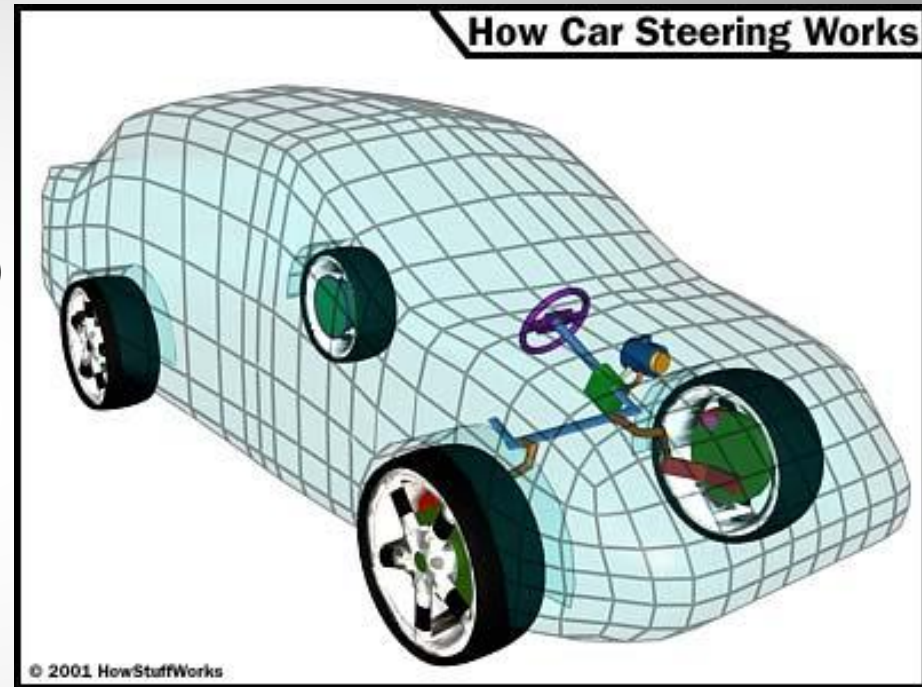


Steering System

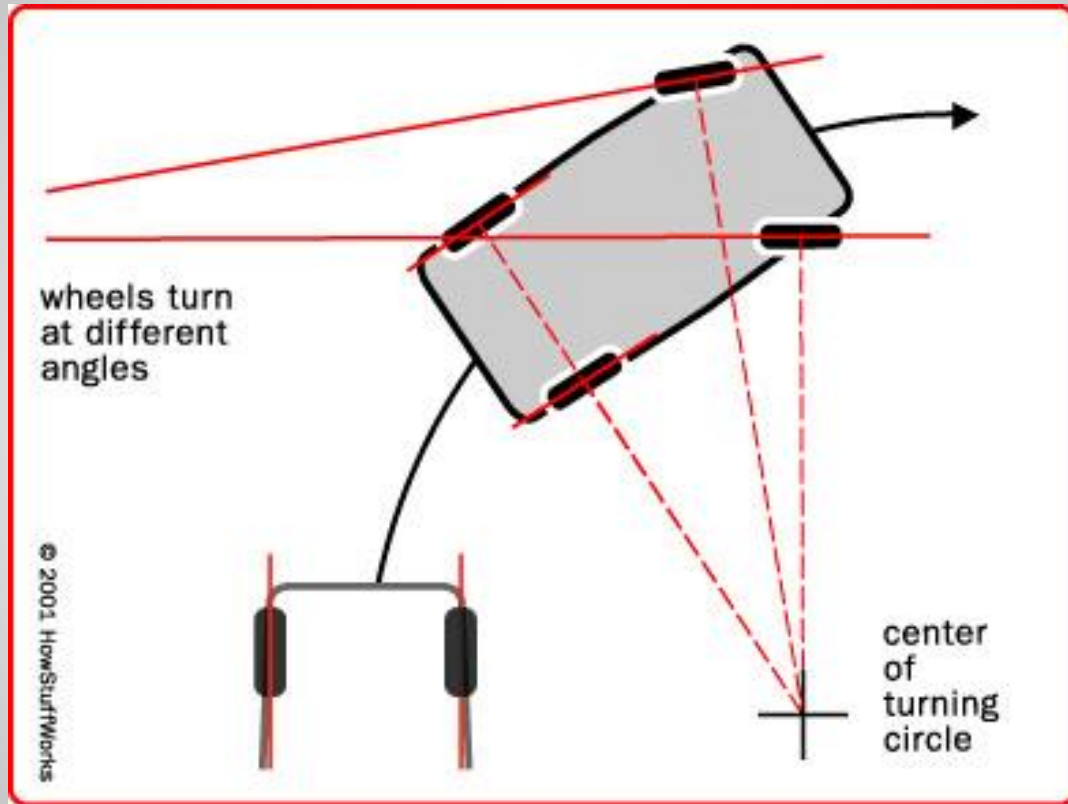
Function of Steering System

- Control of front wheel (sometimes rear wheel) direction.
- Transmit **road feel** (slight steering wheel pull caused by the road surface) to the drivers hand.
- Maintain correct amount of effort needed to turn the wheels.
- Absorb most of the shock going to the steering wheel as the tire hits holes and bumps in the road.
- Allow for suspension action.



Steering System

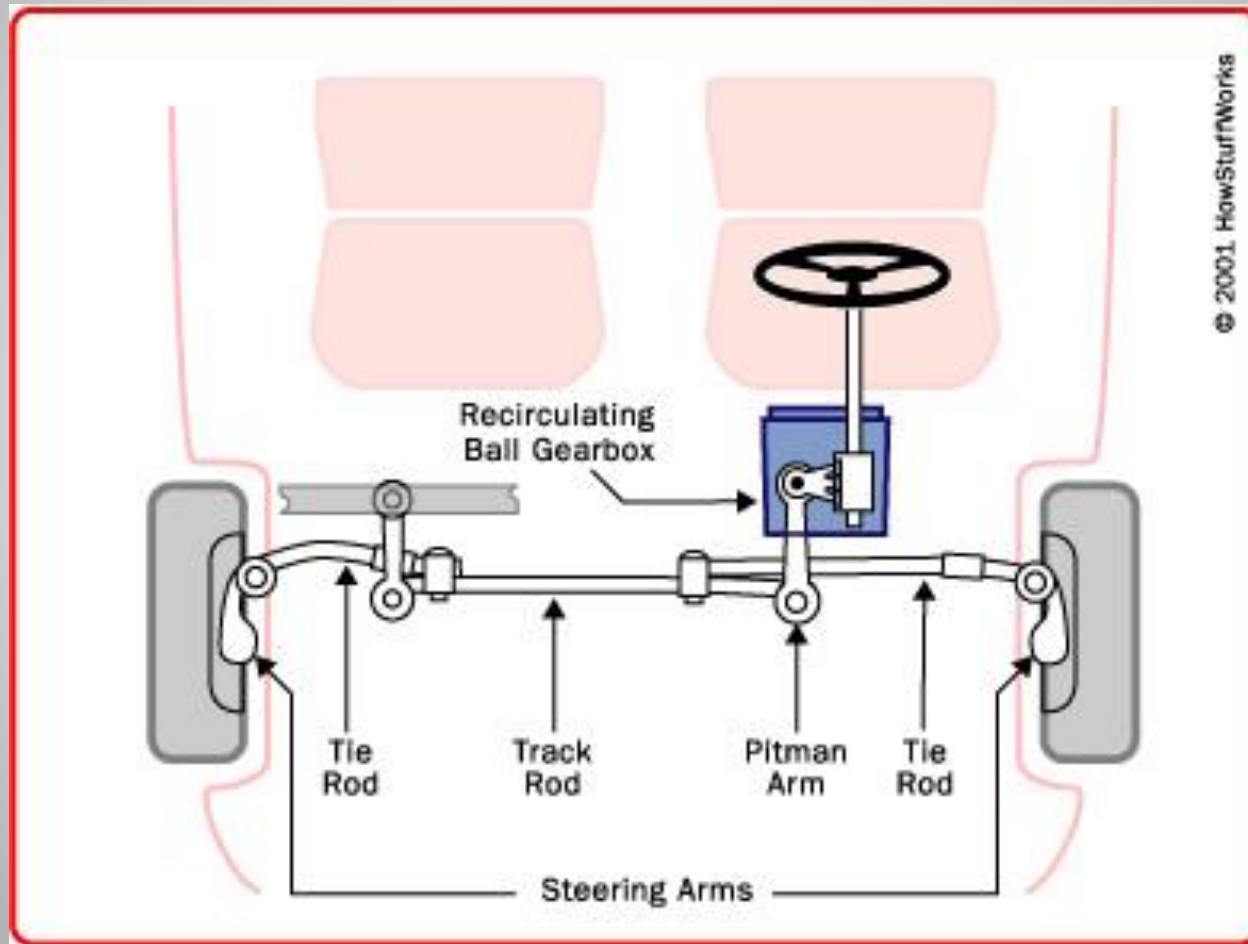
Turning the Car (when turning, front wheels don't point the same direction)



- Inside wheel turns at a smaller radius, hence the inside wheel turns at a steeper angle than the outside wheel.

Steering System

Linkage Steering System (Worm Gear)



Steering System

Linkage Steering System (Worm Gear) Parts

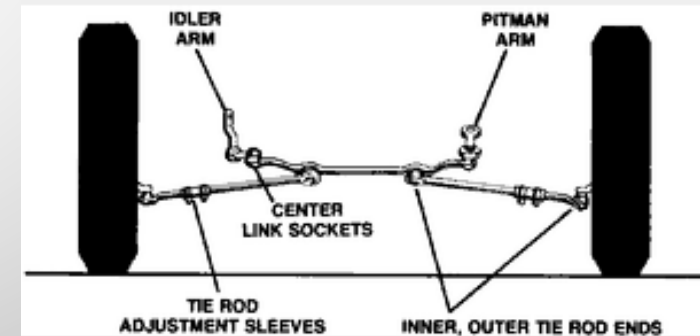
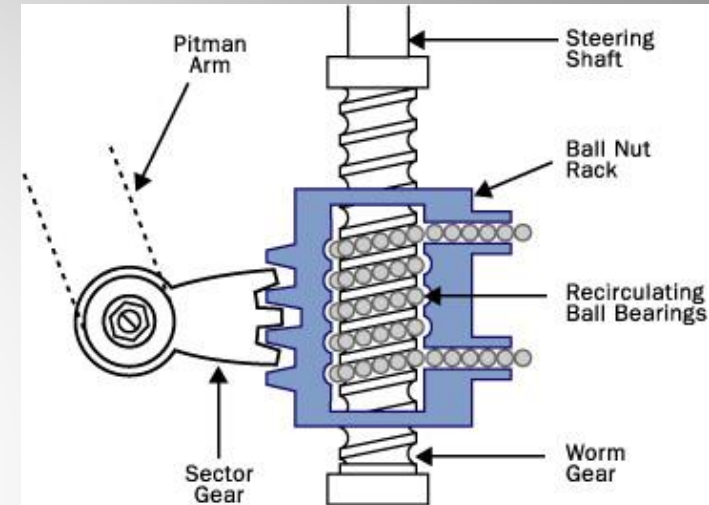
- **Steering Wheel** – used by the driver to rotate a steering shaft that passes through the steering column.
- **Steering Shaft** – transfers turning motion from the steering wheel to the steering gearbox.
- **Steering Column** – supports the steering column and steering shaft.



