Ackerman Steering

Ackerman steering geometry is a fundamental principle in vehicle design, particularly beneficial for automated cars. This steering mechanism ensures that all wheels follow the correct path during a turn, which is crucial for maintaining control and reducing tire wear, and here are some advantages of Ackerman steering for automated cars:

- Improved Maneuverability: one of the primary benefits of Ackerman steering is its ability to improve the maneuverability of a vehicle. By allowing the wheels to turn at different angles, it ensures that each wheel follows its optimal path during a turn. This is particularly useful for automated cars, which need to navigate tight corners and complex routes with precision. Enhanced maneuverability makes it easier for these vehicles to operate in urban environments where space is limited.
- Increased Driving Stability: Ackerman steering also contributes to increased driving stability. By ensuring that the wheels are correctly aligned during turns, it reduces the likelihood of skidding or slipping, which can be particularly dangerous at high speeds. For automated cars, which rely on precise control systems to maintain safety, this added stability is crucial. It helps the vehicle maintain its intended path, even in challenging driving conditions.
- Reduced Tire Wear: Another significant advantage of Ackerman steering is the reduction in tire wear. When wheels are not aligned correctly during a turn, they can scrub against the road surface, leading to increased wear and tear. Ackerman steering minimizes this issue by ensuring that each wheel follows the correct path, thereby extending the lifespan of the tires. This is not only cost-effective but also enhances the overall efficiency of the vehicle.
- Enhanced Steering Control: Ackerman steering provides enhanced steering control, making the vehicle more responsive to inputs. For automated cars, which rely on precise steering mechanism to navigate, this improved control is essential. It allows the vehicle to make smooth and accurate turns, which is critical for maintaining safety and comfort for passengers. The precise control also helps in executing complex maneuvers, such as parallel parking or navigating through narrow streets.
- Simplified Wheel Alignment: the Ackerman steering mechanism simplifies the process of wheel alignment. Proper wheel alignment is crucial for the optimal performance of any vehicle, and automated cars are no exception. Simplified alignment simplified alignment processes mean that maintenance tasks can be preformed more quickly and efficiently, reducing downtime and ensuring that the vehicle remains in top condition.
- Better Handling of Low-Speed Maneuvers: Automated cars often need to perform low-speed maneuvers, such as parking or navigating through traffic. Ackerman steering is particularly effective in these situations, as it allows for precise control of the vehicle’s

direction. This makes it easier for the car to handle tight turns and complex driving scenarios, enhancing the overall user experience.

-

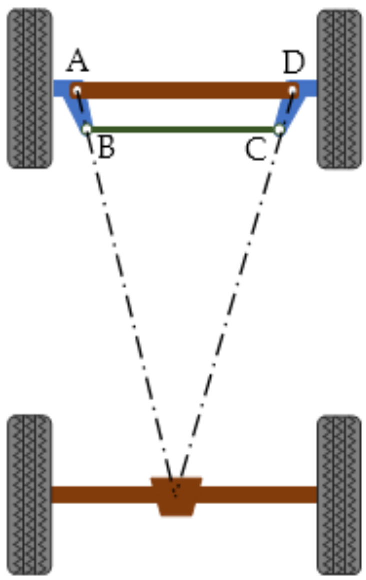


Figure 1: Ackermann steering with links AD and BC of unequal length and AB and CD of equal length

