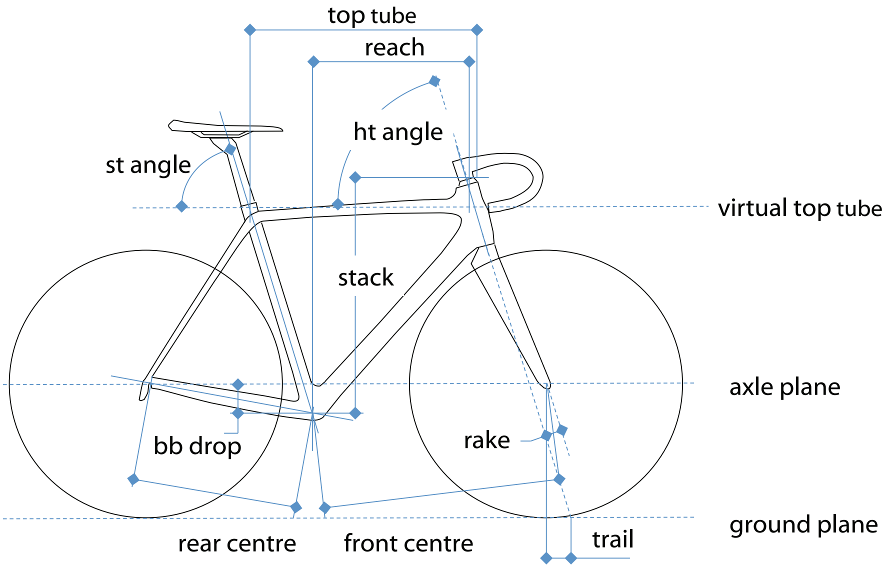
The following document sets forth the results of our research into bicycle handling and front end geometry. For further research, we recommend reading David E. H. Jones' *The Stability of the Bicycle*, which appeared originally in Physics Today, published by the American Institute of Physics, April 1970, pages 34-40.

The benefits of low flop geometry

What is wheel flop?

Essentially, wheel flop is the bicycle's tendency to lower the front end as the handlebars turn. Because of the relationship between the head angle and the trail, the bike will tend to 'dip' the front end as the rider turns the handlebars seeking an equilibrium point where the dipping motion will stop.



The geometry of the bike will determine the wheel flop factor according to this formula:

$f = \sin \partial \cos \partial \, t$
(where ∂ = head angle ; t = geometric trail)

The resulting number then yields a dimension in millimeters, which reflects the amount the front wheel dips relative to straight ahead when turned to reach its equilibrium point. In other words, the higher the number, the more the characteristics of wheel flop are pronounced. Here are the wheel flop numbers for a small selection of bicycles.

Bicycle	Model	Size	HT angle (º)	Rake (mm)	Flop (mm)
Storck	Fascenario .6	47	71	38	23
Pinarello	Dogma 65.2	47	70.5	43	23
Cervelo	R5	48	70.5	53	20
Cannondale	Supersix Evo	48	71.5	45	20
Parlee	Z5	XS	71.5	43	20
Specialized	Tarmac	49	72.25	45	18
Cipollini	RB1000	XS	72	45	18
A2J	Rolo	S	73	50	14

As described in the formula, the head angle and fork offset will determine geometric trail and thus the wheel flop factor. Turning the handlebars will lower the front end of the bike until the point of zero trail and zero flop. At this point, the bike is balanced. Another way to illustrate the wheel flop factor is to look at how far the handlebars need to be turned for the bicycle to remain balanced upright when attempting a track stand. When performing the track stand with the wheel pointing left, the high flop bike will have its bars turned at approximately 8 o'clock and the low flop bike will be balanced at approximately 1 o'clock.

In this way the wheel flop will act like a type of power steering helping the rider to 'fall' towards the inside of a corner. The formula shows that this effect is larger the shallower the head angle (typically smaller size bikes) and is compounded by large geometric trail (also typical for smaller size bikes, as on most modern carbon bikes, manufacturers use the same rake fork for all sizes).

Steering the bicycle

Cornering on the bicycle should be an intuitive process allowing the rider to 'think' the bike through a curve. The only way to initiate a turn and lean a bike into a curve is by first moving the wheels to the outside of the curve, which will rotate the bike around its center of gravity. The reason the bicycle needs counter steer to initiate the turn is that the rider needs to move his center of gravity towards the inside of the turn.

