OPTI 421/521 – Introductory Opto-Mechanical Engineering

Homework 4:

Part 1) Short answer

1) Consider a 50 mm diameter plano-convex BK7 lens with 345 mm focal length. (R1 = 180, ct = 8 mm). For ETD of 0.2 mm, determine wedge, deviation, decenter, optical axis, and mechanical axis. Show these on a sketch.

2) Consider the above lens with 0.15 mm ETD mounted in a barrel, using the convex surface as the datum. Describe how the optical axis of the lens can be aligned to the barrel axis. Provide a sketch of this showing the definition of the optical axis of the lens. With the lens aligned, determine the radial TIR of the outer cylinder of the lens with respect to the barrel axis.

3) Consider a 50 mm diameter nearly concentric meniscus BK7 lens with the following properties:

   R1 = 180 mm convex

   R2 = 157 mm concave

   Ct = 8 mm

   (-2700 mm focal length)

   For ETD of 0.15 mm, determine wedge, deviation, decenter, optical axis, and mechanical axis. Show these on a sketch.

4) Consider the above lens with 0.15 mm ETD mounted in a barrel, using the convex surface as the datum. Describe how the optical axis of the lens can be aligned to the barrel axis. Provide a sketch of this showing the centers of curvature. Determine the radial TIR of the lens outer edge cylinder with respect to the barrel axis.

5) Consider the lens above with a 3 mm wide edge flat on the concave surface, made so the edge flat is aligned to the outer cylinder. Consider the case where the lens is mounted using the outer cylinder and the edge flat as the reference. Use a sketch and show the optical effect created by using the mechanical surfaces for mounting.

6) Consider the lens from 1) where Surface 1 is made to be aspheric

   R1 = 180 mm convex

   K1 = -0.35 (ellipsoid surface)

   deviation = 2 arcmin

   Make sketches that correctly depict the lens for two different cases:

   a) Case 1: Assume the outer edge cylinder is true to the aspheric surface, meaning that the axis of the outer cylinder coincides with the axis of the ellipsoidal surface.

   b) Case 2: Assume surface 2 (the flat) is true to the aspheric surface, meaning that the axis of the ellipsoidal surface is normal to the flat surface.

7) A 25 mm diameter surface has a requirements of R = 1000 +/= 1 mm. Calculate the tolerance in terms of the sag of the surface. Is this tight?

Part 2) SolidWorks Assignment
Design a simple lens mount. Provide a brief report that documents your design.

a. Generate the following components

1) 1 Plano-convex lens, made from BK7

R1 = 75 mm convex (make the surface aspheric if you want!)

Ct = 4 mm

OD = 25 mm

2) 1 barrel made of aluminum

3) 1 retainer ring made of brass

Choose all dimensions and tolerances that seem appropriate.

b. Put the three component s together

Show the 3D assembly picture in your report. Use appropriate views to show the important aspects of the assembly.

c. Create their mechanical drawings

1.) Create an assembly drawing. Label the parts.
2) Provide a complete mechanical drawing for each component.
3) Show all dimensions on the component drawing. Use datum features to show alignment and registration of important features.
Your drawings should be complete enough that they could be provided to a machinist to make the metal parts. Your drawing of the lens must completely specify all optical properties.

Part 3) Rules of Thumb
Provide three rules of thumb using the format provided.

Part 4: Tolerance Analysis and Technical Report

The report must be submitted for peer review.

- **Submit the report as hard copy in class**
- **This should be a standalone report separate from the other parts of your homework**

You will collect a report from one of your peers and provide a peer review, due the following class. Submit the peer review form with your name on it, attached to the report.

The following optical system is used to focus a collimated HeNe laser beam onto a Position Sensing Detector (PSD).

20 mm entrance pupil diameter
Nominal EFL = 100 mm
Wavelength = 632.8 nm (HeNe)
Diffraction limited operation, SR > 80%
(A fine focus adjustment will be made by moving the PSD.)
The resolution for this adjustment is ±5 um

A nominal optical design has been supplied, see the following page. The design residual of this system is 0.002 λ rms, which is negligible.

