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Motorcycle Geometry Analysis and Dynamic Handling Investigation

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1 Introduction

This report will cover a selection of motorcycles, looking at their proportions, geometry and how these affect their handling and intended use. It will focus on key parameters such as rake angle, trail, wheelbase and frame dimensions to determine the centre of gravity and discuss how this position influences the rider on the motorcycle. The report will then examine two other motorcycles that are specifically designed for purposes, explaining how their geometry and design are tailored to achieve these roles. From this comparison, I will propose possible improvements that could be applied to the motorcycles I studied initially.

2 Geometric Data

Below are rough schematics for the positions of forks, wheels, sprockets and swing arms for my two chosen motorcycles, one being a CRF450R and the other being an Aprilia RS 250.

The Blue dots represent the centre of gravity of the machine, and the green is the centre of gravity with the rider present.

Figure 1 CRF450R Schematic

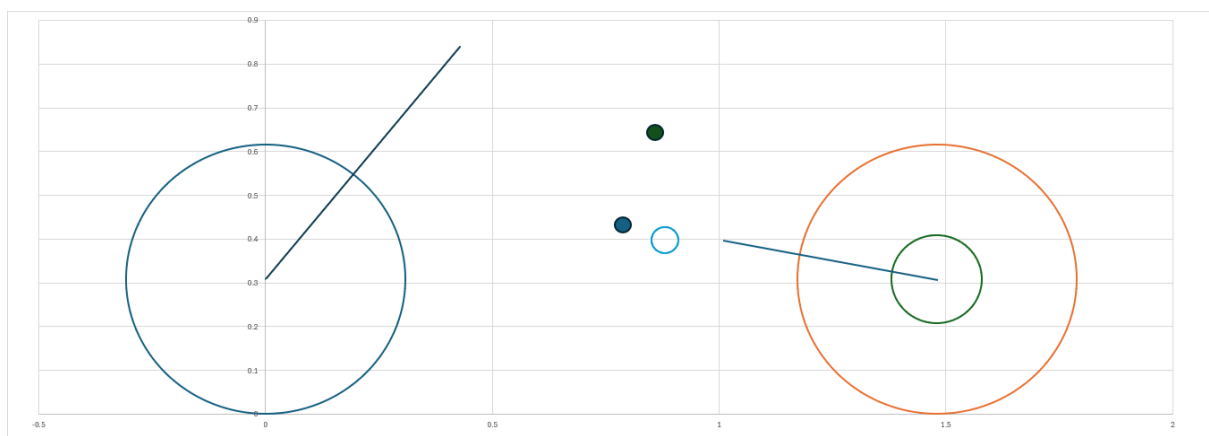
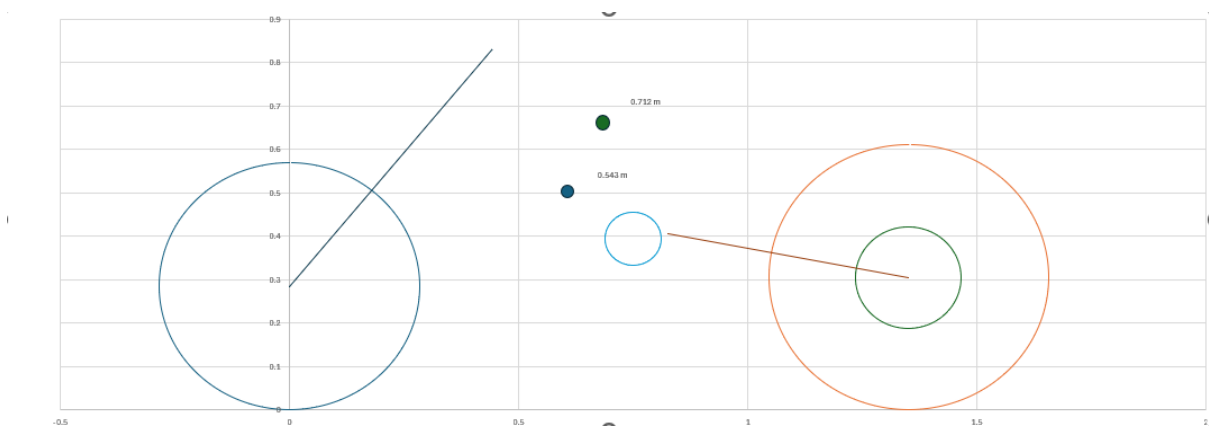


