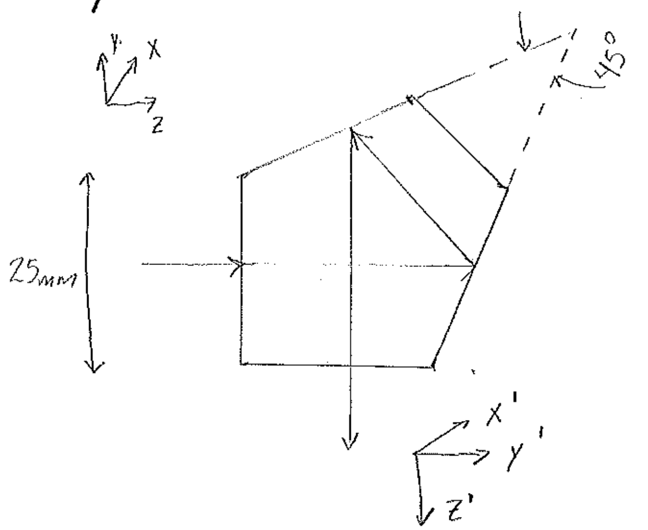
OPTI 421/521
Introductory Optomechanical Engineering
Homework 3

Part 1

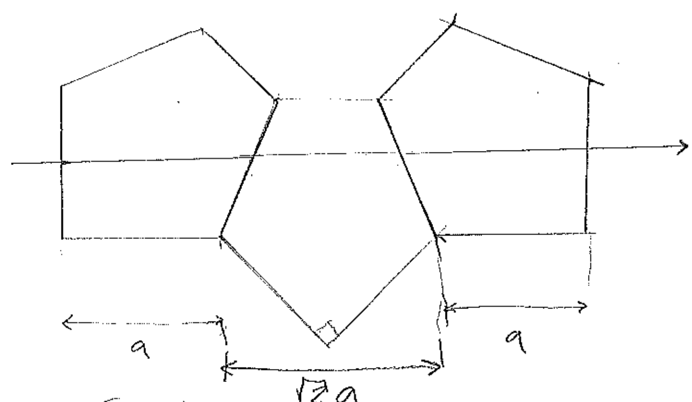
1) Penta



Mirror Matrix

$$M = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 0 & -1 \\ 0 & 1 & 0 \end{bmatrix}$$

Tunnel Diagram



$t = a + a + \sqrt{2}\, a$

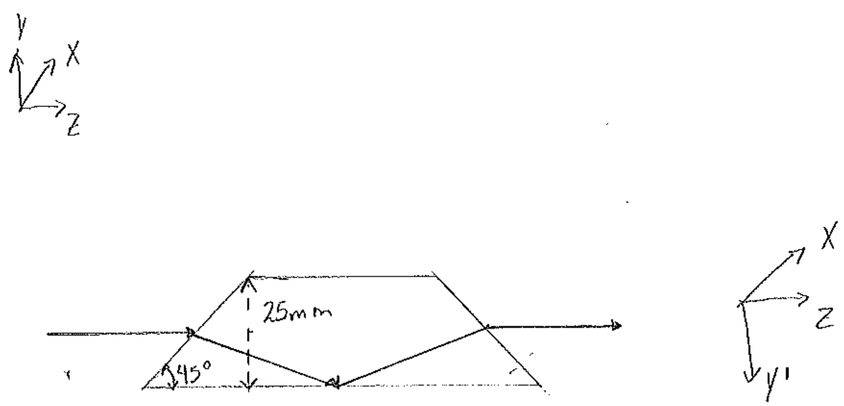
$a = 25mm$

Reduced Thickness

$$\tau = \frac{t}{n} = \frac{25 + 25 + \sqrt{2} \cdot 25}{1.5} = \underline{56.9mm}$$

