Handout 10 - Borealis Front Uprights

Front Uprights — some considerations

To estimate values for the points A' and B' on the upright in Handout 4, it is necessary to go into detail where the lower A-arm meets the upright. For our solarcars, to have:

(1) high ground clearance,
(2) A-arms out of the air stream,
(3) steering angles able to do the U-turn test,

the outer end of the Lower A-arm fits into a cavity in the upright. The cavity must provide adequate clearance for the upright to move in bump/rebound/left & right turns without hitting the A-arm (and spring mount, which we want as far out on the arm as possible), and it must allow adequate STRENGTH of the upright, since maximum bending in cornering and braking will occur where the lower A-arm mounts.

The Aurora 2-4 and Borealis I uprights had the lower spherical bearing mounted so the pivot bolt was vertical, but in BII we tried a horizontal arrangement.

The following consists of some handwritten notes to the Front Susp team for BI, starting with an Aurora style A-arm. Drawings of the Aurora 4 front suspension are included. I did not re-organize or edit this stuff, so you'll have to live with my writing & sketches. You will need to get into this material and examine the BI / BII cars to fully appreciate what is being discussed.

The next pages describe some "tradeoffs" ~ (design choices) for various cavity features for an Aurora type A-arm (having one leg perpendicular to the centerline of the car), and estimated turning angles of $\theta_{inside} \approx 22^\circ$, $\theta_{outside} \approx 18^\circ$, and a vertically mounted pivot bolt. And we'd try to have the A-arm legs be two-force members → pointing towards the center of the outer spherical bearing. (We did not achieve this on any of the Aurora cars)

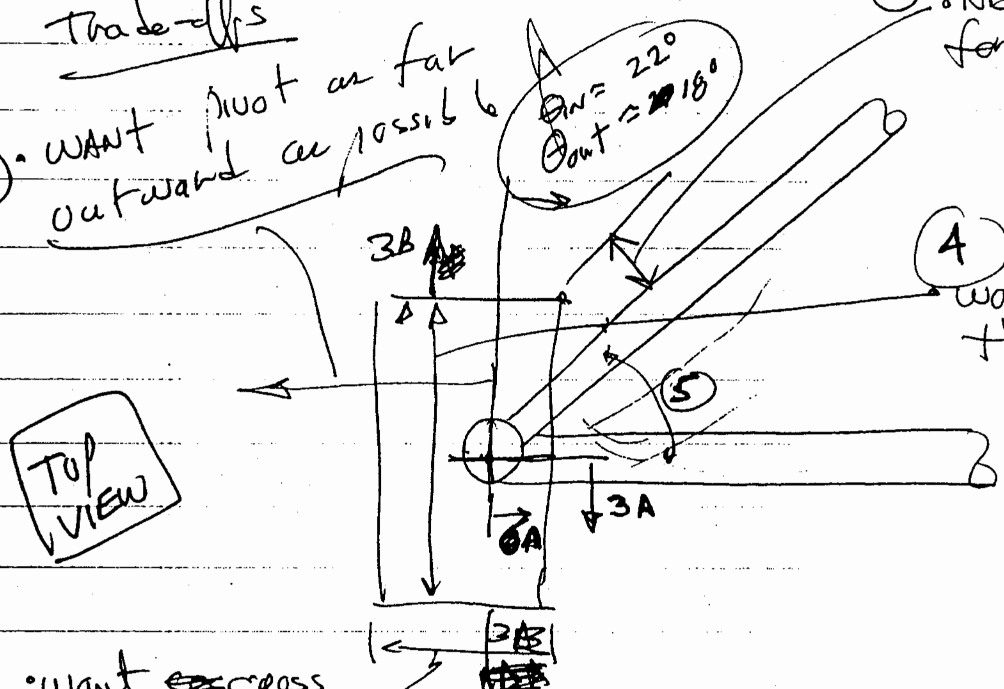
Page 126 is the memo initiating the BII upright.

UPRIGHTS

Trade-offs

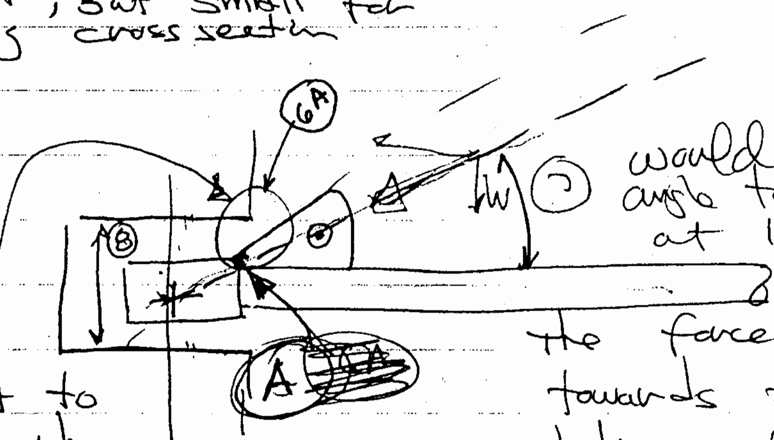
(1) • want pivot as far outward as possible

(3) • NEED clearance for TURNING



(4) want the width of the hole SMALL to Reduce the physical size — A Large width is not a good way to increase Bending stiffness due to CORNERING or Bump

(2) • want cross section "deep" or big for Bending strength, but small for fairing cross section



(7) would like this angle to be "steep" — at least 45°, and the force vector to act towards the Brg ℄ at static and if not at static, then in Bump, when the spring shock forces are high

(6) Need clearance in Rebound and we want the spring mount to also attach to the Brg Housing at (A)

(5) want this design of A-arms due to high loads in Bump & CORNERING ⇒ one arm ⊥ to vehicle ℄ and the axis of each arm to meet at the joint ⇒ This was Re-examined later

(8) would like this to be small to reduce the Bending load on the Bolt used as the Pivot / But if large, it

slightly lowers the bending on the upright →

comments

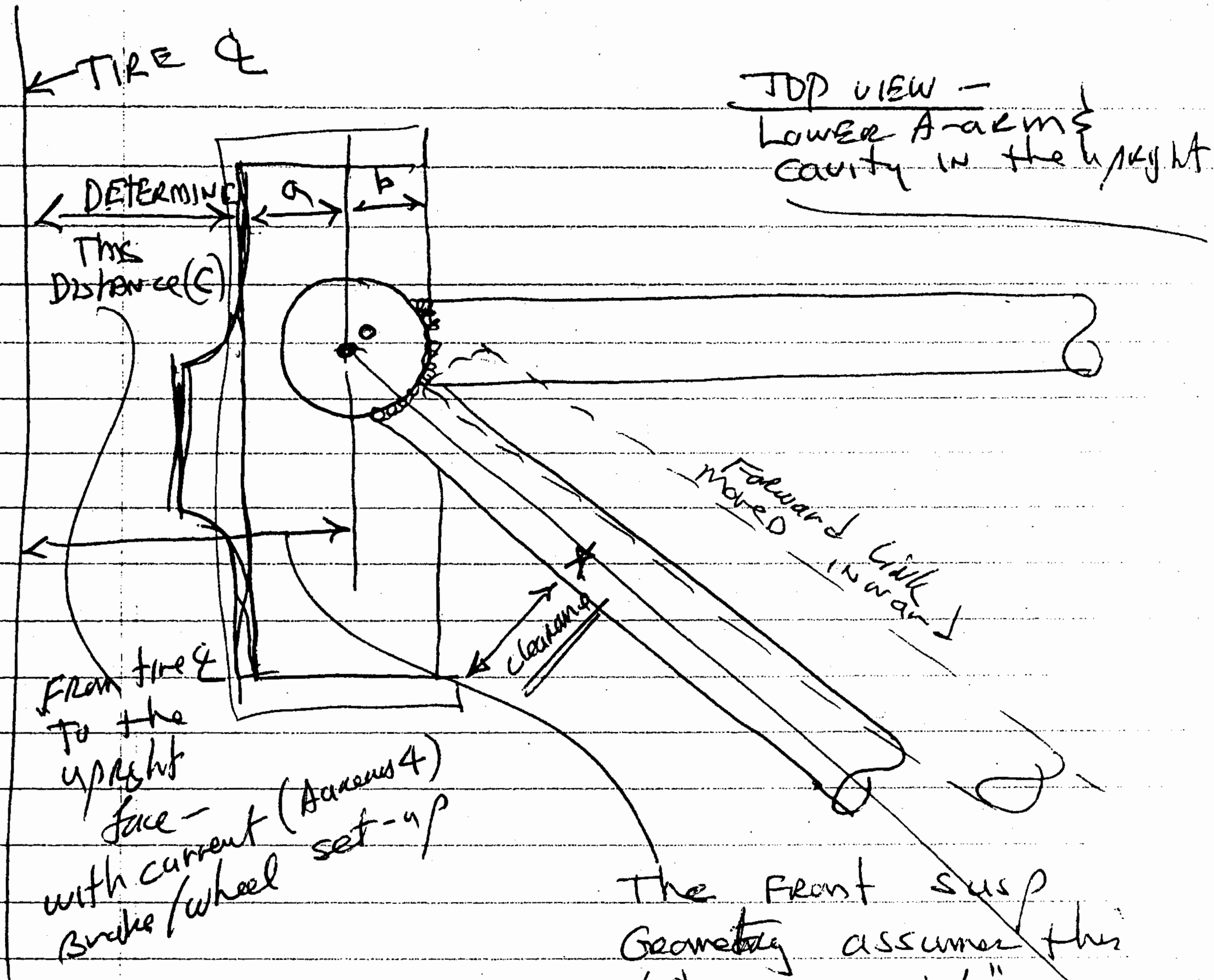
(3A) - move pivot ℄ off to one side to allow more clearance when turning