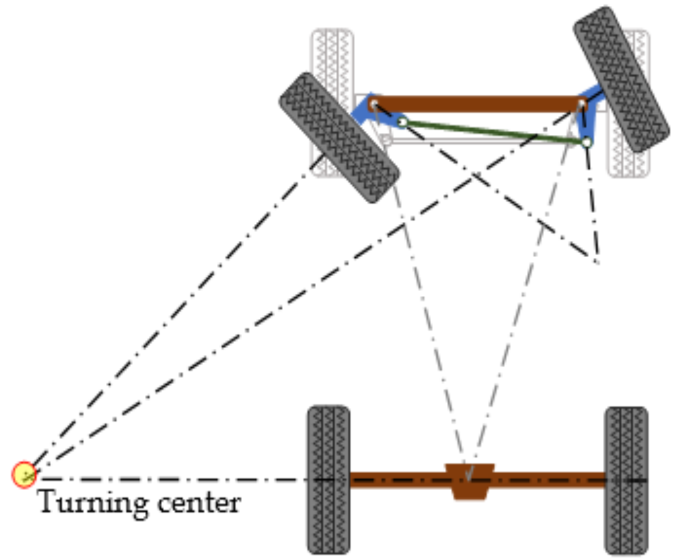
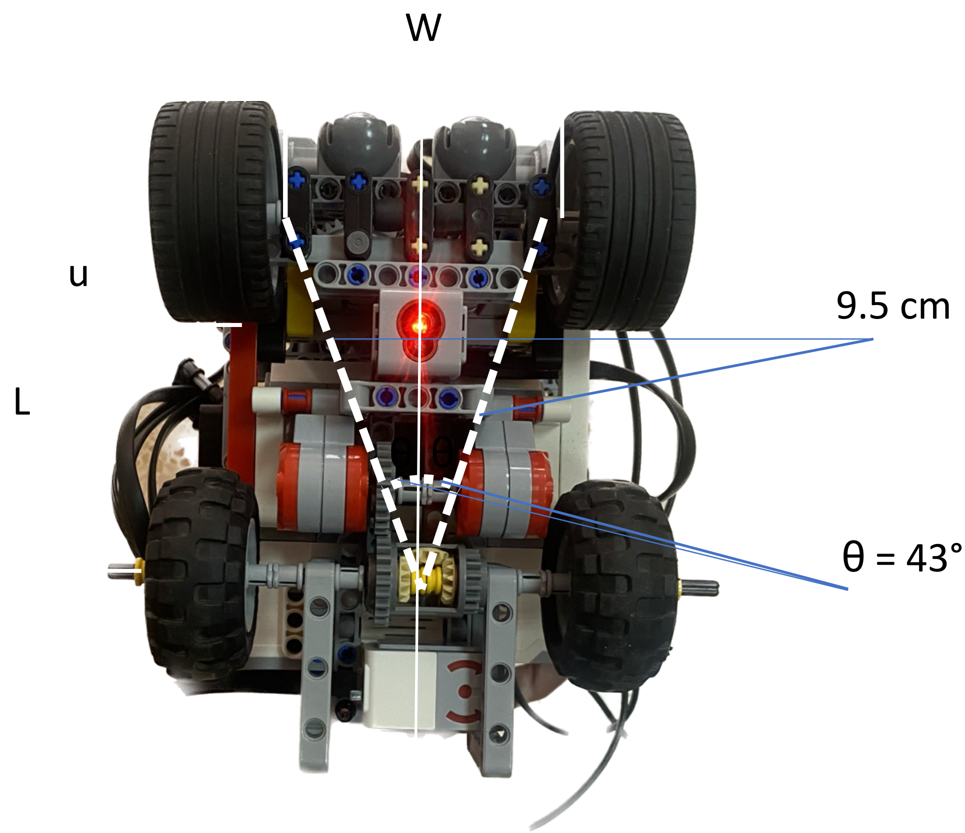