Steering System

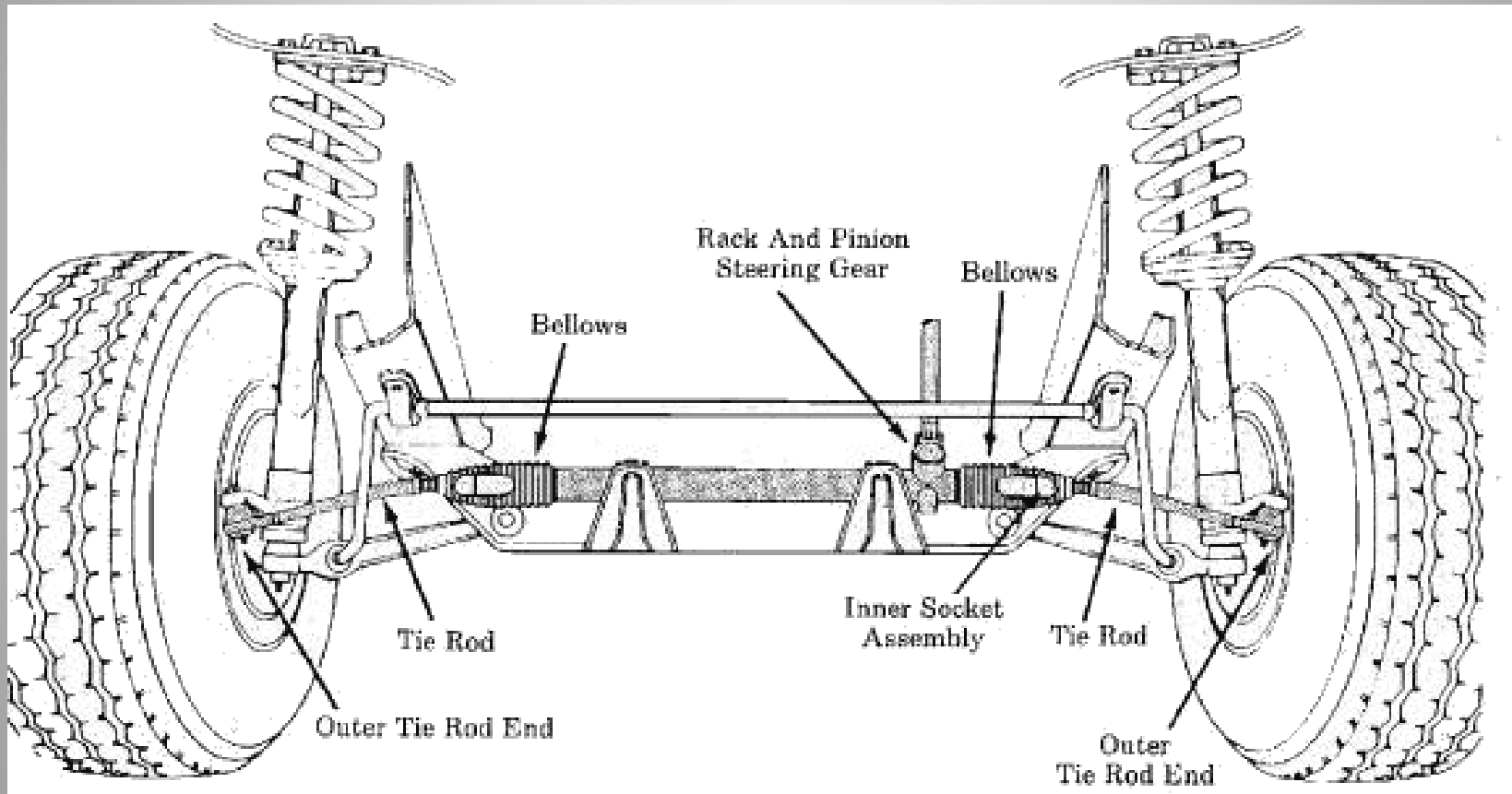
Linkage Steering System (Worm Gear) Parts

- **Steering Gearbox** – changes turning motion into a straight-line motion to the left or right.
- Steering gear box ratios range from 15:1 to 24:1 (with 15:1, the worm gear turns 15 times to turn the selector shaft once).
- **Steering linkage** – connects the steering gearbox to the steering knuckles and wheels.



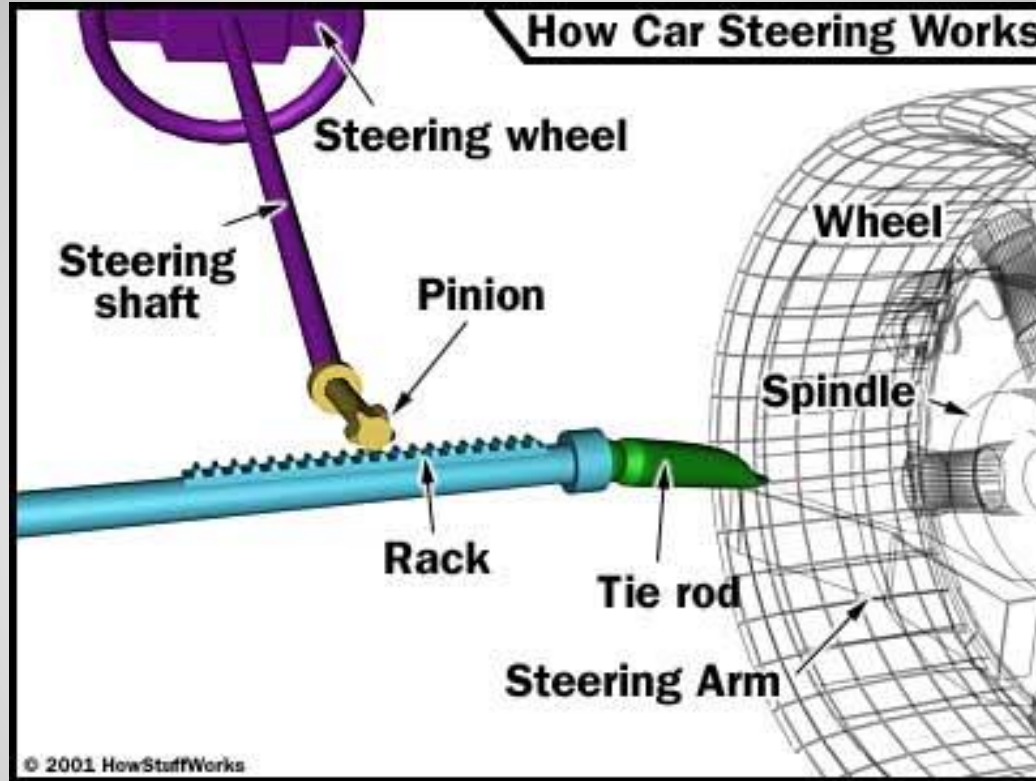
Steering System

Basic Rack-and-Pinion Steering



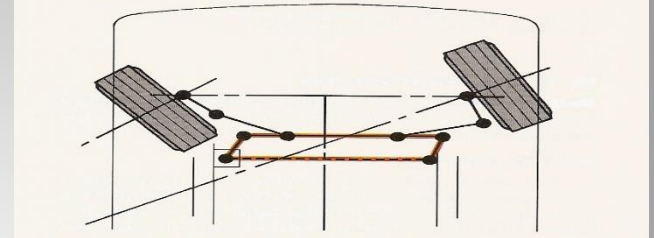
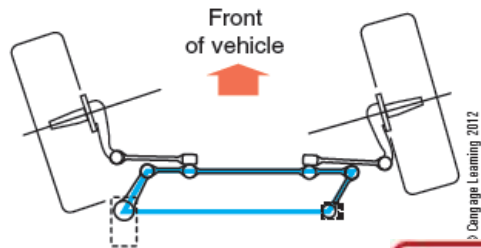
Steering System

Basic Rack-and-Pinion Steering

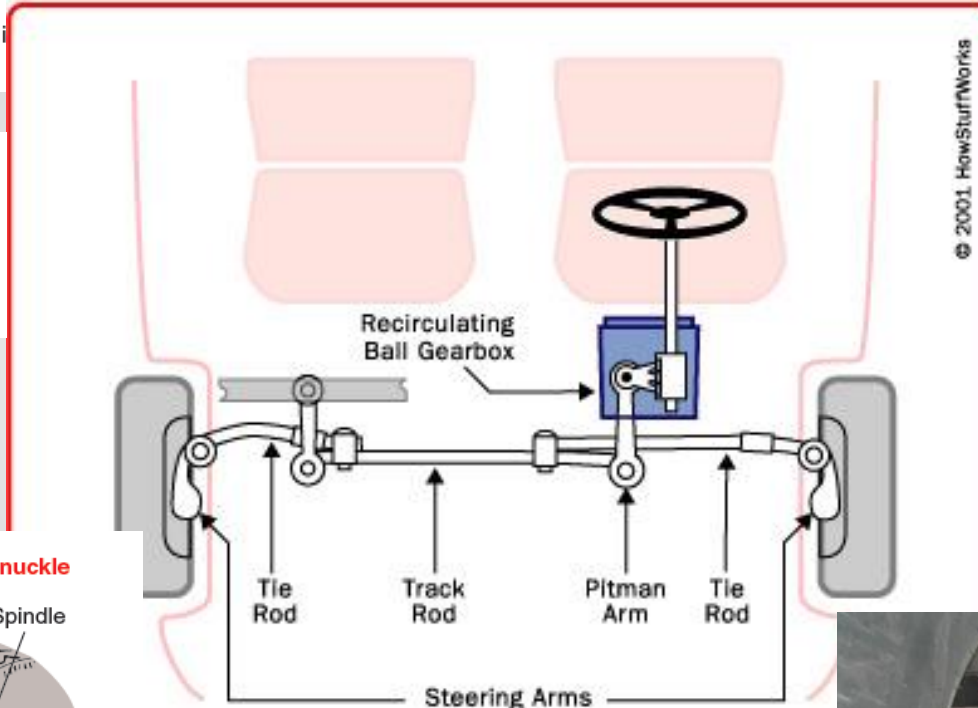


- **Pinion Gear**- rotated by the steering wheel and steering shaft; its teeth mesh with the teeth on the rack.
- **Rack**- long steel bar with teeth along one section; slides sideways as the pinion gear turns.

