

MECH 200

Design Project #3

Centrifugal Clutch

Group 16

[REDACTED]

[REDACTED]

Ben Roberts - V00974976

[REDACTED]

[REDACTED]

Table of Contents

1.0 Design Calculations	1
1.1 Free-Body Diagram of Forces:	3
2.0 Engineering Bill of Materials:	4
3.0 Assembly Drawing	5
4.0 Detailed Part Drawings	6
4.1 Clutch Drum	6
4.2 Center Bearing with 3/16 Square Keyway	7
4.3 Clutch Shoe	8
4.4 Medium-Friction Clutch Lining	8
4.5 Guide Plate	10
4.6 Extension Spring	11
Appendix	12

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 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:

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

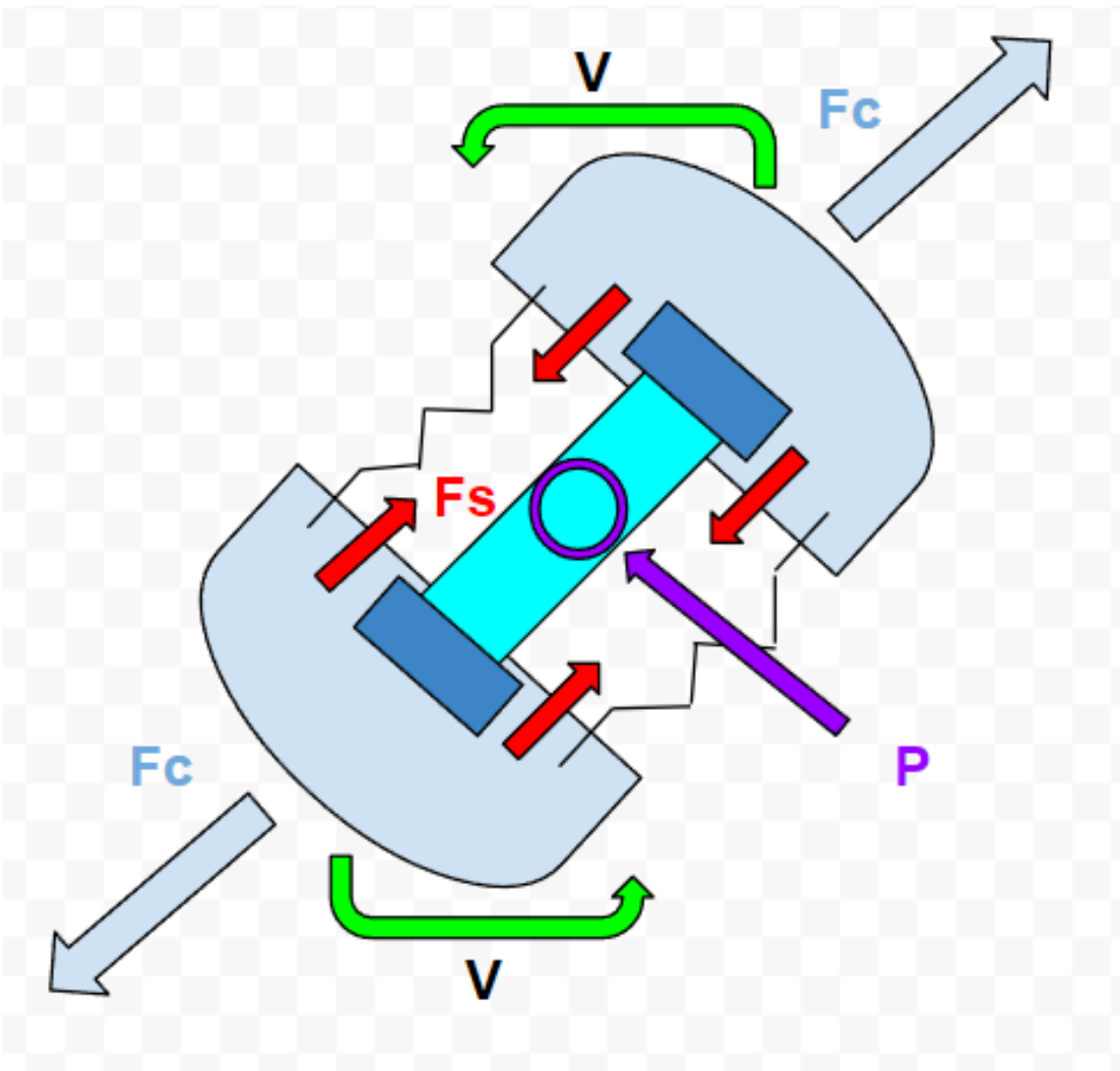
McMaster-Carr part:

- 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:

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

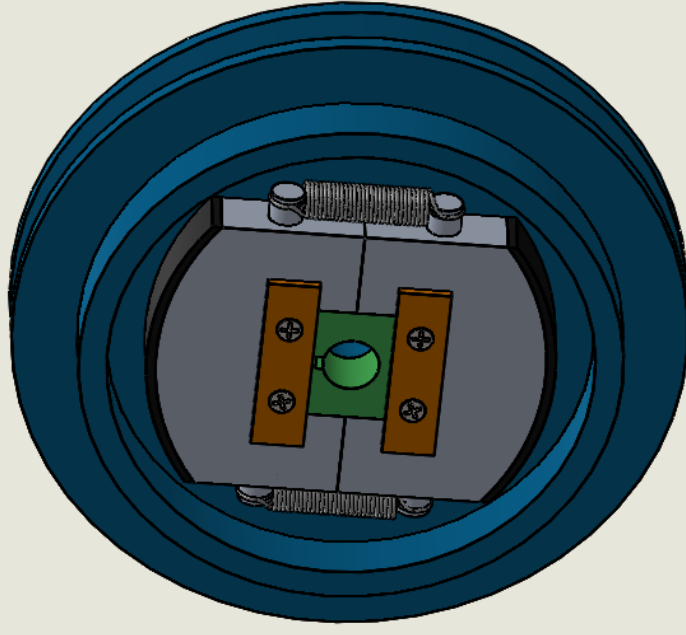
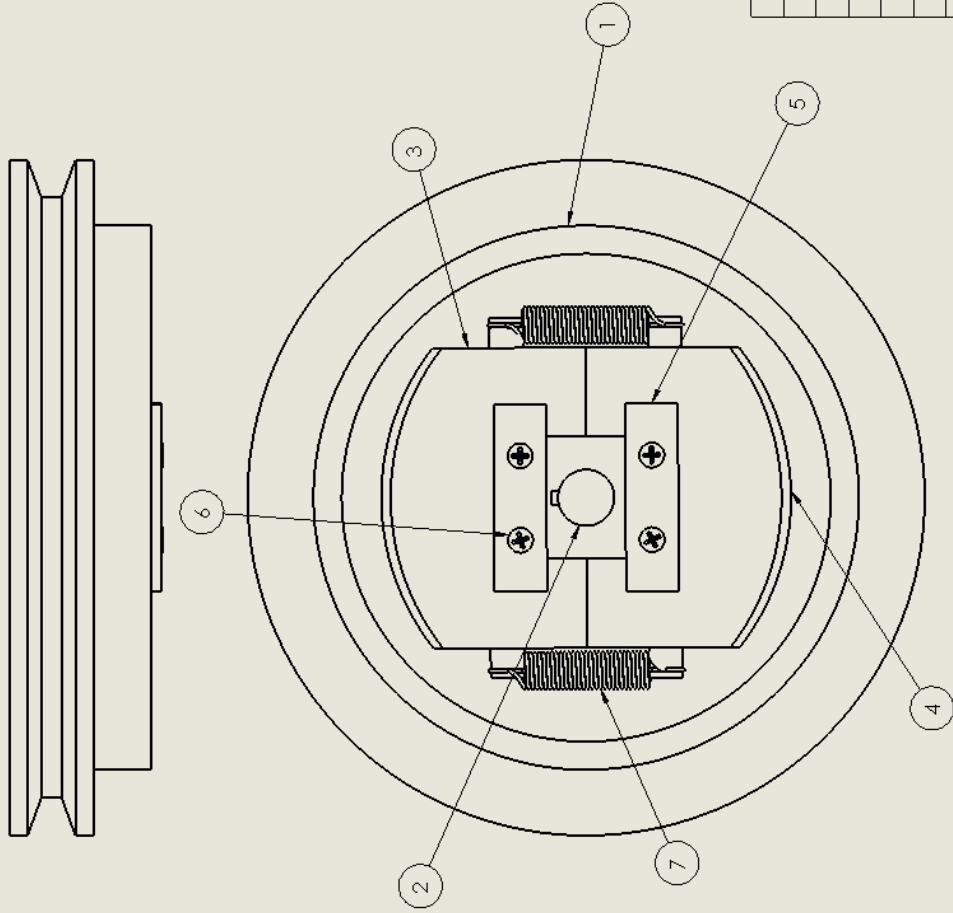
1.1 Free-Body Diagram of Forces:



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
TOTAL				448.61	

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 Linking	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.