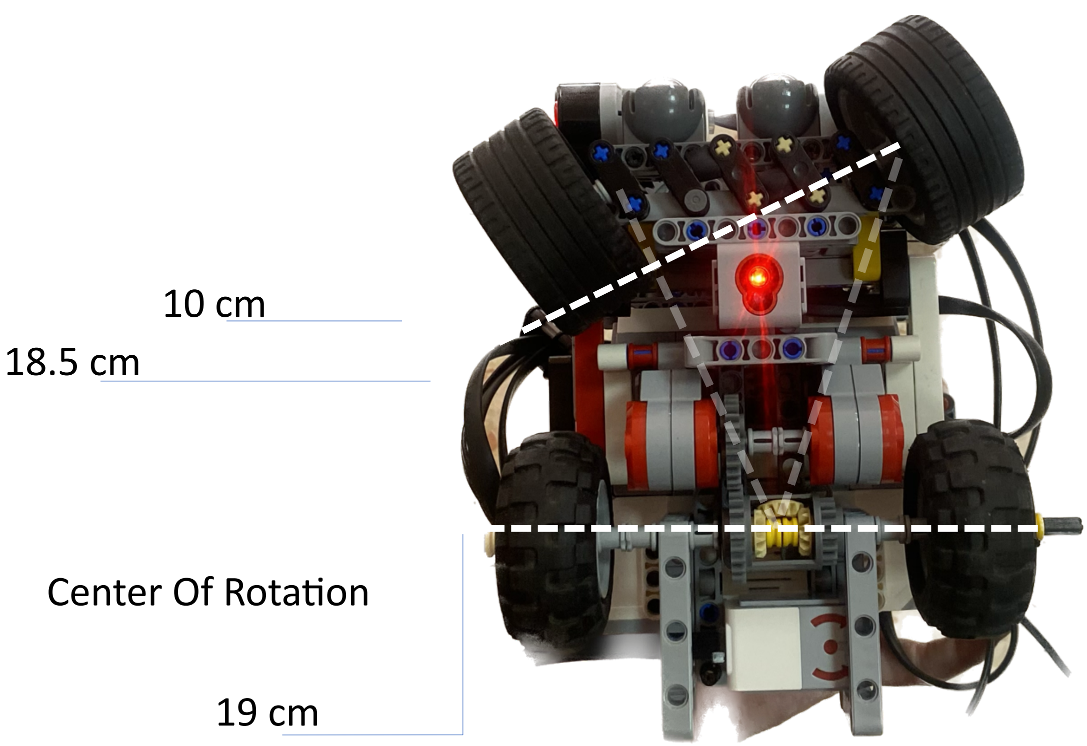
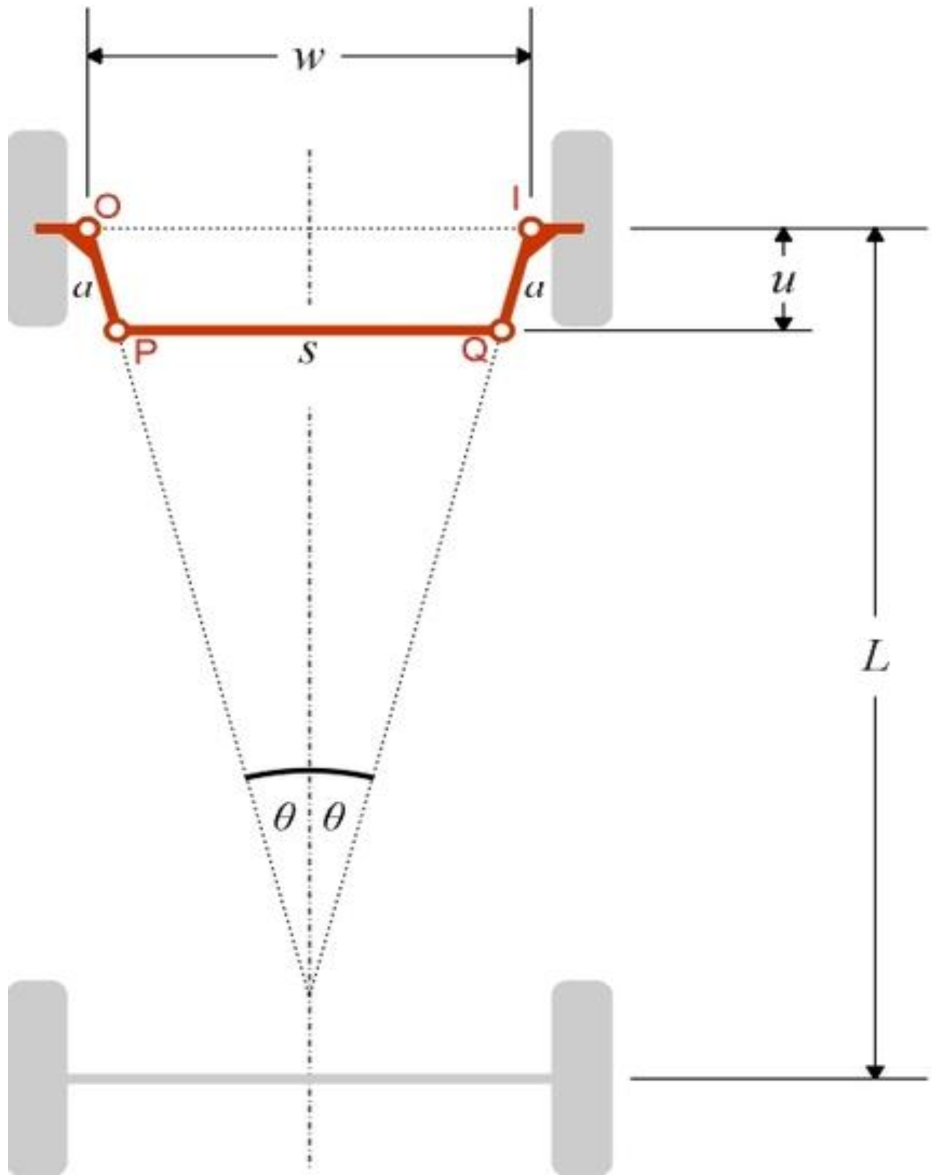