Figure 2 Aprilia RS 250 Schematic



3 Theoretical Top Speeds

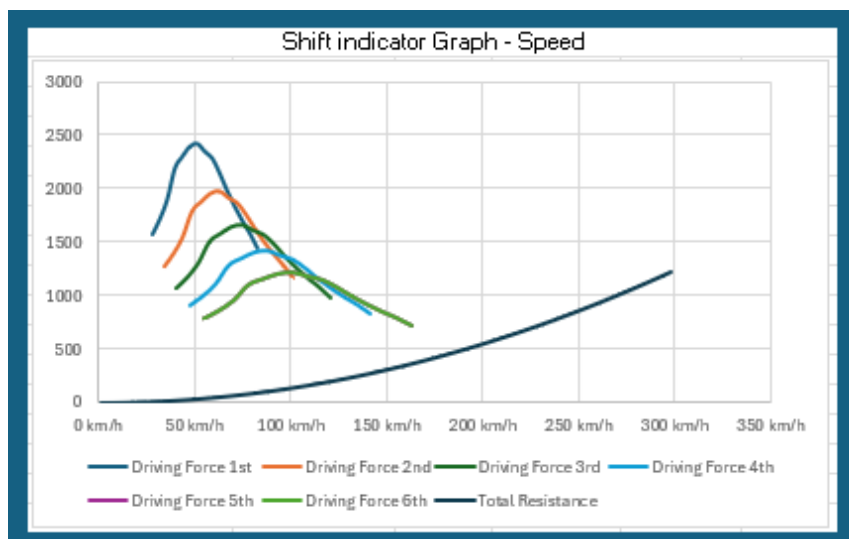
For this analysis, I used my two chosen motorcycles a Honda CRF450R and an Aprilia RS 250. The calculated theoretical top speed of the CRF450R is presented in Figure 3. Figure 4 then shows the gear-shift graph with aerodynamic and rolling resistance included, illustrating that the available engine power is insufficient for the motorcycle to reach its theoretical terminal velocity. Present on figure 4 there is a 6th driving force, but it is not relevant as the crf450r only has five gears the same can be seen on figure 3 as 5th and 6th are duplicates. I have done it in such a way that I could use the same calculations for the RS 250 as it has 6 gears. The same overall result can be said for the RS 250 it does not have enough power to reach its terminal velocity as the 6th gear doesn't cross over the resistance calculated from the frontal area of the bike, air resistance and then rolling resistance.

3.1 CRF450R Graphs

Figure 3 CRF450R Gear Calculator

Gear Calculator						
Primary	23	63				
FINAL	15	45				
Diameter	Goldspeed Dry		0.6166			
RPM	11000					
Ratios			Speeds	Revs	Falls	
1st	15	27	86 km/h	11000		
				8987		2013
2nd	17	25	106 km/h	11000		
				9240		1760
3rd	17	21	126 km/h	11000		
				9350		1650
4th	20	21	148 km/h	11000		
				9524		1476
5th	22	20	171 km/h	11000		
				11000		0
6th	22	20	171 km/h	11000		

