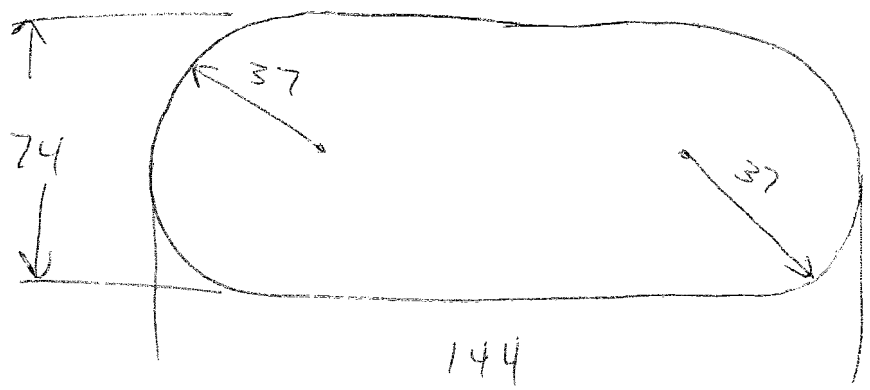
Name_____ Fold flat specs

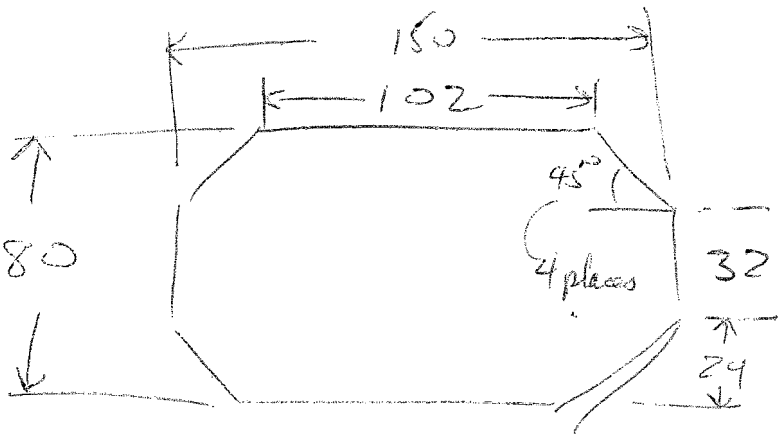
1) Draw a picture of the beam footprint on the fold flat with dimensions. Remember to use all field positions to get the full extent of the beam. The picture does not have to be more specific than the radii of the two ends of the footprint and the long and short overall dimensions.



Could be smaller by a mm or 2 anything larger would be ok but adds to cost

Area = $\pi(37^2)$ = 4300 + 70 x 74 = 9480 ≈ 9500

2) Make a mechanical drawing of the flat allowing a reasonable width outside the clear aperture and a reasonable outline shape considering cost and ease of manufacture. The thickness will be calculated in another problem so simply dimension it as T. What might be a sensible tolerance on the thickness independent of the actual thickness?



These are about minimum possible dimensions

Area 102 x 80 = 8160
+ 2 x 56 x 24 = 2688
10848

3) Assume that the mirror should sag no more than 50 nm peak-to-valley simply supported, that is, with free edges, under its own weight in the long direction of 150 mm. Use the simple formula in the notes to calculate the thickness required. The Young's modulus and density for glass are essentially the same as those for aluminum, a useful tip to remember. Does the answer surprise you? What does this say about how the mirror has to be supported?

$$\text{sag (deflection)} = \frac{q\,a^4}{E\,t^3} = 50\text{ nm} = 2\times10^{-6}\text{''}$$

In psi $q = .08$ psi $\quad a = 3''$ $\quad E = 1\times10^7$ psi

$$t^3 = \frac{(.08)(81)}{(1\times10^7)(2\times10^{-6})} = \frac{6.48}{20} = .324 \text{ in}^3$$

$t = .689'' \approx 17.5$ mm ← Thicker than expected.

Mount must avoid introducing moments.

4) Given your outline and thickness, how much does your mirror weigh? Assume the density of the glass is 2.2 gm/cm^2.

Area at least 10848 $\quad$ Volume = 190000 mm^3

$\therefore$ 190 cm^3

Mass = 2.2 × 190 = 418 gms = .97 lb

5) Visit http://www.us.schott.com/borofloat/english/index.html. Would this be a suitable material for the mirror and does it come in a thickness suitable as a starting place for fabricating this mirror. Did you see any other ways of cutting the outline of the mirror than those suggested in class?

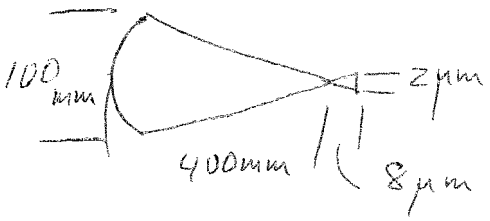
Available in 18 & 19 mm thicknesses

Abrasive waterjet laser scribing

6) What would be a reasonable protective chamfer to specify?

≈ 1 mm face width - perhaps 2 mm

7) What is a reasonable number for the figure, or form (3/?) tolerance? Assume we want to hold the spot size to 2 μm diameter (about half a pixel). What change in radius of a wavefront would cause a perfect spot (in a geometrical optics sense) to expand to a 2 μm size if the beam diameter started out 100 mm in diameter and was an f/4 beam? What does this correspond to in terms of sag difference? What radius would a perfectly flat mirror have to be changed to to produce the same sag over a 140 mm diameter. Check your answer by changing the radius on the flat in Zemax. Remember to use a pickup since the light hits the flat twice.



8 μm change in radius

$$\Delta sag = \frac{1}{2}\left(\frac{y}{R}\right)^2 \Delta R = \frac{1}{2}\left(\frac{50}{400}\right)^2 \Delta R$$

$$= 7.8\times10^{-3} \times 8\,\mu m = 62.5\ nm$$

$$sag = \frac{y^2}{2R} \quad \text{or} \quad R = \frac{y^2}{2\,sag} = \frac{(70)^2}{2\times62.5\times10^{-6}} = \frac{4900}{125\times10^{-6}} = 39.2\times10^{6}\ mm$$

So figure tolerance of about ~~50~~ 25 nm or λ/20 p-v (factor of 2 for reflection)

8) What might a reasonable surface imperfection tolerance be for the fold mirror? Does the fact that the mirror will be highly reflecting when coated play into your answer. Once you decide on a spec, what percentage of the area of the clear aperture would be covered by imperfections?

In class suggested .4 to .006 or .16 to .00004 in area

Default 5 x .63

Since mirror half way between pupil & image

Something like .25 might be reasonable, maybe a little less because reflecting, say .16

If .25 → area of imperfections .063 mm^2

.16 " " " .025 mm^2

Clear aperture ≈ 9500 mm^2

So percentage = $\frac{.025}{9500} \times 100 = .0002.6\ \%$

or $\frac{.063}{9500} \times 100 = .0006.6\ \%$