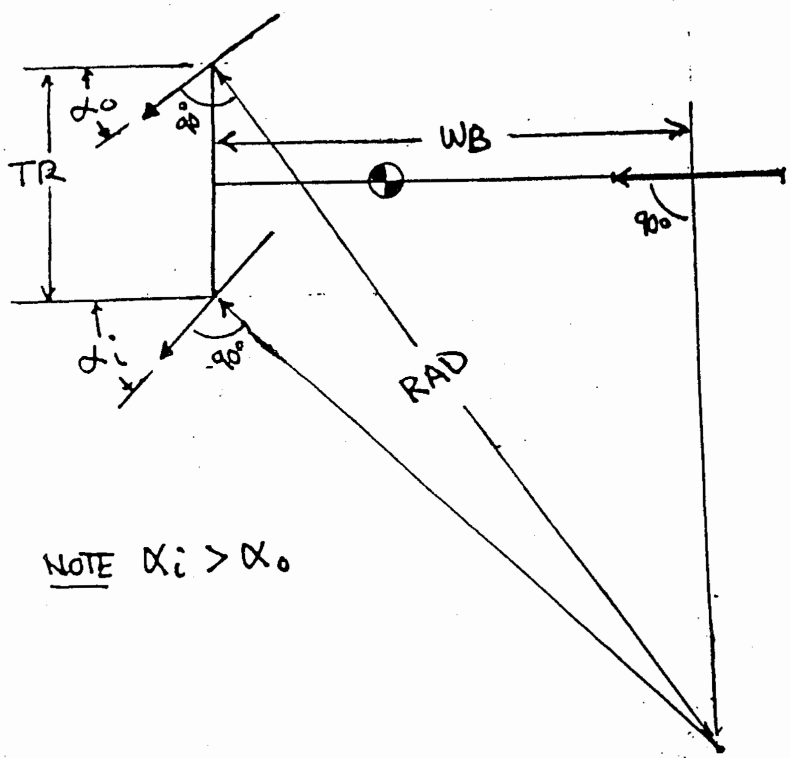
# HANDOUT 6 STEERING ISSUES

This handout discusses two design issues regarding steering geometry. The hardware of rack and pinion steering will be acknowledged but not examined. The Geometry issues can be associated with "views" of the vehicle –

"Ackerman" STEERING Geometry (TOP view)
The following diagram was in the "Systems Interactions" handout of the solar vehicle Seminar in FALL 2003.




TOP VIEW –
3 OR 4 WHEELER IN A SLOW TURN: TIRES ROLLING WITH NO SIDE SLIP.

$\alpha_o$ = angle of "outside" wheel
$\alpha_i$ = angle of "inside" wheel
RAD = RADIUS of turn

Rule (6.14) (old #): RAD ≤ 8 m

ANGLES $\alpha_o, \alpha_i$ can be related to WB, TR and RAD using simple GEOMETRY (THERE ARE MORE REFINED TREATMENTS, but this is a start) MECH/AERO TEAMS DERIVE THE EQN.

This diagram shows a simplified front suspension that has:
- zero kingpin inclination angle
- zero caster angle
- zero offset

This is O.K. to start with to convey the Ackerman idea – which refers to the fact that for any radius, RAD, angles $\alpha_o$ and $\alpha_i$ will differ. That is, if specified a wheelbase, WB, and Track, TR, then we could find a table of $\alpha_i$ and $\alpha_o$ values that correspond to different values of RAD:*

