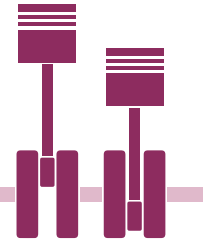


## Steering System



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### Learning objectives



1. To make the students to understand on need and types of steering system.
2. To make the students to understand upon various components, construction and working principle of a steering system.





## 8.0 Introduction

The most conventional steering arrangement is to turn the front wheels using a hand-operated steering wheel which is positioned in front of the driver to allow it to deviate somewhat from a straight line. The system allows a driver to use only light forces to steer a heavy vehicle. Front axle carries the weight of the front part of the automobile as well as facilitates steering and absorbs shocks due to road surface variations. Let us see about the structure and its functioning in the following segment.



## 8.1 Functions of the steering system

- Steering system is helps to turn the front wheels on desired direction with the help of steering wheel.
- This system provides to vehicle steer in turning are also stabilize the vehicle on the straight road.



## 8.2 Parts of steering system

1. Steering Wheel
2. Steering Column
3. Steering Shaft
4. Steering Gear Box
5. Cross Shaft
6. Drop arm (or) Pitman arm
7. Drag Link (or) Pull and Push rod
8. Tie Rod or Track Rod
9. Ball Joint
10. Front Axle
11. Road Wheel

### 8.2.1 Steering parts and its uses

#### 1. Steering Wheel

It is a circular wheel mounted at the centre portion with two or three rods. The steering wheel is connected with steering gear box through steering shaft. So the road wheels are turns easily when rotation of steering wheel.

#### 2. Steering Column

It is hollow shaft in which is made up on alloy steel. The steering shaft rotates with the help of bearing. In modern vehicles, the gear change lever is provided at the steering column for the convenience of the driver.

#### 3. Steering Shaft

It is made up of good quality steel. The upper end is fixed in steering wheel with the help of splines (or) key. The other end is connected to the steering gear box.

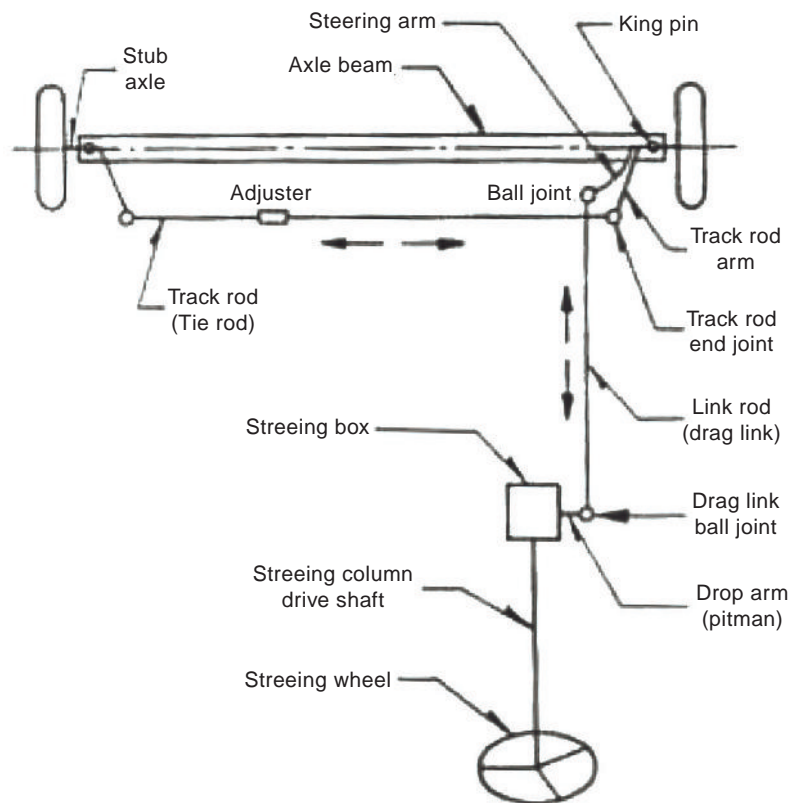
#### 4. Steering Gear Box

The steering gear box serves the following purposes.

1. It provides mechanical advantages and enable the driver to steer the vehicle easily.
2. It converts the turning motion of the steering wheel into the to-and-fro motion of the link rod of the steering linkage.

#### 5. Steering Linkages

- When the steering wheel is turned its motion is carried to the steering gear box through the steering shaft.



**Figure 8.2.1 (a)** Steering system

- This motion is converted into angular motion of the drop arm which is connected to the link rod.
- The other end of link rod is connected to the steering arm by means of ball joint. The steering arm is connected to the lower end of the stub axle. Both the steering arms are connected by a tie rod.
- When the steering wheel is to be turned to the right side or left side, the stub axle turns to the wheels either left or right side. The steering linkage as shown in figure 8.21 (a).



### 8.3 Steering gear box

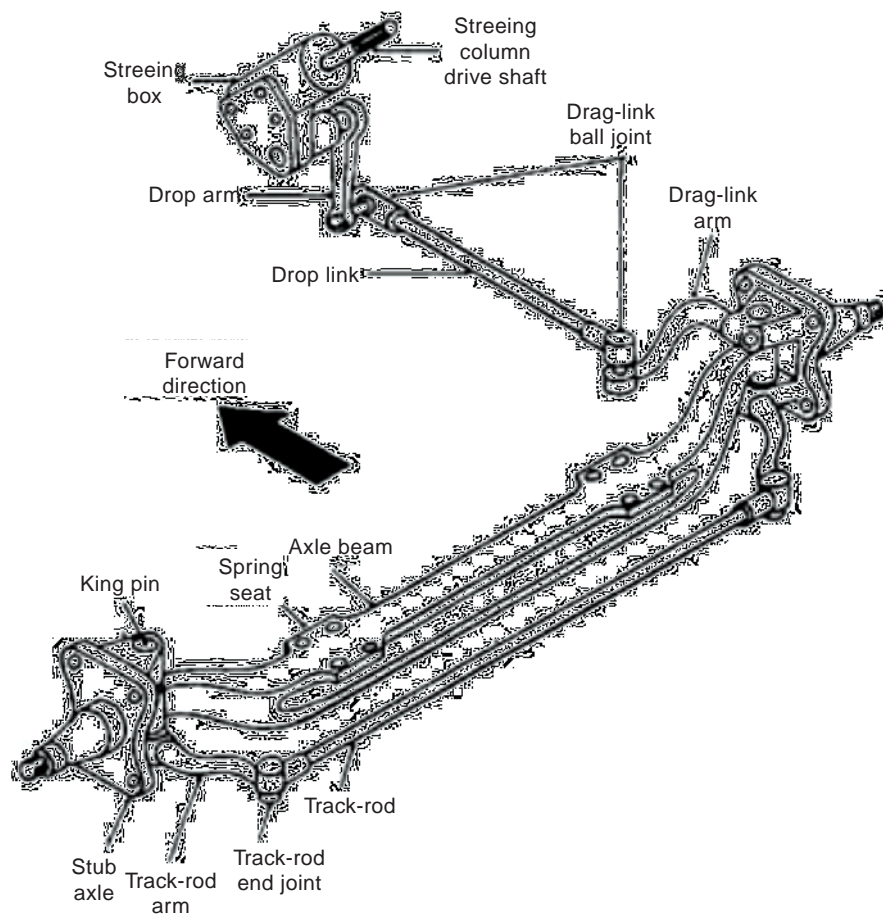
- The case which holds the steering gear is called as steering gearbox.
- The Rotary movement of the steering wheel is converted into reciprocating motion of the steering linkage.

- The driver easily turns the stub axle either left or right side with the help of steering gear box.

