

Suspension systems and its geometry.

Isabella Wratten

Andrew Noble

Wales Institute for Science and Art
BEng Motorsport Engineering

Introduction

The suspension system is one of the most crucial components of any vehicle, ultimately designed to manage any dynamic forces applied upon it, making it responsible for comfort along with its ride and handling capabilities.

Its primary purposes are to

- Support both the sprung and un-sprung mass of the vehicle
- Absorb and dissipate any changes in the road surface
- Maintain the maximum contact patch between the tyre and road surface

The system needs to allow for any vertical movement of the wheel. Minimise any changes in wheel alignment during dynamic motion as well as minimising change in wheel alignment during steering.

History

Development of suspension systems dates back to the early 20th century. Where they provided basic shock absorption abilities.

- 1920's William Bushnell Stout develops the first independent front suspension system.
- In the 1930's hydraulic shock absorbers are implemented.
- 1950's coil springs are added to the systems. This is where Earle S. Macpherson combined the two to create the MacPherson strut. Which is still seen frequently in today's cars.
- 1980's electronic systems were added, that allowed for real time adjustments (Discover Engineering, 2024).

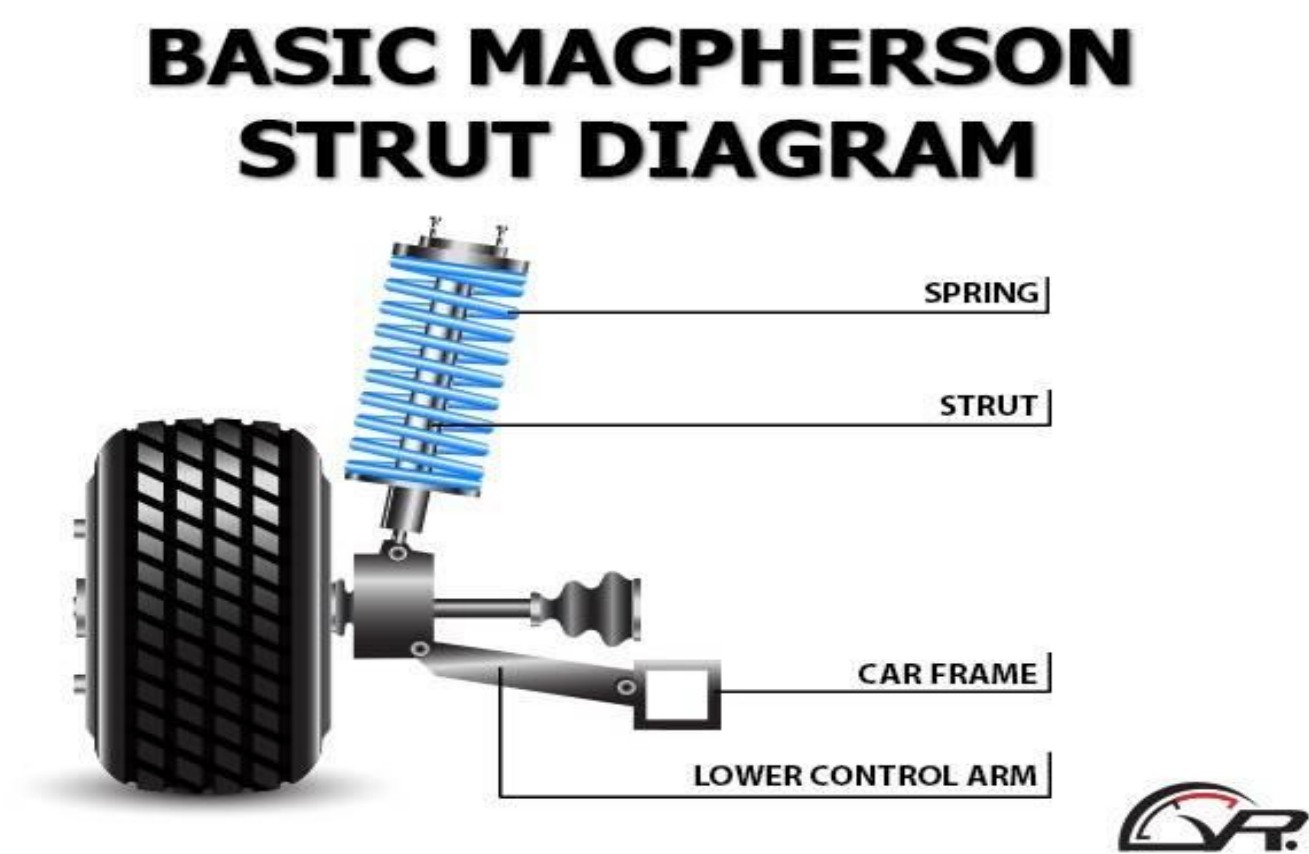


Figure 1 – MacPherson strut (image courtesy of revvolution.com)