	L.O.S	Image Rotation
Pitch α	0	0
Roll γ	1:1 γ	1:1 γ
Yaw β	1:1 β	1:1 β

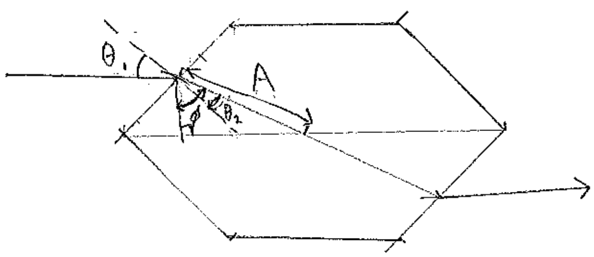
2) Dove



Mirror Matrix

$$M = \begin{bmatrix} 1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

Tunnel Diagram



Use Snell's law

$\theta_1 = 45^\circ$

$\theta_2 = \sin^{-1}\left(\frac{\sin 45^\circ}{1.5}\right) = 0.4909 \text{ rad}$

Reduced Thickness

$\phi = 45^\circ + \theta_2 = 1.276 \text{ radians}$

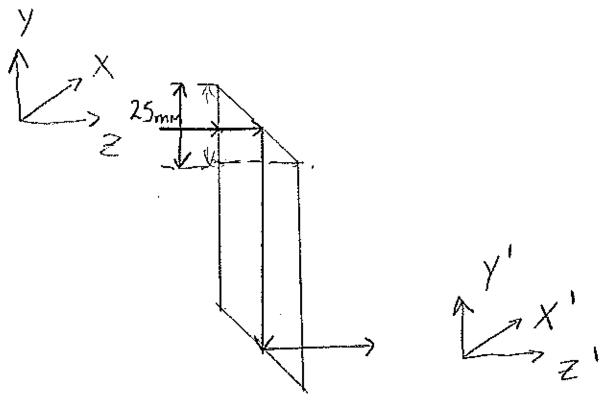
$\cos\phi = \frac{12.5}{A}$

$\Rightarrow A = 43.06$

$\tau = \frac{t}{n} = \frac{2A}{n} = 57.4 \text{ mm}$

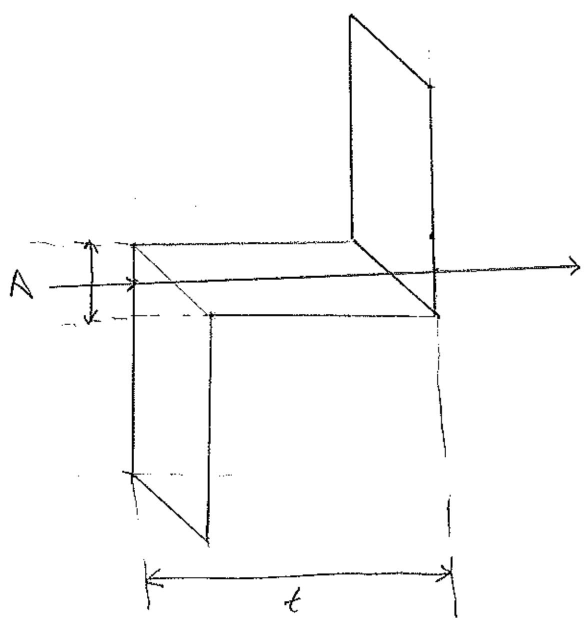
	L.O.S	Image Rotation
Pitch α	2α	0
Roll γ	0	2γ
Yaw β	0	0

3) Rhomboid



Mirror Matrix

$$M = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$



$t = d + A$

Reduced thickness

$$\tau = \frac{t}{n} = \frac{d+A}{n} = \frac{25}{1.5} + \frac{d}{1.5}$$

$$\tau = 16.67 + \frac{d}{1.5}$$

	LOS	Image Rotation
Pitch α	0	0
Roll γ	0	0
Yaw β	0	0

Part 2

Mirror Matrices

Porro prism

$$M = \begin{bmatrix} 1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & -1 \end{bmatrix}$$