Figure 4 CRF450R Shift Indicator

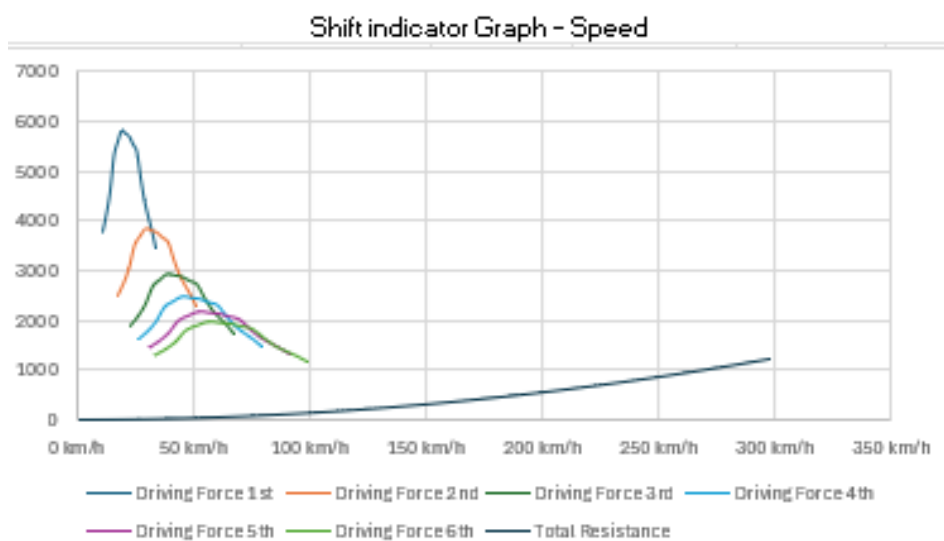


3.2 Aprilia RS 250 Graphs

Figure 5 RS 250 Gear Calculator

Gear Calculator					
Primary	23	59			
FINAL	14	42			
Diameter	Goldspeed Dry		0.325		
RPM	11000				
Ratios			Speeds	Revs	Falls
1st	11	27	36 km/h	11000	
				7282	3718
2nd	16	26	54 km/h	11000	
				8362	2638
3rd	17	21	71 km/h	11000	
				9310	1690
4th	22	23	84 km/h	11000	
				9645	1355
5th	24	22	96 km/h	11000	
				10080	920
6th	25	21	104 km/h	11000	

Figure 6 RS 250 Gear Shift Indicator



4 Handling

4.1 CRF450R

The Honda CRF450R is a full motocross bike that is meant to be ridden on a closed course, so it does not come with road-legal additions. Because it is not designed for the road, Honda can focus almost completely on how it performs and handles on a motocross track (Cycle World, 2023). Over the years they have changed the frame, suspension and geometry to make it turn better give it a more stable feel and be easier to ride.

The CRF450R has a steep rake of about 27° and a trail of around 114 mm, along with a short wheelbase (Cycle World, 2023; Dirt Rider, 2024). This kind of setup is aimed at giving quick, sharp steering and a strong, positive feel from the front wheel. Test riders often describe the bike as very agile and “front-end-focused”, meaning it holds a line well and feels accurate when turning into ruts or berms (Dirt Rider, 2024). This fits with the idea that a steeper rake and relatively short wheelbase help the bike change direction quickly.

The downside is that this sort of geometry can make the bike more sensitive to setup. On some of the recent models, riders have said the front can feel harsh or a bit nervous if the suspension clickers and rider sag are not set correctly (Dirt Rider, 2023). Small adjustments in fork height or rear sag can noticeably change how stable it feels at speed and how easily it turns in. So, while the CRF450R’s design gives very good performance for motocross, it also means the bike works best when it is properly set up for the rider and the track (Cycle World, 2023; Dirt Rider, 2024).

4.2 Aprilia 250 RS

The Aprilia RS 250 is a two-stroke race-replica mainly built for fast riding on tarmac, not for comfort or everyday commuting. It uses a lightweight aluminium beam frame, a braced swingarm and fully adjustable suspension, much closer to a small GP bike than a normal road bike (Rose, 2019). Reviews often say it has “amazing handling” and one of the best chassis and brake packages of its time, which shows how focused the design is on cornering performance (Motorcycle News, 2023).

The RS 250 runs with a rake of about 25.5° and a trail of roughly 102 mm, with a wheelbase around 1370 mm (Rose, 2019). This setup gives quick, light steering and lets the bike change direction very easily but keeps enough stability to feel secure when leant over in a fast corner. Riders often say it feels like it is “on rails” mid-corner, which matches these relatively sporty geometry numbers (Motorcycle News, 2023).

