RC TEK Information & Resources for the Model Car Racer

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Ackerman Steering Principle

This article is part of a section of the RcTek site devoted to radio controlled model car handling. As car handling is an extremely complex subject, it will be quite some time before it is finished.

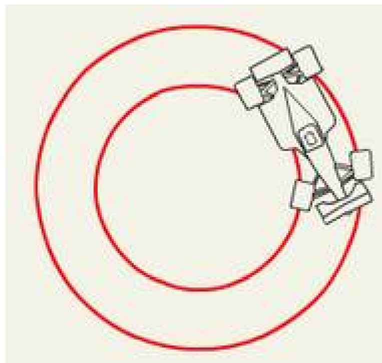
This article deals with the Ackerman Steering Principle, which is sometimes referred to as toe-out on turn.

Ackerman Steering Principle

The Ackerman Steering Principle defines the geometry that is applied to all vehicles (two or four wheel drive) to enable the correct turning angle of the steering wheels to be generated when negotiating a corner or a curve.

Before this principle was developed the vehicles of the time (horse drawn) were fitted with parallel steering arms and suffered from poor steering performance. A Mr Rudolf Ackerman is credited with working out that using angled steering arms would cure these vehicles of such steering problems.

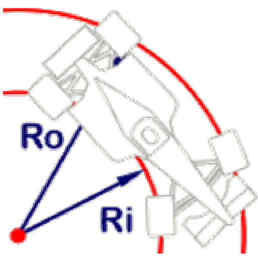
Why & How?



The animation on the right depicts a car travelling around a corner (in this case, a continous one!). The red lines represent the path that the wheels follow. If you Play it you will notice that the inside wheels of the car are following a smaller diameter circle than the outside wheels.

If both the wheels were turned by the same amount, the inside wheel would scrub (effectively sliding sideways) and lessen the effectiveness of the steering. This tyre scrubbing, which also creates unwanted heat and wear in the tyre, can be eliminated by turning the inside wheel at a greater angle than the outside one.

You may Stop the animation if required.



The difference in the angles of the inside and outside wheels may be better understood by studying the diagram to the right, where we have marked the inside and outside radius that each of the tyres passes through. The Inside Radius (Ri) and the Outside Radius (Ro) are dependant on a number of factors including the car width and the tightness of the corner the car is intended to pass through.

Measurements for angles of the arms are therefore *not* derived from these lines, they are derived from the distances shown in More, Less & True Ackerman Steering section below.

Aligning both wheels in the proper direction of travel creates consistent steering without undue wear and heat being generated in either of the tyres.

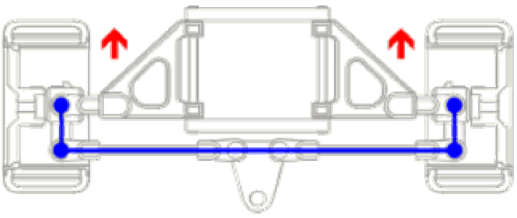
Obviously with turning one wheel more than the other you are mis-aligning the wheels and you need to do this whilst allowing both wheels to be pointing straight forward when the car is not turning. To enable this to happen, the mis-alignment needs to progress from zero (wheels pointing straight ahead) to a point where there is a sufficiently different angle between both wheels to create the alignment of both wheels when they are both fully turned.

Steering Arm Angles

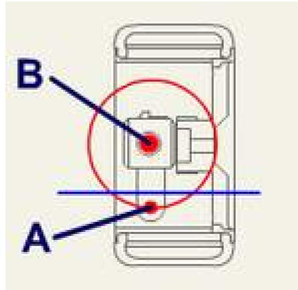
Creating mis-alignment of the wheels is, as mentioned in the introduction, achieved by a combination of the angle and the length of the steering arms. Below we have a few diagrams that give examples using parallel and angled steering arms to demonstrate why there is a need for using the Ackerman Steering Principle.

Please ignore the size difference of the yellow circles in the diagrams below. They are a result of the way the steering arms were drawn for simplicity and are not meant to add confusion to the description of the Ackerman Principle we are describing in this article.

Parallel Steering Arms



The steering arms in the diagram to the left are straight and parallel to the sides of the vehicle, which would create a situation where equal movement of the steering servo would produce equal angular movement of the wheels.



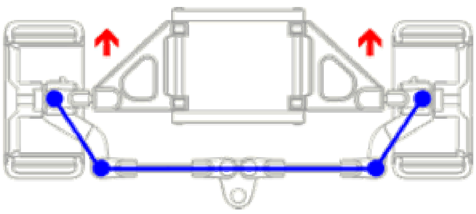
Why this equal angular movement occurs can be seen by studying the animation of a wheel to the right, where a red circle has been drawn to show how the sideways movement of the steering arms is converted in a circular one. As the steering arm pivot point (A) is vertically aligned with the king pin pivot point (B) when the wheel is pointing straight ahead, the same amount of movement to the Left or to the Right moves the steering arm pivot point the same vertical distance forward of it's starting point.

You can reset the animation to its Starting position if required.

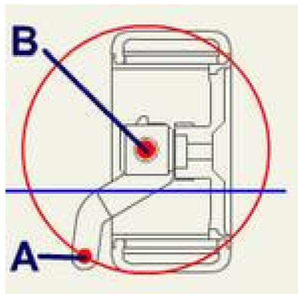
A more complete explanation of the issues involved is available in our The Circle article.