Steering Linkage



Pitman Arm transfers gearbox motion to the steering linkage.



Tie-Rod Assemblies: Two tie-rod assemblies are used to fasten the center link to steering knuckles.

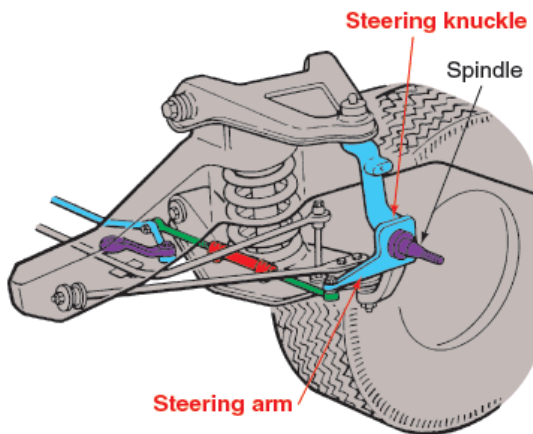
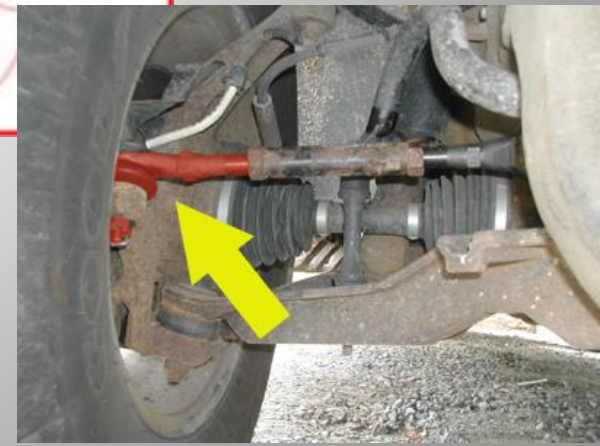


Figure 65.15 Steering arm and knuckle.



Figure 65.12 A cutaway of a tie-rod end.



Steering Geometry-

Reasons To Align Tires

- Easier steering equals less fatigued drivers
- Longer tire life which saves money
- Less wear on front-end parts, which reduces downtime and maintenance costs,
- Better fuel economy because it requires less horsepower to push misaligned tires

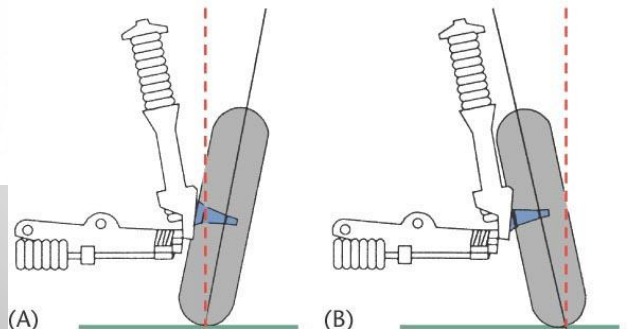
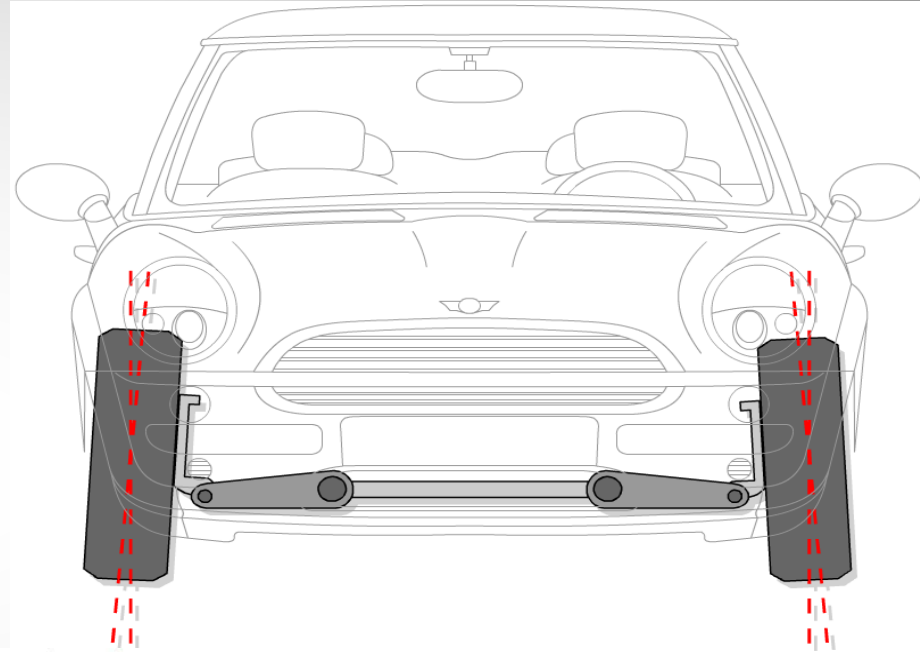
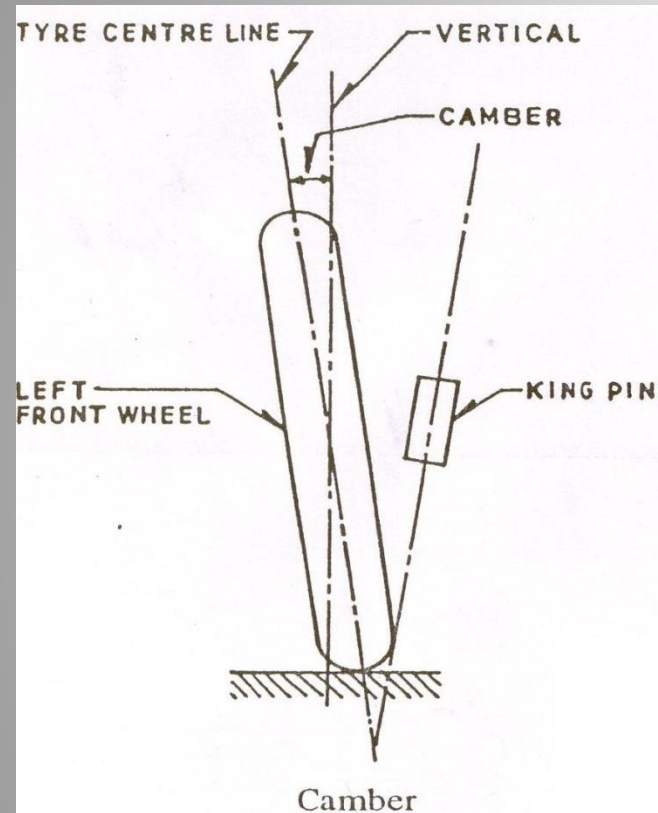
Steering Geometry-

• **Definition :-** “ The angular relationship among the front wheels, the front wheel attaching parts and the car frame is known as Steering geometry. ”

- Camber
- King Pin Inclination (Steering Axis Inclination)
- Combined Angle & Scrub Radius
- Castor
- Toe

1.Camber

Definition :- “Camber is the tilt of the car wheels from the vertical. ”



- Positive camber - top of wheels tilt outward.
- Negative camber - top of wheels tilt inward.

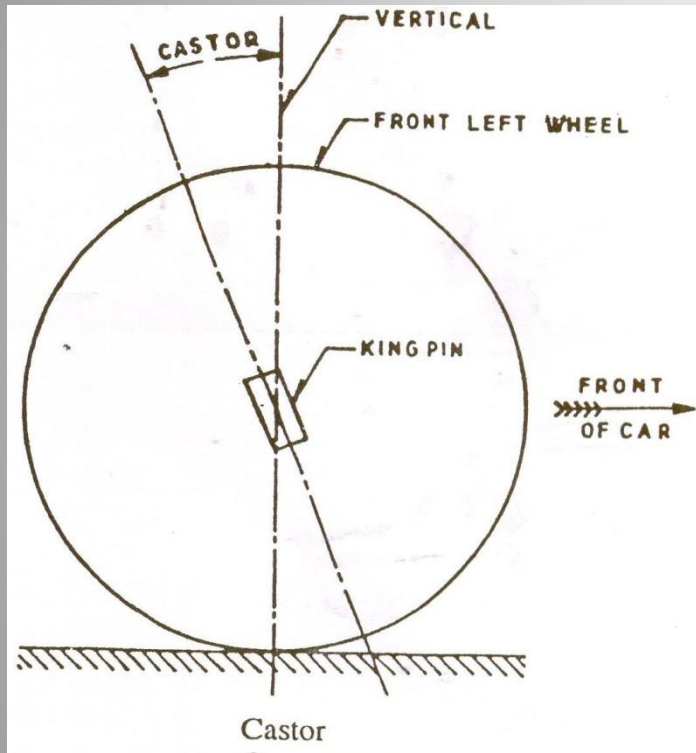
Functions:-

- To have easier control.
- To reduce the effect of road shocks on the steering gear

Camber should not generally exceed 2° . Rear wheels usually have zero camber.

2.Caster

Definition :- “ The angle between the king pin centre line (or steering axis) and the vertical, in the plane of the wheel is called the caster angle.”



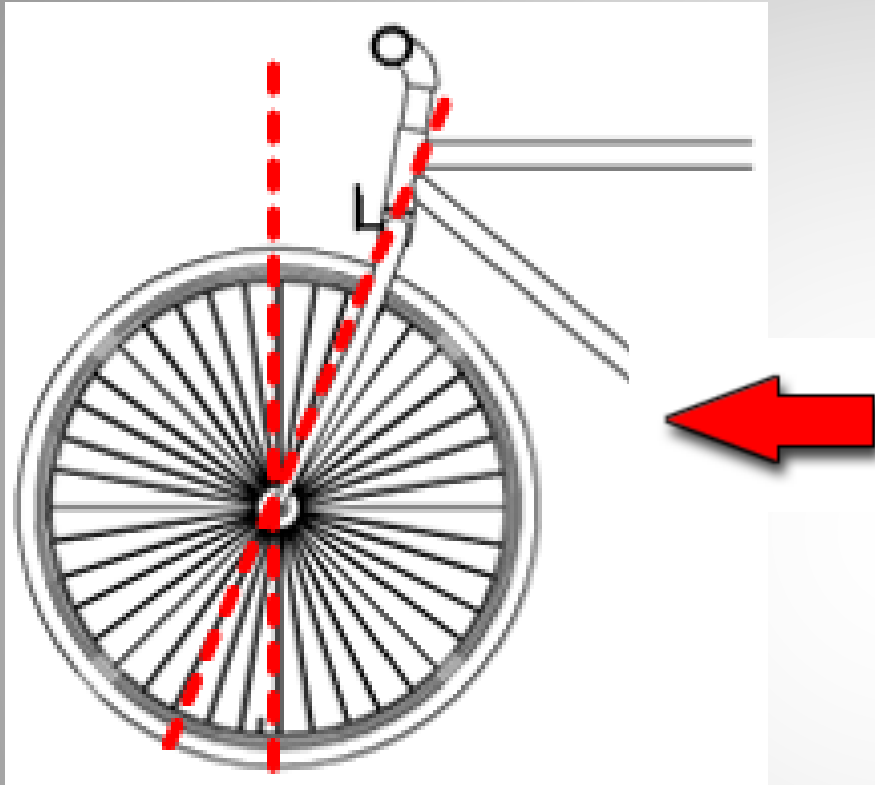
- **Positive Castor-** If the king pin centre line meets the ground at a point ahead the vertical wheel centre line

- **Negative Castor-** If the king pin centre line meets the ground behind the vertical wheel centre line.