Compared with other 250 two-stroke race replicas, the RS 250 is one of the heaviest, at about 141 kg dry, but this extra weight is used well (Rose, 2019). The good suspension and slightly more conservative steering geometry help it stay stable when changing direction at high speed and make it less likely to develop tank-slappers on bumpy roads. Testers describe the combination of chassis, suspension and powerful Brembo brakes as giving a lot of rider confidence, especially on twisty roads or track days (Motorcycle News, 2023).

Overall, the RS 250 is a sharp-handling, track-biased bike. Its rake and trail are sporty enough to give very fast turn-in and a strong front-end feel, but not so extreme that it becomes completely unstable. This makes it a good contrast to the CRF450R, because both are performance-focused machines but aimed at very different types of riding.

5 Tailored Designs

For the Dakar-style bike, I have used the KTM 450 Rally Replica, which is basically the customer version of KTM's Dakar race bike. It uses a steel frame with the rear fuel tank acting as the subframe, and long-travel WP PRO suspension front and rear, which is all aimed at off-road racing over long distances (KTM, 2025). The focus here is straight-line stability, comfort when standing up and the ability to carry a lot of fuel, rather than very sharp steering.

Published geometry figures for the 450 Rally Replica give a wheelbase of about 1.5 m, with a fairly relaxed rake of around 27° and a large amount of trail, over 110 mm (Motorcyclespecs, 2025). It also uses a 21-inch front wheel with a 90/90-21 tyre and around 300 mm of front suspension travel, plus about 280 mm at the rear (Motorcyclespecs, 2025). This combination helps the bike roll over rocks, ruts and dunes without deflecting too much. The longer wheelbase and lazier steering make it stable at high speed in sand and on rough tracks. KTM also mention that the frame is hydro-formed and designed with specific flex to absorb energy and keep the bike stable in a straight line, which suits multi-day rally stages in harsh terrain (KTM, 2025). With split fuel tanks and roughly 35 litres on board, the chassis also has to cope with changing fuel loads without the bike becoming unstable (KTM, 2025).

A modern MotoGP bike is almost the complete opposite in terms of what it is designed to do. Instead of dunes and rocks, it spends all of its time on smooth tarmac circuits, braking from over 300 km/h and changing direction very quickly through fast chicanes. Typical MotoGP chassis numbers are a wheelbase in the 1.40–1.45 m range, with a steeper rake of about 24° and trail close to 100 mm. Both wheels are 17-inch, using wide slick tyres, and the suspension travel is much shorter than on a rally bike, because the track surface is relatively smooth and the main aim is to keep the tyre loaded evenly rather than absorb big bumps. The frame is usually an aluminium twin-spar design which is very stiff to handle huge braking forces and to keep the geometry stable at high lean angles.

Because of this, the MotoGP bike can turn in very quickly and hold a precise line at high speed, but it would be uncomfortable and nervous on loose surfaces. The shorter wheelbase, steeper rake and smaller 17-inch front wheel would all be a disadvantage in deep sand or rocks compared with the Dakar bike. In contrast, the KTM 450 Rally Replica,

with its longer wheelbase, relaxed steering angle, 21-inch front wheel and long travel suspension, is built to be stable, predictable and manageable over long off-road stages rather than ultra-sharp on a smooth circuit (KTM, 2025; Motorcyclespecs, 2025). This shows how the same basic geometry ideas—wheelbase, rake, trail, wheel size and frame design—are pushed in different directions depending on whether the bike is meant for the desert or a MotoGP track.

6 Possible Improvements

For both the Honda CRF450R and the Aprilia RS 250 there are simple and more over realistic adjustments that can be made to improve handling using the standard suspension and chassis.