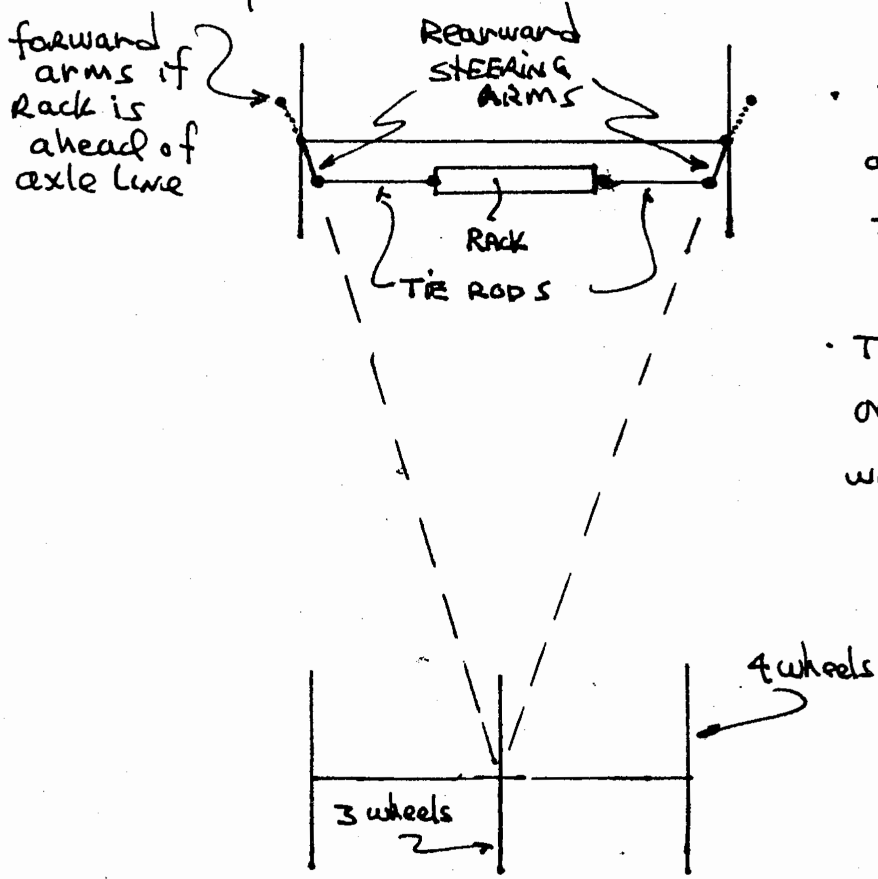
| | RAD | $\alpha_o$ | $\alpha_i$ |
|---|---|---|---|
| smallest → | • | : | : |
| | ⋮ | : | : |
| "Largest" → | • | : | : |

The smallest RAD will be close to the 8 m. Required by the rules for a U-turn

The "largest" could be near ∞, corresponding to nearly straight ahead running.
The $\alpha_o, \alpha_i$ values at the smallest RAD can be used to determine clearances with the A-arms and upright, and the front fairings.
The $\alpha_o, \alpha_i$ for nearly straight running are probably more useful when trying to minimize tire drag due to mis-alignment. For our solarcars, it may then be helpful to try to achieve the $\alpha_o, \alpha_i$ relationship for large radius turns

* (The $\alpha_o, \alpha_i$ can be found using the figure and geometry)

Ackerman steering refers to arranging the steering hardware in such a way as to achieve the $\alpha_o, \alpha_i$ relationship for "all" Radii. The top view of typical Rack and pinion steering components is shown below.