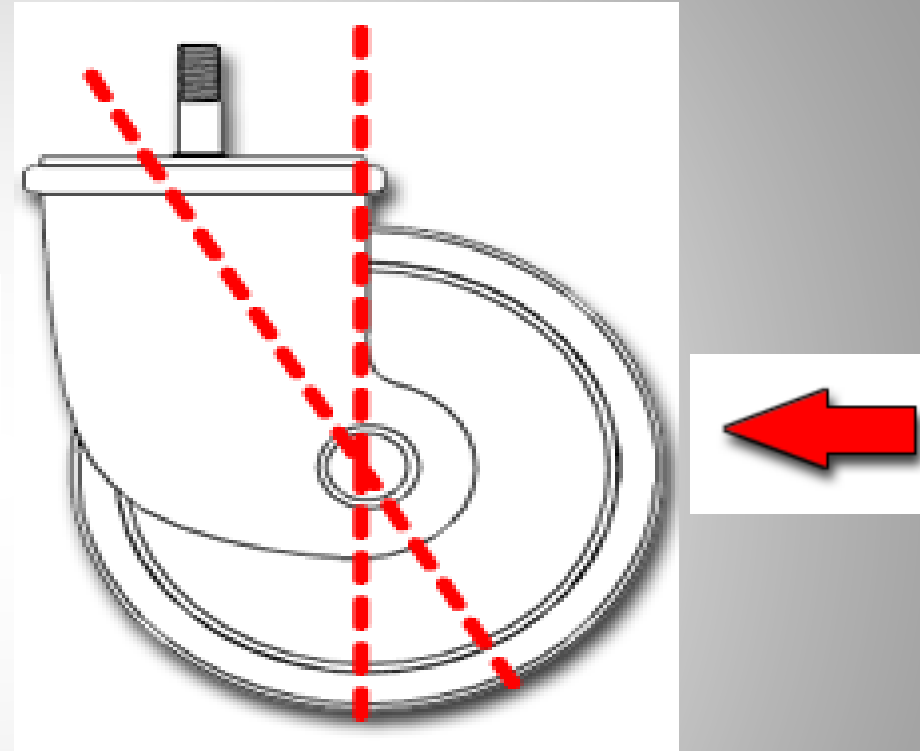


- Positive caster on the car wheels provides directional stability.
- As the change of caster angle result in the change of the other angles of the steering geometry, it is very important that caster angle is adjusted first and other angles adjusted later.
- About 3° caster angle gives good results.

Castor continued.....



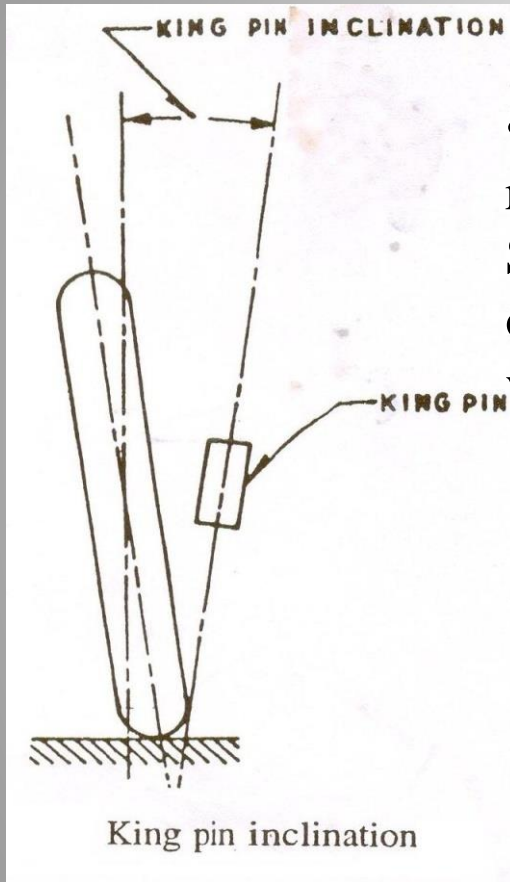
Castor on the front wheel
of the cycle.



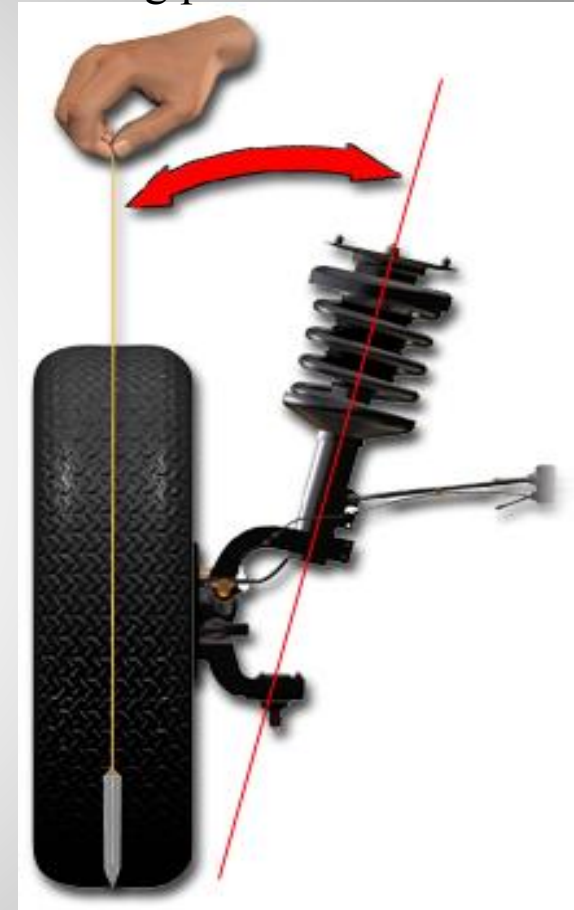
Castor on the furniture or
shopping trolley.

3. King pin inclination or steering axis inclination(SAI)

Definition :- “ The inclination of king pin from vertical is called as the king pin inclination.”



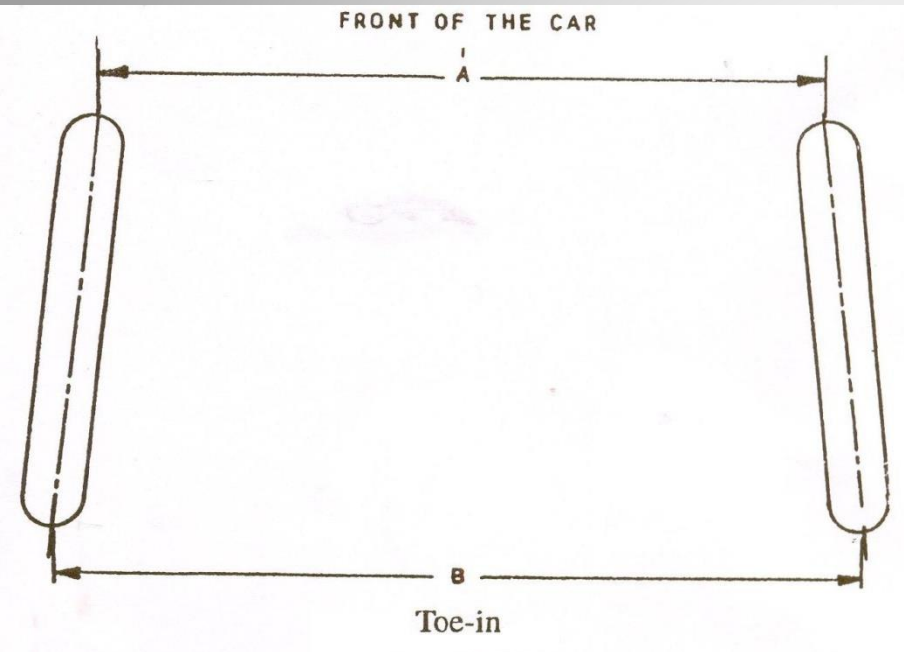
- In modern cars, this king pin is replaced by ball joints termed as SAI and is defined as the inclination of the ball joint axis from the vertical.
- King pin inclination (or SAI) helps the straight ahead recovery, thus providing directional stability.
- When the vehicle takes a turn, the inclination of king pin causes the vehicle body to move up, in relation to the wheels.



- About 7 to 8° SAI is provided and exact value also depends on camber angle.

4. Toe-in and Toe-out

A) **Toe-in**:- “Toe-in is the amount by which the front wheels are closer together at the front than at the rear wheels when the vehicle is stationary.”



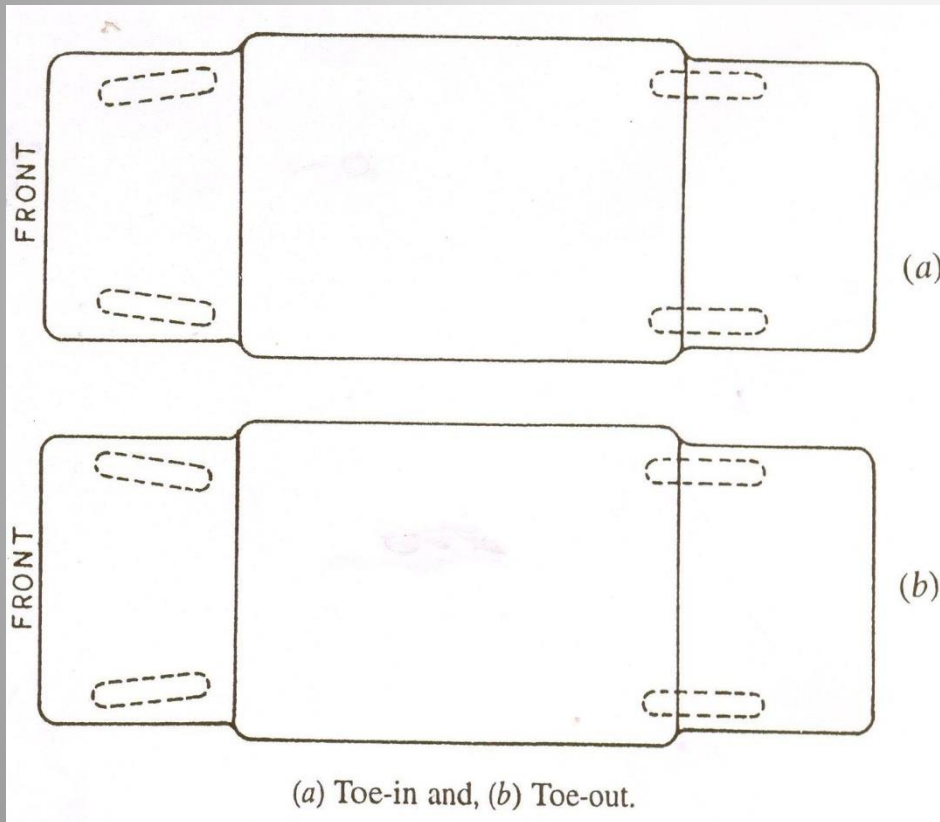
- $\text{Toe-in} = B - A$

- The main purposes of Toe-in is
 1. To keep the parallel rolling of the front wheels.
 2. To stabilize steering.
 3. To check side slipping and excessive tyre wear.