Rotation about X-axis

$$M_{Rx} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & -\alpha \\ 0 & \alpha & 1 \end{bmatrix}\begin{bmatrix} 1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & -1 \end{bmatrix}\begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & \alpha \\ 0 & -\alpha & 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & -\alpha \\ 0 & \alpha & 1 \end{bmatrix}\begin{bmatrix} 1 & 0 & 0 \\ 0 & -1 & -\alpha \\ 0 & \alpha & -1 \end{bmatrix}$$

$$= \begin{bmatrix} 1 & 0 & 0 \\ 0 & -1-\alpha^2 & 0 \\ 0 & 0 & -1-\alpha^2 \end{bmatrix}$$

Rotation about Y-axis

$$M_{Ry} = \begin{bmatrix} 1 & 0 & \beta \\ 0 & 1 & 0 \\ -\beta & 0 & 1 \end{bmatrix}\begin{bmatrix} 1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & -1 \end{bmatrix}\begin{bmatrix} 1 & 0 & -\beta \\ 0 & 1 & 0 \\ \beta & 0 & 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 & \beta \\ 0 & 1 & 0 \\ -\beta & 0 & 1 \end{bmatrix}\begin{bmatrix} 1 & 0 & -\beta \\ 0 & -1 & 0 \\ -\beta & 0 & -1 \end{bmatrix}$$

$$= \begin{bmatrix} 1-\beta^2 & 0 & -2\beta \\ 0 & -1 & 0 \\ -2\beta & 0 & \beta^2-1 \end{bmatrix}$$

Rotation about Z-axis

$$M_{Rz} = \begin{bmatrix} 1 & -\gamma & 0 \\ \gamma & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}\begin{bmatrix} 1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & -1 \end{bmatrix}\begin{bmatrix} 1 & \gamma & 0 \\ -\gamma & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} = \begin{bmatrix} 1 & -\gamma & 0 \\ \gamma & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}\begin{bmatrix} 1 & \gamma & 0 \\ \gamma & -1 & 0 \\ 0 & 0 & -1 \end{bmatrix}$$

$$= \begin{bmatrix} 1-\gamma^2 & 2\gamma & 0 \\ 2\gamma & \gamma^2-1 & 0 \\ 0 & 0 & -1 \end{bmatrix}$$

Roof Porro Prism

$$M = \begin{bmatrix} -1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & -1 \end{bmatrix}$$

- Rotation about x-axis

$$M_{Rx} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & -\alpha \\ 0 & \alpha & 1 \end{bmatrix} \begin{bmatrix} -1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & -1 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & \alpha \\ 0 & -\alpha & 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & -\alpha \\ 0 & \alpha & 1 \end{bmatrix} \begin{bmatrix} -1 & 0 & 0 \\ 0 & -1 & -\alpha \\ 0 & \alpha & -1 \end{bmatrix}$$

$$= \begin{bmatrix} -1 & 0 & 0 \\ 0 & -1+\alpha^2 & 0 \\ 0 & 0 & -1-\alpha^2 \end{bmatrix}$$

- Rotation about y-axis

$$M_{Ry} = \begin{bmatrix} 1 & 0 & \beta \\ 0 & 1 & 0 \\ -\beta & 0 & 1 \end{bmatrix} \begin{bmatrix} -1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & -1 \end{bmatrix} \begin{bmatrix} 1 & 0 & -\beta \\ 0 & 1 & 0 \\ \beta & 0 & 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 & \beta \\ 0 & 1 & 0 \\ -\beta & 0 & 1 \end{bmatrix} \begin{bmatrix} -1 & 0 & \beta \\ 0 & -1 & 0 \\ -\beta & 0 & -1 \end{bmatrix}$$

$$= \begin{bmatrix} -1-\beta^2 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & -\beta^2-1 \end{bmatrix}$$