#### 8.3.1 Types of steering gear box

Based on the construction and working principle the steering gear box are classified into the following types

1. Worm and sector type
2. Worm and Roller type
3. Worm and Nut type
4. Worm and wheel type
5. Recirculating Ball type steering gearbox
6. Cam and Peg Steering Gear Box
7. Cam and Roller type
8. Rack and Pinion Steering Gear Box



**Figure 8.2.1 (b)** Steering system

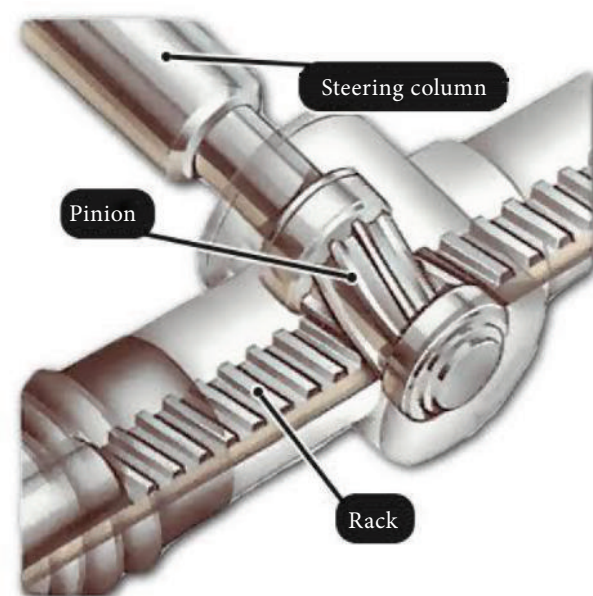
### 8.3.1.1 Rack and pinion steering gear box

#### Construction

- In this type of steering gearbox, in place of cam or worm, the pinion gear is attached to the steering shaft through universal joints.
- The pinion is meshed with rack gear. The circular input motion of the pinion is converted into a linear rack output movement.
- The tie rod at each end of the rack is connected to the steering arm by means of ball joint.

#### Working Principle

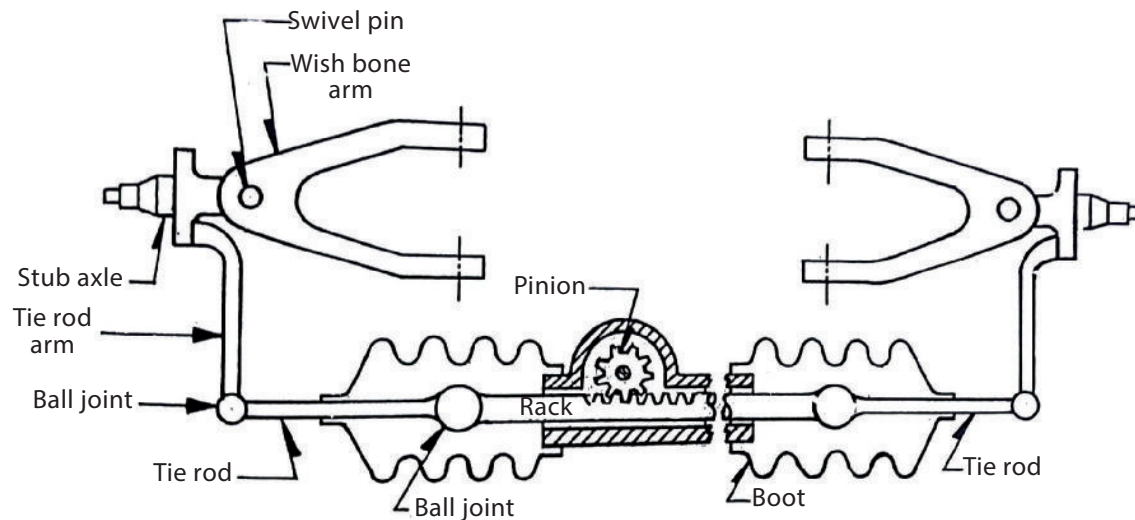
- When the drive turns the steering wheel, the pinion at the end of steering wheels rotates at its own axis.
- Based on the direction of rotation of the pinion, the rack moves towards the left or right.



**Figure 8.3.1.1 (a)** Rack and pinion type steering gear box







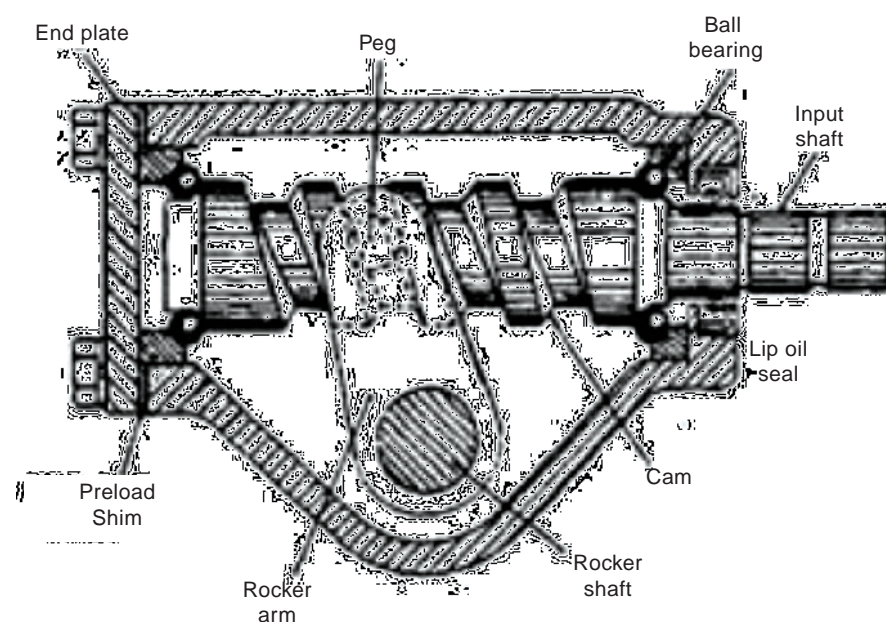
**Figure 8.3.1.1 (b)** Rack and pinion type steering gear box

- This rack movement, make the tie rod to push the steering arm on one side and to pull the steering arm on other side.
- This turn the stub axle at its pivot point. The wheel attached in the stub axle is also turned and thus the steering movement is achieved.

### 8.3.1.2 Cam and Peg Steering Gear Box

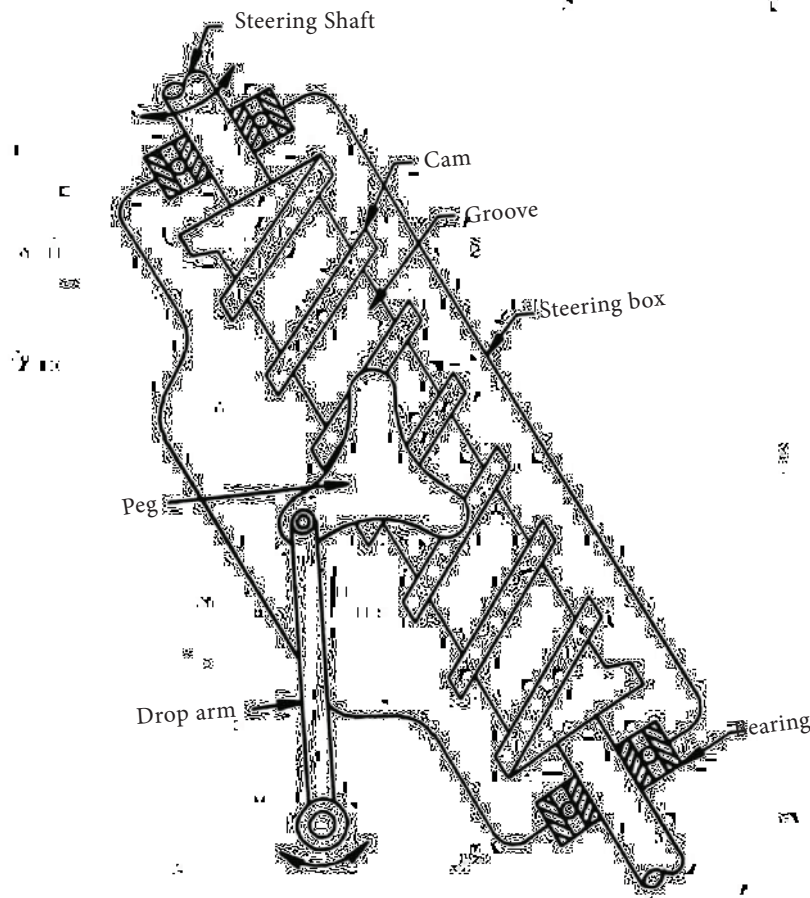
#### Construction

- This type of steering box, in place of worm, a cylindrical shaft, supported by two roller bearing in the housing.
- The cylindrical shaft carried a deep spiral groove, usually a variable pitch



**Figure 8.3.1.2 (a)** Cam & peg type steering gear box





**Figure 8.3.1.2 (b)** Cam and peg type steering system

on its surface between its bearing and this shaft is known as a cam.

