



# Unit I

## Front Axles & Steering System

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## ❖ Syllabus:

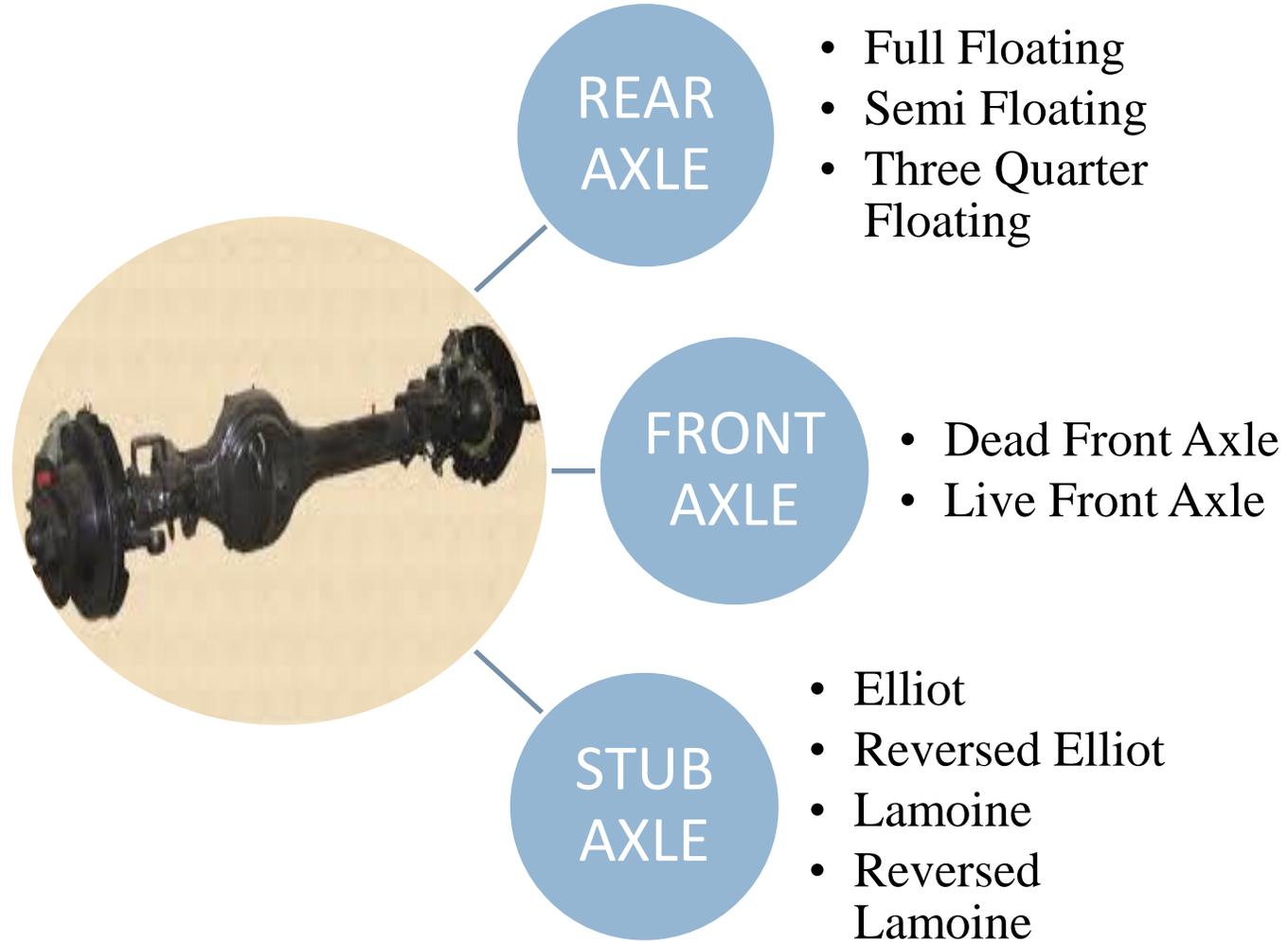
Functions of front axle, Types of front axle, Construction, Stub axle and Wheel bearing, Front wheel steering Geometry – castor, Camber, King pin inclination, toe-in, toe-out, Centre point Steering, Self returning property, Adjusting and checking of front wheel geometry, Ackerman and Davis steering linkages, Steering system layout, Steering gear boxes.