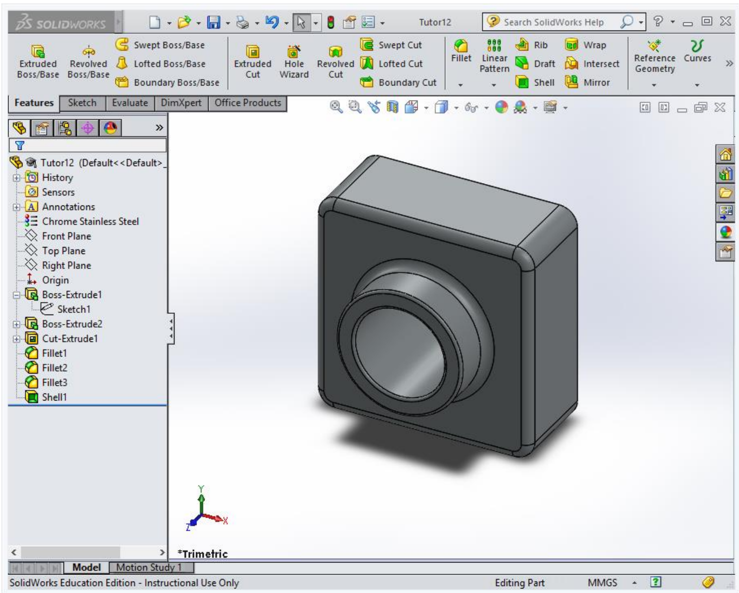
- Rotation about z-axis

$$M_{Rz} = \begin{bmatrix} 1 & -\gamma & 0 \\ \gamma & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} -1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & -1 \end{bmatrix} \begin{bmatrix} 1 & \gamma & 0 \\ -\gamma & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} = \begin{bmatrix} 1 & -\gamma & 0 \\ \gamma & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} -1 & -\gamma & 0 \\ \gamma & -1 & 0 \\ 0 & 0 & -1 \end{bmatrix}$$

$$= \begin{bmatrix} -1-\gamma^2 & 0 & 0 \\ 0 & -\gamma^2-1 & 0 \\ 0 & 0 & -1 \end{bmatrix}$$

