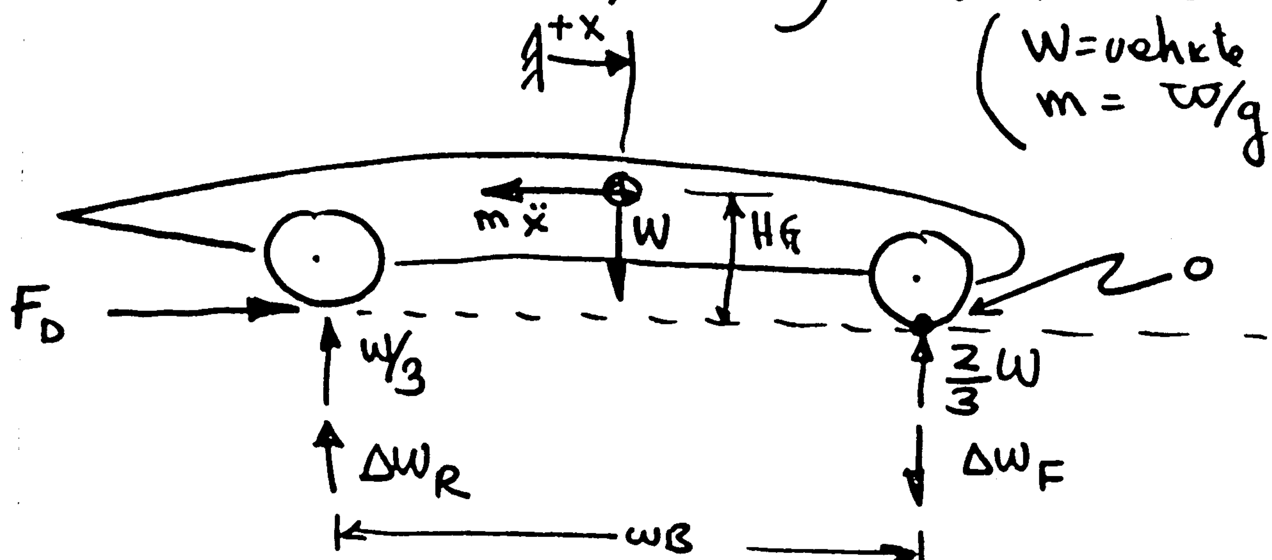
# Handout 9. Swing Arm Rear Suspension and Anti-Squat Geometry

This presents another view and draws the same "Anti-Squat Line" as in Handout 3.

Consider a 3 wheeled vehicle, 2 at front, one at rear with equal weight on each corner statically. Suppose drive force $F_D$ is applied at the rear wheel by the ground causing acceleration, $\ddot{x}$. First consider NO suspension. Also, ignore the aerodynamic & rolling resistance.

(W = vehicle wt, $m = W/g$)




- Static weight W cancells static wheel loads W/3 and $\frac{2}{3}W$
- weight $\Delta W_R$ is transferred to the rear and $\Delta W_F$ is removed from the front
- inertia force $M\ddot{x}$ acts at the CG
- $\Sigma F_y$ direction shows $\Delta W_R = \Delta W_F$

sum torques about point O, ignoring the static loads which cancell:

$$(\Delta W_R)(WB) = (m\ddot{x})(HG)$$

OR $$\Delta W_R = m\ddot{x}\left(\frac{HG}{WB}\right) \qquad (1)$$

since $M = W/g$, we can write this as:

$$\Delta W_R = W\left(\frac{\ddot{x}}{g}\right)\left(HG/WB\right)$$

← DEFINE this as "$f_a$" = fraction of "g" acceleration

$$\therefore \Delta W_R = (W)(f_a)\left(HG/WB\right) \qquad (2)$$

Get a feel for values ~
$W \approx 800$ Lbs, $HG \approx 16''$, $WB \approx 96''$