(6A) - same as (3A) and will assist in providing ~~shocks~~ clearance for spring/shock mount in rebound

(3B) ~~(3A)~~ - widening the cross section will provide clearance for turning and

IDEA can this be posed as an optimization problem ?, with the ~~hole width~~ window width, depth, height and hole location as vars?

ITEMS 1–8



The Front susp Geometry assumes this distance is 1.6" – can we Do that?

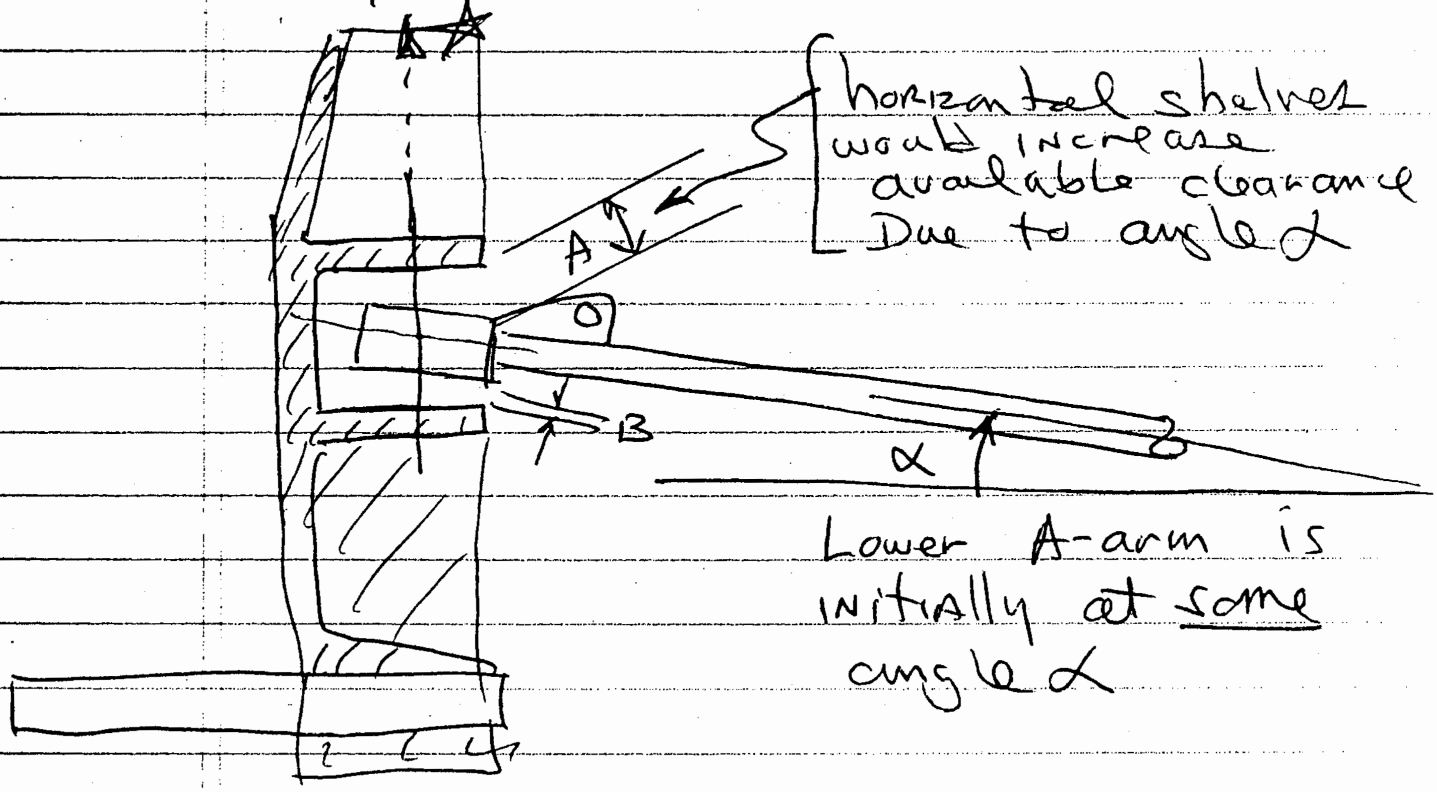
$a + c = 1.6"$?

<u>clearance*</u> can be increased by

1) making a bigger, b smaller which makes it harder to maintain $a+c = 1.6"$ and ~~~~ MAY increase Kingpin inclination angle

2) move the ~~~~ forward member of the A-arm inward, which produces a bending moment on the welded fitting ~~~~ from the A-arms

ITEM (6) – we can angle the "shelves" in the upright to favorably reflect ~~the~~ upon the ~~ug~~ clearance issue –



☆ But we need to be able to drill the hole ~~for~~ the Bolt

and have clearance at B in Bump

10/25/00

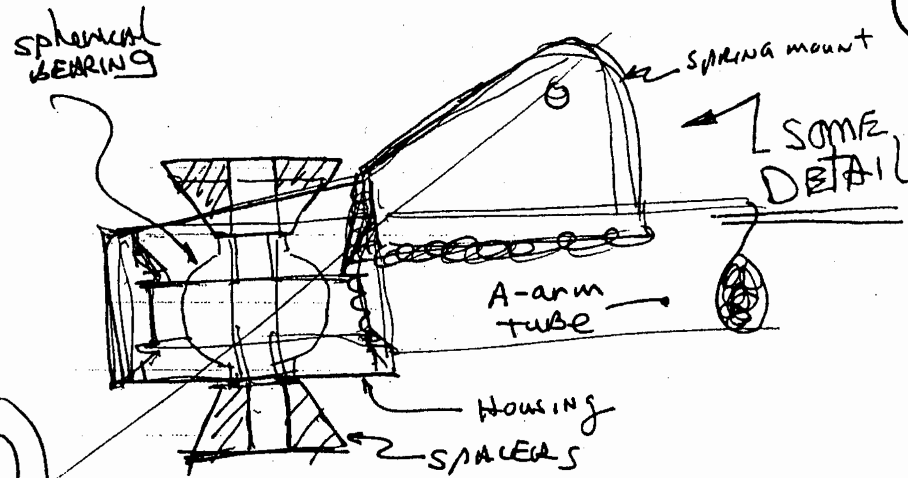
- AURORA 4 has the forward link moved inward slightly —

Suppose we (A) don't move it in
 " AND (B) maintain a+c = 1.6"
 (check the Aurora 4 value)