In Motorsport

Motorsports now typically use double wishbone or pushrod suspension systems, while also using a multitude of sensors and actuators so that the set up can be changed in real time, as well as providing better wheel movement and alignment (Discover Engineering, 2024).



Figure 2 – Double Wishbone Suspension (image courtesy of FactoryFiveRacing)

Geometry

Suspension geometry relies on three main areas, those are camber, caster and toe and changing any one of these will have a significant effect on how a car handles.

Camber

Camber is the angle of the wheels relative to the roads surface. When the top of the wheel leans away from the cars centre it is positive and when it leans towards its negative. Camber is adjusted to aid in controlling any attitude change in the tyres during cornering to maintain the best contact patch (Discover Engineering, 2024).

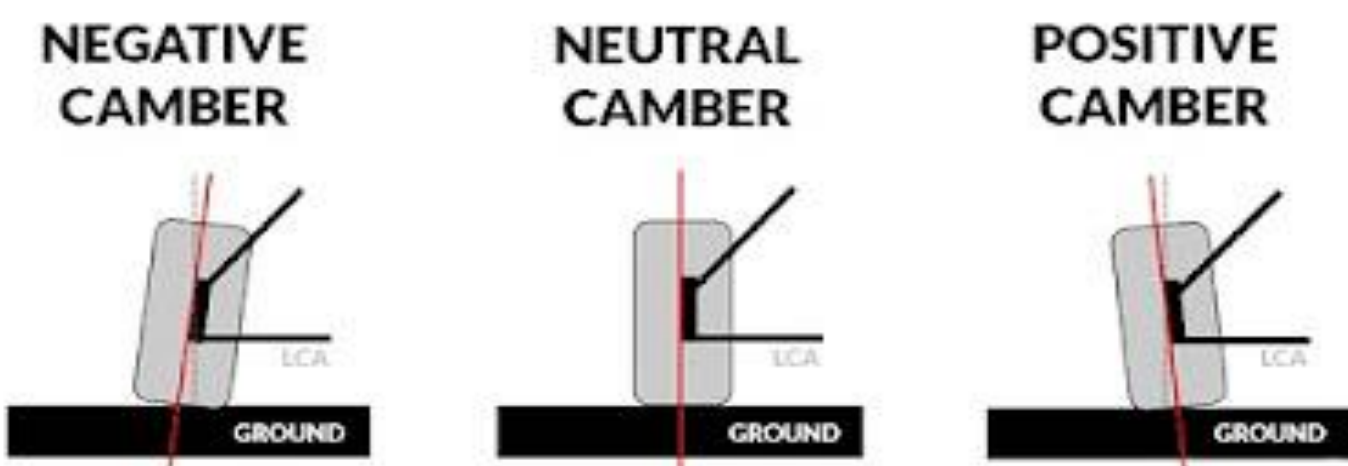


Figure 3 – Camber (Chong, 2020)

Caster

Caster is the angle of the steering axis in relation to the vehicle vertical axis (Discover Engineering, 2024). This effects the steering characteristics and as a result, most vehicles will run on positive caster as it helps maintain straight line stability. Negative caster causes instability and makes the steering heavier.