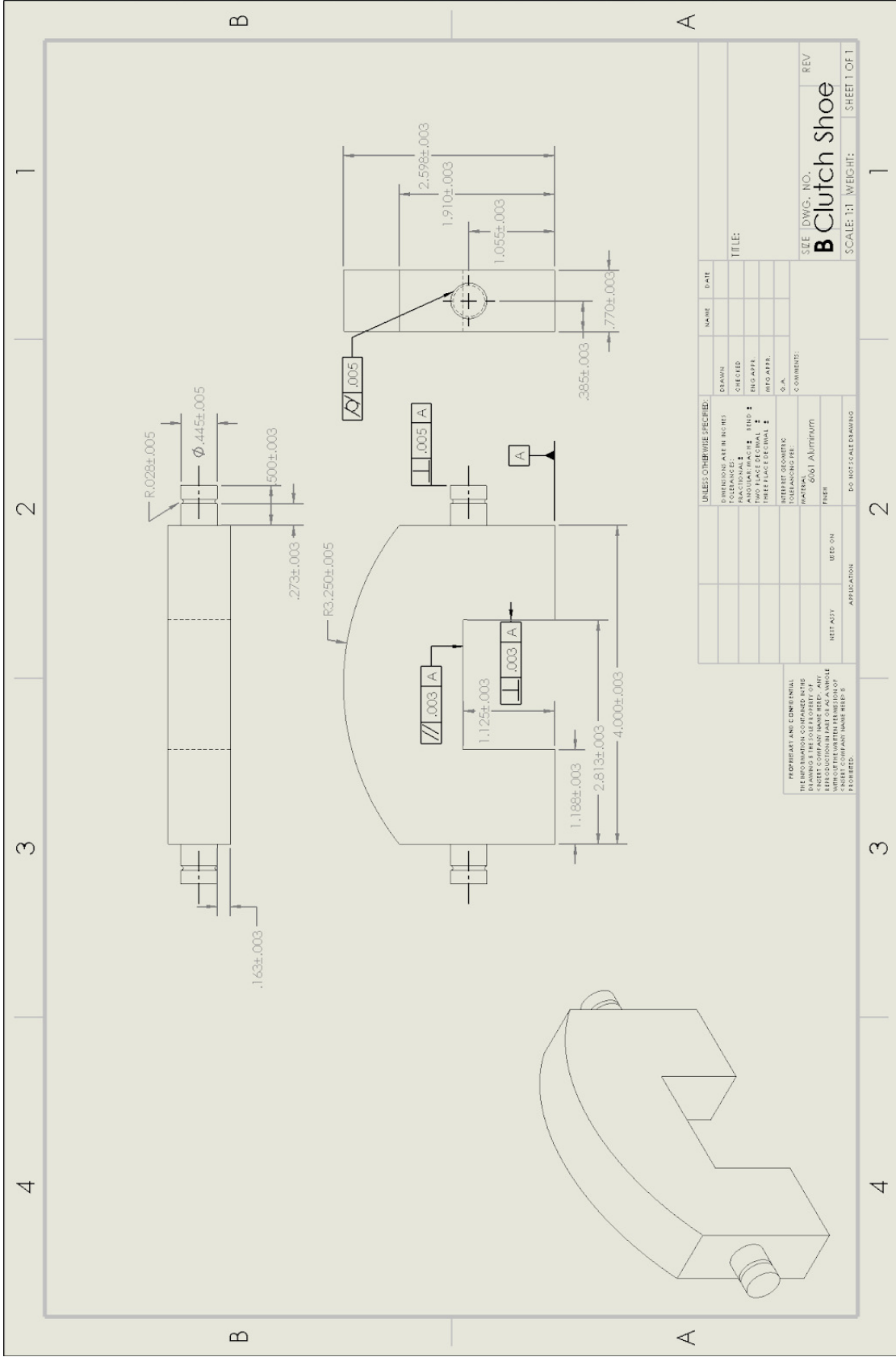
B Assembly

REV

SCALE: 2:3 WEIGHT:

SHEET 1 OF 1

4.3 Clutch Shoe

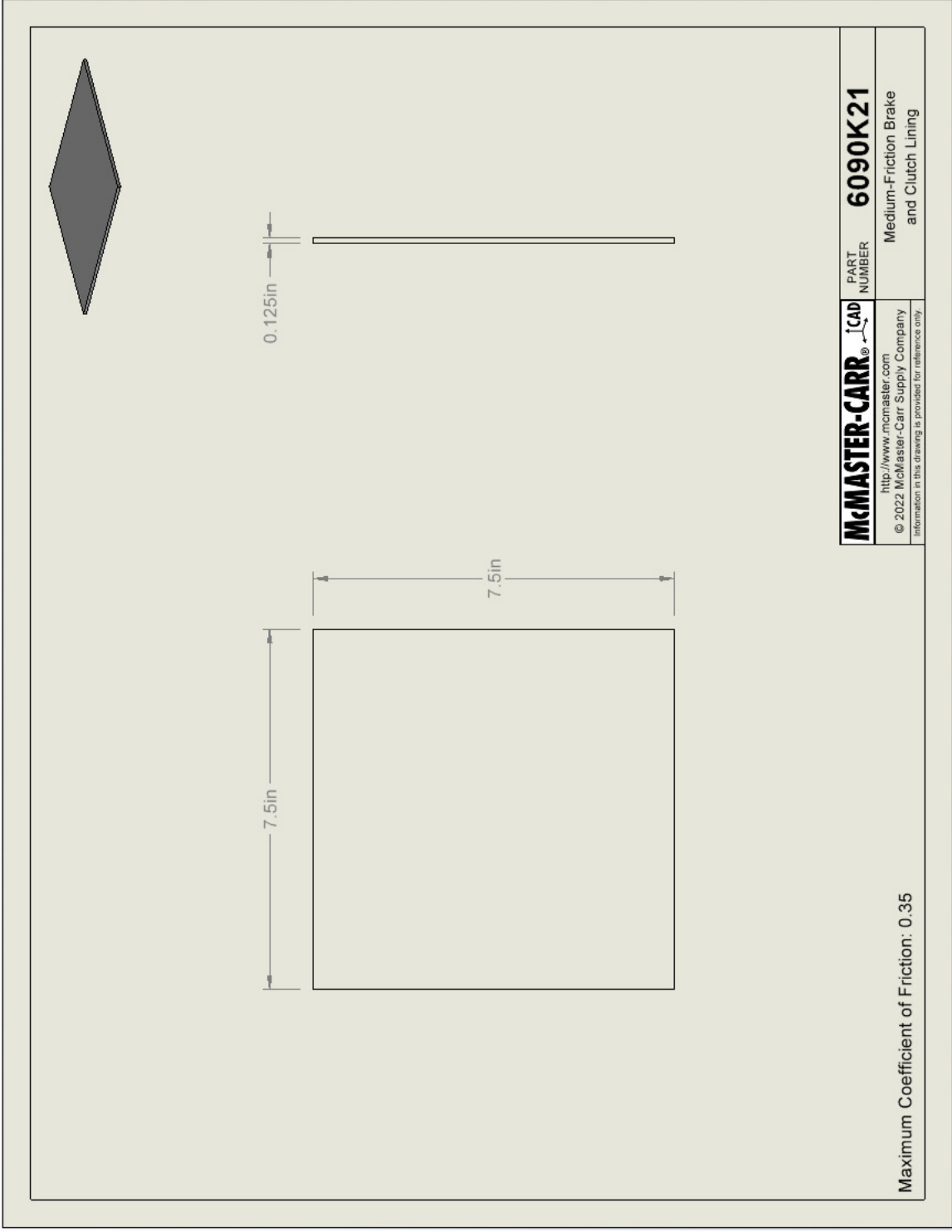


UNLESS OTHERWISE SPECIFIED:		DATE
DRAWN		
CHECKED		
FRACTIONAL DIMS		
DECIMAL DIMS		
THREE PLACE DECIMAL		
TWO PLACE DECIMAL		
ONE PLACE DECIMAL		
NO DIMS		
INTEGRAL DIMS		
TOLERANCING PER		
ASME Y14.5		
MATERIAL		
FINISH		
USED ON		
NET ASY		
APPLICATION		
DO NOT SCALE DIMENSIONS		