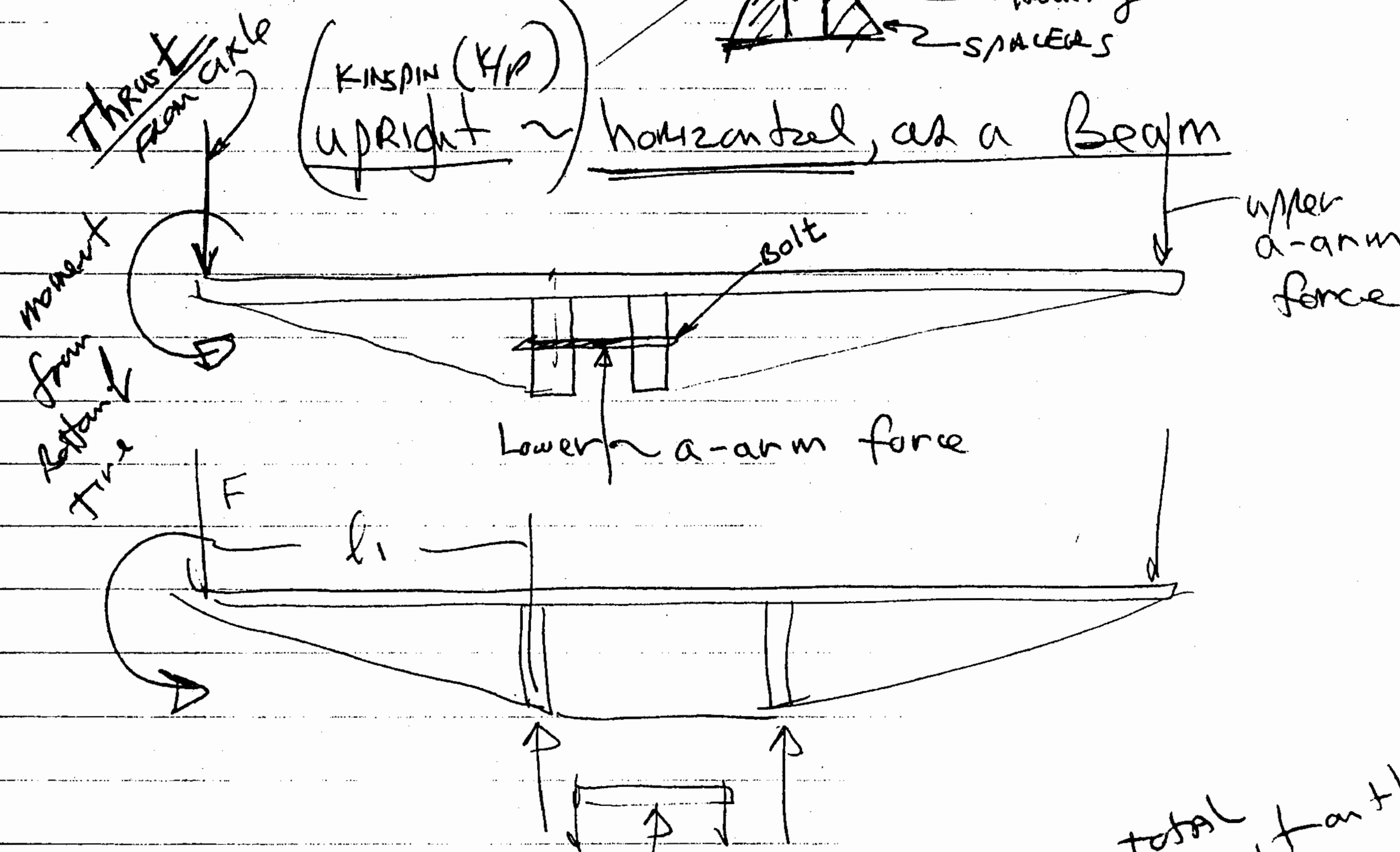
Then find shape of a rectangular cavity needed to clear in TURNS and in Bump / Rebound

Need to know — detail of outer spherical brg attachment on Lower A-arm
— ± steering angle
— Bump/droop travel
— approx detail of spring link mount —

Item 8 observation



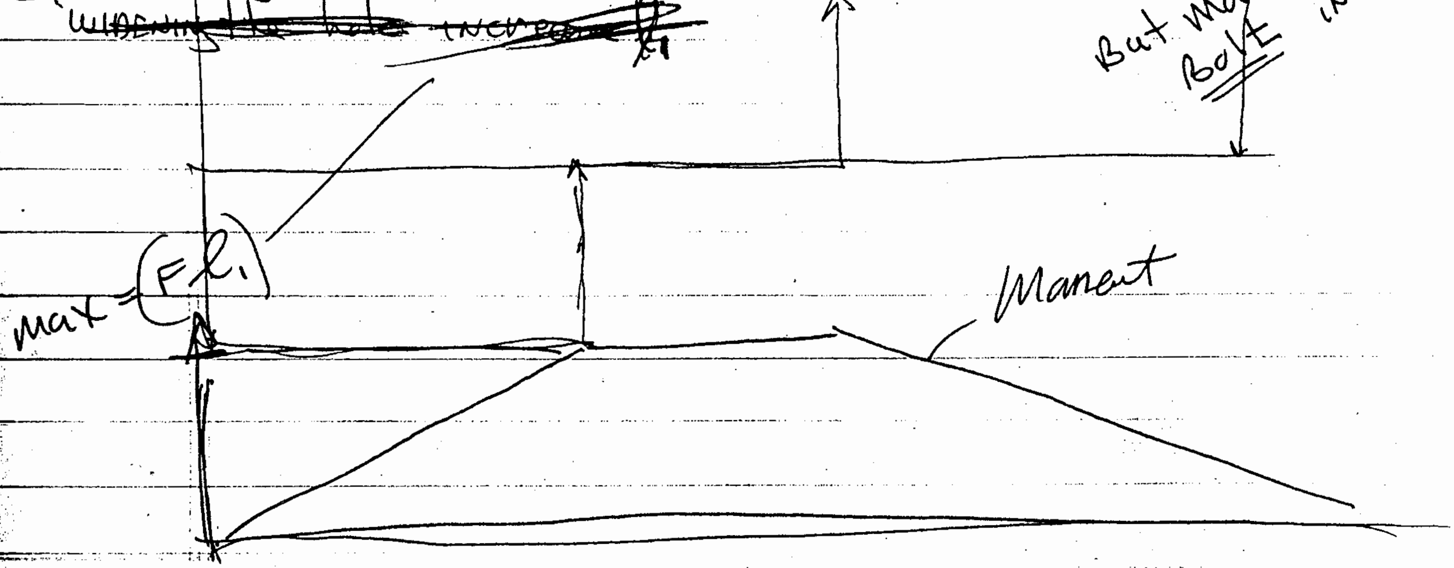
Kinspin (K/P) upright ~ horizontal, as a Beam