- An integral rocker arm and shaft is placed half-way along the cam. At the free end of the rocker arm a conical peg is fitted which engages the groove.

### Working Principle

When the steering wheel and shaft rotate the camshaft, one side of the spiral groove screws the peg axially forward or backward, depending upon the direction of turning of the cam. This forces the rocker arm to pivot about its shaft axis and as a result a similar angular motion is transferred to the drop arm, which is attached to the shaft's outer end. Thus the road wheels are turned either left or right.

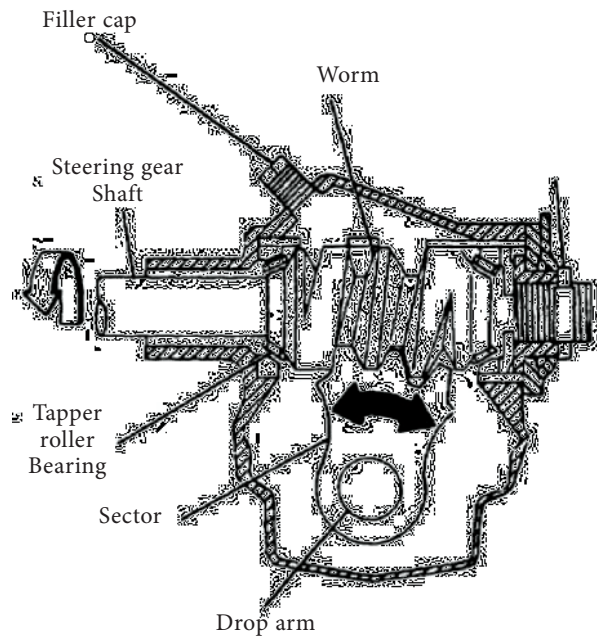
### 8.3.1.3 Worm and Sector Steering Gearbox

#### Construction

- The worm is firmly connected to the inner column of the steering shaft.
- Worm shaft is mounted on the housings with the help of two taper roller bearing makes the rotation of shaft easily.
- The sector gear is meshed with worm.
- The sector gears form a part of the rocker shaft in the steering gear box.

#### Working principle

- When the driver turns the steering wheel, the worm will turn and turns the sector gear. The rotary motion of



**Figure 8.3.1.3** Worm and sector steering box

the steering wheel is converted into angular motion of the sector gear.

- The drop arm attached to the sector is also oscillated and through the steering linkages, the wheel is turned to the required degrees in the required direction.

#### 8.3.1.4 Recirculating ball type steering gear box

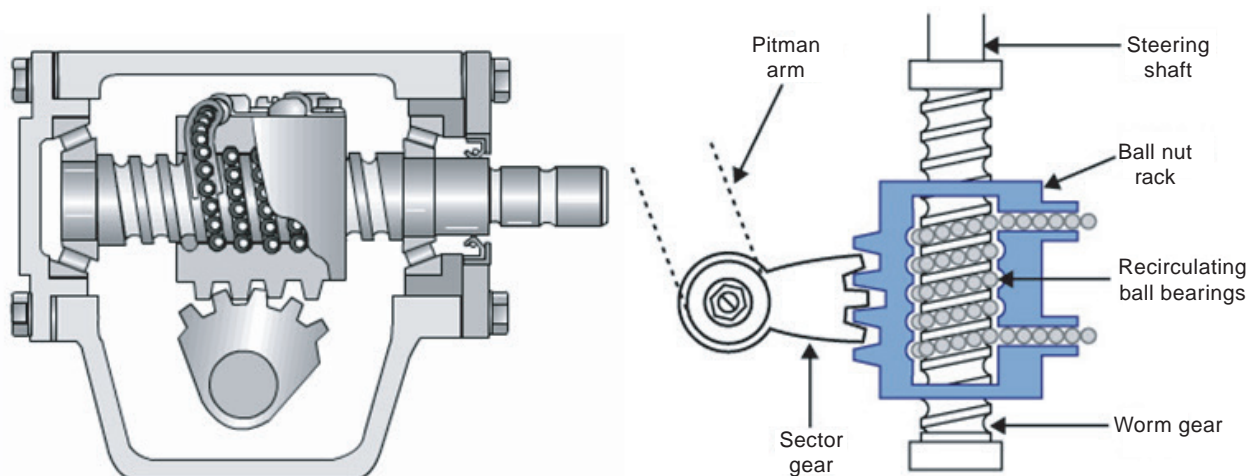
It consists of a worm at the end of a steering rod. A nut is mounted on the

worm with two sets of balls in the grooves of the worm, in between the nut and the worm. The balls reduce the friction during the movement of the nut on the worm. The nut has a number of teeth on the outside, which mesh with the teeth on a worm wheel sector, on which is further mounted the drop arm. 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. The balls, which are in 2 sets, are recirculated through the guides. The movement of the nut causes the wheel sector to turn at an angle and actuate the link rod through the drop arm, resulting in the desired steering of the wheels.