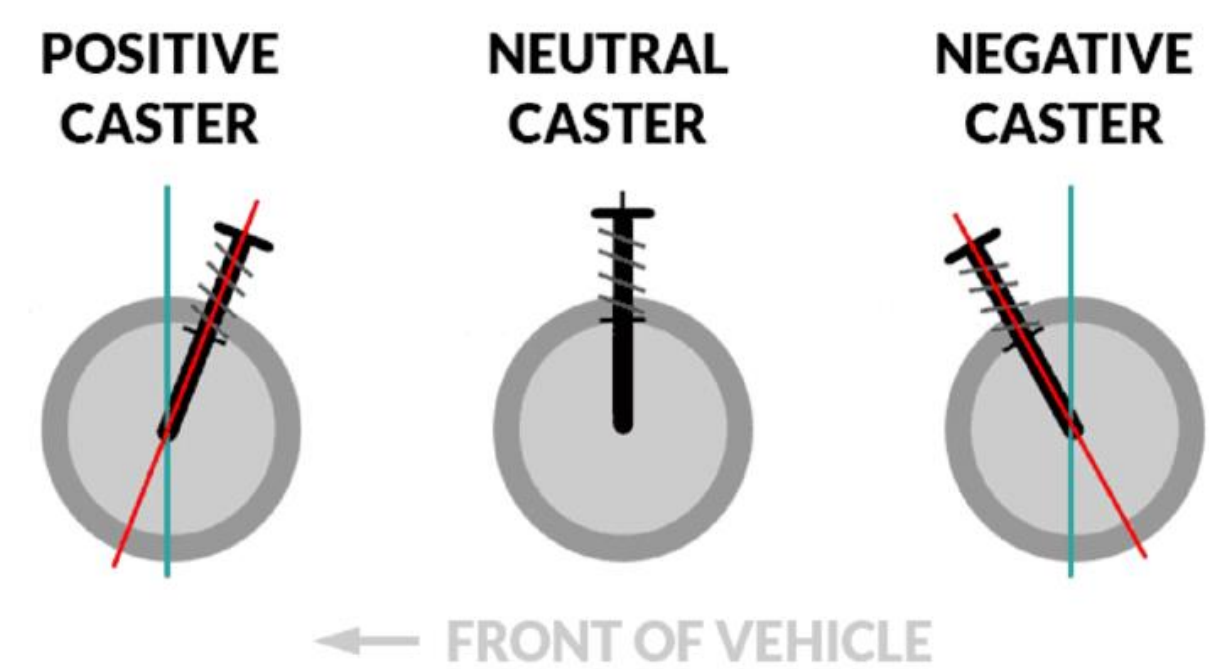


Figure 4 – Caster (Chong, 2020)

Toe

Toe is the angle of the wheels relative to the longitudinal axis of a vehicle (Discover Engineering, 2024) and affects the turn in response. Toe in is where the front of the wheels is pointing towards the centreline of the car, with toe out pointing away.

Toe in and toe out are opposites of each other so where toe in is more stable in straight lines and slightly slower going into turns, toe out is the opposite therefore less stable on the straights but faster to react in a turn.

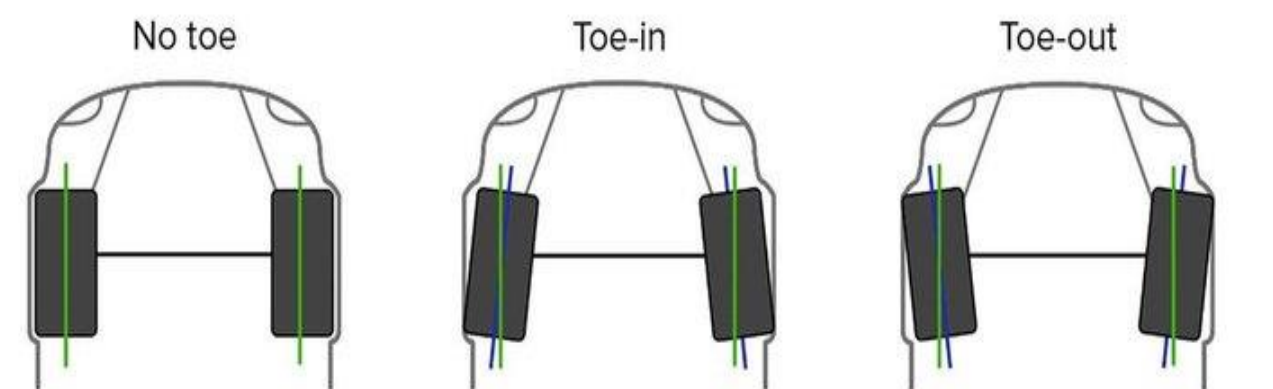


Figure 5 – Toe (Chong, 2020)

References

Discover Engineering. (2024, 10 24). *Automotive Suspension Systems*. Retrieved from Discover Engineering.org

Chong, A. (2020, October 2). *A Beginner's Guide: Setting Up Your Car's Alignment - Toe, Camber, & Caster*. Retrieved from Motorist.