WIDENING the hole, decreases l_1

~~WIDENING the hole increases l_1~~

so the total moment on the K/P is slightly less — But moment on BOLT INCREASES

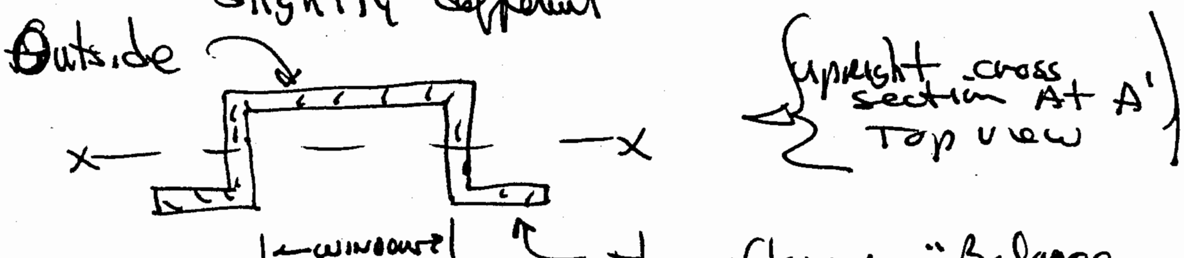


Upright –

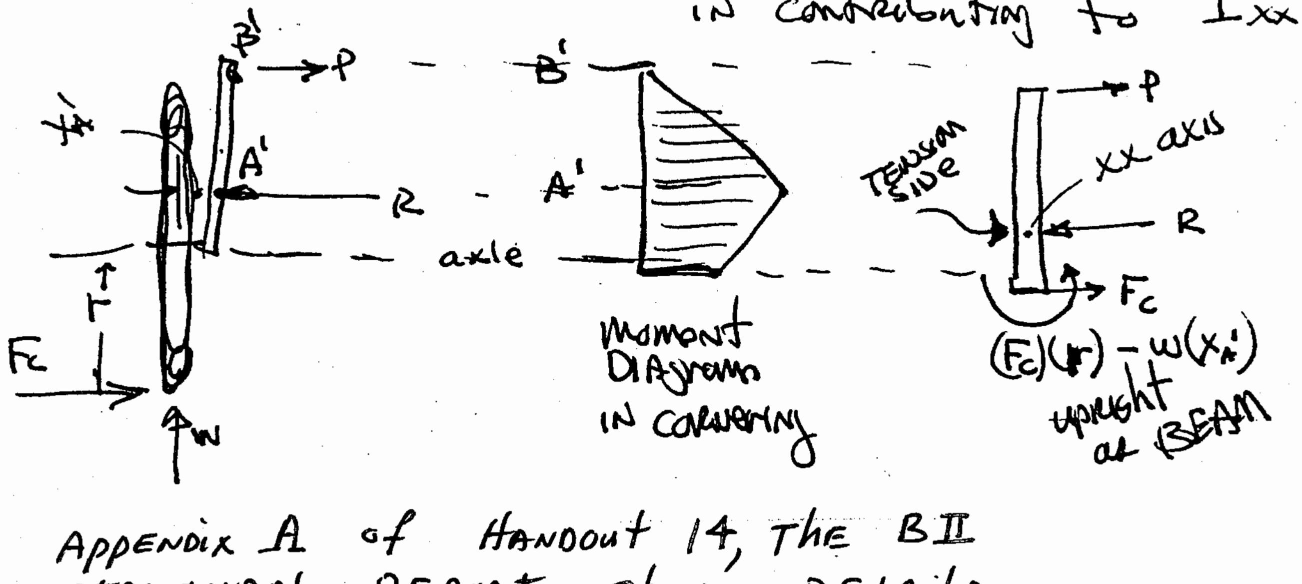
- Bending moments in cornering & Braking
- Devise cross sections that have reasonable C/I values : stress(Bending) = $M\frac{C}{I}$

  M = max moment

  would like the (C/I) for the tension side to be less than for the compression side, if they are slightly different

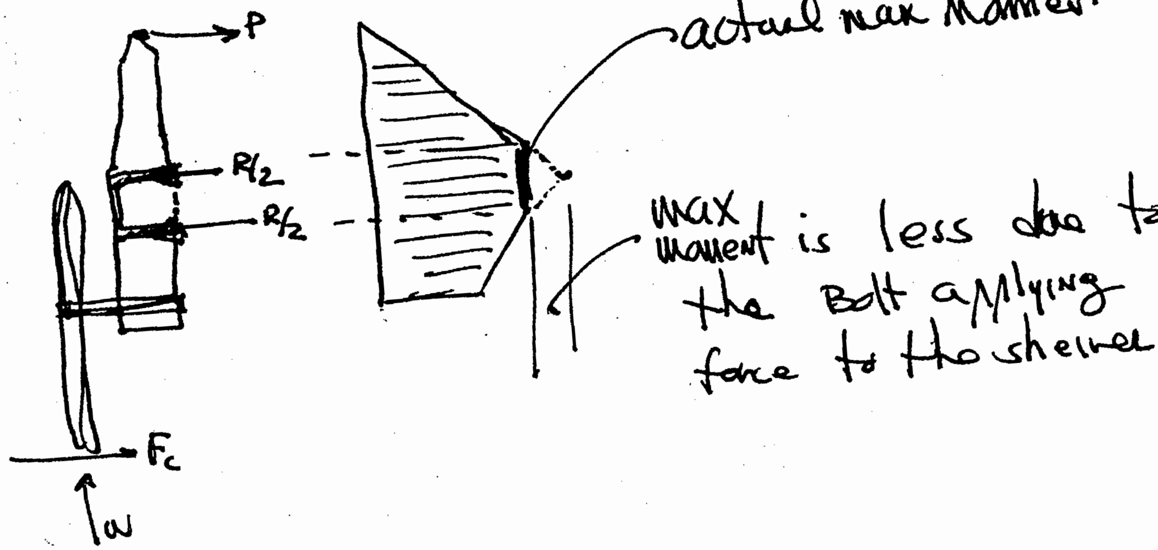


the flanges "Balance" the outside surface in contributing to I_{xx}

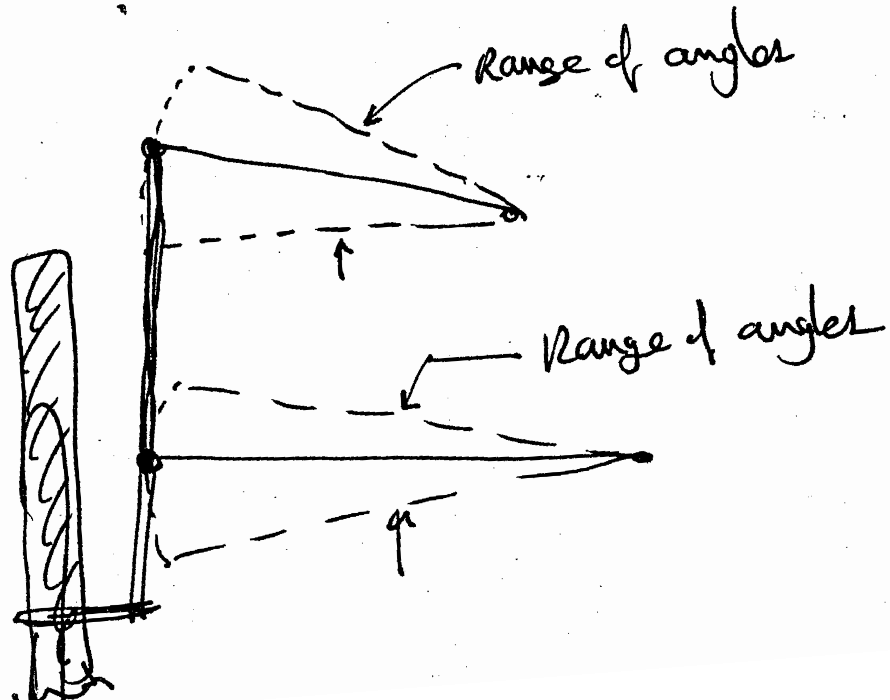


Appendix A of Handout 14, The B II structural Report, shows details of these force/moment and moment of inertia analyses.