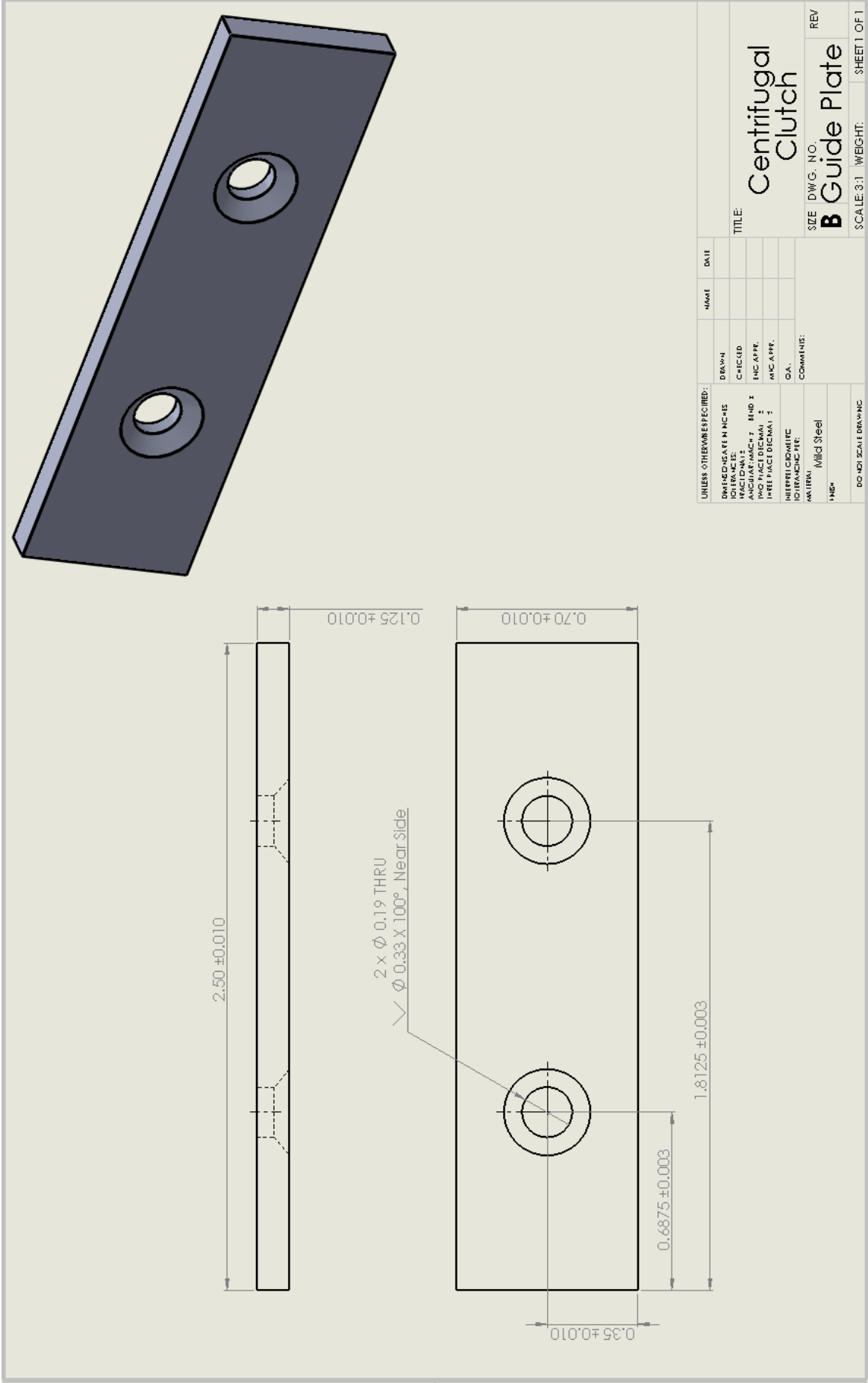
PROPRIETARY AND CONFIDENTIAL
 THIS INFORMATION IS THE PROPERTY OF
 FORTRESS INDUSTRIES, INC. AND IS NOT TO BE
 REPRODUCED OR TRANSMITTED IN ANY FORM OR
 BY ANY MEANS, ELECTRONIC OR MECHANICAL,
 INCLUDING PHOTOCOPYING, RECORDING, OR BY
 ANY INFORMATION STORAGE AND RETRIEVAL
 SYSTEMS, WITHOUT THE WRITTEN PERMISSION OF
 FORTRESS INDUSTRIES, INC.