## ❖ Axle:

- An axle is a central shaft for a rotating wheel or gear.
- On wheeled vehicles, the axle may be fixed to the wheels, rotating with them, or fixed to the vehicle, with the wheels rotating around the axle.
- Bearings or bushings are provided at the mounting points where the axle is supported.

## ❖ Types of Axles



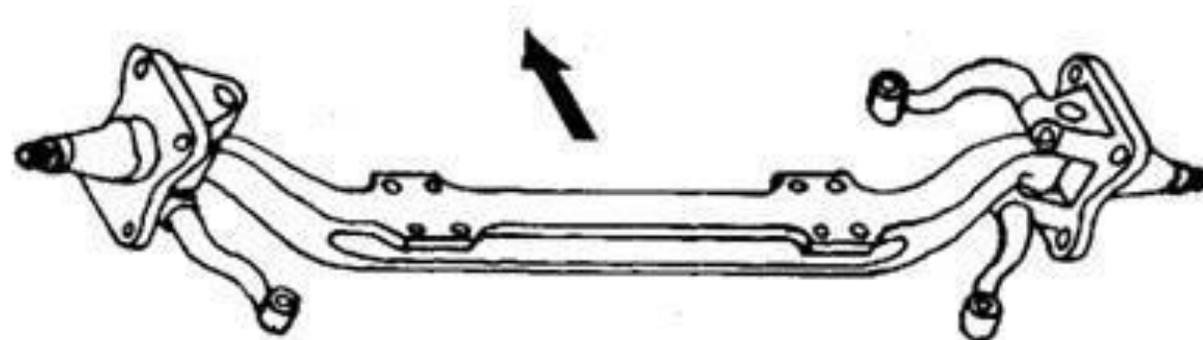


## ❖ **Front Axle:- Functions**

- It supports the weight of front part of the vehicle.
- It facilitates steering knuckles and suspension springs.
- It transmits weight of vehicle through springs to the front wheels.
- It absorbs torque applied on it due to braking of vehicle.

## ❖ Front Axle

- The front axle is designed to transmit the weight of the automobile from the springs to the front wheels, turning right or left as required.
- To prevent interference due to front engine location, and for providing greater stability and safety at high speeds by lowering the centre of gravity of the road vehicles, the entire centre portion of the axle is dropped.
- As shown in Fig. front axle includes the axle-beam, stub-axles, ack-rod and stub-axle arm.





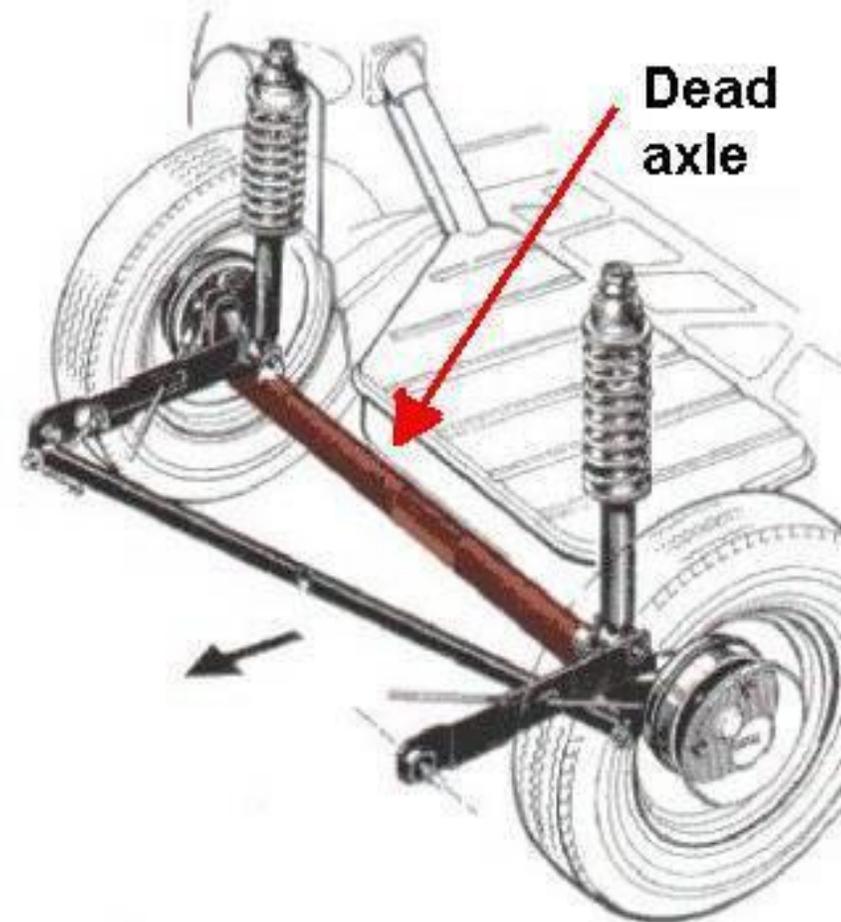
- Front axles can be live axles and dead axles.
- A live front axle contains the differential mechanism through which the engine power flows towards the front wheels.
- For steering the front wheels, constant velocity joints are contained in the axle half shafts.
- Without affecting the power flow through the half shafts, these joints help in turning the stub axles around the king-pin.