Figure 2: Ackermann steering mechanism with two correct steered positions


W
u
L
9.5 cm
θ = 43°


10 cm
18.5 cm
Center Of Rotation
19 cm



You can easily notice that the inner wheel and the outer wheel are rotating different angles.

To make a start, we need to attach symbols to the various lengths and angles that define the movement of the linkage. First let's look at the fixed parameters – the ones that are built into the chassis of the car and don't change when the wheels are swiveled. There are six of them: L, w, a, θ, u, and s, as shown in figure 2. L is the distance between the front and rear axles, usually known as the wheelbase. The points O and I are the points where the pivot axes intersect the road surface, and we shall refer to the distance between them as the track width w (this is a simplification - previously we defined the track width as the distance between the wheel centerlines, and although this is not quite the same thing, each pivot axis usually intersects the road very close to the center of its corresponding contact patch, and it is convenient to assume they coincide). Attached to the wheel hubs are lever arms OP and IQ, each of length a. When the steering is in the dead-ahead position, each lever arm makes an angle θ with the car's longitudinal axis, and the track rod is spaced a distance u rearward of the front axle centerline. Finally, the two lever arms are linked by the track rod PQ, whose length is denoted by s.

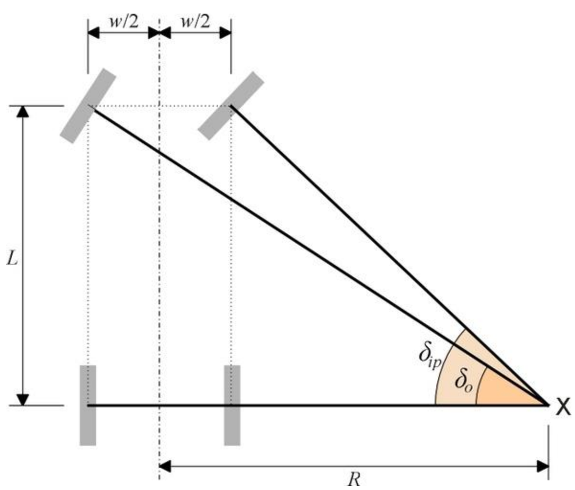
$$a = u.\sec\theta \quad (1)$$

$$s = w - 2a\sin\theta = w - 2u\tan\theta \quad (2)$$

$$\tan\theta = {}^{w} \ (3)\ 2l$$

In the figure [3] it is explained how does actually Ackerman steering $\delta_{ip} = \cot^{-1}(\cot\delta_0 - {}^{w})$ (4)

L



$$\cot\delta_0 = \cot\delta_{ip} =$$

$$^{2}\ (5)\ L$$

$$R -{}^{1} w$$

$$^{2}\ (6)\ L$$

$$R +{}^{1} w$$

$$\cot\delta_{ip} = \cot\delta_0 - {}^{w}\ (7)$$

If we take our robot car for example:

$$\theta = 43°, u = 28mm, L = 95mm$$

So "a" becomes:

(1). $$a = 28 \times \sec 43° \approx 38.2851mm$$

(2). $$s = w - 2a \sin\theta = 68 - 60 \times \sin 43 = 27.0801\ mm$$

(3). $$\tan\theta = \frac{w}{2L} = \frac{68}{2\times 95} = 0.3578$$

So if we need our robot car to turn by radius 50mm (for example):

(4). $$\cot\delta_0 = \frac{R + \frac{1}{2}W}{L} = \frac{50 + \frac{1}{2}\times 68}{95} = 0.8842$$

Calculating the torque required for an Ackerman steering system involves understanding the forces at play and the geometry of the steering mechanism.

Understanding Ackerman Steering Geometry: Ackerman steering geometry ensures that all wheels of a vehicle follow concentric circles when turning, minimizing tire slip. This is achieved by angling the front wheels differently: the inside wheel turns at a sharper angle than the outside wheel.

Our medium motor torque which is controlling the Ackerman steering has a running torque of 8 N/cm and is connected to a series of gears to control the steering, that would make our equation of calculating the whole torque of the Ackerman as the following:

$$\boldsymbol{T = torque\ of\ motor * ratio\ of\ bigger\ gear\ to\ the\ smaller\ gear}$$

$T = 8 * 10^{-2} * 40/8$

$T = 40 * 10^{-2}$ (N/m)