- When the motor is moving forward, the wheels tend to roll parallel on the road even though they are set to toe-in slightly.

- There is definite relation between toe-in and camber. The more the camber, the more is the toe-in and vice versa.

B) Toe-out: “ Toe-out is the amount by which the wheels may be set closer at the rear than front in which the difference of the distances between the front wheels at the front and the rear is called Toe-out”

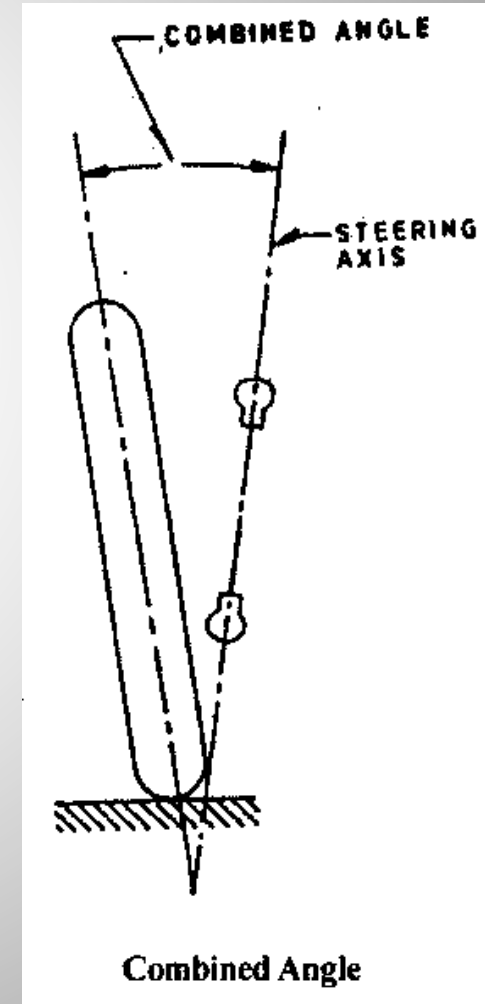


- Toe amount affects the handling characteristics. i.e. increase in toe-in would result in decreased over steer and increased directional stability at high speeds.
- where as increased toe-out would result in reduced under steer and greater ease in steering.

5. Included angle(or combined angle)

Definition:- “The sum of camber and SAI angles in front suspension is called as included angle.”

- Combined angle or included angle is the angle formed in the vertical plane between the wheel centre line and the king pin centre line.
- This angle is measured indirectly and is used primarily to diagnose bent suspension parts such as spindles and struts.

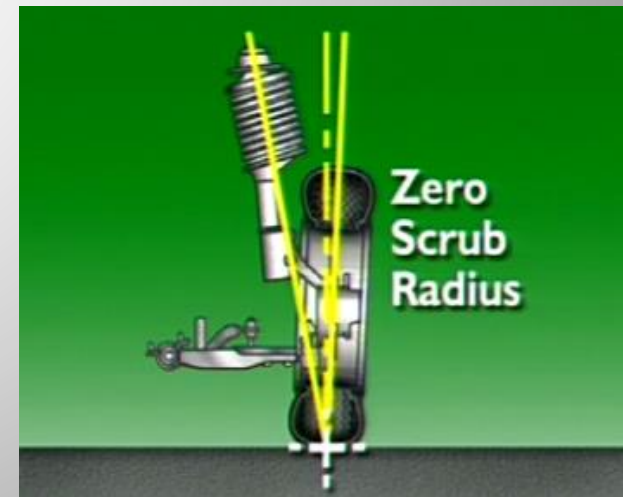
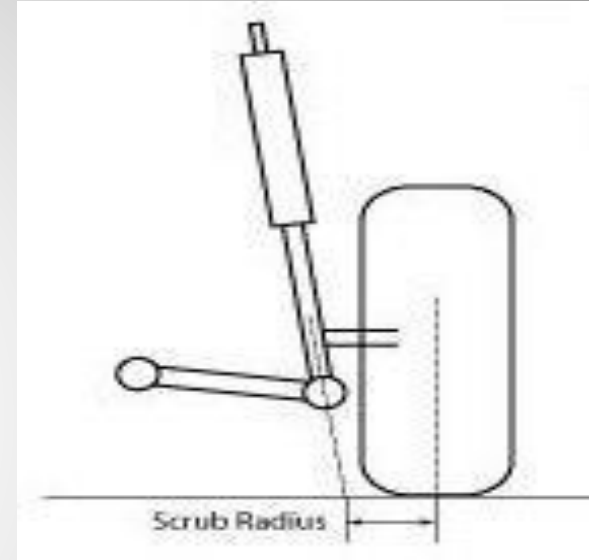


Scrub Radius

Definition:- “The **scrub radius** is the distance in front view between the King pin axis and the center of the contact patch of the wheel, where both would theoretically touch the road.”

- It is measured in mm.
- If these two points intersect at the center of the tire, at the road surface, then the scrub radius is **ZERO**.
- If they intersect below the road surface, scrub radius is **POSITIVE**.
- If they intersect above the road surface, scrub radius is **NEGATIVE**.

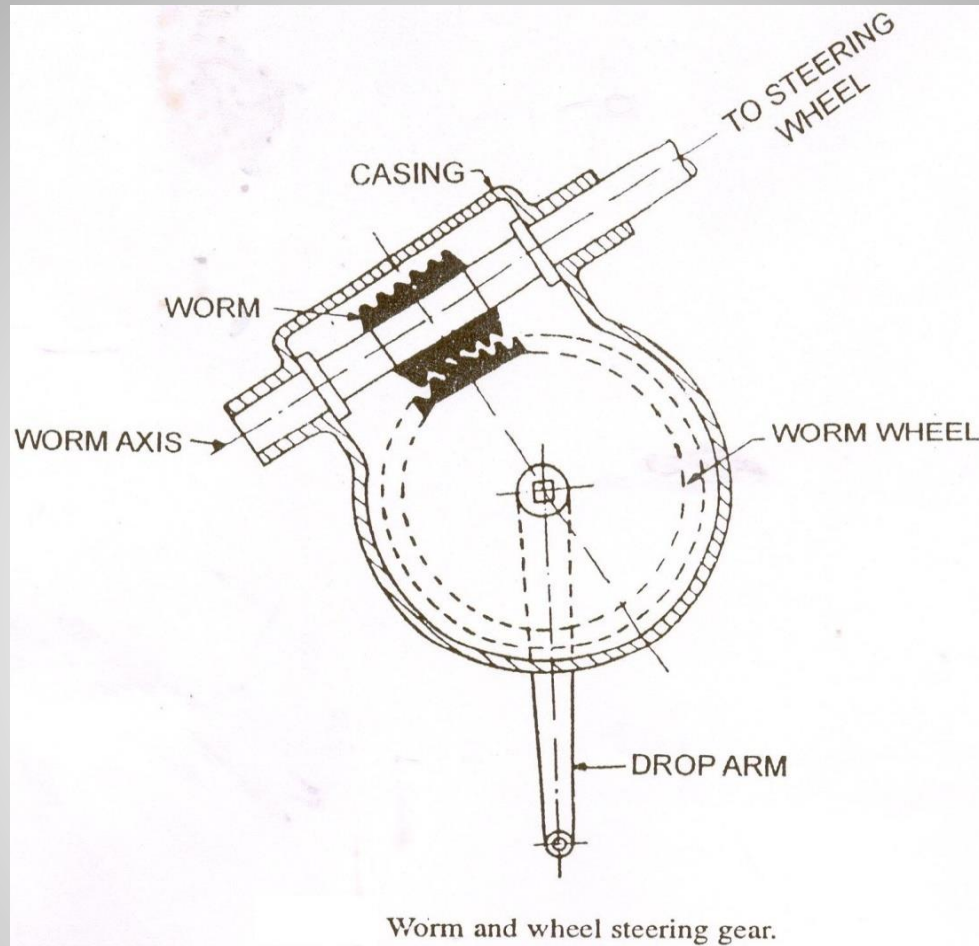
If scrub radius is zero then the wheel keeps its straight position, without any tendency to toe-in or toe-out.



Types of Steering Gear Boxes

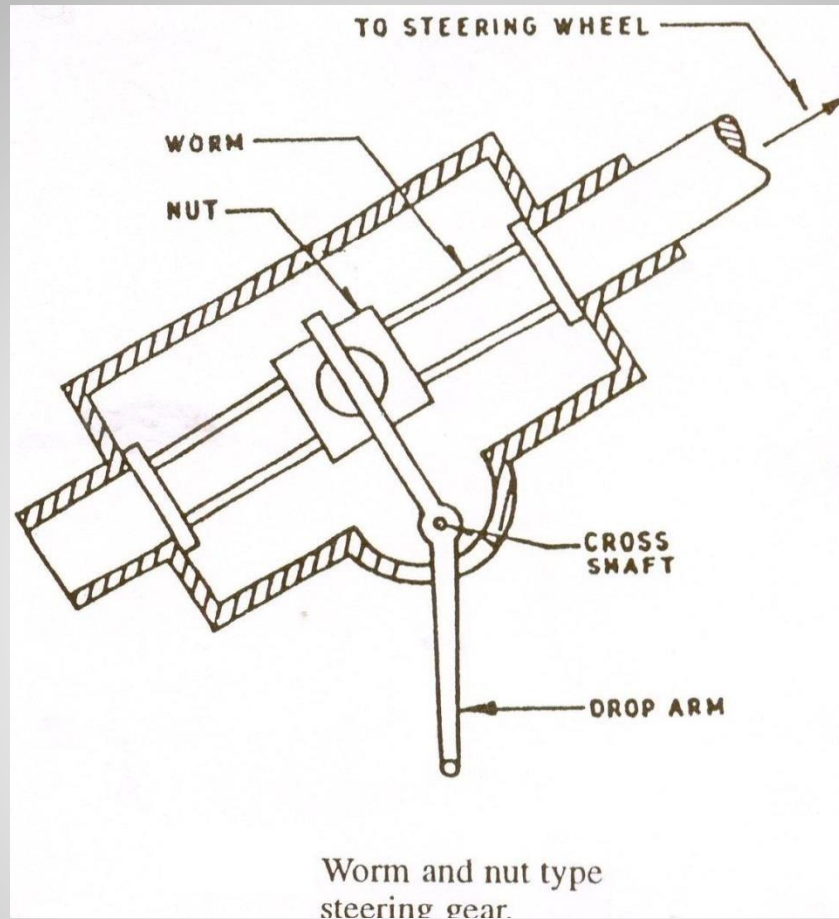
1. Worm and Worm wheel gear
2. Worm and Nut steering gear
3. Recirculating Ball Type steering gear
4. Rack and Pinion steering gear
5. Cam and double roller steering gear
6. Cam and peg steering gear
7. Screw and Nut steering gear