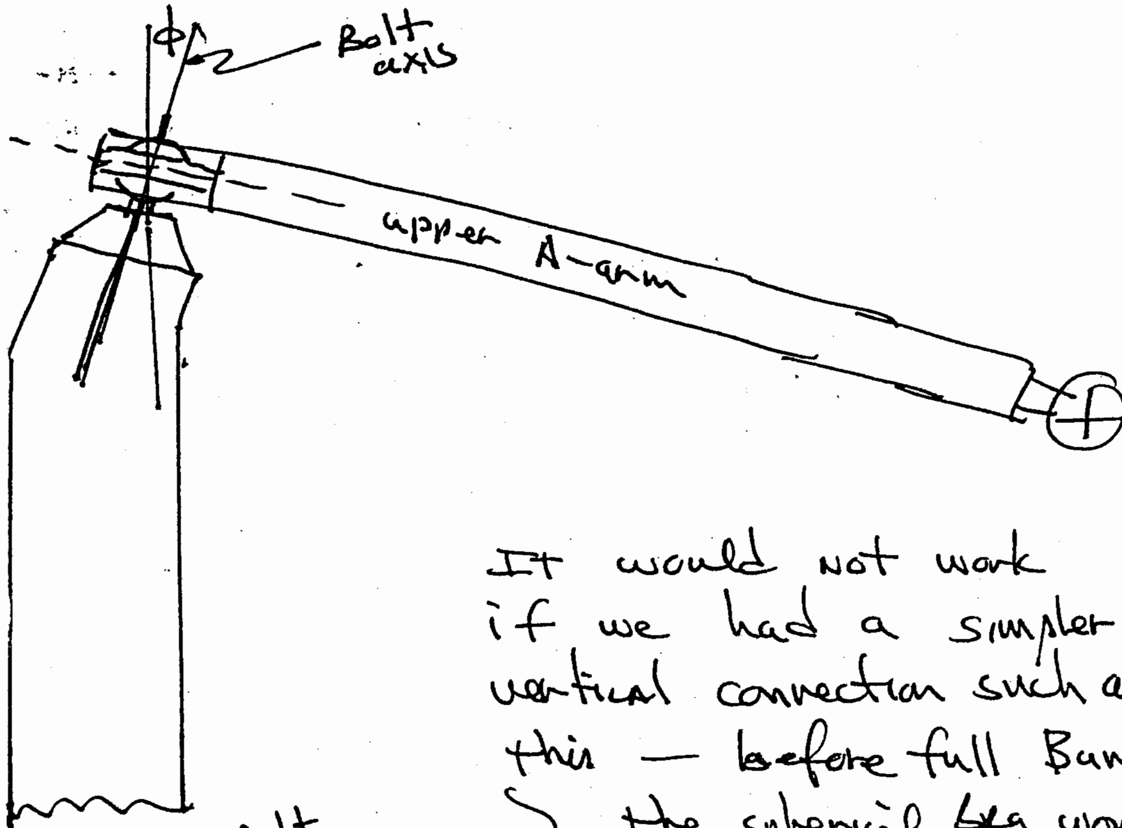
the moment is actually less due to the "shelves" — the moment diagram would look like —



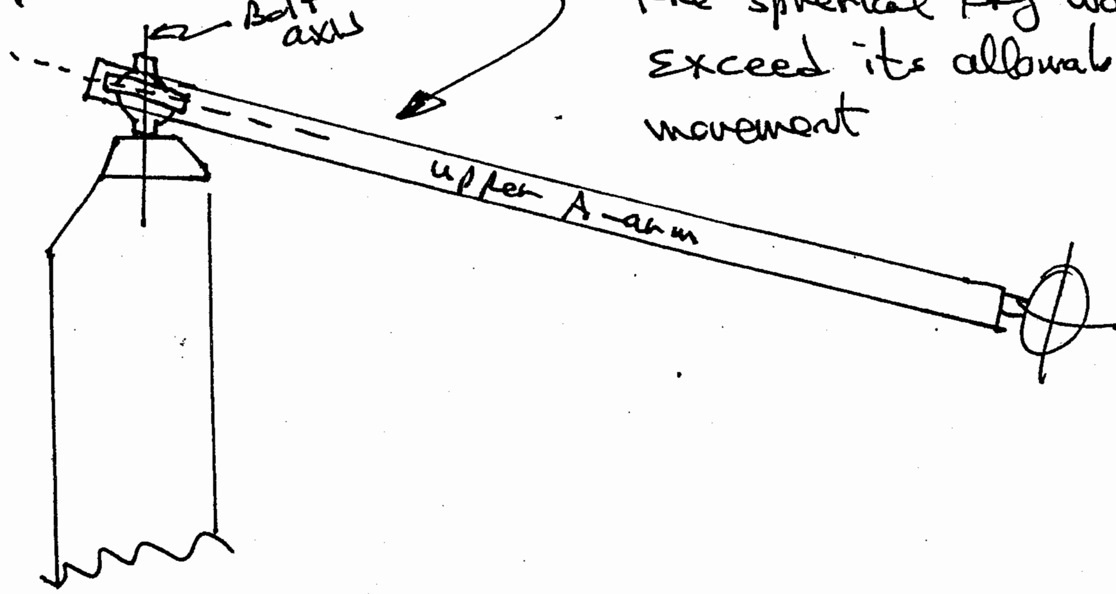
• NOTE How much Room is needed for the hardware to clear all the close surfaces — need to have an idea of sizes of all pieces and angles



We mounted the spherical bearings in line with the A-arms — The upper A-arm mount on the upright had to be angled. — to accomodate the motion —

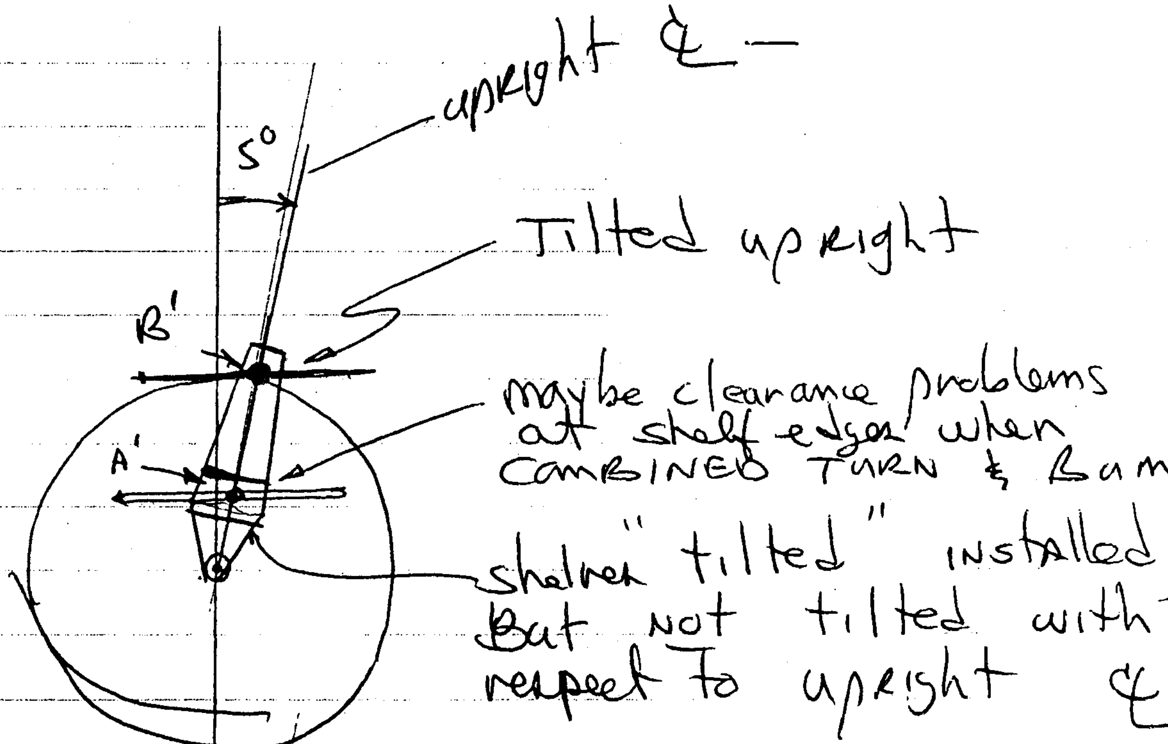


It would not work if we had a simpler vertical connection such as: this — before full Bump, the spherical brg would exceed its allowable movement

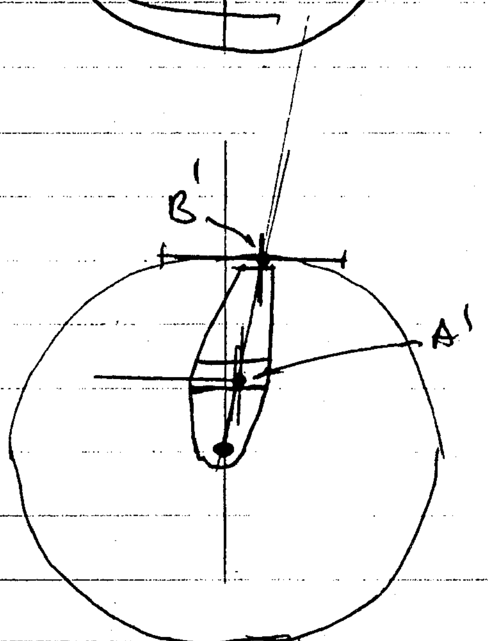


Caster considerations — say 5° as in past vehicles

(A) Tilt the upright with caster



(B)