## 8.4 Power steering

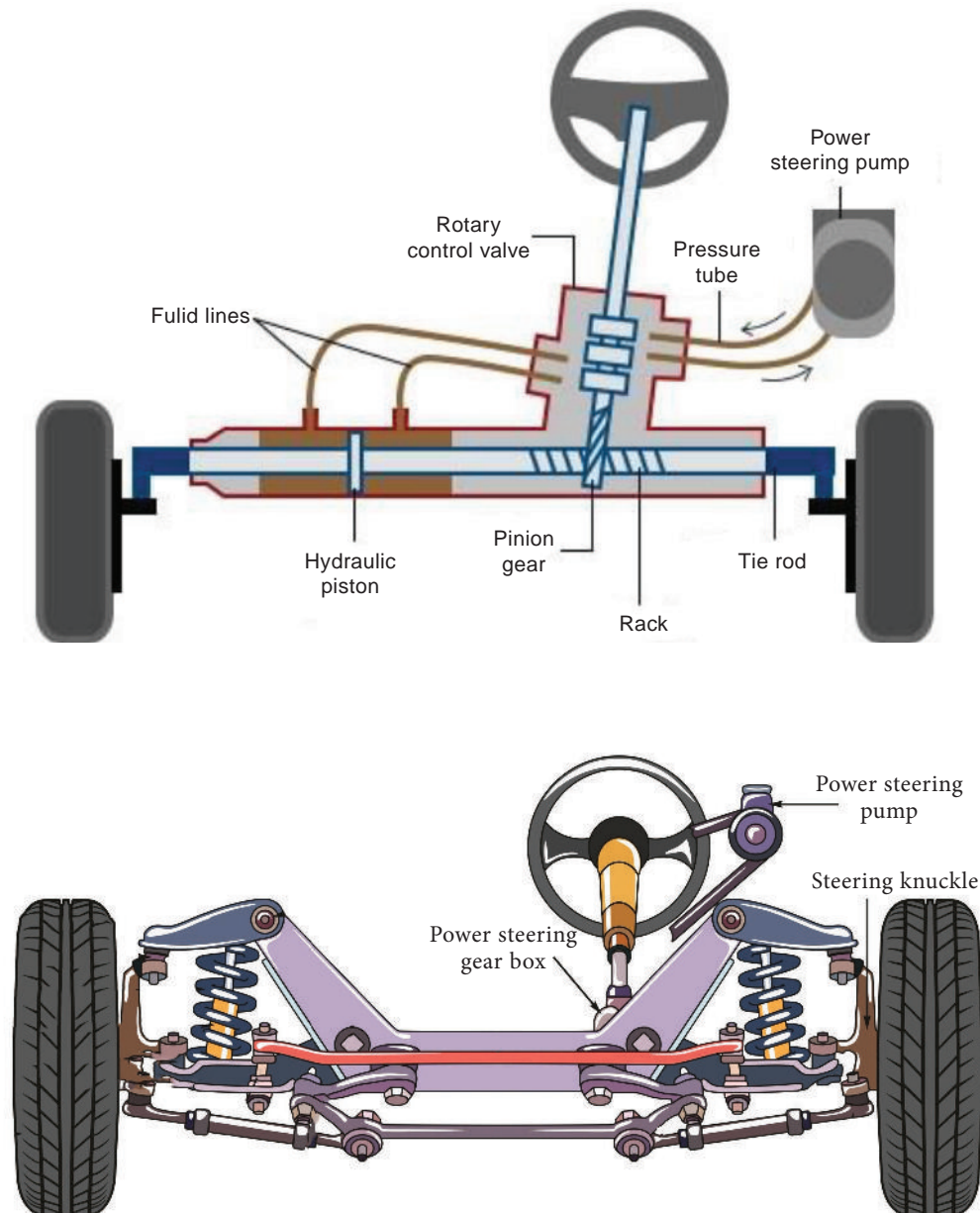
- In medium and heavy commercial vehicles, the driver has to put lot of physical effort to turn the vehicle. If the driver continuously drives the vehicle for longer duration, then the driver will be very tired.
- In order to reduce the steering effort by the driver for easy turning, an energy source that aids the driver in turning the wheels is called as power



**Figure 8.3.1.4** Recirculating ball type steering gear box







**Figure 8.4** Power steering

steering system. Most automotive power steering systems are hydraulic.

- A pump supplies high pressure fluid when the driver turns the steering wheel. This provides 80% of the required steering effort and the remaining 20% is by driver's physical effort.

### Types of Power steering

1. Integral type
2. Linkage type



### 8.5 (a) Reversible Steering

- Steering gear is said to be reversible if the deflection of steered wheel due to road surface is transmitted through steering linkages and steering gears to the steering wheels.

### (b) Irreversible Steering

- Steering gear is said to be irreversible if the deflection of steered wheel due to road surface is not transmitted





through steering linkages and steering gears to the steering wheels.



### 8.6 Steering play

- The position of the steering wheel may change with the vibrations in the wheels, result in directional instability of vehicle. To avoid this, the steering wheel should be set to be free to rotate to a small degree and this play is called as steering free play.



### 8.7 Steering ratio

- The ratio between rotation of steering wheel to that of the turning angle of the stub axle is called as steering gear ratio. Example  $360^\circ : 36^\circ$  (ie) 10 : 1.



### 8.8 Turning radius

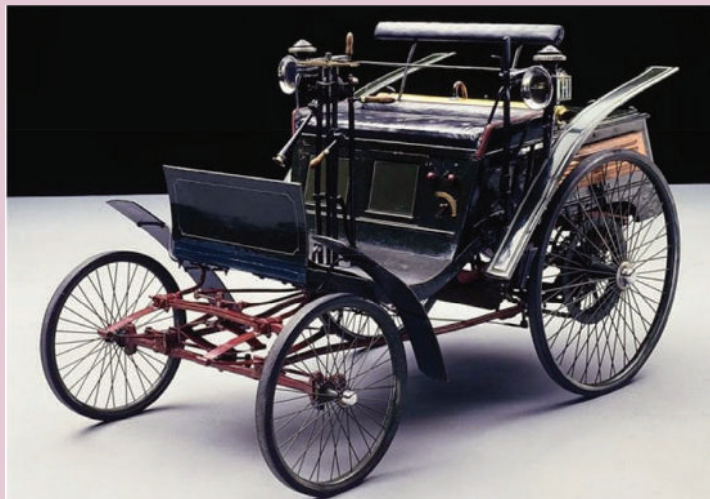
- Turning radius is the smallest radius takes place when the vehicle takes a turn



- Roads were first made for bicyclists, not cars.



- The first cars did not have steering wheels. They were operated by a lever.





- The first windshield wipers were hand-operated.



- The first car to use a rear-view mirror was driven by inaugural Indy 500 winner Ray Harroun in 1911 to see the cars catching up behind him.







## 8.9 Wheel Alignment

- It refers to the angular relationship between the front wheels and parts attached to it with that of car frame. Wheel alignments ensure that all four wheels are consistent with each other and are optimized for maximum contact with the surface of the road.

### 8.9.1 Aim of wheel alignment

- To turn the steered wheel easily and to ensure vehicle directional stability.
- To reduce the tyre wear to a minimum.

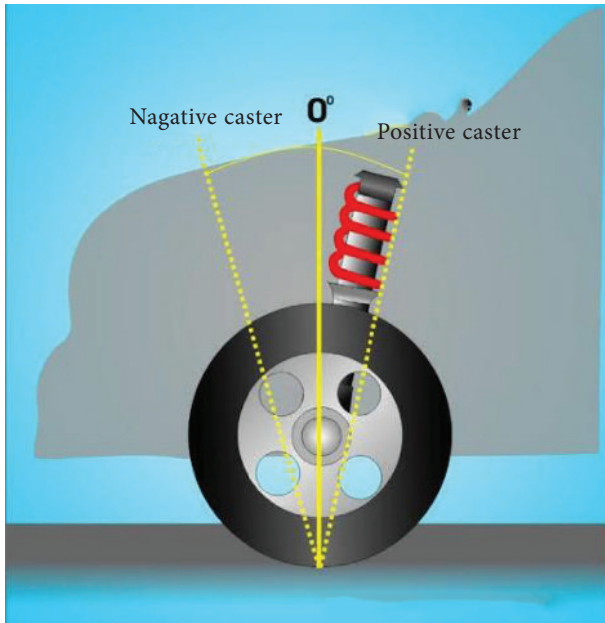


Figure 8.9.2.1 (a) Caster angle

### 8.9.2 Angles in wheel alignment

- Caster Angle
- Camber Angle
- King pin inclination
- Toe-in and Toe-out

#### 8.9.2.1 Caster Angle

The angle between the king pin centre line (or steering axis) and the vertical axis, when viewed from the side of the vehicle, is called the Caster angle. Caster angle is about  $2^\circ$  to  $3^\circ$ . As shown in figure 8.9.2.1 (a), (b), (c).