1. Worm and Worm Wheel gear



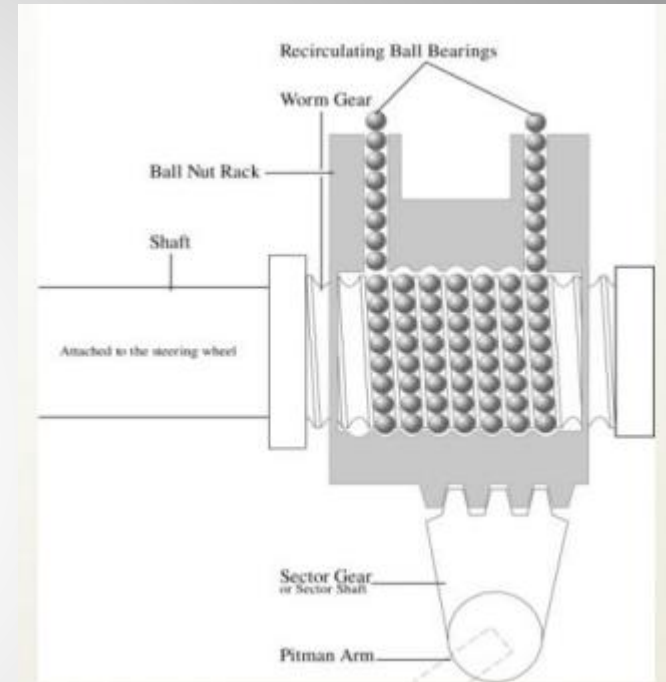
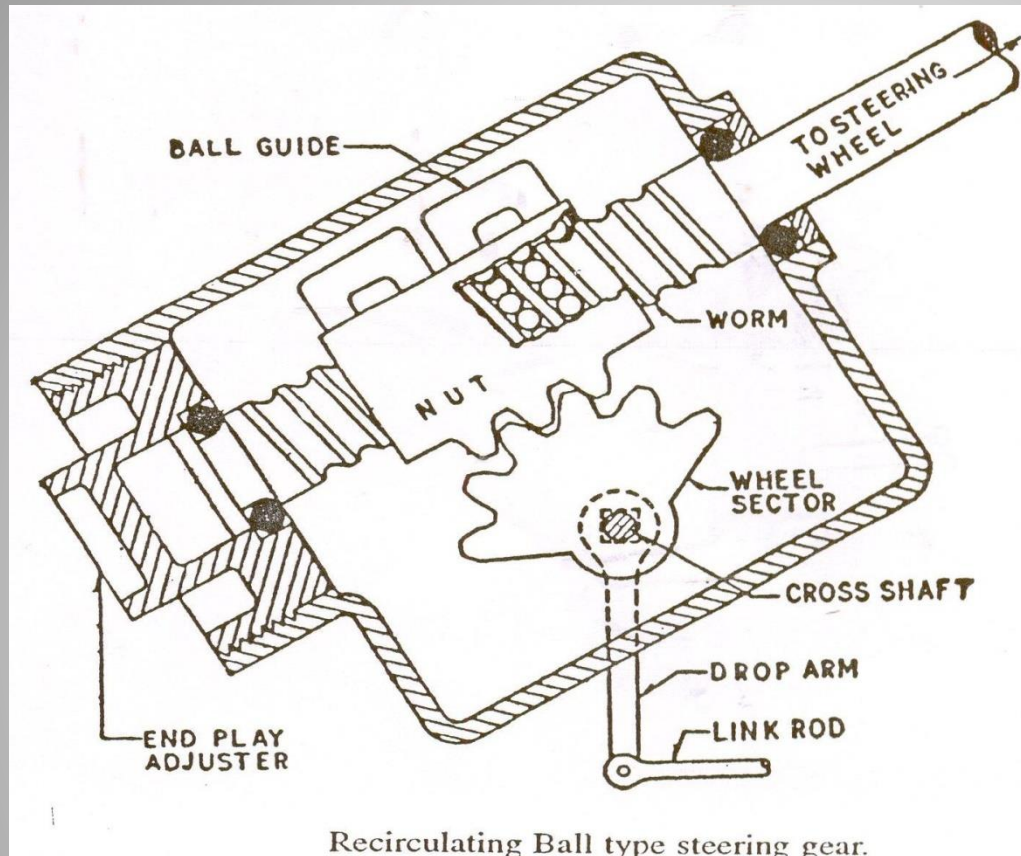
- Movement of steering wheel turns the worm, which in turn drives the worm wheel.
- Drop arm is rigidly attached to wheel spindle, so that a rotation of the steering wheel corresponds to a linear motion of the drop arm end, which is connected to the link rod.

2. Worm and nut steering gear



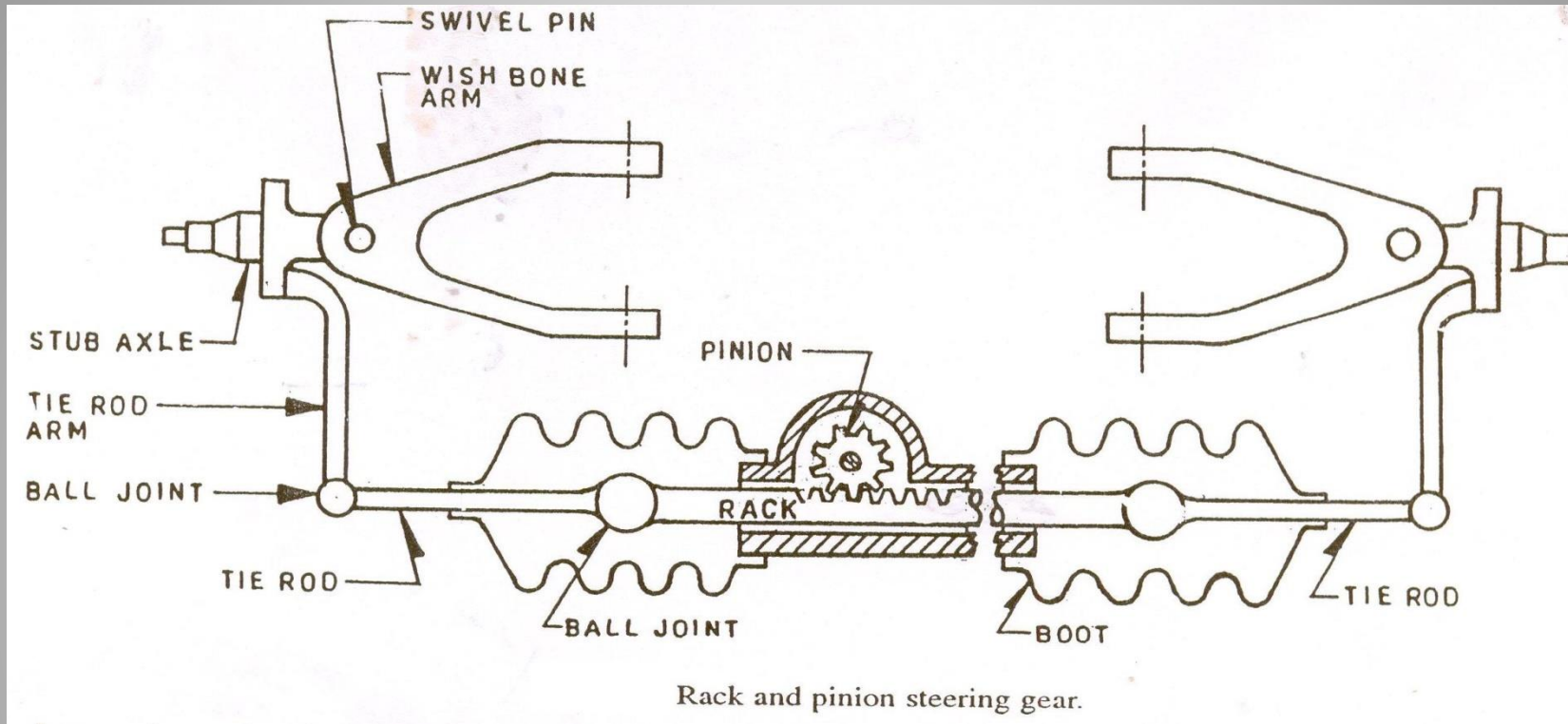
- This gear consists of a steel nut, screwed on to a multi-start Acme thread formed on the inner column.
- The steering wheel rotation rotates the worm which in turn moves the nut along its length.
- This causes the drop arm end to move linearly, further moving the link rods and steering.

3. Recirculating Ball type steering gear



- If a nut with steel balls acting as threads is used in worm and nut steering gear, a higher efficiency of 90% can be obtained. This is improved form of worm and nut.
- It consists of a worm at the rod of the steering rod. A nut is mounted on the worm with two sets of balls in the grooves of the worm, in between the nut and the worm.
- When the steering wheel is turned, the balls in the worm roll in the grooves and cause the nut to travel along the length of the worm.

4. Rack and pinion steering gear



- The rack and pinion steering has rack acting as the centre section of a three piece track rod.
- The rotary motion of steering wheels is transmitted to the pinion is transferred into the linear rack movement, which is further relayed through the ball and tie rods to the stub axles for the wheels to be steered.
- It is simple, light and responsive. Also occupies very small space and uses lesser number of linkages compared to worm and worm wheel type steering gear.