SEE DWG. NO. **B Clutch shoe**
 SCALE: 1:1 WEIGHT: SHEET 1 OF 1

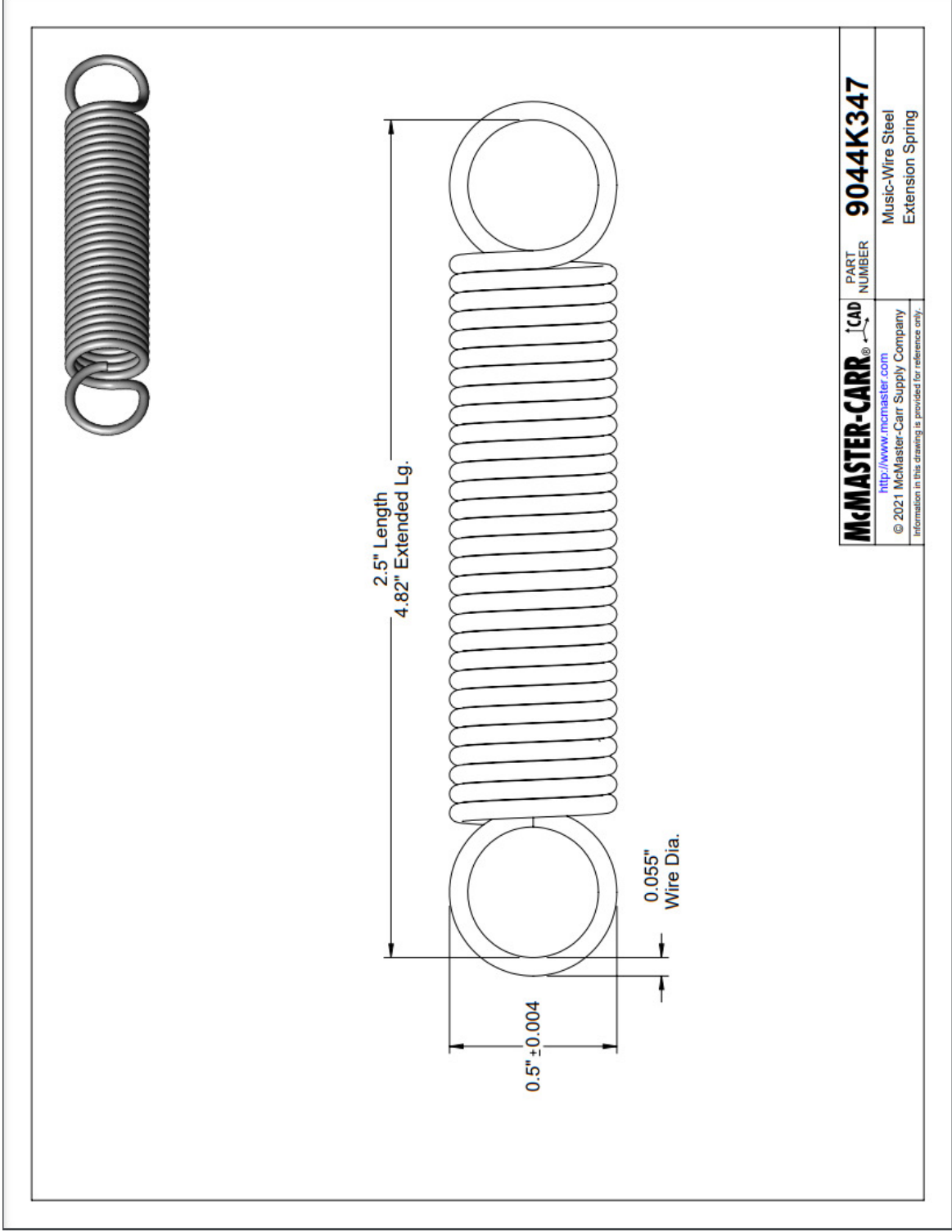
4.4 Medium-Friction Clutch Lining



4.5 Guide Plate



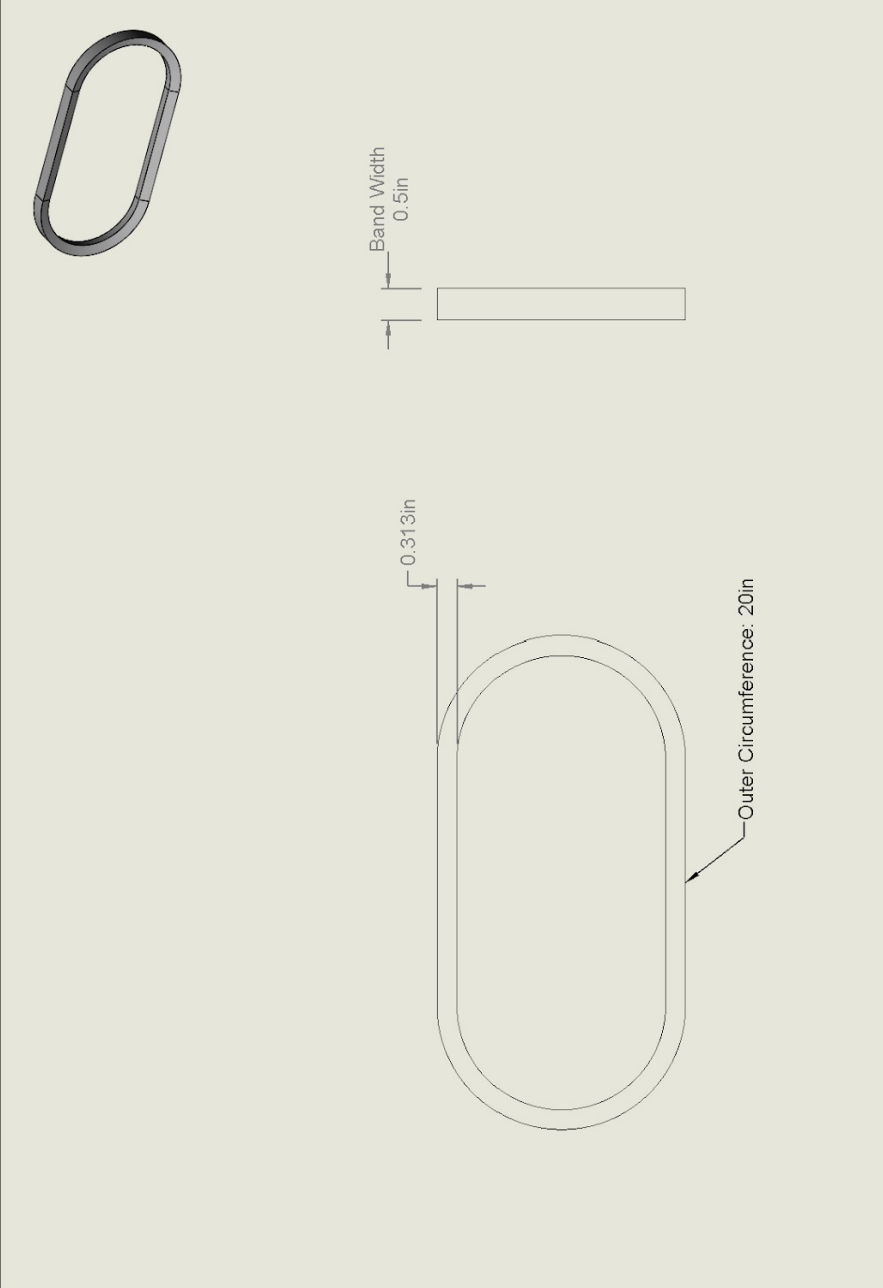
4.6 Extension Spring



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-down view of the belt's shape. The top view is an elongated oval with rounded ends. A dimension line indicates a width of 0.313 in at the narrowest part of the oval. Another dimension line indicates the outer circumference of the belt is 20 in. The cross-section shows a trapezoidal shape with a top width of 0.5 in, labeled as 'Band Width 0.5 in'.

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