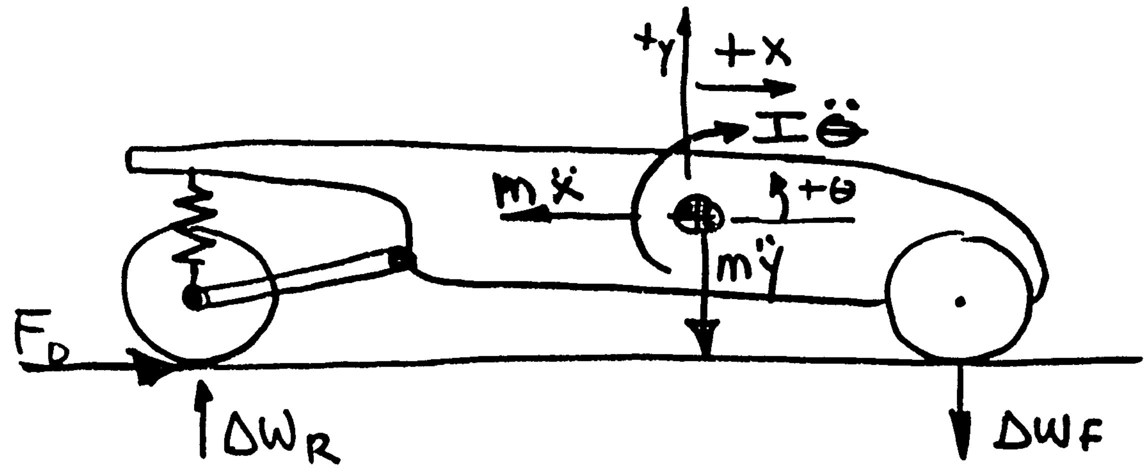
$$\therefore \Delta W_R \approx (f_a)(800)\left(\frac{16}{96}\right) = (f_a)(133)$$

say $f_a = .15$ { .15 g acceleration is 0 – 30 mph in 9 sec }

Then $\Delta W_R = (.15)(133) = \underline{20 \text{ Lbs}}$ (3)

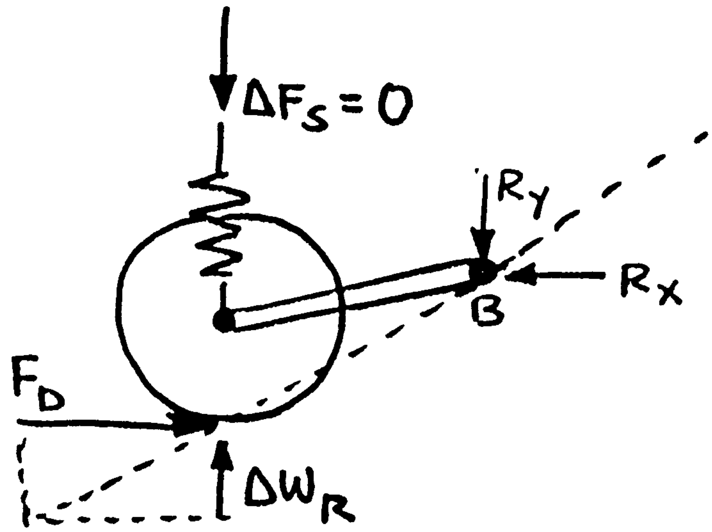
not much weight shift

NOW ADD SUSPENSION AT THE REAR —
use A SWING ARM —




- As before, ignore the static weight and reactions as they cancell.
- Now the vehicle has more degrees of freedom ~ x, y, θ, when $F_D$ is applied - so we must show inertial reactions in all opposite directions.

- Can we find conditions when there is **NO** y or θ movement? This would occur if there were NO change in the spring force from its static value. So explore the rear arm FBD:




{ $R_Y$, $R_X$ are reactions at arm pivot B on the chassis due to accel.

