MSc Human and Biological Robotics

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HCARD Report 1: Mechanism - 4 bar link

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Four Bar Linkage

A Four Bar Linkage (FBL) system is comprised of four bars joined by pin joints. The relative length of the bars dictates the behaviour and dynamics of the system. The system is implemented in a planar fashion almost ubiquitously, one exception is the Bennet spatial FBL. One of the primary constraints of the mechanism is determined by the Grashof Condition. The FBL system has many applications, two of which lie in the automotive industry - double wishbone suspension and Ackermann Steering. These concepts are presented below.

Grashof Condition

The Grashof Condition, if satisfied, states that the shortest link is able to fully rotate with respect to the neighbour link without incurring snap-through. Given the shortest link, S, then longest link, L, and the two intermediary length links, M1 and M2, the Grahof condition is satisfied if $S + L \geq M1 + M2$.

Double Wishbone Suspension

One example of a FBL system is a double wishbone suspension system as shown in fig. 1. The four bars consist of: the two wishbones, the wheel knuckle and the line linking the location at which the wishbones attach to the chassis. This is another example of a spatial FBL since the wishbones are connected to the knuckle via a ball and socket joint. Double wishbone suspension is typically used over MacPherson in fast, agile cars as the set-up is more customisable. This preference allows for appropriate adjustment of camber angle when cornering, maximising the surface area of the tyre in contact with the road, creating greater grip during cornering.

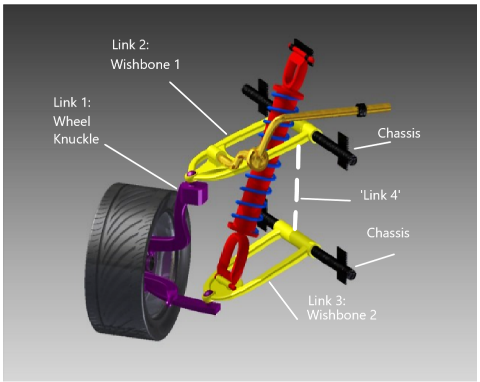
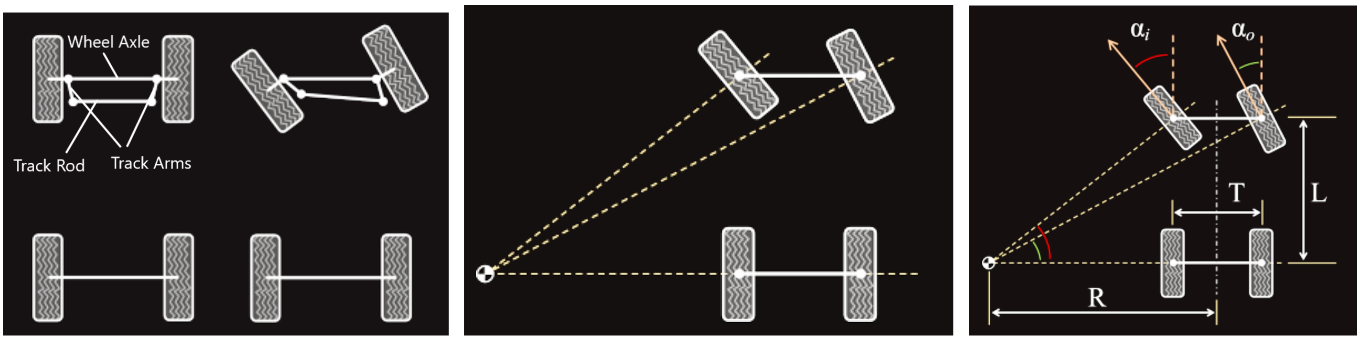


Figure 1: Double Wishbone Suspension Set-up (McLaughlin, 2014)

Ackermann Steering

Ackermann Steering was first developed in the 1800s by a German carriage builder Georg Lankensperger. It consists of the wheel axle, one track arm extending from each wheel knuckle and a track rod connecting these arms (fig. 2(a)). The purpose is to try to mimic ideal steering which centres the turning circles of the inside and outside wheel on the same point (fig. 2(b)). This set-up creates individual points about which each wheel turns. The ability to do this is derived from the geometry of the FBL; the track rod is shorter than the wheel axle, creating a trapezium. In effect, this allows the inside wheel to rotate more that the outside wheel. For ideal steering, from the nomenclature specified in fig. 2(c), the angles α_i and α_o are given by

$$\alpha_i = tan^{-1}\left(\frac{L}{R - \frac{T}{2}}\right) \quad ; \quad \alpha_o = tan^{-1}\left(\frac{L}{R + \frac{T}{2}}\right). \tag{0.1}$$



(a) Ackermann Steering FBL

(b) Ideal Steering

(c) Ideal Steering showing the inner wheel with a smaller turning circle than the outer wheel.

Figure 2: (*DataGenetics: Ackermann Steering*, n.d.)

References

DataGenetics: Ackermann Steering (n.d.), http://datagenetics.com/blog/december12016/index.html. Accessed: 01-02-2018.

McLaughlin, E. (2014), CAD Project 2: Suspension, Technical report, University of Bristol, Department of Mechanical Engineering.