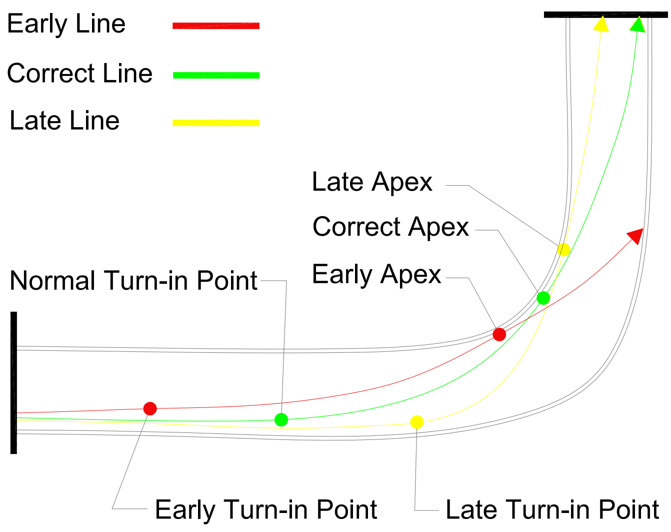
Since the bicycle has a self-balancing tendency, and since the rider needs to push against the bike in order to shift his center of gravity towards the inside of the curve, the bicycle will steer towards the outside of the curve. As soon as the rider's center of gravity has started to shift towards the inside of the turn, the rider will be able to lean the bicycle towards the inside of the curve, initiate 'local' gravity, and enter the turn. The entire counter steering process appears almost instantaneous and many riders are never aware of it.

(As a further illustration, picture a rider on a bicycle not using his hands. As the rider initiates a turn, he leans in the direction he wishes to turn. At the same moment, the front wheel will naturally counter steer but then come back towards the direction of the turn as soon as local gravity takes effect.)

During cornering the rider leans the bike using gravity to counterbalance the centrifugal force. So when cornering the result of the centrifugal force pulling the bike and rider outwards and gravity pulling straight down initiates local gravity, which is a function of the two. This force must balance the two primary components of gravity and centrifugal force perpendicular to the center axis of the rider and thus cancel them out.

To initiate a turn the rider needs to apply a slight counter steering pressure on the bars (this is typically done on a subliminal level) and wheel flop will then act as a power steering mechanism lowering the rider into a lean through the turn. The more the rider leans, the less he needs to turn the handlebars and consequently the faster he go. As he goes faster, he will in fact have to steer even less from the handlebars.

Bikes with high flop geometries strongly reinforce the steering input, so the slightest input of the rider will initiate a turn. Bikes with low flop geometries will require a more deliberate input but they offer more precise handling and better adjustability of the bike in mid corner.



High Flop

As explained above, the high flop bike will want to fall into the turn on a fairly tight radius (see track stand analogy above) and the higher the flop factor, the tighter the radius. The rider then catches this fall, which sets up the bike exiting the curve on a straightening trajectory.

In a longer turn however (or any turn over 90°) the rider needs to initiate a second turn and catch the bike again only to perhaps initiate a third turn whilst in the same curve (such as a switchback). As a result the rider rounds sweeping curves in a series of jerky movements describing smaller arcs rather than a smooth trajectory. In the process he looses speed and has to focus more attention or course correction.

Low Flop

A bike with low flop geometry has less power steering. Since the bike does not tend to fall into the turn the rider has more control over its trajectory and the rider can corner on a constant radius as well as adjust the trajectory with only minute steering inputs.

At the exit of the curve a very small steering input will bring the bike back into an upright position. It is easier to ride through hairpins or changing radius curves on a precise and constant radius, and to hit the apex of the corner with a much larger accuracy.

Higher Cornering Speeds

A high flop bike will fall into a curve on smaller radius than a low flop bike and must therefore go slower.

Since the low flop bike will not fall into the turn, its radius is correct allowing the rider to carry more speed into and through the turn. A low flop bike that corners at a constant radius with a higher likelihood of hitting the apex will also better handle a variety of situations throughout the turn because the rider can precisely adjust its trajectory if necessary.