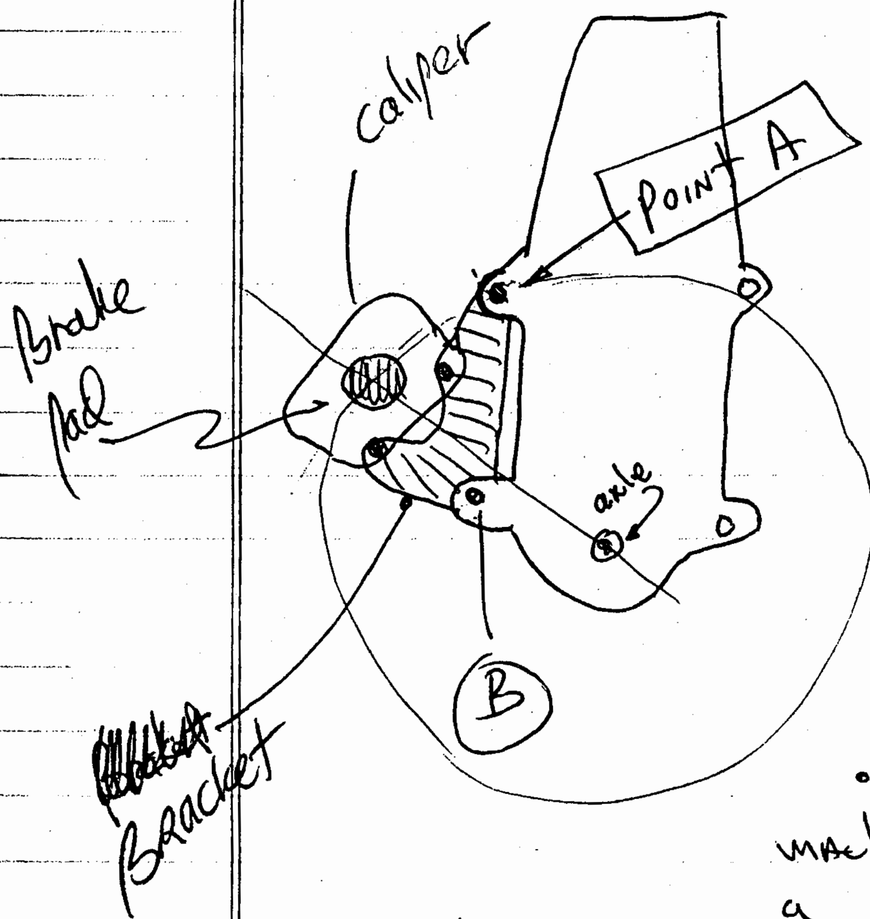
"Tilt" designed into upright —

— "horizontal shelves"

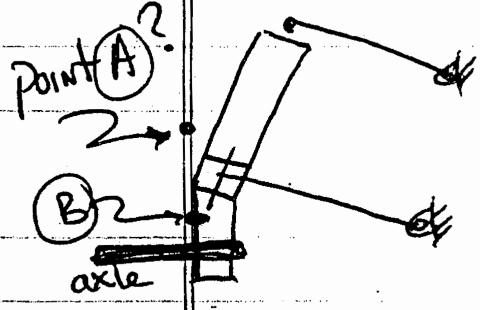
—

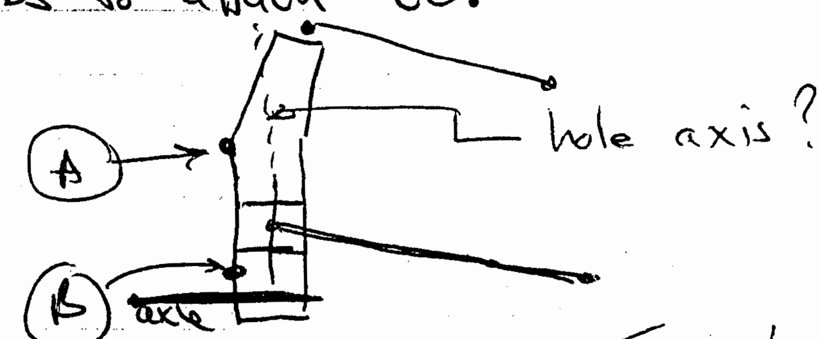
THESE DISTINCTIONS may not be of any consequence

Brake mounts



- why does the caliper mount like this?
- Supporting point A with the ~~caliper~~ upright requires "tabs" to be machined on the upright —
- Its easier to machine if there is a "plane of material" for the tabs to attach to:





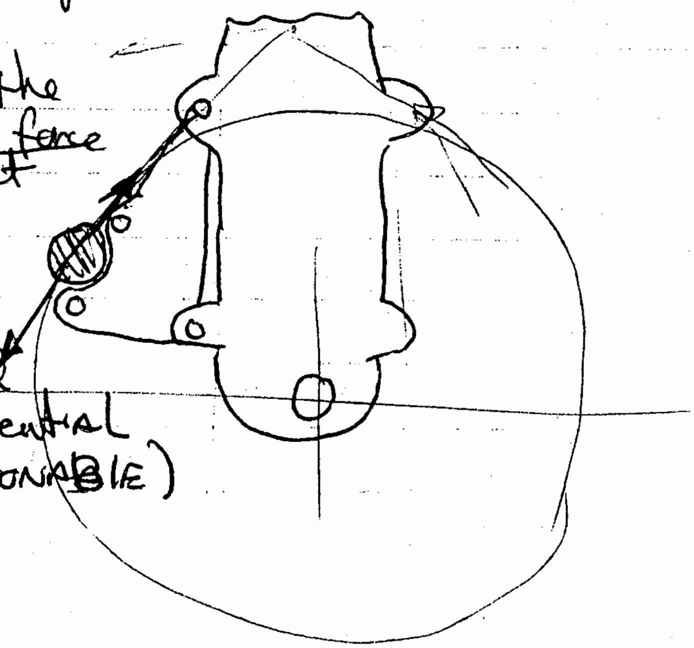
this upright design doesn't have a "plane of mat'l" at A

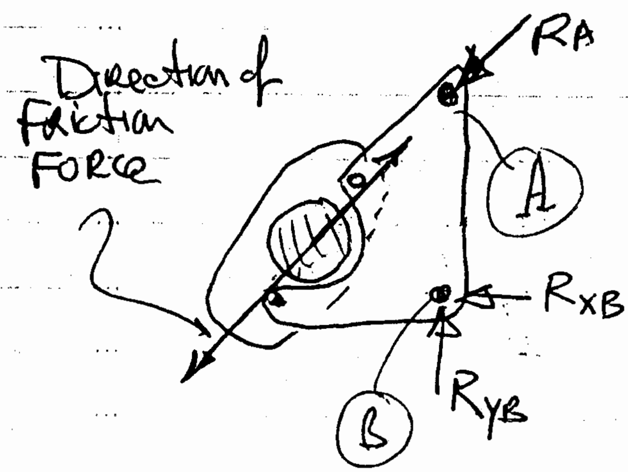
This design does have a plane at A

What's important about point A?