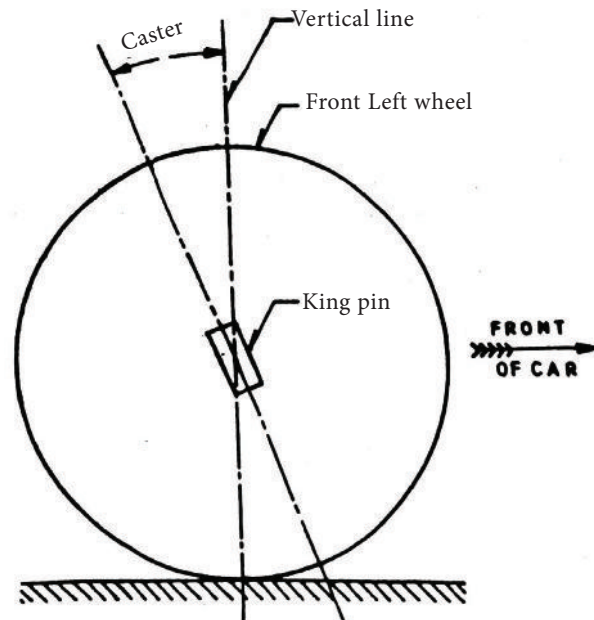


Figure 8.9.2.1 (b) Caster angle

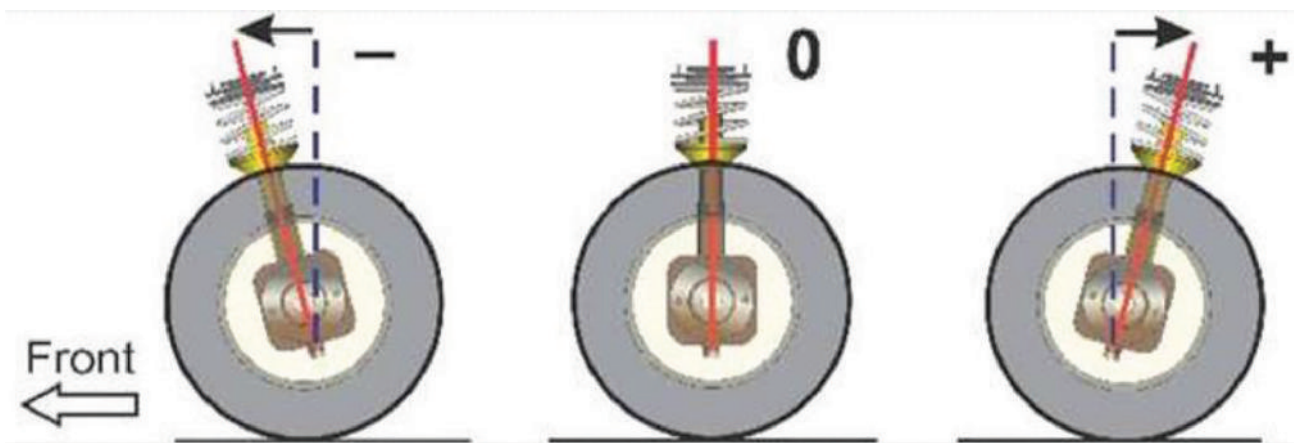


Figure 8.9.2.1 (c) Caster angle

## Importance of Caster Angle

1. Positive Caster provides directional stability.
2. To prevent pulling of wheel on one side during braking
3. To reduce the tyre vibration

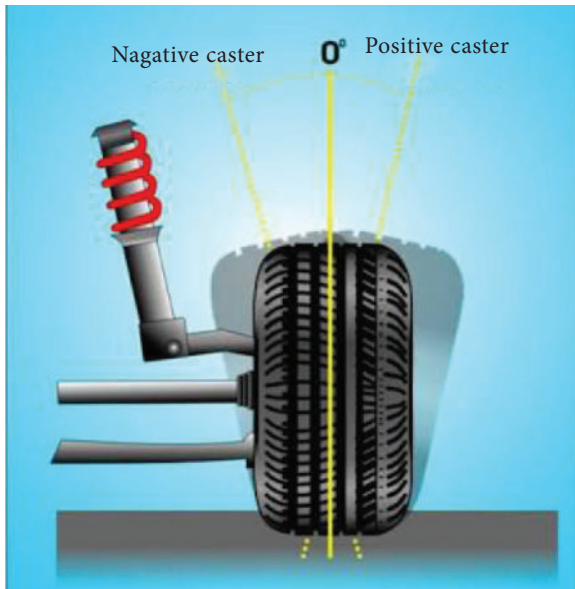


Figure 8.9.2.2 (a) Camber angle

## 8.9.2.2 Camber angle

The angle between the centre line of the tyre to the vertical line when viewed from the front of the vehicle is known as Camber. It is approximately  $1^\circ$  to  $2^\circ$ . As shown in figure.