A top level system budget has been performed in terms of rms wavefront error:

Assembly tolerances	0.04 λ rms	This term includes lens positions errors
Lenses	0.04 λ rms	This term covers errors from lenses themselves
Operational changes	0.04 λ rms	Thermal changes, residual focus
RSS	**0.07 λ rms**	

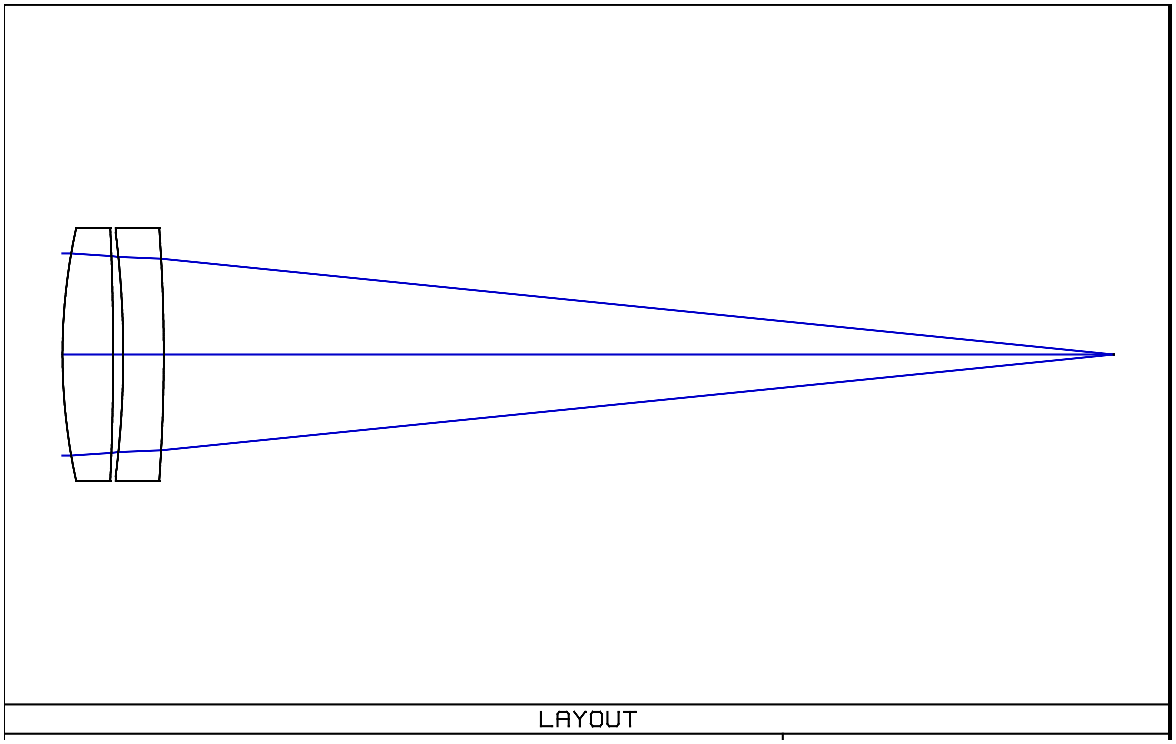
Your job is to perform an initial strawman budget for the assembly tolerances, adding up to 0.04 λ rms. You should include all degrees of freedom for mounting the lenses including tilt, decenter, and axial position. Assume focus compensation by moving the image plane.

You should use a ray trace program such as Zemax, CodeV, Oslo, to determine the sensitivities. Then create a spreadsheet to help set the tolerances to sensible values. (The sensitivities can be provided to you if you do not have access to such a program.)

You should write a report called “Mounting requirements for focusing doublet.” Later in the term, we may support cells for these lenses.

Do not simply push the “tolerance” button on Code V. You can run the automated tolerancing, but you must verify that CodeV has calculated the sensitivities appropriately.

Focusing Doublet



SURFACE DATA SUMMARY:

Surf	Type	Radius	Thickness	Glass	Diameter
OBJ	STANDARD	Infinity	Infinity		0
STO	STANDARD	Infinity	0		20
2	STANDARD	58.6	5.0	N-SK15	25
3	STANDARD	-277.0	1.0		25
4	STANDARD	-97.0	4.0	N-SK15	24
5	STANDARD	-174.0	93.824		25
IMA	STANDARD	Infinity			

INDEX OF REFRACTION DATA:
Index data is relative to air at the system temperature and pressure.
Index of refraction at 632.8 nm
N-SK15 1.620702