EXAMINE THE FBDiagram of the caliper & Bracket

Assume the Friction force acts at the center of the Brake pad and is Tangential (All REASONABLE)





with point A in-line with the friction force, the Bracket & caliper can be in equilibrium in this plane with only force RA —

so $R_{XB} \approx R_{YB} \approx 0$

Here's an example of how thinking thru the geometry of the force directions and mounts reduces some forces [It may not be the best arrangement, but it reduces moments in the Bracket]

9/29/02
P. Stam

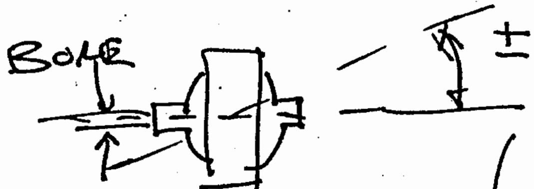
"NEW HANDOUT" —

Some ideas for changing the upright & lower A-arm — (Like McGill's Car)

we've always mounted the outer front spherical BEARINGS with the Bolt axis vertical — which needs the "shelves" in the upright cavity —

At FSAE 2002 we saw McGill have their lower outer a-arm pivots with a horizontal axis — Michigan's 2001 car had them like that, too — the problem is that there's an angle limitation on movement

[SEE HANDOUT 16 FOR ANGLE DATA]

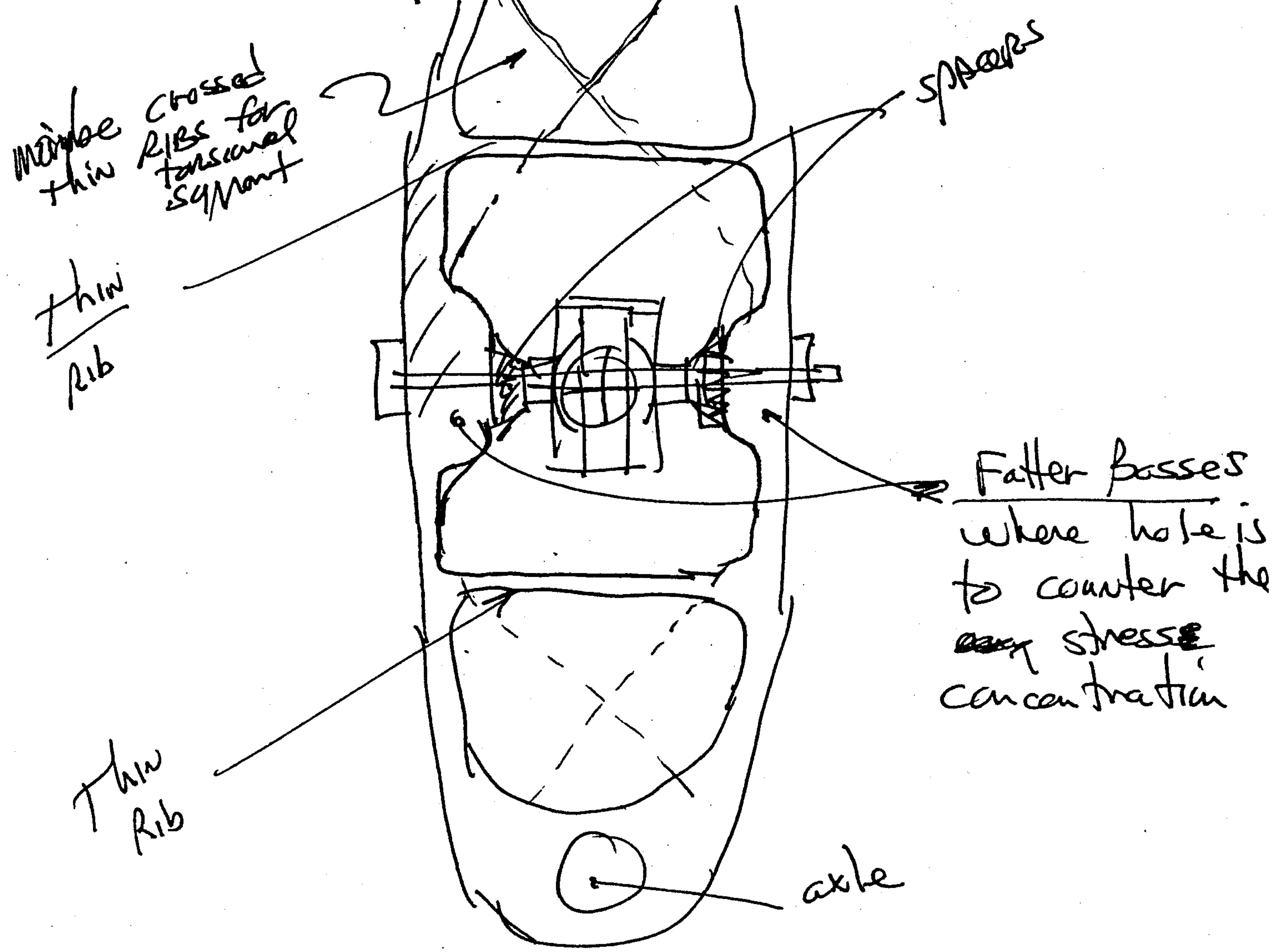


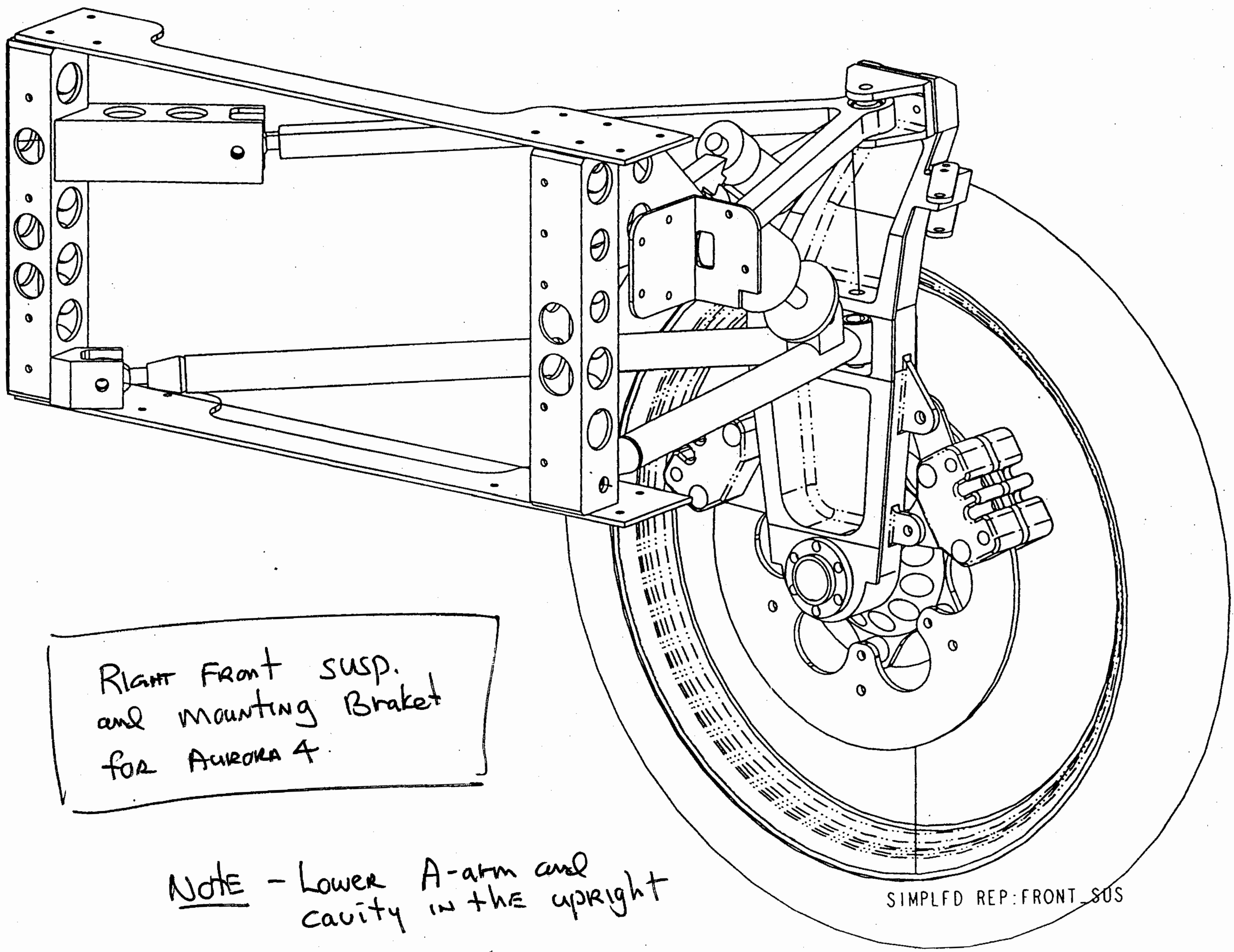
± 23° for 3/8 Bore *
±22° for 7/16" Bore

(McGill used a 1/4" fitting with ± 24°

* (we usually use a 7/16" Bore spherical Brg. with spacer-sleeves for a 3/8" Bolt — These allow for a custom fit — {hand sanding} into the cavity) —

