Handout 5

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Sept, 2000

NO scrub Discussion – Part 1
For Solarcar

FRONT VIEW of LEFT FRONT Double A-arm SUSPENSION

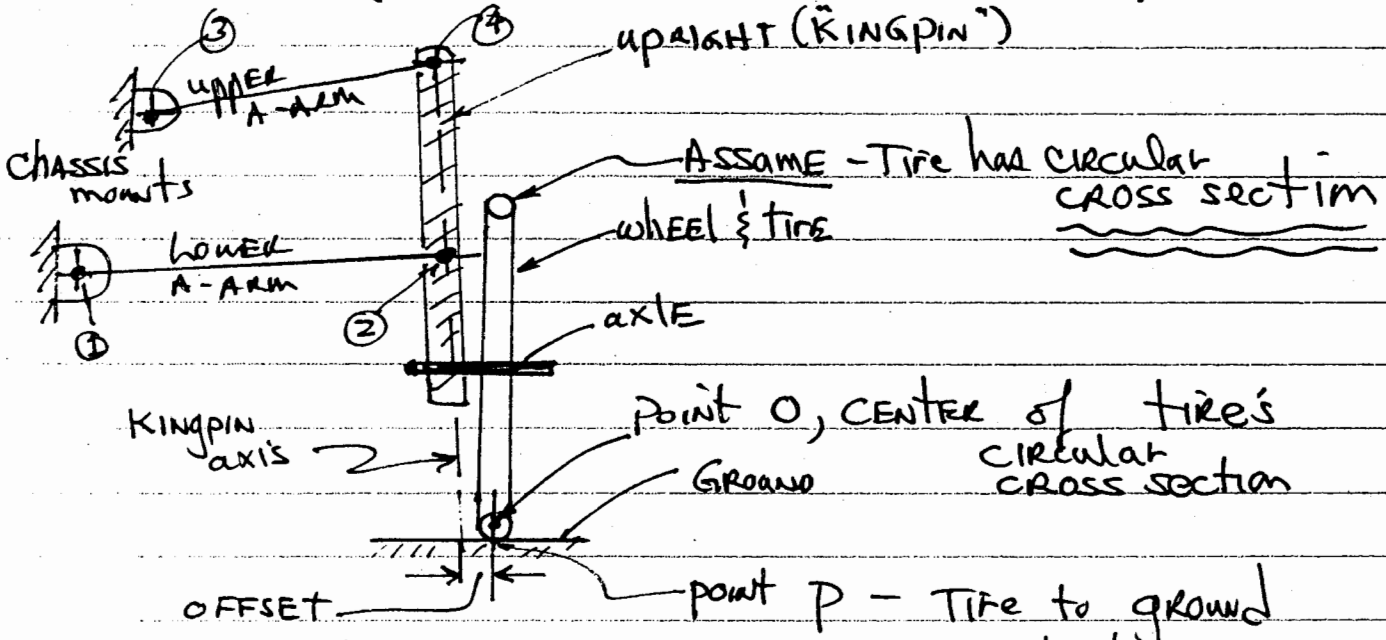


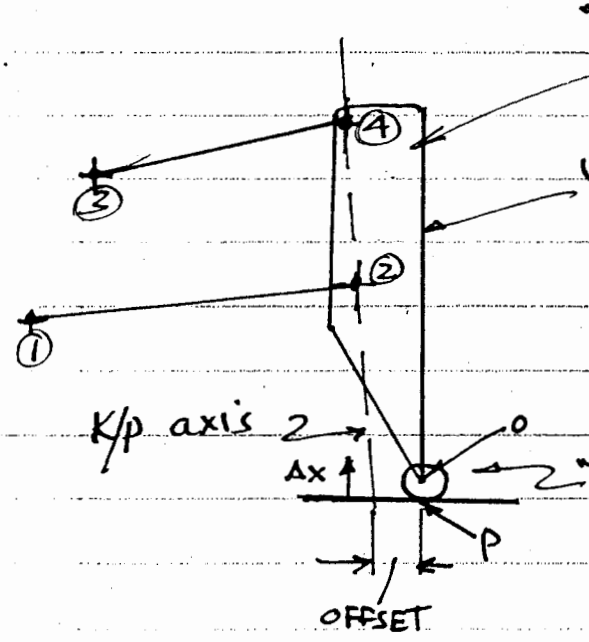
Diagram corresponds to "static position" – suspension at the position when on-road, loaded with driver, etc, ready to go.

points ①, ②, ③, ④ are pivots

As the Ground moves up & down relative to the chassis (or vice-versa), there may be lateral movement of point P on the tire with respect to the ground – the movement is called "scrub", and ① wears the tire faster and ② INCREASES TIRE DRAG, which slows the vehicle.