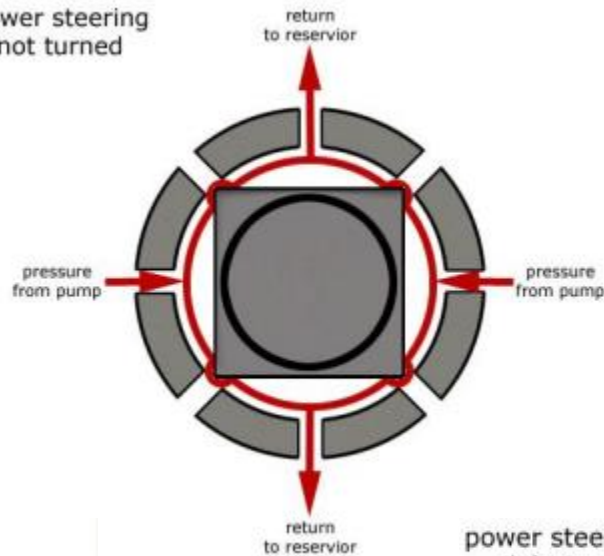
Power Steering

- Steering systems on most cars today are power assisted
 - Some manual units are still made
- Most power steering is hydraulic
 - Pressure supplied from crankshaft by belt-driven pump

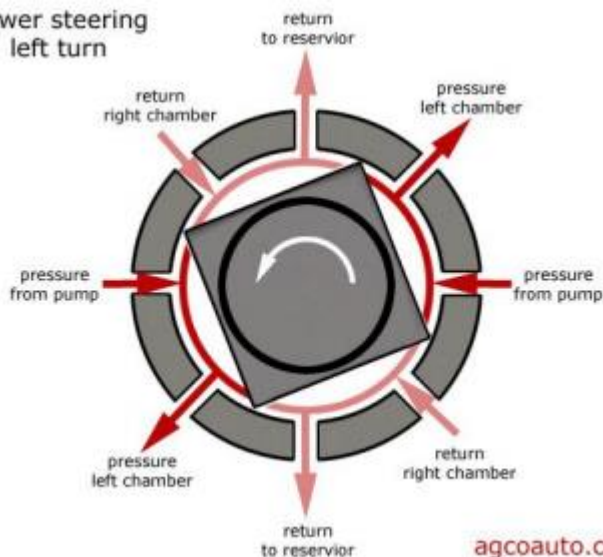
Power Steering System

Power Steering normally use an engine driven pump and a hydraulic system to assist steering action.

power steering
not turned

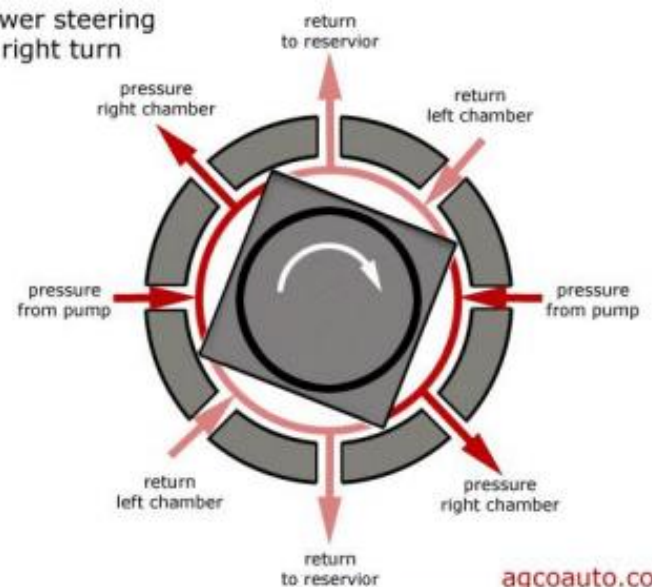


power steering
left turn



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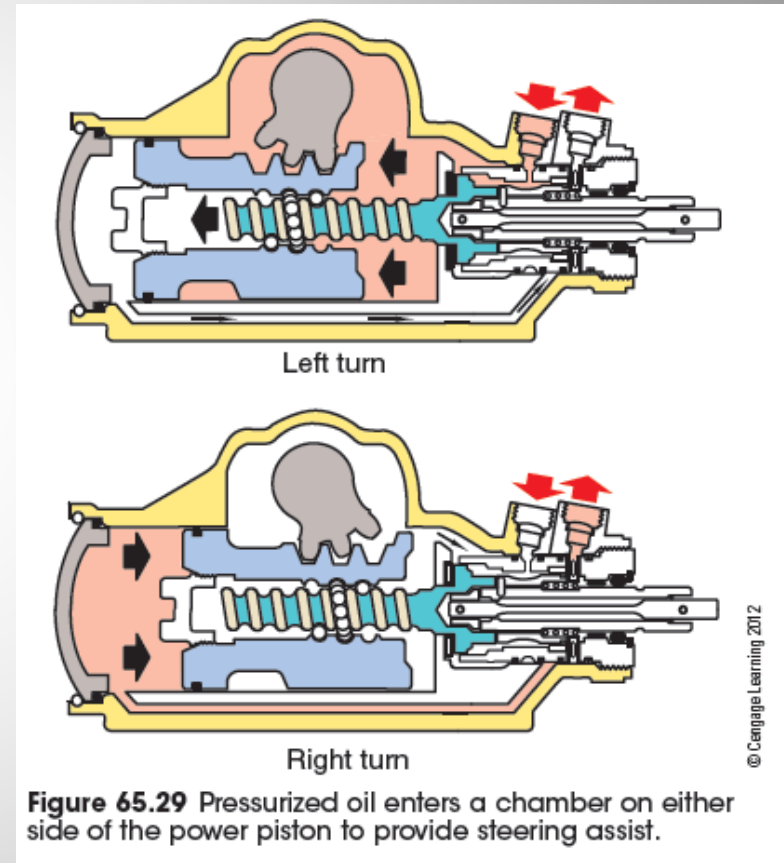
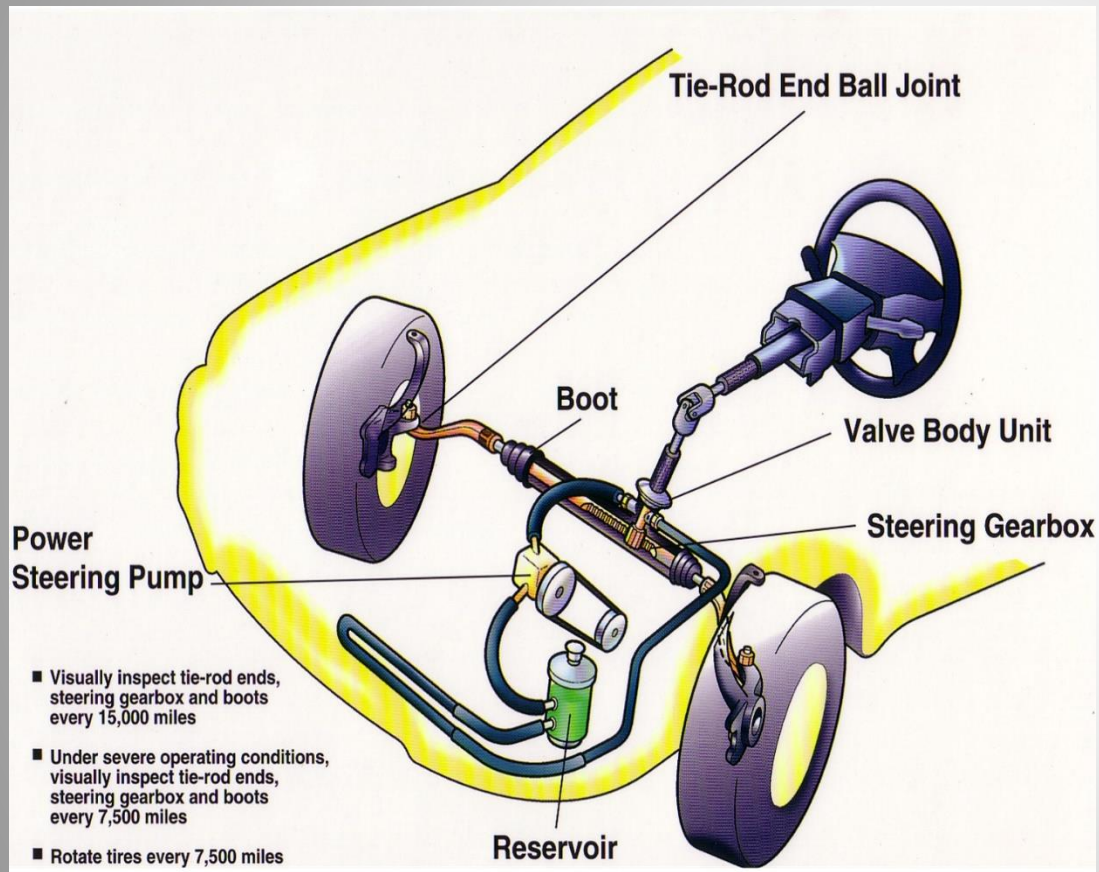
power steering
right turn



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Power Steering System

Power Steering normally use an engine driven pump and a hydraulic system to assist steering action.