On the CRF450R, the most important step is to set the suspension up correctly for the rider. The bike is supplied with fully adjustable Showa suspension and is intended to be tuned to rider weight and track conditions (Honda, 2024). Setting rider sag at the rear in the recommended range and matching the front sag helps the bike sit correctly or as Honda intended, which improves stability and turn-in. Once a rider has set sag correctly small changes to compression and rebound damping can be used to fine-tune the feel. Forum advice for heavier riders on similar CRF models often recommends fitting springs to suit rider weight, then starting from stock clicker settings and making gradual adjustments to calm harshness or instability, rather than immediately changing hardware (ThumperTalk, 2018; CRF's Only Forums, 2014). Slight changes to fork height in the yokes, raising the forks up within the yoks, are also commonly used to either speed up steering or improve straight-line stability, and are easily done at home (CRF's Only Forums, 2014; Honda, 2024).

For the Aprilia RS 250 a basic suspension refresh and setup can also add a lot to its handling. The RS 250 was sold with fully adjustable suspension as standard, but many examples are now decades old (Rose, 2019). Fresh fork oil, returning the adjusters to the factory baseline and then setting front and rear sag provides a solid starting point. On Apriliaforum, users report that after setting sag and then softening compression damping by a few clicks, the bike becomes more compliant and confidence-inspiring on bumpy roads while still handling well in corners (Apriliaforum, 2014). Small changes in fork height to sharpen or calm steering with a new set of modern tyres at appropriate pressure are further a few further changes that match how owners improve these bikes in practice (Apriliaforum, 2014; Rose, 2019).

From both case studies we can see that correct sag alongside sensible damping changes and minor geometry tweaks can noticeably improve handling without needing major modifications.

7 References

apriliaforum.com (2014) *suspension settings*. Available at:

<https://www.apriliaforum.com/forums/showthread.php?293155-suspension-settings>

(Accessed: December 2025).

Casey Casper (2025) *2025 Honda CRF450R Test | Dirt Rider*. Available at:

<https://www.dirtrider.com/tests/honda-crf450r-review/> (Accessed: December 2025).

Cody Johnston (2024) *Riding the 2024 Honda CRF450R | Dirt Rider*. Available at:

<https://www.dirtrider.com/tests/honda-crf450r-long-haul-review/> (Accessed: December 2025).

crfonly.com (2014) *Trail riding click adjustment please help. -CRF's Only Forums*. Available

at: <https://crfonly.com/forum/viewtopic.php?t=40285> (Accessed: December 2025).

Cycle World Staff (2024) *2025 Honda CRF450R Buyer's Guide: Specs, Photos, Price | Cycle*

World. Available at: <https://www.cycleworld.com/honda/crf450r/> (Accessed: December 2025).

Honda Motor Co., I. (2025) *Honda CRF450R Motocross Dirt Bike | Honda Powersports*.

Available at: <https://powersports.honda.com/motorcycle/motocross/crf450r> (Accessed: December 2025).

Honda Motor Co., Ltd. (2021) "Owner's Manual."

KTM (2020) *APRILIA RS250 (1994-2004) Review | Speed, Specs & Prices*. Available at:

<https://www.motorcyclenews.com/bike-reviews/aprilia/rs250/1994/> (Accessed: December 2025).

KTM Sportmotorcycle GmbH (2024) *2025 KTM 450 Rally Replica*. Available at:

<https://www.motorcyclespecs.co.za/model/ktm/ktm-450-rally-rep-2025.html> (Accessed: December 2025).

KTM Sportmotorcycle GmbH (2025) *2026 KTM 450 RALLY REPLICA - DOMINATE THE DUNES |*

KTM. Available at: <https://www.ktm.com/en-int/models/adventure/2026-ktm-450-rallyreplica.html> (Accessed: December 2025).

Steve Rose (2019) *Aprilia RS250 - Modern Classic Review & Buyers Guide*. Available at: <https://www.bennetts.co.uk/bikesocial/reviews/bikes/classic/aprilia-rs250-modern-classic-review-value-spec> (Accessed: December 2025).

thumpertalk.com (2018) *Suspension Settings for 220lb Rider - CRF450R/RS/RWE & RX - ThumperTalk*. Available at: <https://www.thumpertalk.com/forums/topic/1265455-suspension-settings-for-220lb-rider/> (Accessed: December 2025).