We would like to adjust pivots ①,②③④ so as to minimize the scrub—

First we'll represent the tire, upright, etc., as a link with a roller as shown below



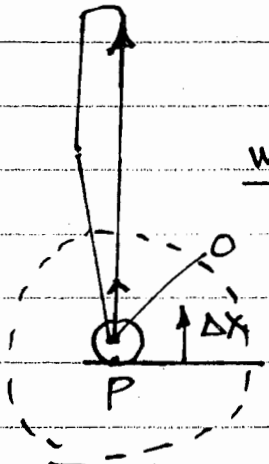
Vertical line through point O at static position

The paths of points O and P will depend on the locations of points ①,②,③,④, and the positions of points O and P on the link, with respect to ② and ④, and on the size of the bump or rebound motion ΔX. ΔX is (+) if bump, and (−) if rebound, measured from static position.

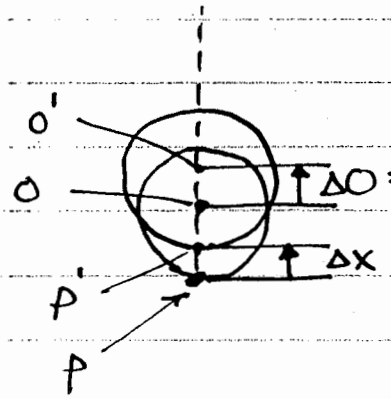
We can say the paths of O "are" "Guided" by the linkage as defined by the locations of ①, ②, ③, ④, ⑤, P and ΔX.

We'll examine some possible motions to get a feel for scrub — we won't examine how to make these motions, just assume we could create a linkage to cause the motions

Strictly vertical tire movement

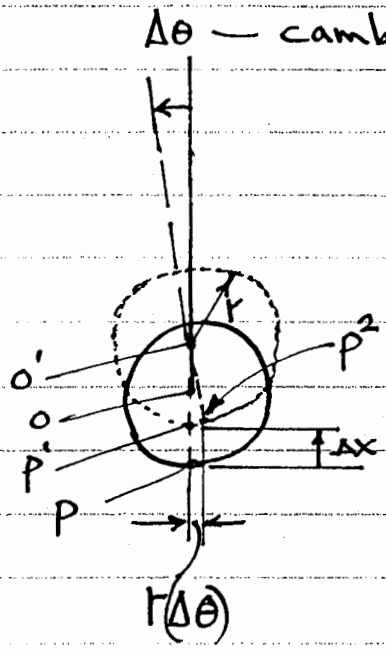


If ΔX goes up and the link only moves vertically, then both points P and O go up ΔX, and there's NO TENDENCY for the "Roller" to Rotate ⇒ NO scrub



P moves to P'
O moves to O'
} all movements on the vertical LINE

Now suppose p and O move vertically, but that the link changes camber by amount $\Delta\theta$ during the vertical movement



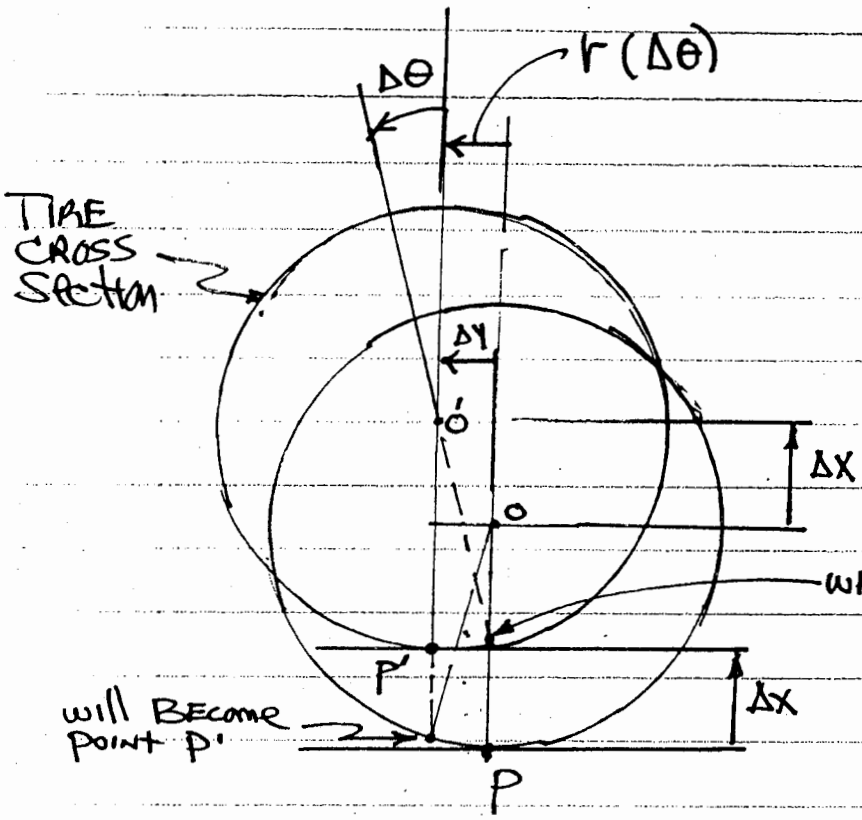
Now the roller would have to "roll" to keep p' on the vertical line — if it did not roll, point p would have moved to p^2 — that is, scrubbed to the right approximately $r(\Delta\theta)$