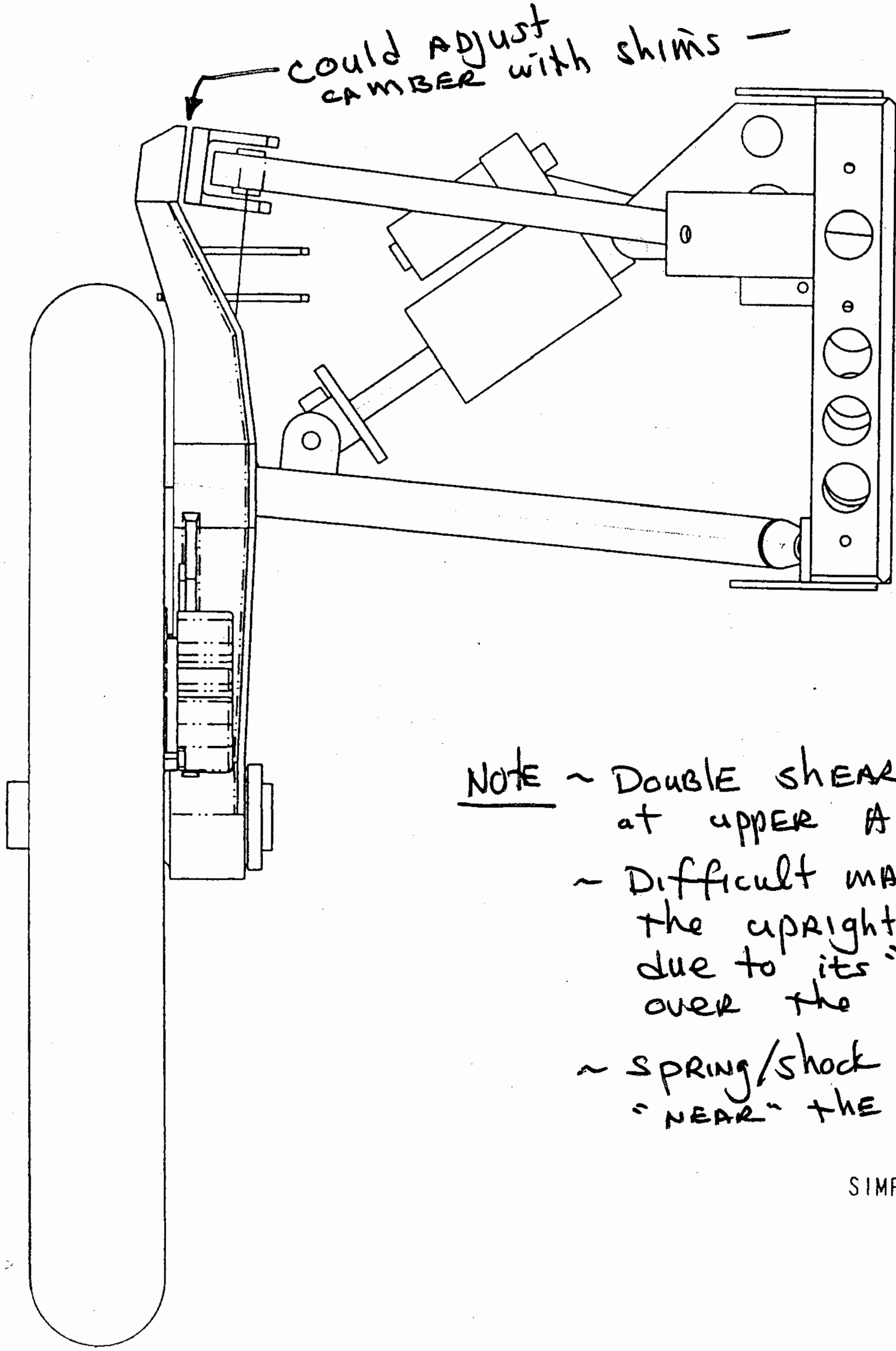
also with a horizontal Bolt, we could mill "Bosses" in the cavity





Right Front susp. and mounting Braket for Aurora 4

<u>Note</u> - Lower A-arm and cavity in the upright

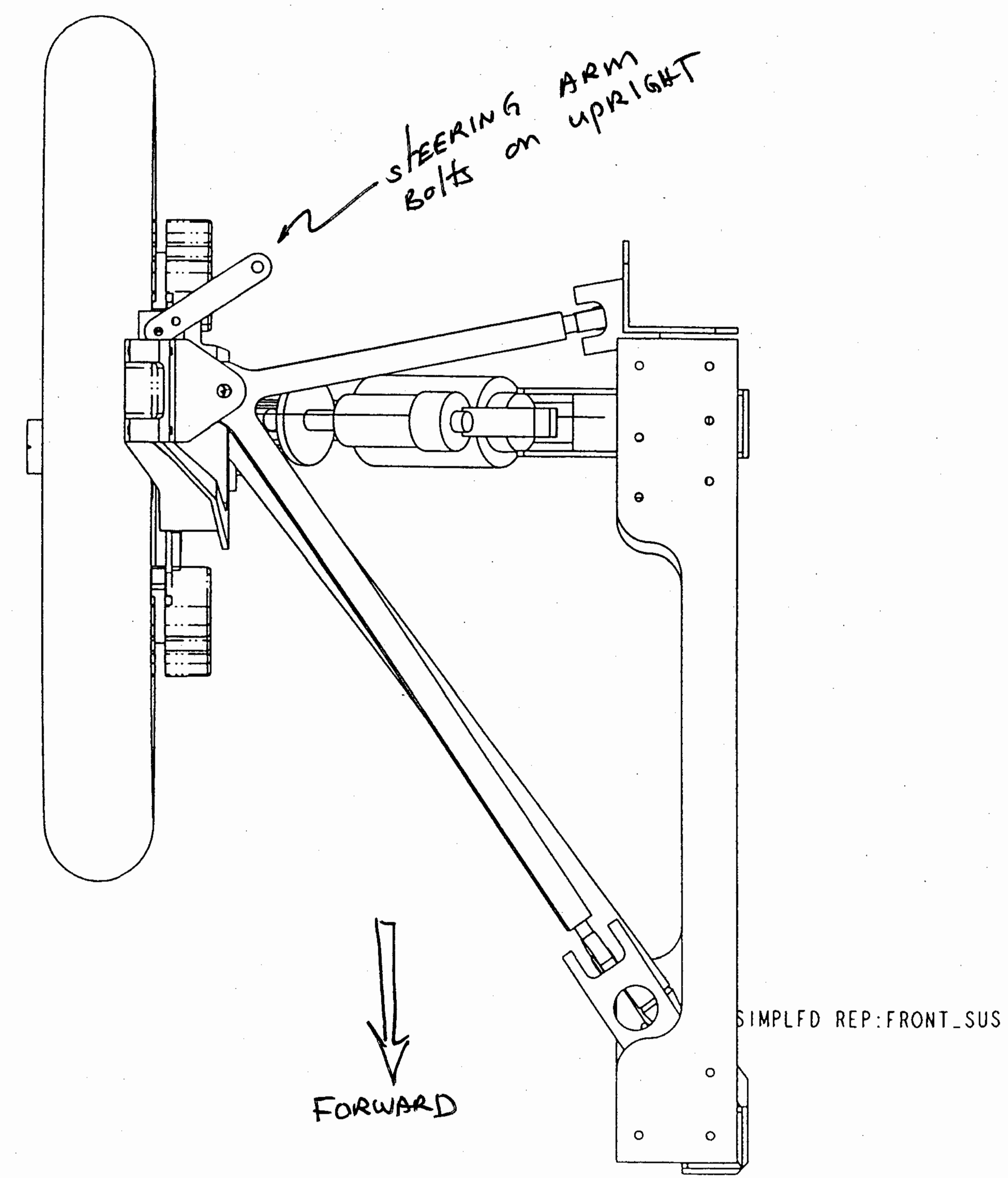


NOTE ~ Double shear mounting at upper A-arm

~ Difficult machining of the upright shape due to its "bending out" over the wheel

~ spring/shock axis aimed "near" the lower pivot

SIMPLFD REP:FRONT_SUS


STEERING ARM
BOLTS ON UPRIGHT
FORWARD
SIMPLFD REP:FRONT_SUS
130