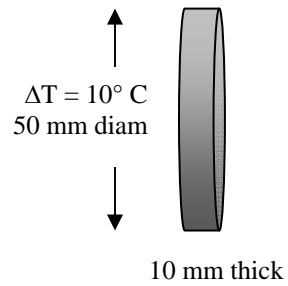


- 3.) (10) Consider a 10 mm thick plano-plano BK7 window with a lateral thermal gradient of 10°C across the 50 mm diameter.
- Determine the angular deviation of light through this window due to the thermal gradient. Take both the dn/dT and the CTE effects into account.
 - Determine the heat flux in W/cm^2 required to maintain this gradient



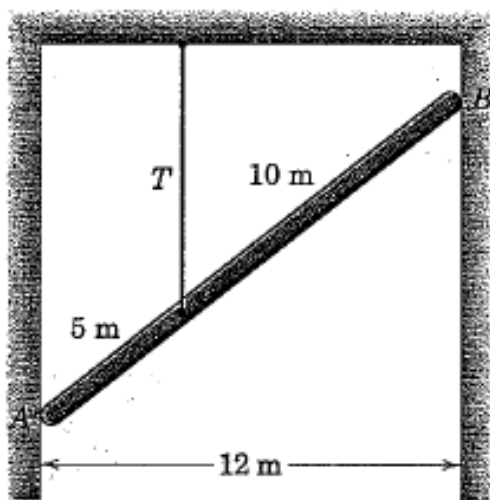
4.) (10) Consider a fused silica vacuum window, 6" in diameter.

a) Determine the window thickness required to limit the bending stress due to the atmospheric pressure to less than 1000 psi tensile stress in the glass.

b) Sketch a design of a mount for this window.

5) (5) Static equilibrium.

The uniform 15-m pole has a mass of 150 kg and is supported by its smooth ends against the vertical walls and by the tension T in the vertical cable. Compute the reactions at A and B .



- 6) (15) A 10 mm BK7 beamsplitter cube is bonded to aluminum with 0.5 mm thick RTV elastomeric adhesive. The bond area is circular, 10 mm diameter.

The adhesive has

200 ppm/°C CTE

1 MPa shear modulus

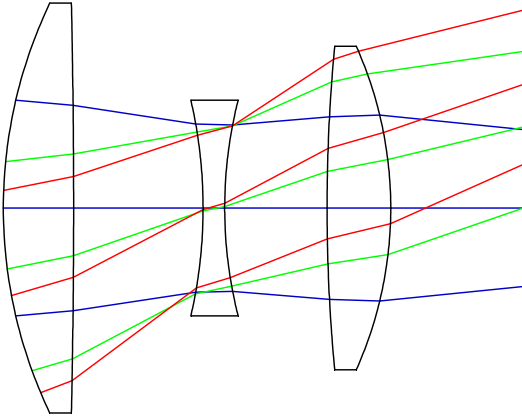
1 GPa bulk modulus

5 MPa adhesive strength, shear and normal

- a) Calculate the strength of the bond. (The force in N required to fail the adhesive.)
- b) Calculate the lateral (shear) stiffness of the bond. (The force in N per mm lateral displacement.)
- c) Calculate the normal (compressive) stiffness of the bond. (The force in N per mm axial displacement.) Hint, consider use of the bulk modulus.
- d) Determine the resonant frequency for shear and compression directions.
- e) Calculate the stress in the bond for a 10°C change in temperature.

- 7) (10) Describe a method for mounting the following lenses which range from 10 to 20 mm diameter. The tilt, decenter, and axial position must be maintained to $50\ \mu\text{m}$ accuracy. Assume the lenses must survive 100 G shock load and $\pm 30\ \text{C}$ temperature.

Describe engineering choices made and issues to consider for assembly, performance and survivability.



8) (10) How do we choose materials for mirrors? Each of the following materials has some outstanding material properties appropriate for mirrors. They also have some important limitations. Provide approximate values for CTE, density, Young's modulus, and thermal conductivity for each. Give an example of a mirror application for this material and discuss the rationale for this choice.

Zerodur

Silicon Carbide

Beryllium

Borosilicate glass (like Pyrex)

9) (10) List the relative advantages, disadvantages, and applications of linear stages that use the follow constraints:

Dovetail slide

Specific Advantages:

Specific Disadvantages:

Application:

Ball bearings

Specific Advantages:

Specific Disadvantages:

Application:

Crossed roller bearings

Specific Advantages:

Specific Disadvantages:

Application:

Air bearings

Specific Advantages:

Specific Disadvantages:

Application:

Flexures

Specific Advantages:

Specific Disadvantages:

Application:

9) (20) Canon sells binoculars that actively stabilize the image using a variable wedge. The angular accelerations are measured with sensors and a correction is applied by changing the wedge of a fluid filled cavity. For the case of 20 x 50 binoculars, calculate the wedge required to fully correct the effect of tilting the binoculars by 1 mrad.

- Give the diameters of the entrance pupil, the exit pupil, and the magnifying power
- Give the general relationship for change in line of sight observed by the viewer as a function of
 - angular deviation due to change in an element
 - the beam diameter at the element
 - the exit pupil diameter
- Show the relationship between a change in the wedge angle α and the deviation it causes in user space.
- If the binoculars are tilted by 1 mrad, how much motion does the user observe (hint: draw a sketch of this or you will probably get it wrong)
- Calculate the required wedge to correct for the 1 mrad tilt of the binoculars