Now any linkage that has the roll center on the ground, which we want, will have some camber change —

So, it looks like we want to control the motion of point O as it moves up and cambers in the direction of $+\Delta\theta$. That is, if point O' moved to the left an amount $r(\Delta\theta)$ then the tire cross section would roll as it moved vertically.

point O moves
- up ΔX
- left ΔY

and the link
- cambers $\Delta\theta$



As the bottom moves up ΔX, the linkage causes point O to move to the left ΔY and causes the link to camber amount $\Delta\theta$. If the amount ΔY equals the value of $r(\Delta\theta)$, then there's NO SCRUB. The circular section "Rolls" to the left as it cambers and RISES.

So, we want a linkage that will move point O to the left an amount $\Delta Y = (r)(\Delta\theta)$ when the link cambers amount $\Delta\theta$ when it RISES.

FOR ANY LINKAGE WE CAN IMAGINE THE FOLLOWING DATA

input

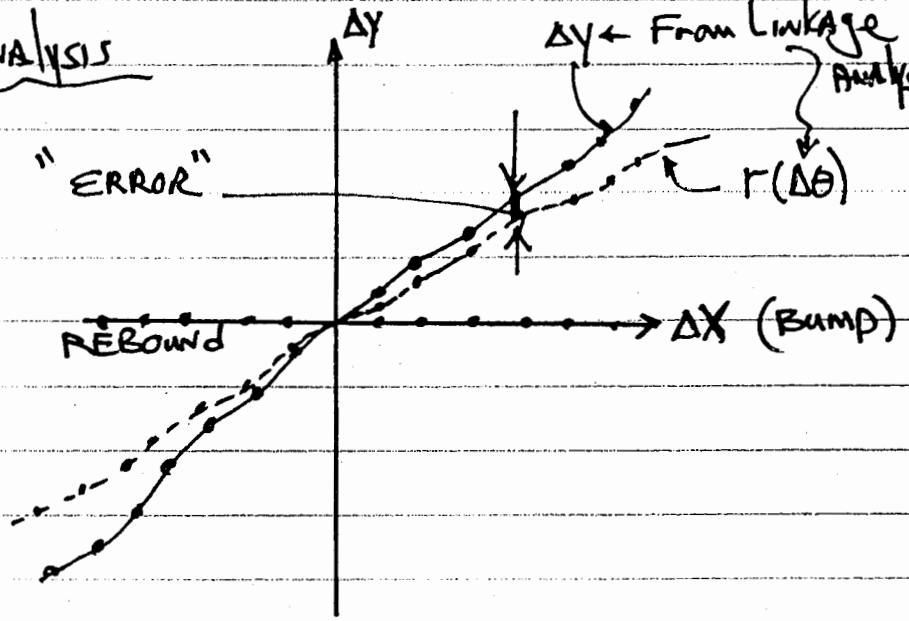
abs value of "error"

ΔX	ΔY	$\Delta\theta$	$r(\Delta\theta)$	$\lvert \Delta Y - r(\Delta\theta) \rvert$
⋮	⋮	⋮	—	—
-.2	(	(	—	—
-.1	(	(	—	—
0	0	0	0	0
+.1	⋮	⋮	—	—
+.2	⋮	⋮	—	—
⋮	⋮	⋮	⌣	⌣

Found from Linkage Analysis

computed

as a plot:



We can create some measure of total error - like summing all the absolute errors, or weighing certain values that have more impact - such as -

1) values for ΔX values "around" static position, since that is where we expect most of the motion to occur.

2) values for ΔX "large" in Bamp since that's when the vertical forces on the tire could be large (at least from the springs), so the effect of scrub could be more severe on wear of the tires.

The next step is to develop a math representation of the linkage so that we can input the locations of pivots ① ② ③ ④ and point O, and then find ΔY and $\Delta\theta$ for various ΔX input values.