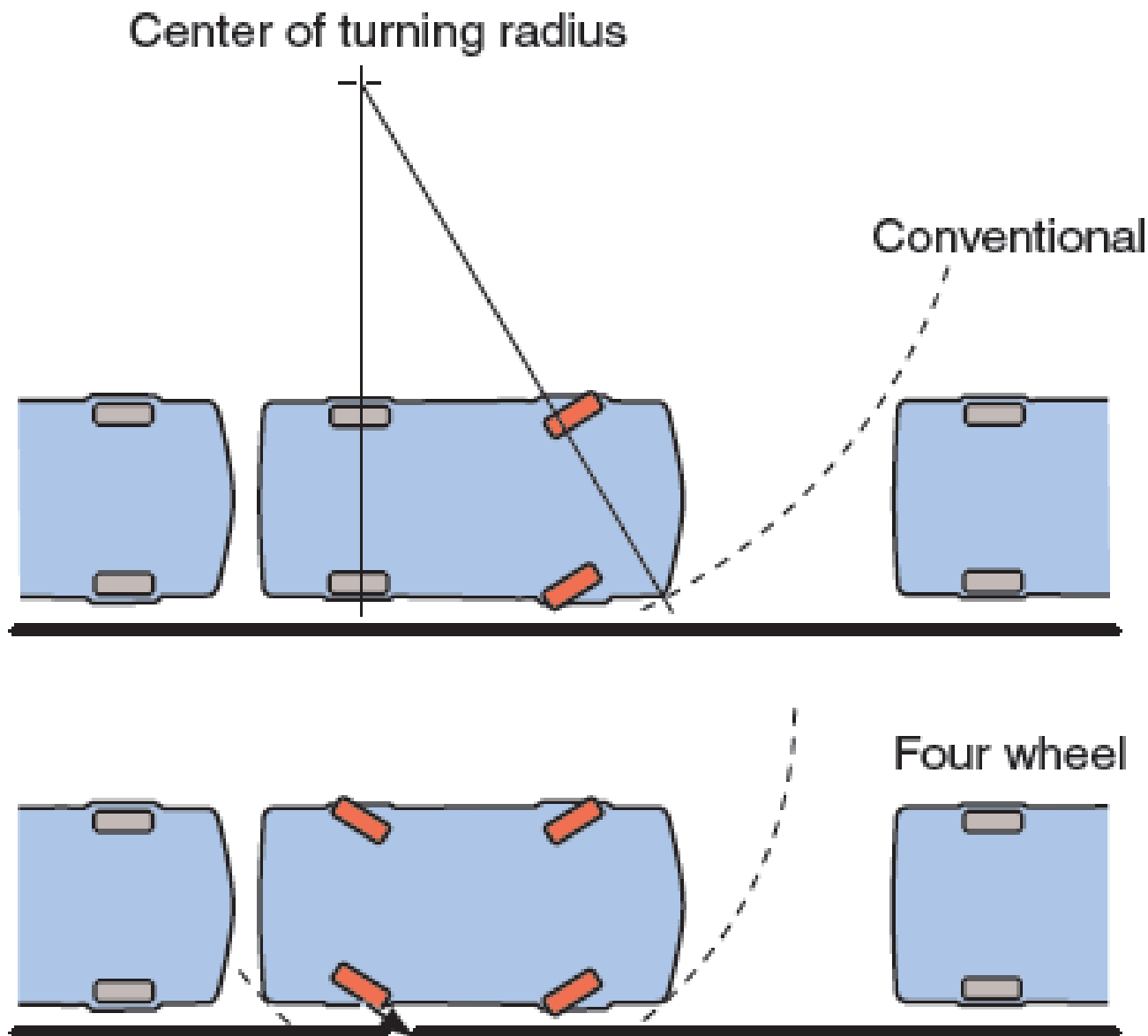


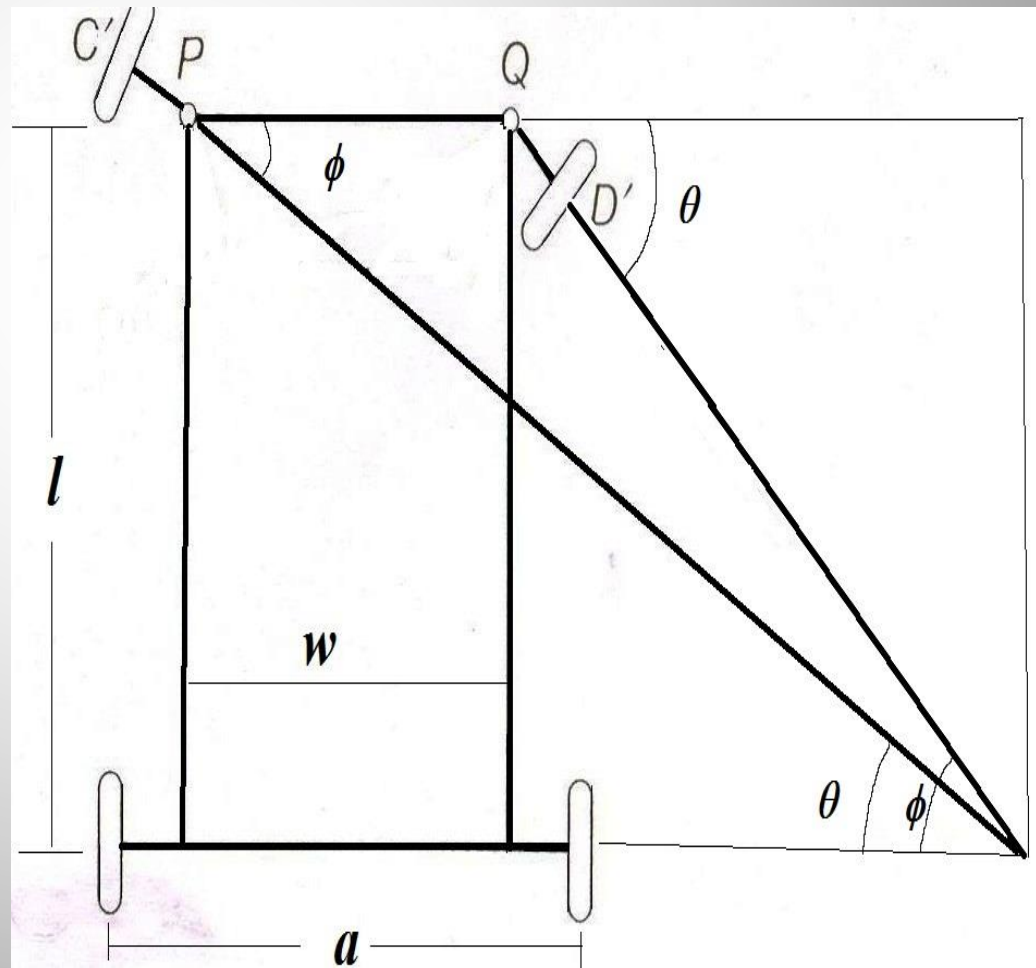
Figure 65.36 The action of conventional front-wheel steering and four-wheel steering when parallel parking.

Automotive steering Mechanism

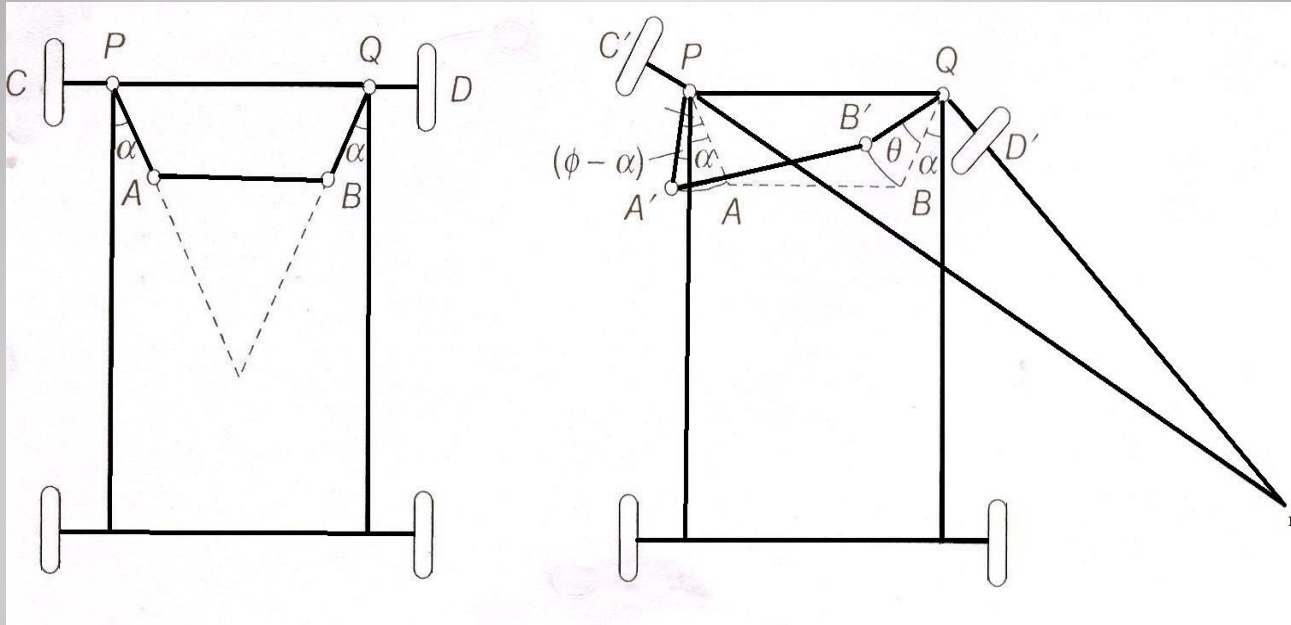
1. Ackerman Mechanism
2. Davis Mechanism

Fundamental equation of correct gearing is given by,

$$\text{Cot } \phi - \text{Cot } \theta = (w/l)$$

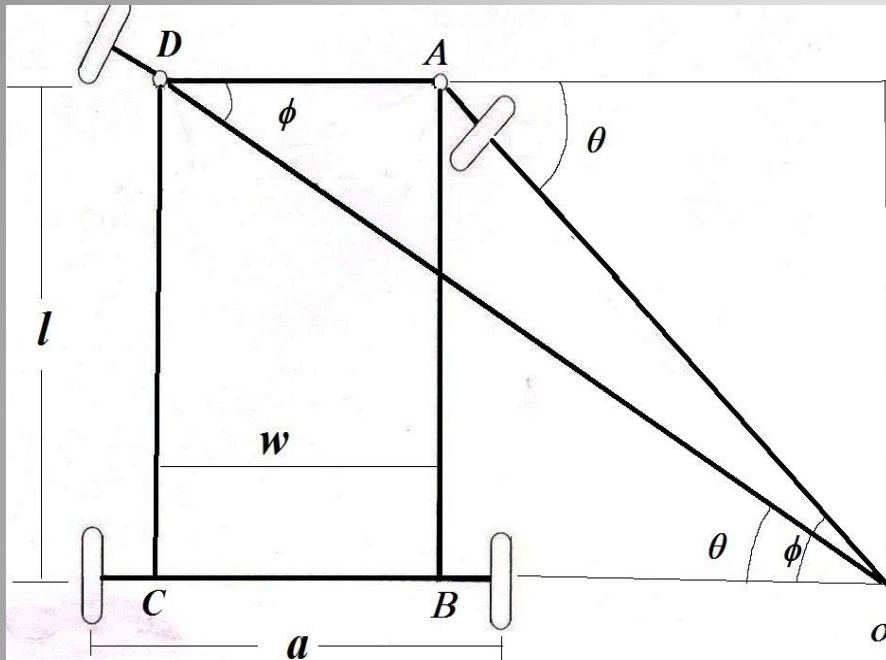


Ackerman Steering Mechanism



- Ackerman gear does not fulfill the fundamental equation of correct gearing in all the positions but only three positions.
- Three positions of correct gearing are
 - 1.When the vehicle moves straight
 - 2.When the vehicle moves at a correct angle to the right, and
 - 3.When the vehicle moves at a correct angle to the left.

Condition for true rolling(pure rolling):-



- During taking a turn or moving on a curved path, the wheels should follow a true radius with each radius originating from the same centre.
- For true rolling and avoiding any lateral slip, the outer steered wheel has to turn through angle θ and the inner steered wheel has to turn ϕ .

$$\text{Now, } CB = OC - OB = CD \cot \theta - BA \cot \phi$$

Since $CD = BA$, therefore dividing by CD throughout

$$(CB/CD) = \cot \theta - \cot \phi \text{ or}$$

$$(w/l) = \cot \theta - \cot \phi$$

Wheel Alignment

Definition:-“ Wheel alignment is defined as the correct adjustment of pivot axes controlling the movement of the wheels. ”

- Wheel alignment is the positioning of the steered wheels to achieve,
 1. Directional stability during straight ahead position.
 2. Perfect rolling condition on steering.
 3. Recovery after completing the turn.

- Different types of alignments:-
 1. The front- end alignment
 2. Thrust angle alignment
 3. Four-wheel alignment