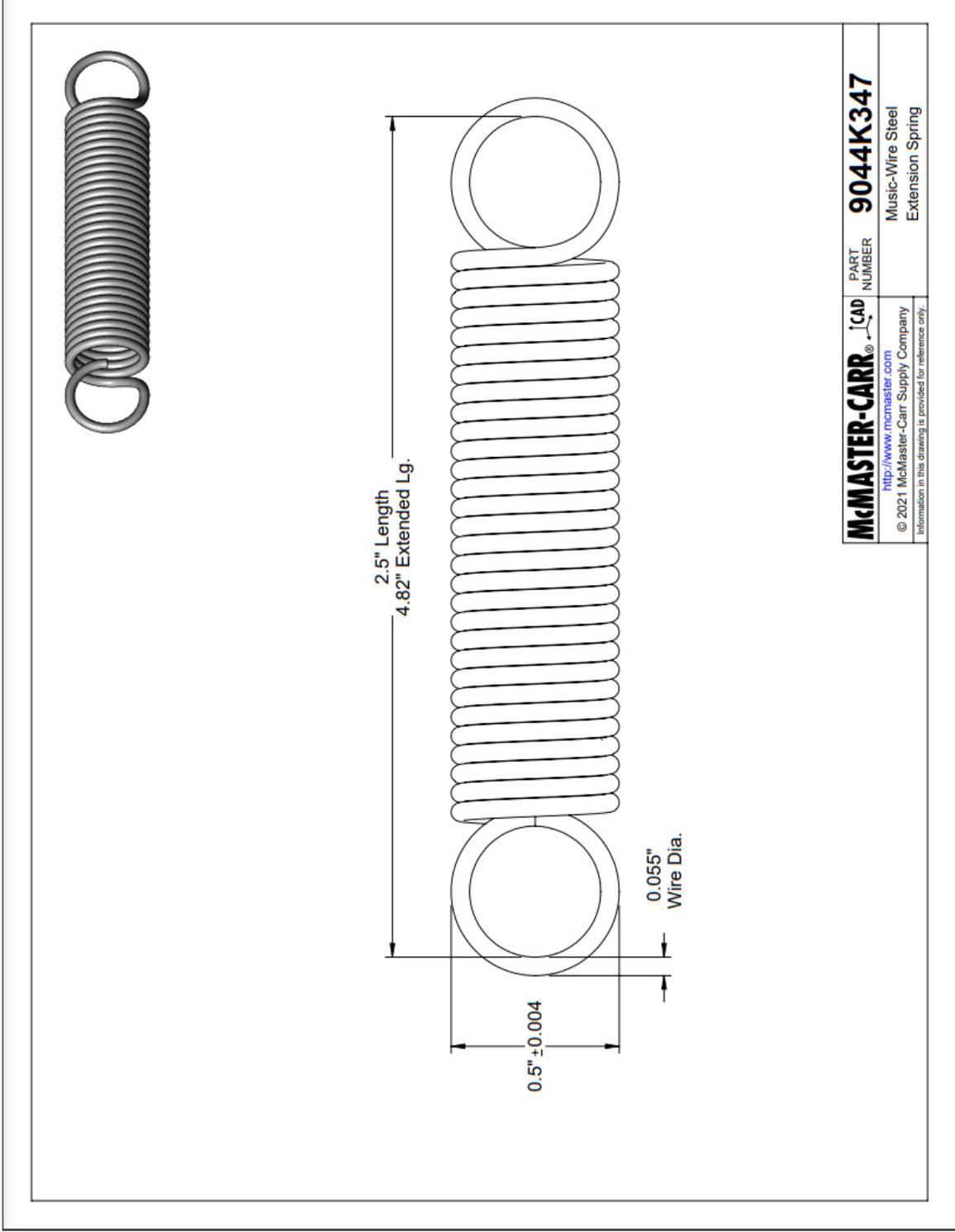
# 4.4 Medium-Friction Clutch Lining



# 4.5 Guide Plate



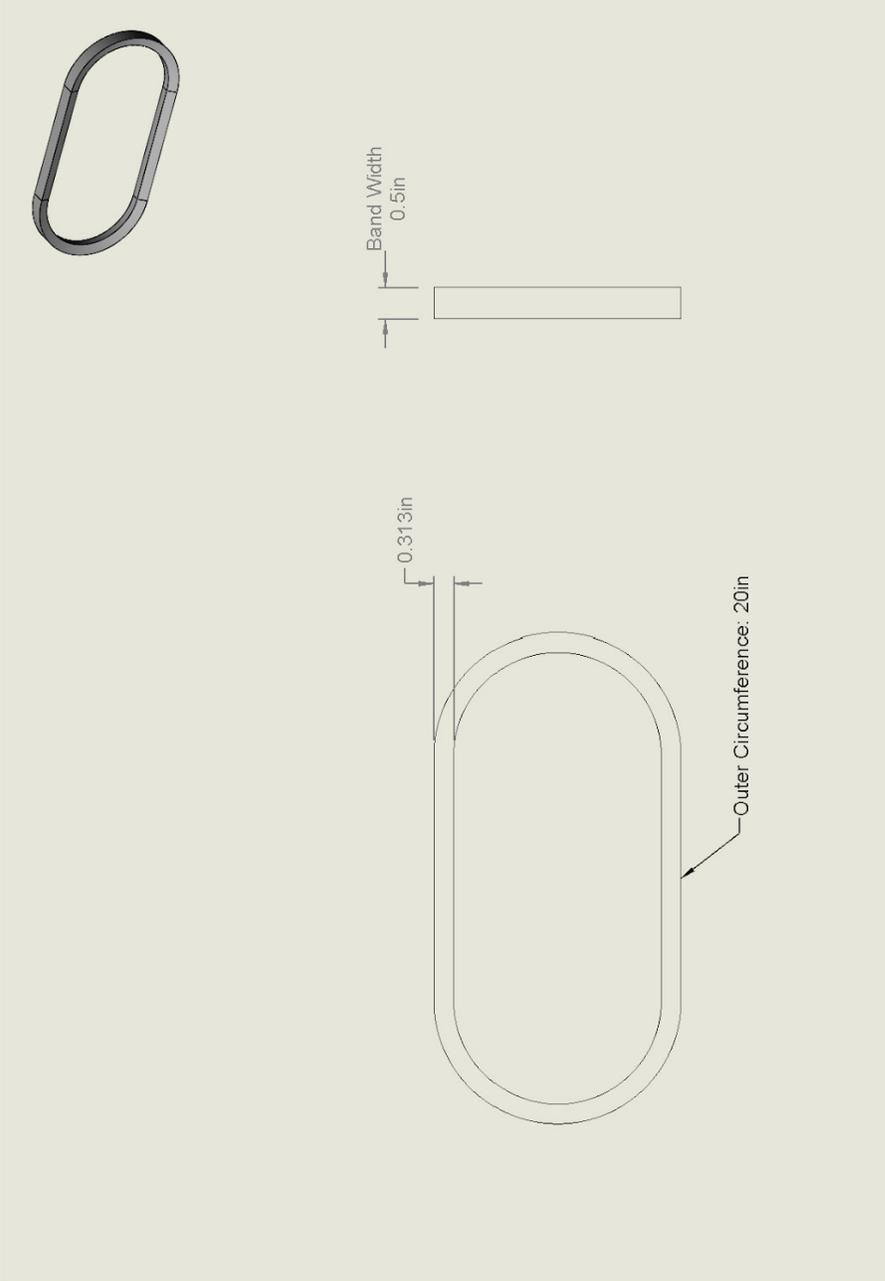
## 4.6 Extension Spring



# Appendix

# 4L V-Belt

The clutch drum was designed to house a 4L V-Belt such as this example from McMaster-Carr (Part I.D.: 6191K13).



The technical drawing illustrates the specifications of a 4L V-Belt. It includes a perspective view of the belt, a cross-sectional view showing a trapezoidal profile, and a top view of the belt's footprint. The top view is labeled with an "Outer Circumference: 20in" and a width of "0.313in". The cross-section is labeled with a "Band Width 0.5in".

Number of Bands: 1 Belt Trade Number: 4L200	<b>McMASTER-CARR</b> <small>McMASTER-CARR</small> <small>McMASTER-CARR</small>	PART NUMBER	<b>6191K13</b>
	<a href="http://www.mcmaster.com">http://www.mcmaster.com</a> © 2022 McMaster-Carr Supply Company Information in this drawing is provided for reference only.		V-Belt