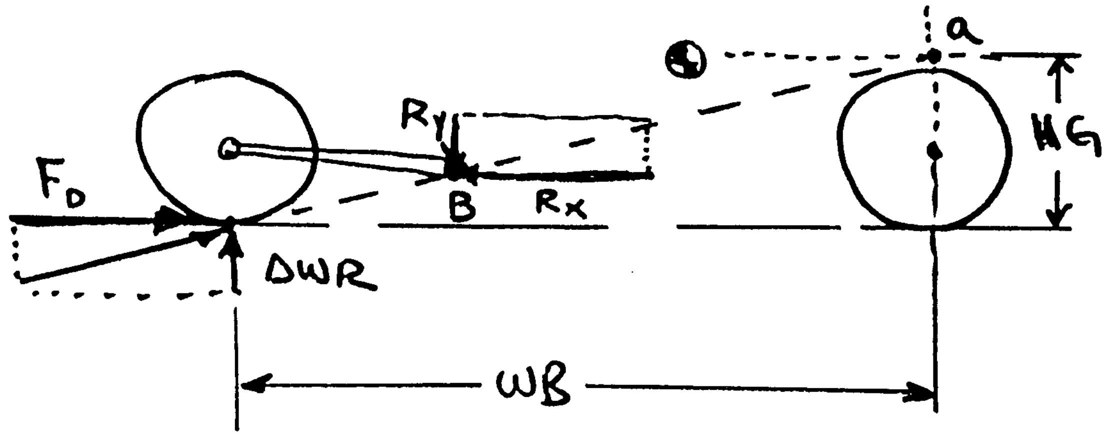
$\Delta F_s$ = change in spring force from static (the static spring force would balance the static load at the bottom of the tire, and any static components in the y dir. at B)

When can $\Delta F_s = 0$? (I) obviously, when $R_Y = \Delta W_R$ and also $F_D = R_x$

(II) More subtley, when we sum torques about B, the resultant of $F_D$ and $\Delta W_R$ must pass through B. But we know how $F_D$ and $\Delta W_R$ are related <u>if</u> there is no $\ddot{\theta}$ and $\ddot{y}$ terms. That is, no "squatting" or "lift" at the rear. Then it would behave as if there were no suspension and equation (1) would apply. (Also note that $F_D = m\ddot{x}$)

FROM EQN 1: $\Delta WR = F_D \left( \frac{HG}{WB} \right)$

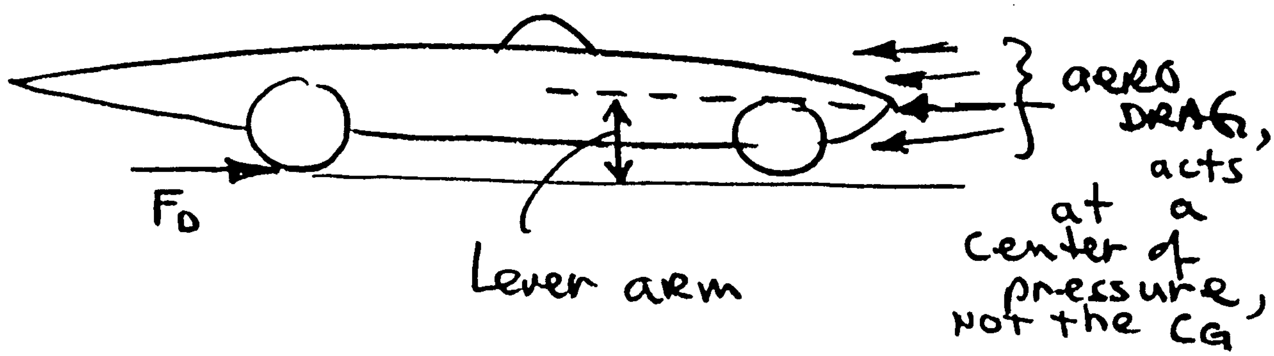
OR
$$\frac{\Delta WR}{F_D} = \frac{HG}{WB} \quad (4)$$




This condition, eqn (4), will occur if swing arm pivot B is on the line running from the rear tire contact up to point a. If point B is on this line, the rear end should not squat, since $\Delta F_S$ would be zero. If point B is <u>above</u> this line Force $F_D$ will cause a combination of $\Delta F_S$ and $R_Y$ to lift slightly and if its below the line, the rear end will squat.

