

## Report Rake Angle and Trail

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Date: 11-12-2018

### Introduction

This report has the purpose of studying and providing reference values for the geometric parameters of the motorcycle, namely the rake angle, offset and trail. The analysis will take into account the book *Motorcycle Dynamics*, by Vittore Cossalter and also the parameters of existing racing motorcycles.

### Definitions

- Rake ( $\epsilon$ ) - angle of the steering axis with respect to vertical
- Offset ( $d$ ) - distance from the steering axis to the front axle
- Trail ( $a$ ) - distance the front tire's contact patch is behind (or "trails") the intersection of the steering axis with the ground

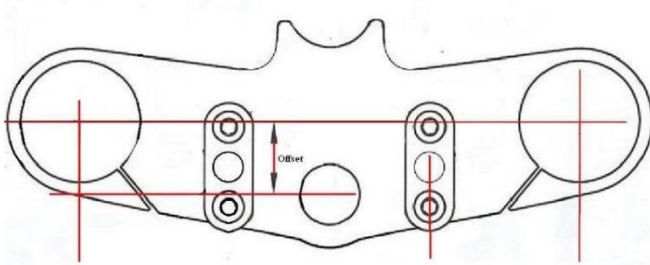


Figura 1 - Offset

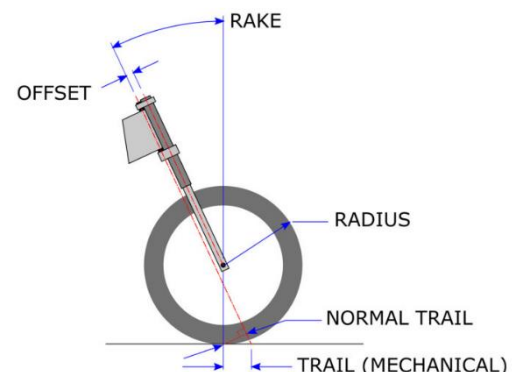


Figura 2 - Steering Parameters

Trail is the most important parameter that determines how a bike steers and how stable it is on the road and positive trail automatically counteracts the deflection of the steering.

More trail → heavier steering effort but more stability

Less trail → steering lighter with less stability

While we cannot adjust trail directly, we can by changing one of the three dimensions that directly affect trail: rake, offset, or front-tire diameter. Fitting a larger front tire, increasing rake, or decreasing offset will all add trail to some degree.

$$a = R \sin(\epsilon) - \frac{d}{\cos(\epsilon)}$$

### Values

It is important to know that there is no perfect setup for a motorcycle and while these values can provide a good starting point, they have to be adapted to the rider and track.

According to Cossalter, the rake angle for a competition or sport motorcycles should be between 21 and 24 degrees. For the trail, the value suggested is 75 to 90mm for competition motorcycles and 90 to 100mm for sport motorcycles.

The values suggested are in line with the ones found in actual sport bikes:

MOTORCYCLE	RAKE(°)	TRAIL(mm)	WHEELBASE(mm)
Yamaha YZF-R6	24	97	1380
Honda CBR600RR	23,9	97.7	1370
Kawasaki Ninja ZX-6R	23,5	100	1390
Suzuki GSX R600	23,25	93	1390
Ducati 749	24,25	97	1420
Energica Ego(Electric)	24	100	1465

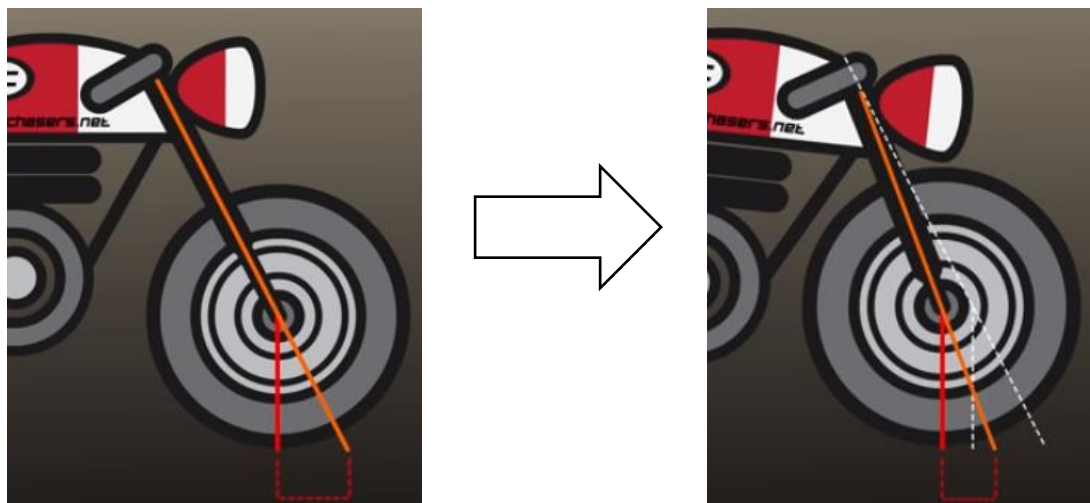
Table 1- Values for Sport motorcycles of 6 different brands

## Dynamics (Braking and Accelerating)

These values refer to a vertical bike with the suspension fully extended, which almost never occurs on track.

Under braking, for example, the front suspension almost fully compresses and the rear suspension extends. This significantly reduces rake and trail and also lowers the CG-(see image below). Under acceleration, the opposite occurs.

These dynamic aspects of geometry mean that suspension set ups, namely spring rates and preload, have a huge importance on how the bike behaves on track.



## Conclusion

A good starting point for the rake and trail for the NOVA 10 motorcycle is to use 24° and 95-97mm, respectively.

Taking into account the team budget, the offset and the wheel diameter are probably going to be fixed. Therefore, the trail will depend only on the rake angle and the motorcycle should be built in a way that allows adjustments to increase or decrease the rake angle, according to the rider's feedback. Finally, we have to take into account that this geometry is constantly changing and this change depends heavily on the suspension's behaviour.

## References

Cossalter, Vittorio, Motorcycle Dynamics, 2006, 2<sup>nd</sup> edition

Trevitt, Andrew, Sport Rider-All About Geometry, January 20, 2016 T - Retrieved from:  
<https://www.sportrider.com/all-about-geometry>