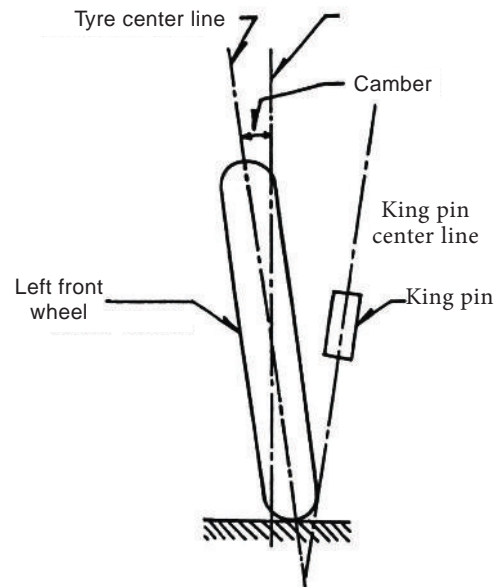


Figure 8.9.2.2 (b) Camber angle

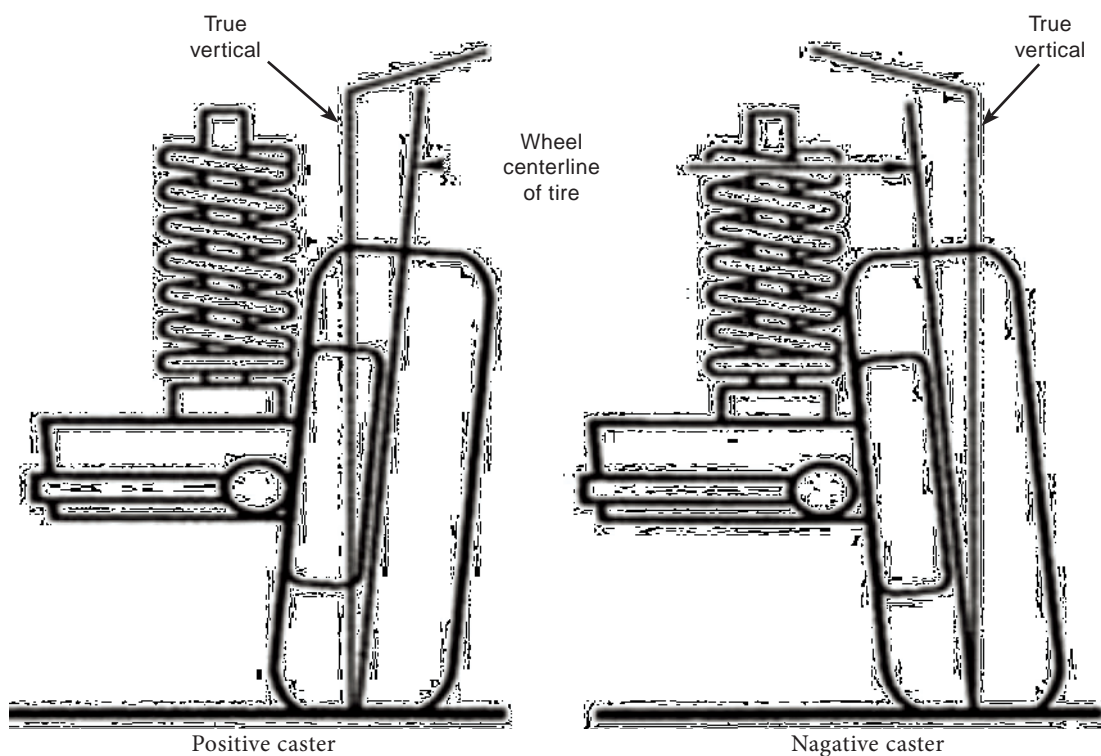


Figure 8.9.2.2 (c) Camber angle



### Importance of Camber Angle

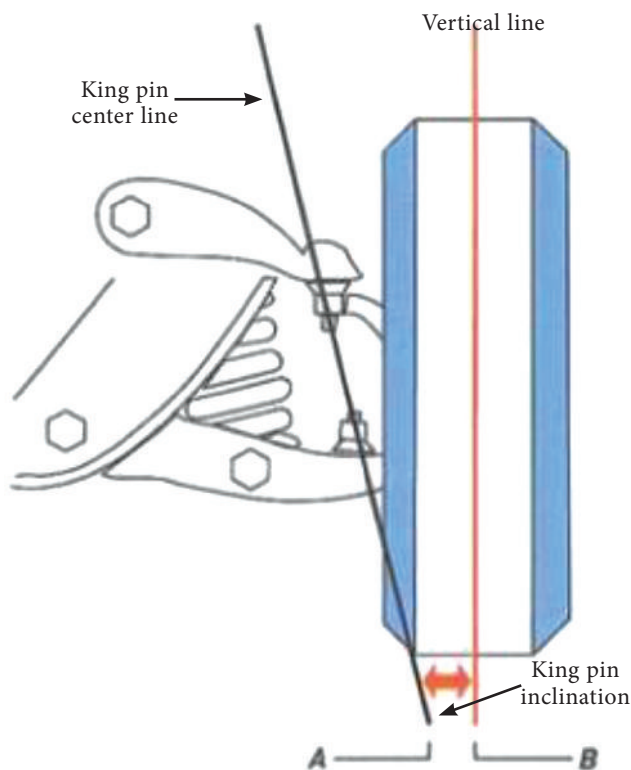
1. At the time of turning, camber angle ensures the ease of steering.
2. To reduce the tyre wear.
3. To reduce the load acting on the king pin and the wheel bearing due to weight of the vehicle.

### 8.9.2.3 King Pin Inclination

When the vehicle is viewed from front, the angle between the inclination of the king pin from the vertical axis is called the King pin Inclination. The inclination is normally kept  $7^\circ$  to  $8^\circ$ .

#### The reason for king pin inclination

1. It gives good road holding on turnings.
2. It reduces steering effort.
3. It reduces the load acting on the wheel bearing.



### 8.9.2.4 Toe-in and Toe-out

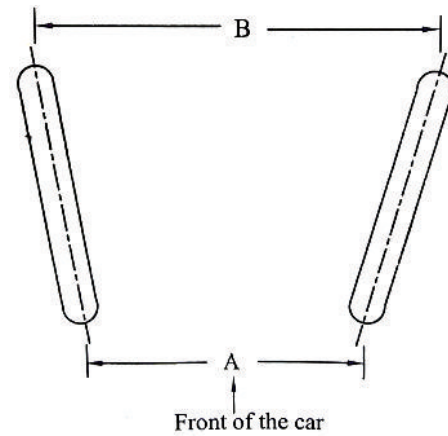


Figure 8.9.2.4 Toe-in

#### Toe-in

When viewed from the top, the distance between the front wheels at the front is less than the distance at the back is called Toe-in. Normally toe-in is up to 3 mm.

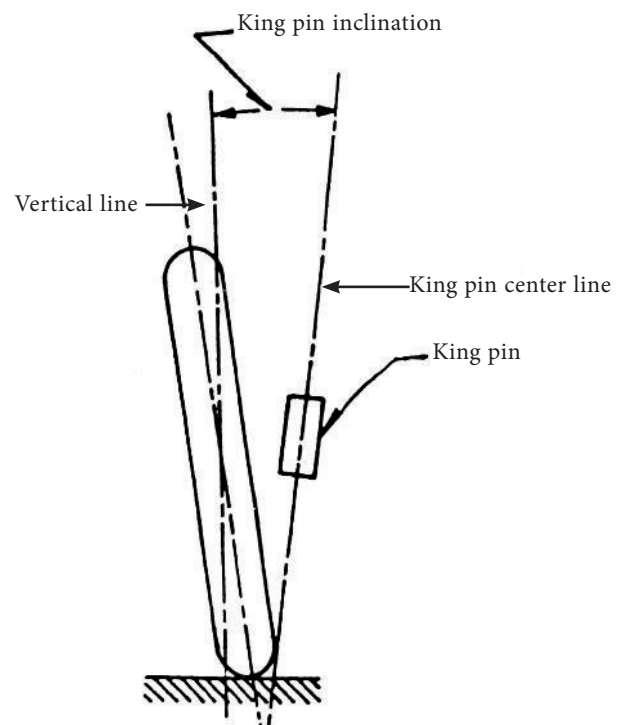


Figure 8.9.2.3 (a) & (b) King pin inclination



## Toe-out

When viewed from the top, the distance between the front wheels at the front is more than the rear side is called toe-out

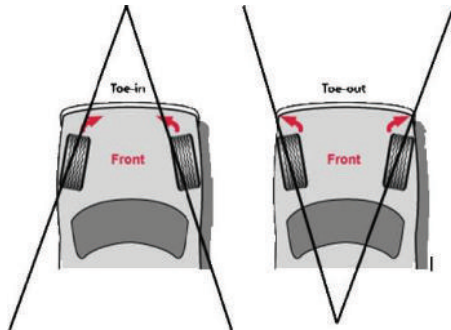


Figure 8.9.2.4 (a) Toe-in & Toe-out

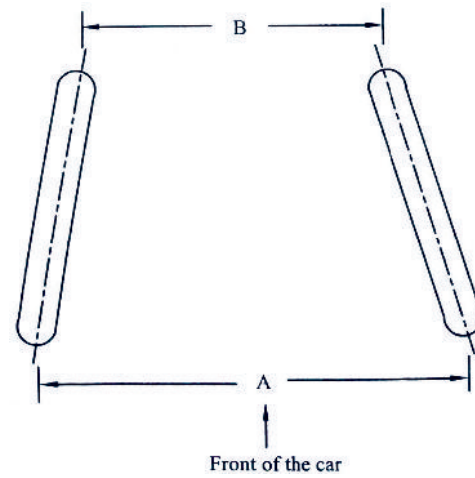


Figure 8.9.2.4 (b) Toe-out



- An airbag takes only 40 milliseconds to deflate.



### 8.9.3 Effects of improper wheel alignment

1. Vehicle will roll over due to centrifugal force acting at the time of turning
2. Wheels are subjected to vibration
3. Increases the tyre wear
4. Reduce the tyre life
5. Hard steering
6. Vehicle pull on one side



## 8.10 Difference between Mechanical Steering and Power Steering

Sl No.	Mechanical Steering	Power Steering
1	Mechanical steering is a system in which Mechanical force is used for steering.	Power steering is a system that helps in steering the wheels using some source of power viz Hydraulic, Electric, Air.
2	Resistance to wheel movement is more.	Resistance to wheel movement is less
3	Widely preferred for Low weight vehicles.	Ease of steering in Comparatively heavy weight vehicles.
4	Steering wheel and column, a Mechanical gearbox and pitman arm or a rack and pinion assembly, linkages; steering knuckles and ball joints, and 4. the wheel spindle assemblies.	A hydraulic pump, fluid reservoir, hoses, lines; and either a power assist unit mounted on, or integral with, a power steering gear assembly.
5	Does not Absorbs road shocks.	Absorbs road shocks.
6	Efforts required for steering is high.	Efforts required for steering is less.
7	Very difficult to control directional at the time of emergency and directional stability is difficult to achieve.	Greater safety and controllability under emergency situation.