If this steering geometry was applied to a remote controlled model car, then either or both of the front wheels would not be at the correct steering angle and would result in unpredictable steering.

Angled Steering Arms



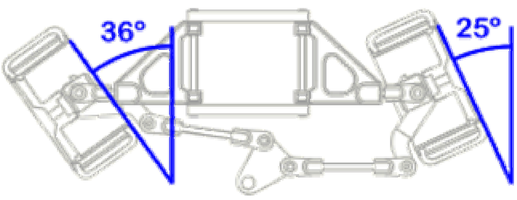
The steering arms in the image to the left are angled inwards to create a means for the wheel angles to change at a different rate. This is the basis of the Ackerman Steering Principle and creates this unequal angular movement of the wheels.



Why this unequal angular movement occurs is shown in the animated image to the right and happens because of the relative position of the steering arm pivot point (A) around the circumference of the red circle that has been drawn in to show how the steering arm pivot point moves around the king pin pivot point (B).

As the steering arms are angled, the pivot point (A) is not vertically aligned and is, in a straight ahead position, part way round the circle. Because of this, a Right movement of the steering arm will cause the pivot point to move a greater distance in the forward direction than a Left movement of the steering arm. You can reset the animation to its Starting position if required.

A more complete explanation of the issues involved is available in our The Circle article.



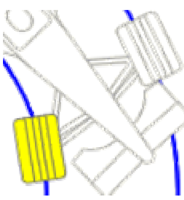
An important point worth noting is that this unequal angular movement is exponential, that is, the more you turn the wheel the greater the angular difference between the wheels - otherwise both the wheels would never point forward when the car is not turning.

The deliberately emphasised example above would result in a wheel angle difference somewhere in the region of the figures given in the image to the left, whereas the parallel steering arm example would have resulted in the same wheel angles being generated on each side.

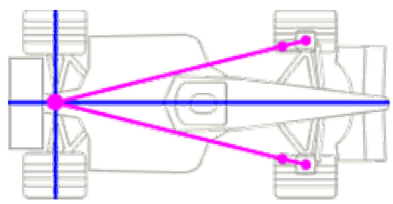
More, Less & True Ackerman Steering

These are often heard terms in model car racing and refer to the amount of inequality of the angles of the wheels relative to true Ackerman steering geometry.

True Ackerman Angle - Zero Toe On Turn In

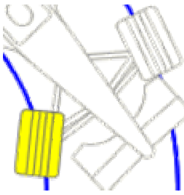


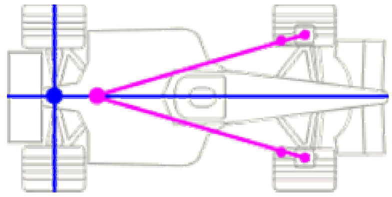
True Ackerman steering geometry is shown in the image to the right. This is defined by angling the steering arms so that a line drawn between both the king pin and steering arm pivot points intersects with the centre line of the rear axle.



As this gives true Ackerman steering geometry, there is no Toe Angle change on the inside wheel (the wheel is aligned with the circumference of the circle), which can be seen in the image above left.

More Ackerman Angle - Toe Out On Turn In

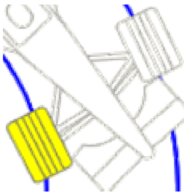


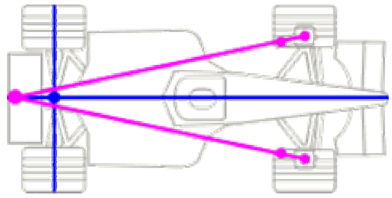


More Ackerman angle can be added to a steering set-up, which involves adjusting the angle of the pivot points on the steering arms so that the point of intersection is *forward* of the centre line of the rear axle. Please refer to the image on the right.

This steering geometry achieves greater angular inequality of the turned wheels, which results in the inside wheel trying to follow a smaller diameter circle than it actually does. This effect can be seen in the image above left and generates Toe Out on the front inside wheel.

Less Ackerman Angle - Toe In On Turn In





Less Ackerman angle can be set on a steering set-up, which involves adjusting the angle of the pivot points on the steering arms so that the point of intersection is *behind* the centre line of the rear axle. Please refer to the image on the right.

This steering geometry achieves a reduced amount of angular inequality of the turned wheels, which results in the inside wheel trying to follow a larger diameter circle than it actually does. This effect can be seen in the image above left and generates Toe In on the front inside wheel.

Steering Arm Length

As the steering arms are levers, their length is more or less a free area, but is restricted by the clearance and available space on the model car.

The amount of movement that can be generated by the servo/steering linkage arrangement is also a primary consideration as you must think about the torque requirements of levers with different lengths.

Summary

This article is only intended to introduce what the Ackerman Steering Principle is, we have left out a description of the effects of More or Less Ackerman angle which will be covered in a related article.

We also have a related article about How Toe Angle Affects Ackerman Steering Angle which is of relevance to this particular area of model car handling.

More importantly though, there is another element in car handling that is particularly important to the model car owner. This element is called *slip angle* and will have a future article devoted to it.

Related Information

- How Toe Angle Affects Ackerman Steering Angles
- Toe-In & Toe-Out
- The Circle