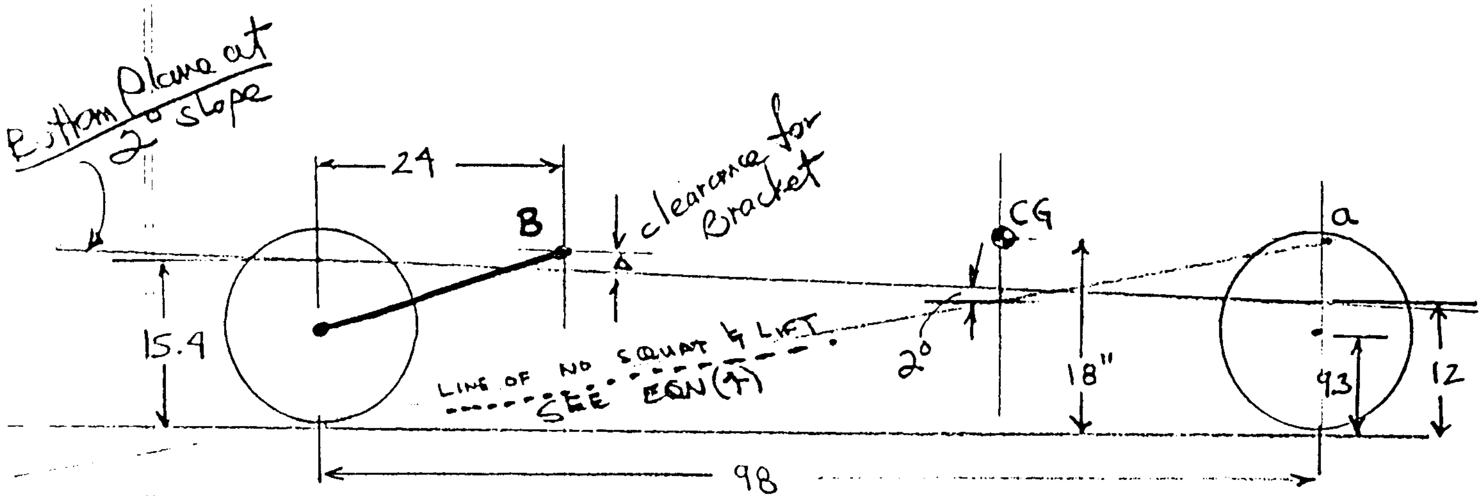
We've seen some solar car suspensions where the swing arm rises over 30° in a forward direction causing much lifting at the rear under acceleration.

If squat or lift occur, its not "BAD". ONE could argue that some lift may be useful to counteract the moment on the vehicle caused by the drag force being applied above the ground — LIKE:




However, if much lift occurs, then we are putting energy into raising the car, rather than propelling it forward — That's bad