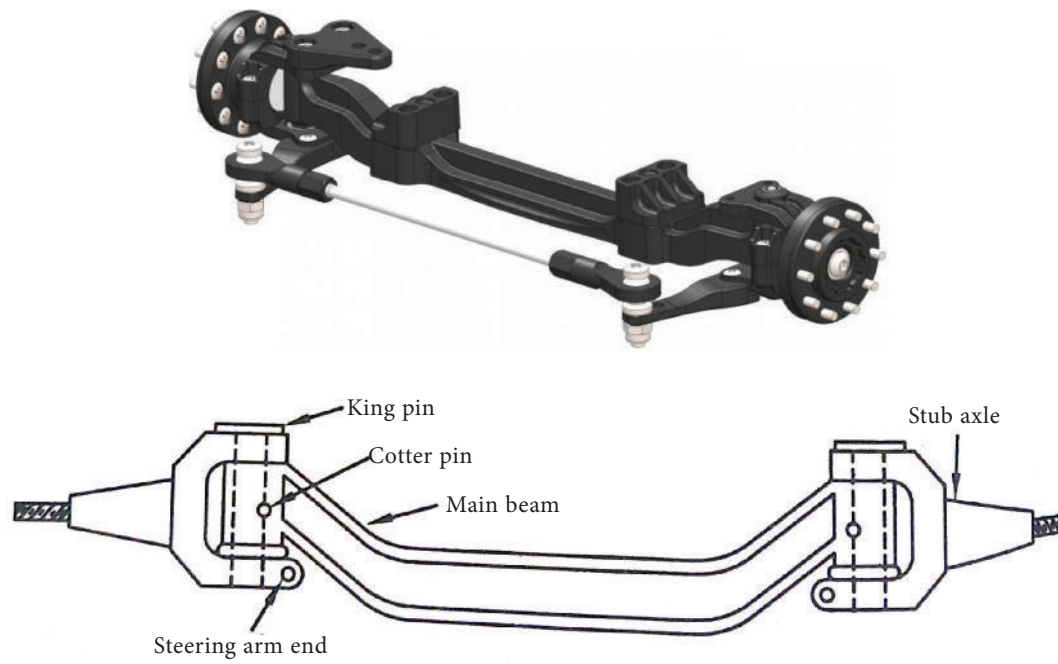


## 8.11 Front Axle

Front axle carries the weight of the front part of the vehicle. Front axle includes axle beam stub axles with brake assembly, track rod and stub axle arm to steer and brake the vehicle. To accommodate front engine and to provide stability and safety, the centre portion of the axle is dropped. It is called as front axle.

### Construction

In light vehicles, front axles are tubular in section and in heavy commercial vehicles, the front axles are made up of I cross section. In both the ends, stub axles are connected with front axle by means of kingpin and steering track arm.



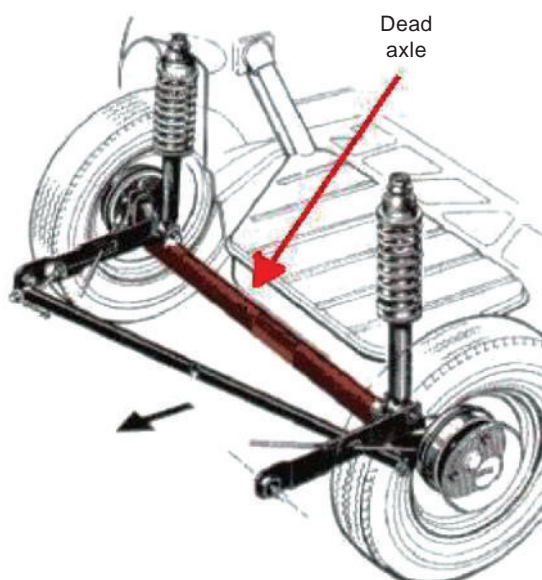
**Figure 8.11** Front axle

### 8.11.1 Types of Front axle

1. Dead Axle
2. Live Axle

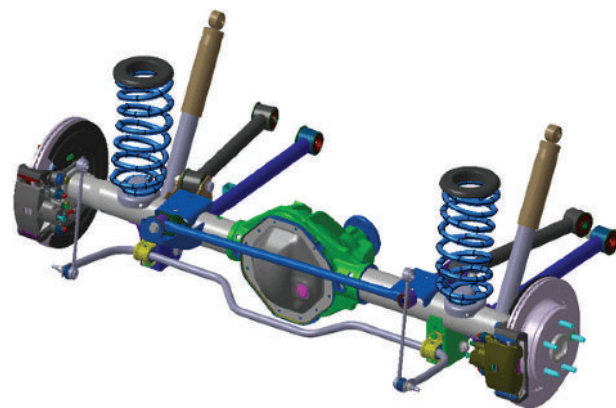
#### 8.11.1.1 Dead axle

- It is a just dummy axle. It having no connections with engine. It has sufficient rigidity and strength to transmit the weight of the vehicle from the steering and brake system without differential and axle shaft.



#### 8.11.1.2 Live axle

- Live axle is the one through which power is transmitted to the wheels by means of differential and axle shaft. In case of front wheel drive or in all wheel drive, the front axle will act as live axle.



### 8.12 Stub Axle

- Stub axle is a short axle. Stub axle are connected to the front axle by means of king pin. The front wheels are mounted on the stub axle.







- Stub axle is capable of limited angular movement about the kingpin for steering the vehicle.
- Stub axle helps to turn the vehicle at desired direction through steering linkage.

### 8.12.1 Types of Stub axle

Front axles are built according to four basic designs for attaching the steering knuckle to the beam. They are

1. Elliot type
2. Reverse Elliot type
3. Lemoine type
4. Reverse Lemoine type

#### 1. Elliot axle

The Elliot type stub axle is shown in the figure 8.12.1 (a). The end of the axles are in the shape of a elliot. A king pin with cotter pin connects the stub axle. So the stub axle turns easily to and fro.

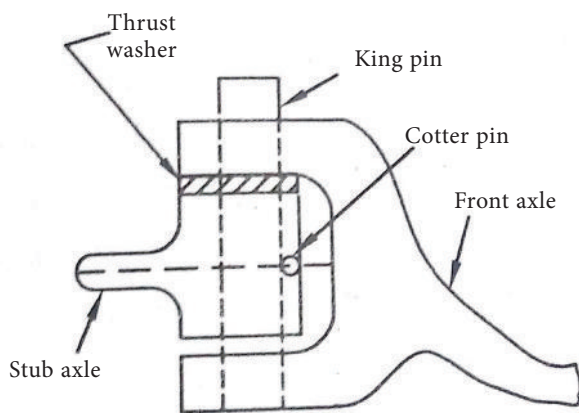


Figure 8.12.1 (a) Elliot type stub axle

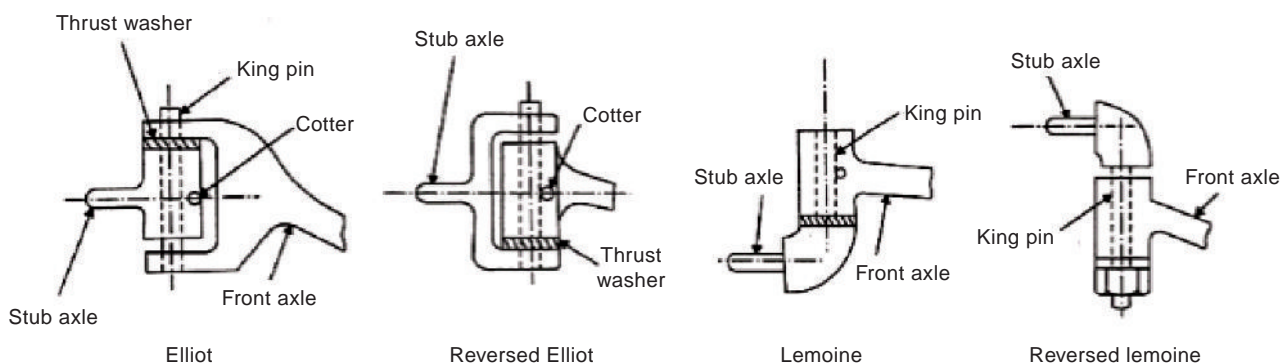


Figure 8.12.1 (a)

#### 2. Reversed Elliot axle

The reverse elliot type is shown in figure 8.12.1 (b) of the stub axle in the reversed Elliot shape. A king pin with cotter pin connects the stub axle. So the stub axle turns easily to and fro.