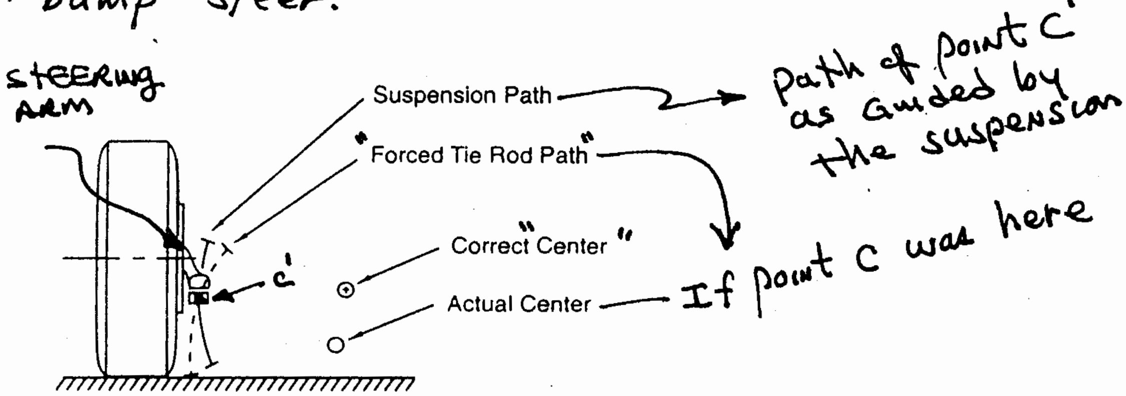



- THE STEERING arms are attached to the front uprights
- The tie Rods pivot on each end, usually with ROD ends
- The steering rack can be behind the axle line, as shown, or IN FRONT of it.

An Approximation to Ackerman steering is achieved by arranging the steering arms as shown above — This CAUSES the inside wheel turns more than the outside wheel. To do a good job at this, it should be posed as an optimization problem where the arm angles and rack location can be adjusted to minimize the error between the ideal $\alpha_o, \alpha_i$ values AND the actual values from the Linkage. All we've done in the past is what is shown above.

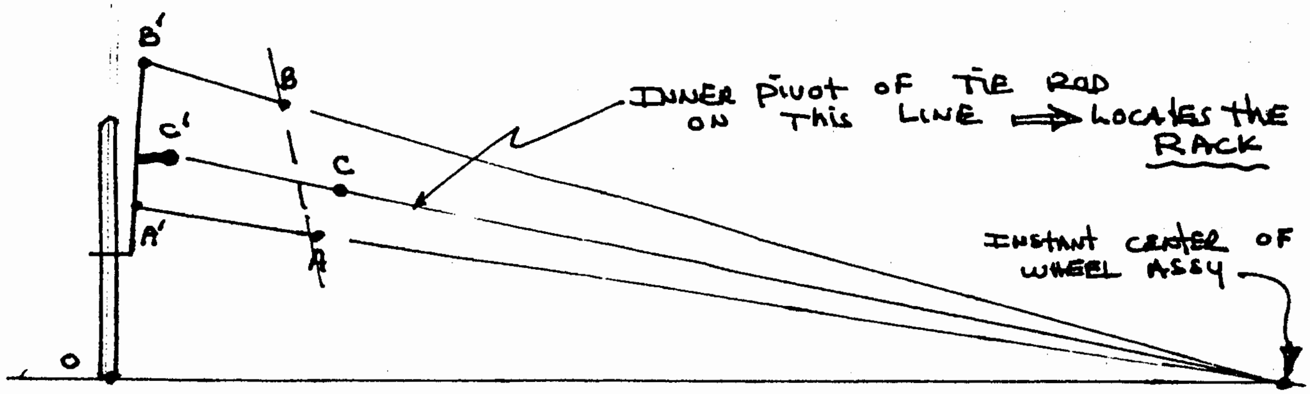
## Bump Steer ~ "Front View"

The outer pivot of the tie rod is on the upright, so its path in bump and rebound is determined to the A-arm layout. However, the inner pivot of the tie rod is on the end of the rack, so it rotates around the end of the rack in a circular path in bump and rebound. If these paths do not match closely, the upright is forced to rotate around the kingpin axis, causing bump steer.




The suspension path may not be an arc of a circle – But can be approximated as such around the static position

The outer tie rod end location is influenced by the location of the rack (ahead or behind axle), and the incorporation of Ackerman geometry. The inner pivot is chosen to reduce bump steer. It is done in two steps. First find the line upon which the pivot must be on as follows.




The inner pivot should be on the line between outer pivot, shown as C', and the instant center of the wheel assy. Note that points A, A', B, B' and C' must be known before this can be done. The second step is to locate C upon the line. This is a special topic and will be discussed with the "steering team". However, we can make an observation: when the rack is behind the axle, then C' is "inside" of the kingpin axis for ackerman geometry, and C will be "inside" of the line through A and B. (as shown above) If the rack is in front, then C' will be "outside" of the kingpin axis and C will be outside of the line through A-B.