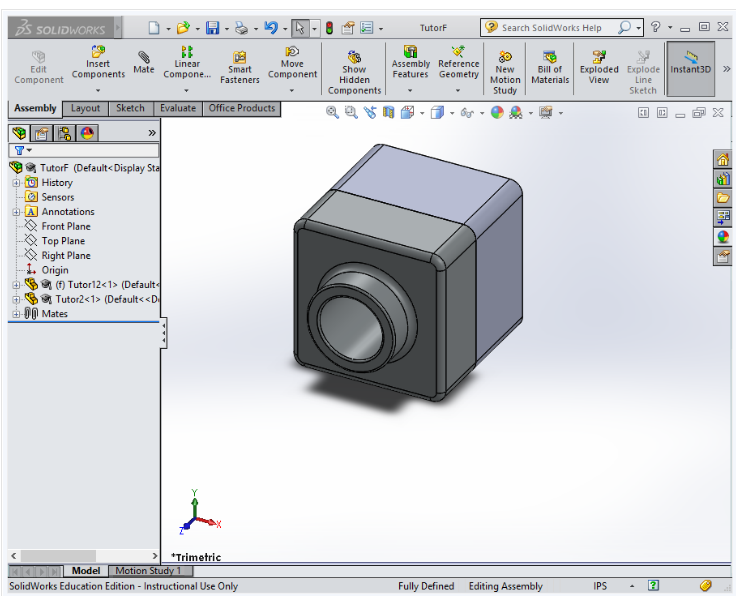
Part 3) SolidWorks assignment

Lesson 1. Parts



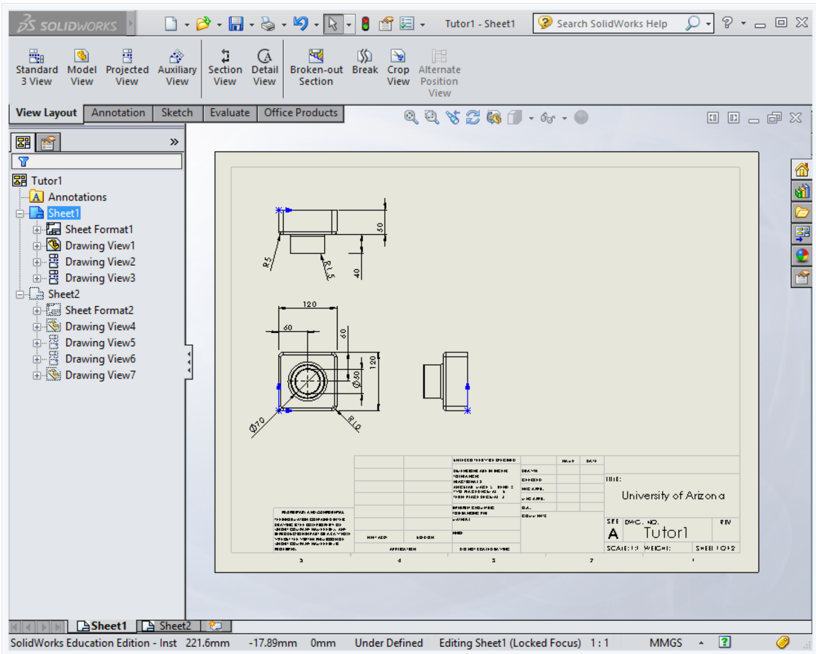
End First Tutorial

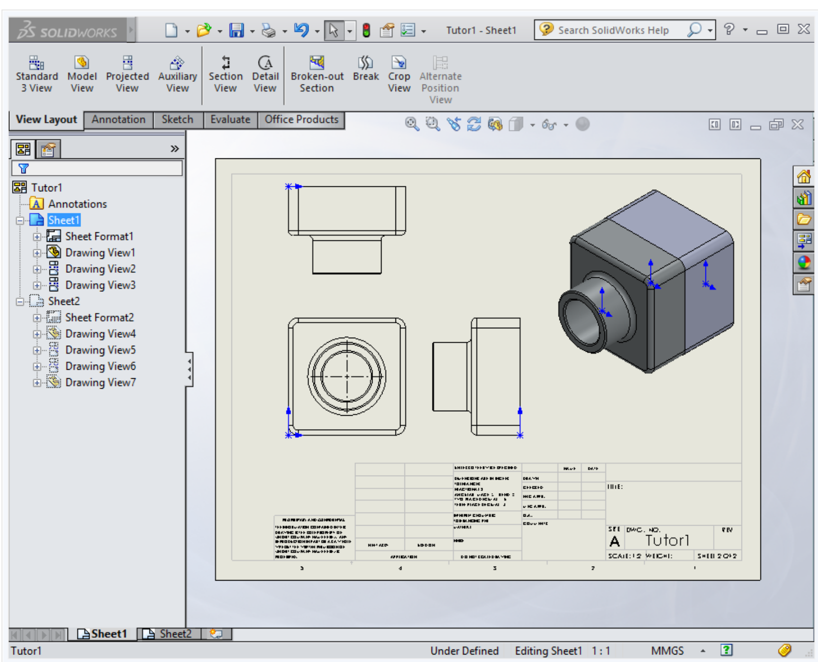
Lesson 2. Assemblies



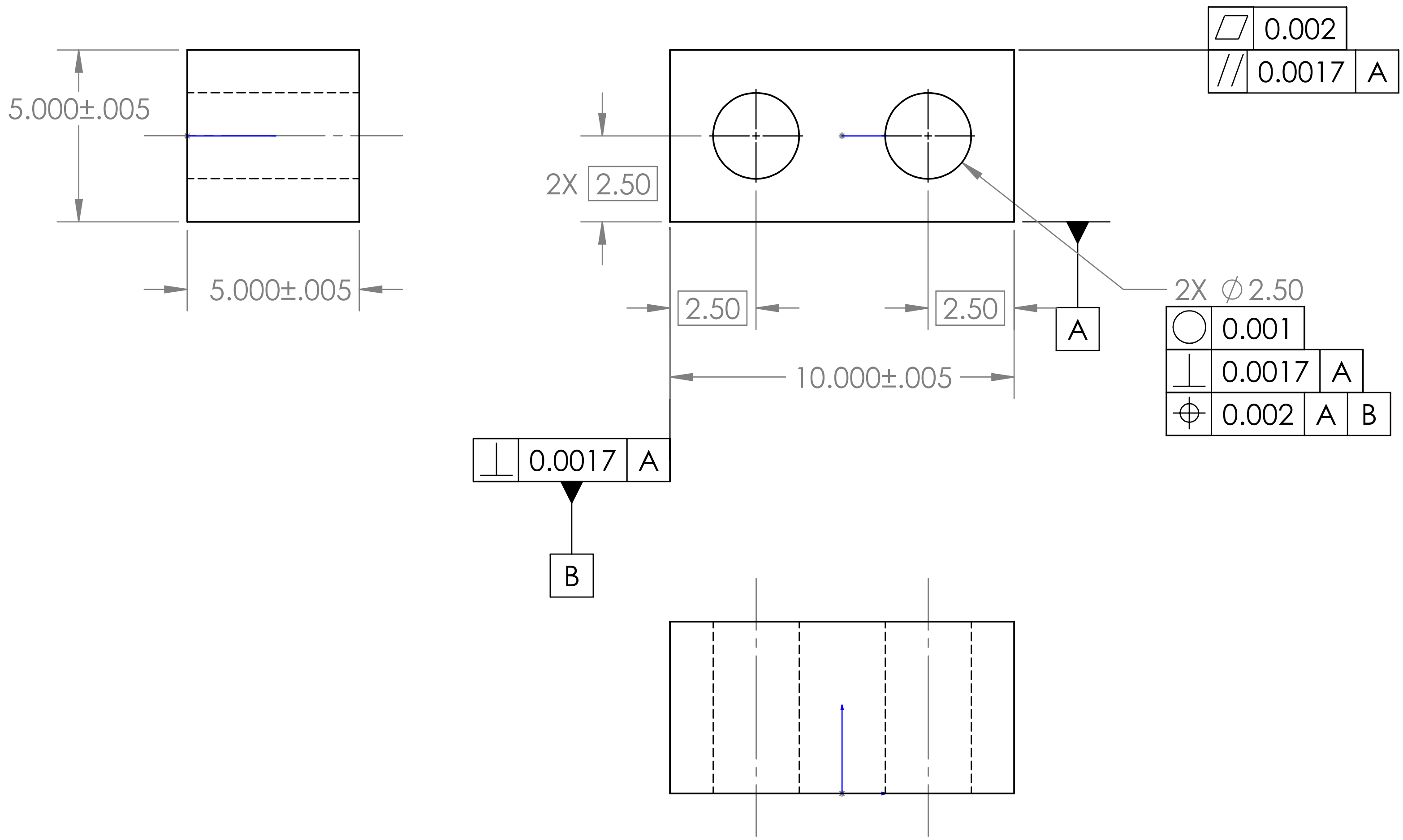
End Second Tutorial

Lesson 3. Drawings





End Third Tutorial



UNLESS OTHERWISE SPECIFIED:

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

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL

FINISH

DO NOT SCALE DRAWING

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

COMMENTS:

NEXT ASSY | USED ON

APPLICATION

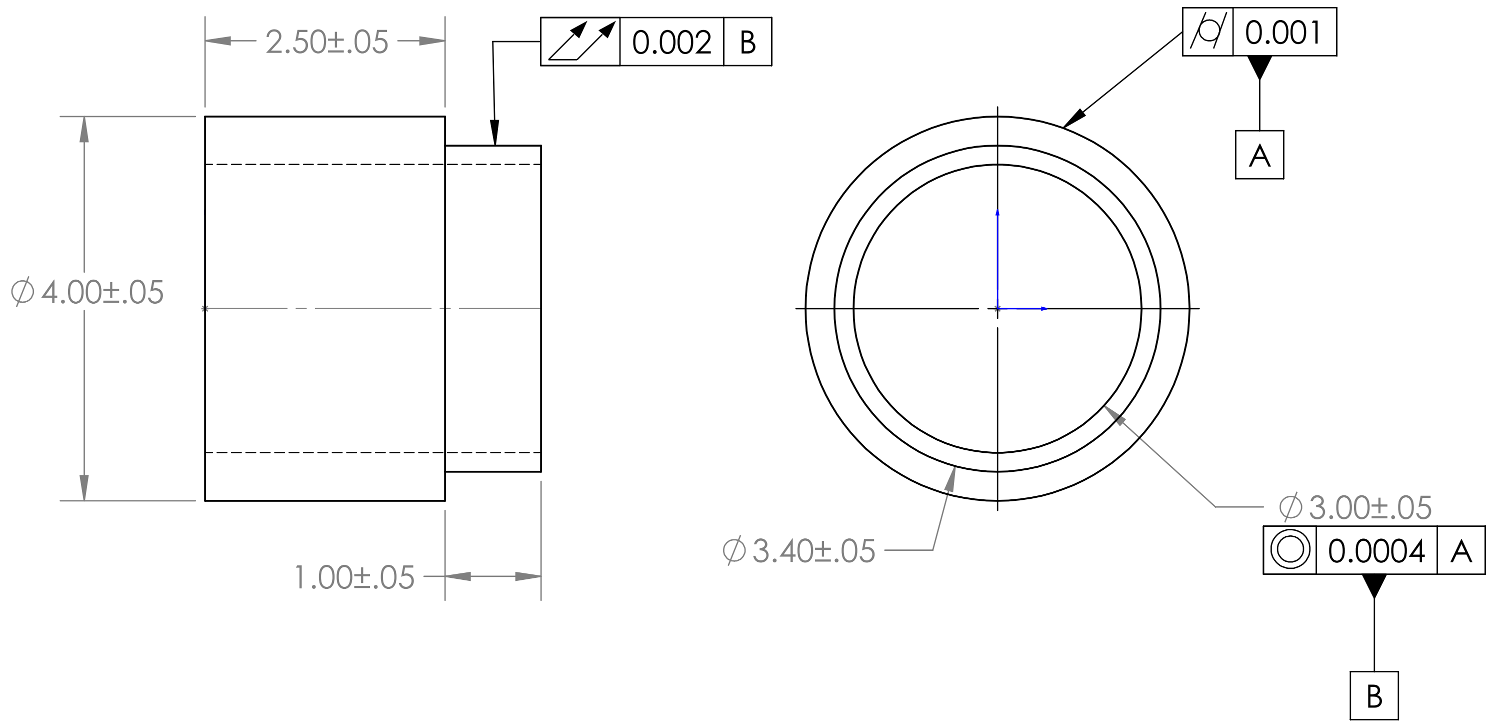
TITLE:

Part A OPTI 421-521-1

SIZE **A** DWG. NO. REV

SCALE: 1:5 WEIGHT: SHEET 1 OF 1

5 4 3 2 1



		UNLESS OTHERWISE SPECIFIED:		NAME	DATE
		DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DRAWN		
			CHECKED		
			ENG APPR.		
			MFG APPR.		
		INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.		
		MATERIAL	COMMENTS:		
NEXT ASSY	USED ON	FINISH			
APPLICATION		DO NOT SCALE DRAWING			

PROPRIETARY AND CONFIDENTIAL

TITLE:

Part B OPTI 421-521

SIZE	DWG. NO.	REV
A		

SCALE: 1:2 WEIGHT: SHEET 1 OF 1

5 4 3 2 1