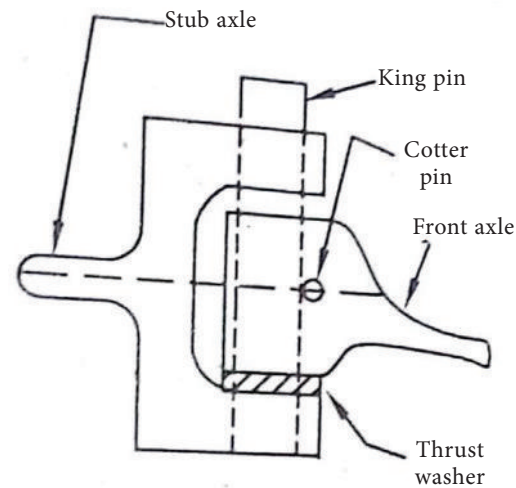


Figure 8.12.1 (b) Reversed elliot

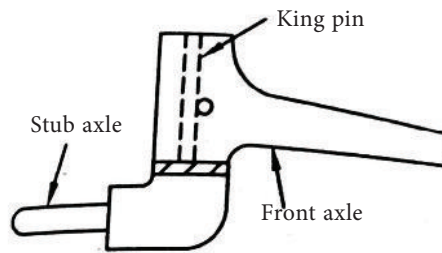
#### 3. Lemoine axle

Two spindles at right angles to each other, stub axle and axle center. Lemoine, a French axle and spring manufacturer designed this. In this design, pivot spindle extended up from the wheel spindle. Tends to raise the axle center above the wheel spindle, hence poorly suited to modern conditions, where low axle centres is preferred.





In this type, the stub axle is attached to the end of the axle by means of king pin. It is used in tractors. As shown in figure 8.12.1 (c).



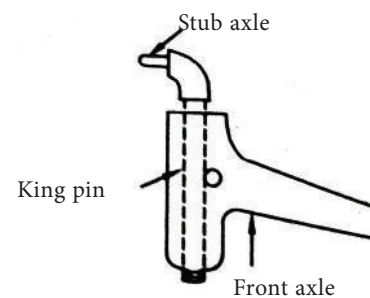
**Fig 8.12.1 (c)** Lemoine type

#### 4. Reversed lemoine axle

Marmon, American passenger car manufacturer, reversed the arrangement

and developed the design. A natural drop to the axle center, is an advantageous feature.

In this type, the stub axle is mounted on the top of the axle by means of king pin. It is used in tractors. As shown in figure 8.12.1 (d).



**Fig 8.12.1 (d)**



## 8.13 Troubleshooting, cause and remedy in a steering system

### 8.13.1 Excessive play in steering system

Sl. No.	Possible cause	Remedy
1	Loose / worn out steering gear (rack or box) mounting.	Tighten steering gear mounting bolts / replace mounting bushes.
2	Loose / worn out steering linkages.	Adjust or replace linkages.
3	Worn out of ball joints in steering system	Rectify / replace

### 8.13.2 Wheel Wobble

Sl. No.	Possible cause	Remedy
1	Mismatched tires or uneven tire pressure.	Inflate tyre upto recommended pressure
2	Unbalanced Wheel	Balance the wheel
3	improper camber angle and toe in	Check the wheel alignment and rectify

### 8.13.3 Hard Steering

Sl. No.	Possible cause	Remedy
1	Low inflation pressure in the tyres	Properly inflate tyre
2	Improper wheel alignment	Check and rectify the wheel alignment
3	Bend in the front axle	Rectify
4	Misalignment in chassis frame	Rectify
5	Broken / damage bearings and bushes in steering gearbox	Replace

### 8.13.4 Vehicle Pulling on one side

Sl. No.	Possible cause	Remedy
1	Uneven tyre wear	Tyre rotation
2	Improper brake adjustment	Check and adjust the brakes
3	Failure of damper / spring in one side	Replace the damper / spring



### Student Activity

1. Students are advised to submit a report based on the visit to the nearest automotive workshop to study about various parts in steering system and its assembly procedure in vehicle.
2. Students are advised to submit a report on construction and working principle of steering system used in Modern cars with sketches based on the visit to the nearest Automotive workshop.

### Glossary

1.	Alignment	–	ஒழுங்கமை
2.	Axle	–	அச்சு
3.	Kingpin	–	பிரதானபின் [சுழல் மூட்டுக்கம்பி]
4.	Camber angle	–	மேல் சாய்வு கோணம்
5.	Ball joint	–	பந்து கிண்ண இணைப்பு
6.	Steering	–	திசை திருப்பி
7.	Worm	–	திருகுருவப் பொருள்
8.	Power steering	–	விசைத் திருப்பி
9.	Irreversibility	–	மீளாத்தன்மை
10.	Stub axle	–	துணை அச்சு



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## Evaluation

### PART - A



#### One mark questions

#### Choose the correct answer

1. During driving, the direction of vehicle is controlled by
  - a. Steering system
  - b. Brake system
  - c. Engine
  - d. Suspension system
2. In steering system, steering arm is connected to
  - a. Steering wheel
  - b. Drop arm
  - c. Steering column
  - d. Tie rod





3. The box in which steering gears are mounted is called as
  - a. Suspension
  - b. Steering gearbox
  - c. Differential
  - d. Steering geometry
4. How many types of steering gearbox are available?
  - a. 3
  - b. 4
  - c. 5
  - d. 8
5. In steering system, the component used to pull steering arm on one side and to push steering arm another side, is called as
  - a. Steering shaft
  - b. Steering gearbox
  - c. Tie rod
  - d. Stub axle
6. In power steering system, the percentage of amplification by means of hydraulic is
  - a. 20 %
  - b. 60 %
  - c. 80 %
  - d. 100 %
7. Which steering system is easy to handling
  - a. Power Steering
  - b. Rack and Pinion
  - c. Worm and Wheel
  - d. Worm and Sector
8. The permissible play in the steering wheel is known as
  - a. Steering alignment
  - b. Steering ratio
  - c. Steering play
  - d. Turning radius
9. The allowable caster angle in degree is
  - a.  $2^\circ$  to  $3^\circ$
  - b.  $7^\circ$  to  $8^\circ$
  - c.  $10^\circ$  to  $12^\circ$
  - d.  $5^\circ$  to  $6^\circ$
10. The angle between the central axis of kingpin and vertical axis, when viewed from vehicle front, is known as
  - a. Camber angle
  - b. Caster angle
  - c. King pin inclination
  - d. Toe-in
11. Front axles are classified into \_\_\_\_\_ types
  - a. 2
  - b. 4
  - c. 5
  - d. 6

## PART - B

### Three mark questions

1. State the functions of a steering gearbox.
2. List out the type of steering gearbox.
3. What do you mean by steering play?
4. Define steering ratio.
5. What are the parameters are there in a wheel alignment?
6. Write short notes on king pin inclination.



## PART - C

### Five marks questions

1. Arrange the parts in a steering gear box.
2. Discuss the power steering system and state the types.
3. Explain camber angle with simple sketch.
4. State the problem arises, if wheel alignment is improper.
5. Explain the role of front axle. Classify the types of front axle.

## PART - D

### Ten mark questions

1. With the aid of neat sketch, explain the construction and working principle of rack and pinion steering gearbox.
2. Describe the construction and working principle of worm and sector type steering gearbox with the aid of necessary sketch.
3. Tabulate the difference between mechanical steering and power steering system.
4. State the reason and remedial step for any two problem that are caused in steering system.