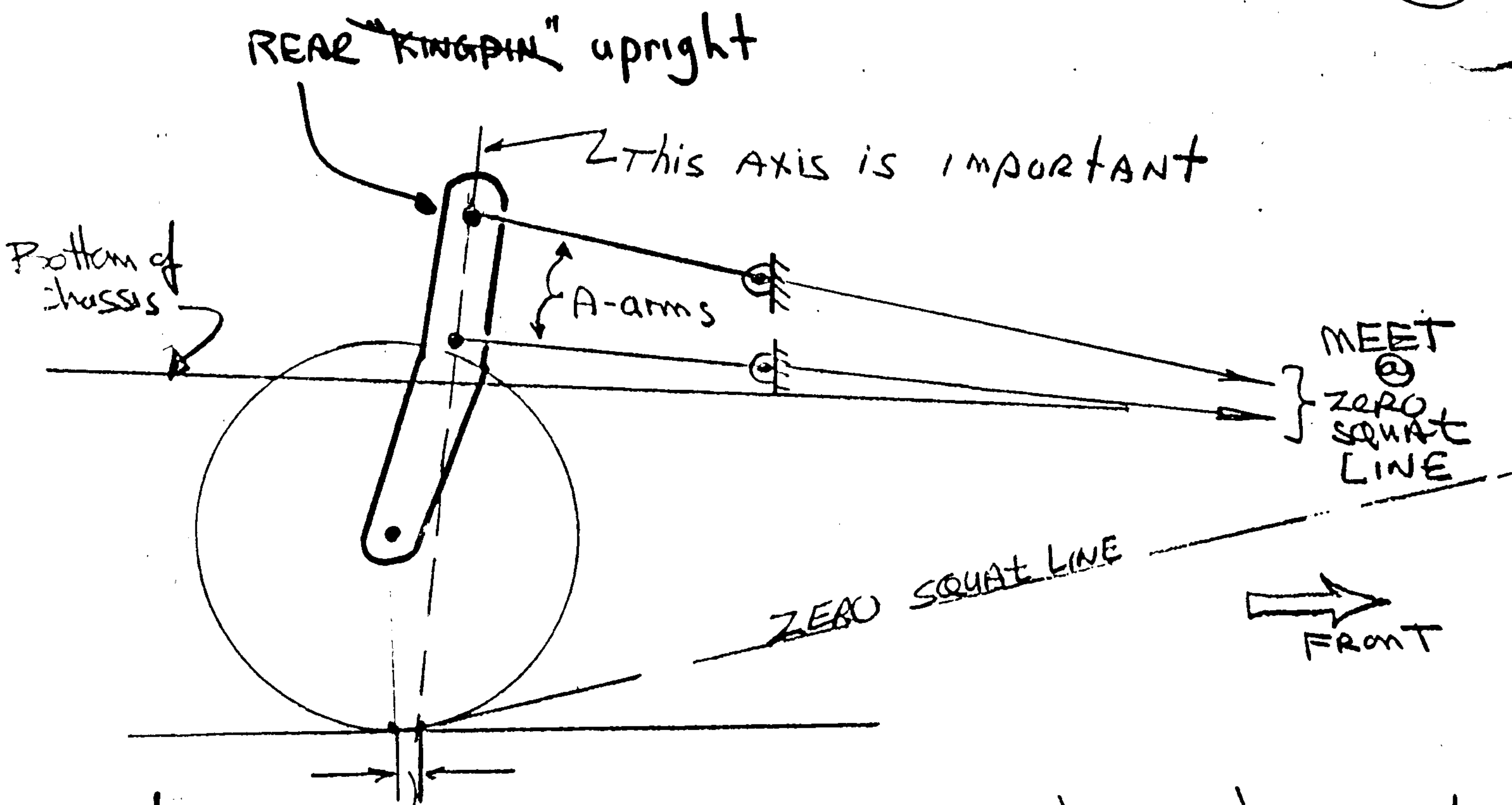
So what about AURORA III? Since we are proposing raising the body and angling the bottom of the chassis, then there won't be a low point to mount a swing arm.




All DIMENSIONS are NOMINAL GUESSES

Note the arm pivot is way above the NO SQUAT LINE – This will cause lift – Severe? we'd have to model it – (we could make estimates)

So? we can consider a 4 bar link arrangement that would kinematically give a zero squat/lift property.




choice

(Question: do we want this ahead, at or behind the center of tire contact? (CONSIDER SIDE LOADS WHEN CORNERING)

NOTE 1. The upright and upper A-arm cannot go thru the body at full bump.

2. the lower A-arm should not go thru the bottom of the chassis at full droop, though its outer end could drop through, since a hole is needed for the wheel and in-wheel motor and lower part of the upright

3. As in the front, the farther apart the A-arms, the smaller the loads.

Next Tasks - Rear susp Group -

Create nominal dimensions for figures (7) & (8) - use current chassis options and body dimensions -

- Estimate the CG height & find the zero squat line
- Try different A-arm lengths and chassis lengths -
- NOTE since the array is to be the 5 meters long (now it was supposed to be 4.4m but I don't think it was), try to estimate the vehicle length (see Aaron in Aero). Then perhaps we need to lengthen the WB ~ maybe in the same proportion as the increase in vehicle length - If so, it will affect the thickness of the body at the rear upright and the ackerman steering angles.