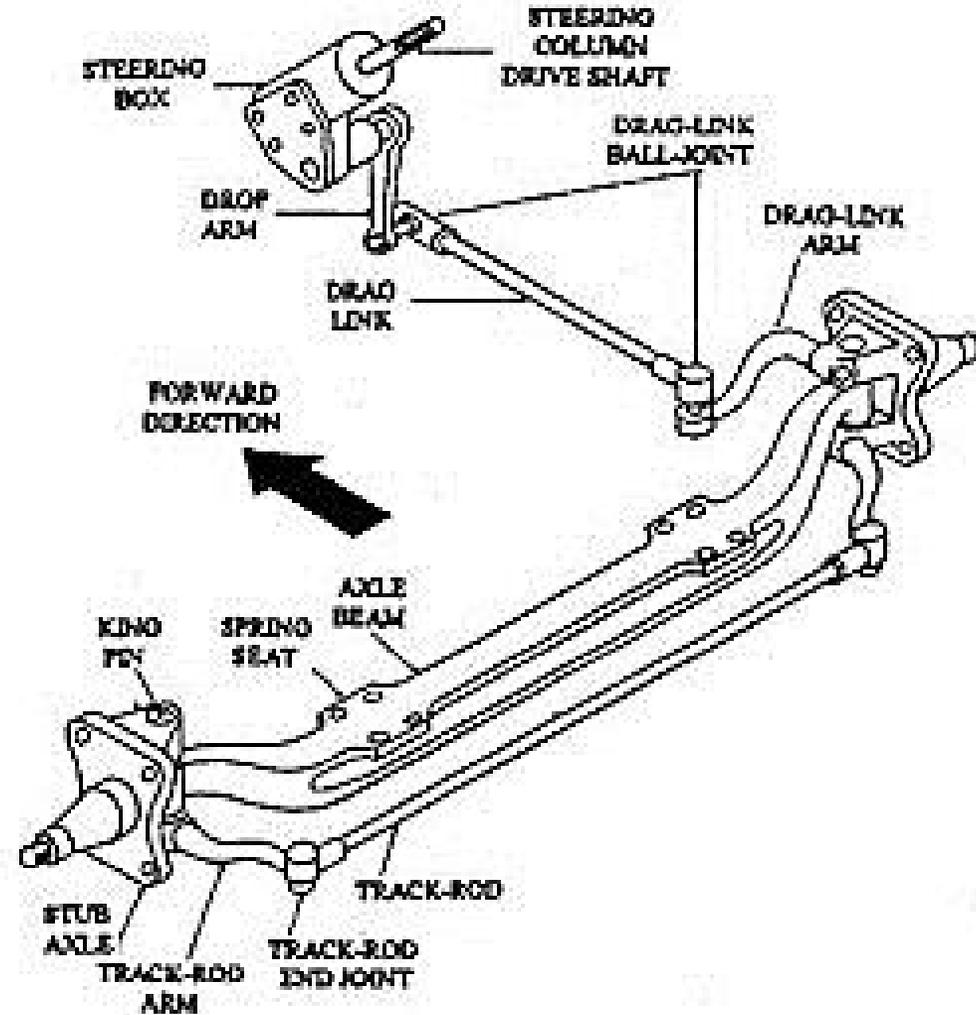


- The front axles are generally dead axles, which does not transmit power.
- The front wheel hubs rotate on anti-friction bearings of tapered-roller type on the steering spindles, which are an integral part of steering knuckles.
- To permit the wheels to be turned by the steering gear, the steering spindle and steering knuckle assemblies are hinged on the end of axle.
- The pin that forms the pivot of this hinge is known as king pin or steering knuckle pin.

## ❖ Dead Axle

- Dead axles are those axles, which do not rotate.
- These axles have sufficient rigidity and strength to take the weight.
- The ends of front axle are suitably designed to accommodate stub axles.

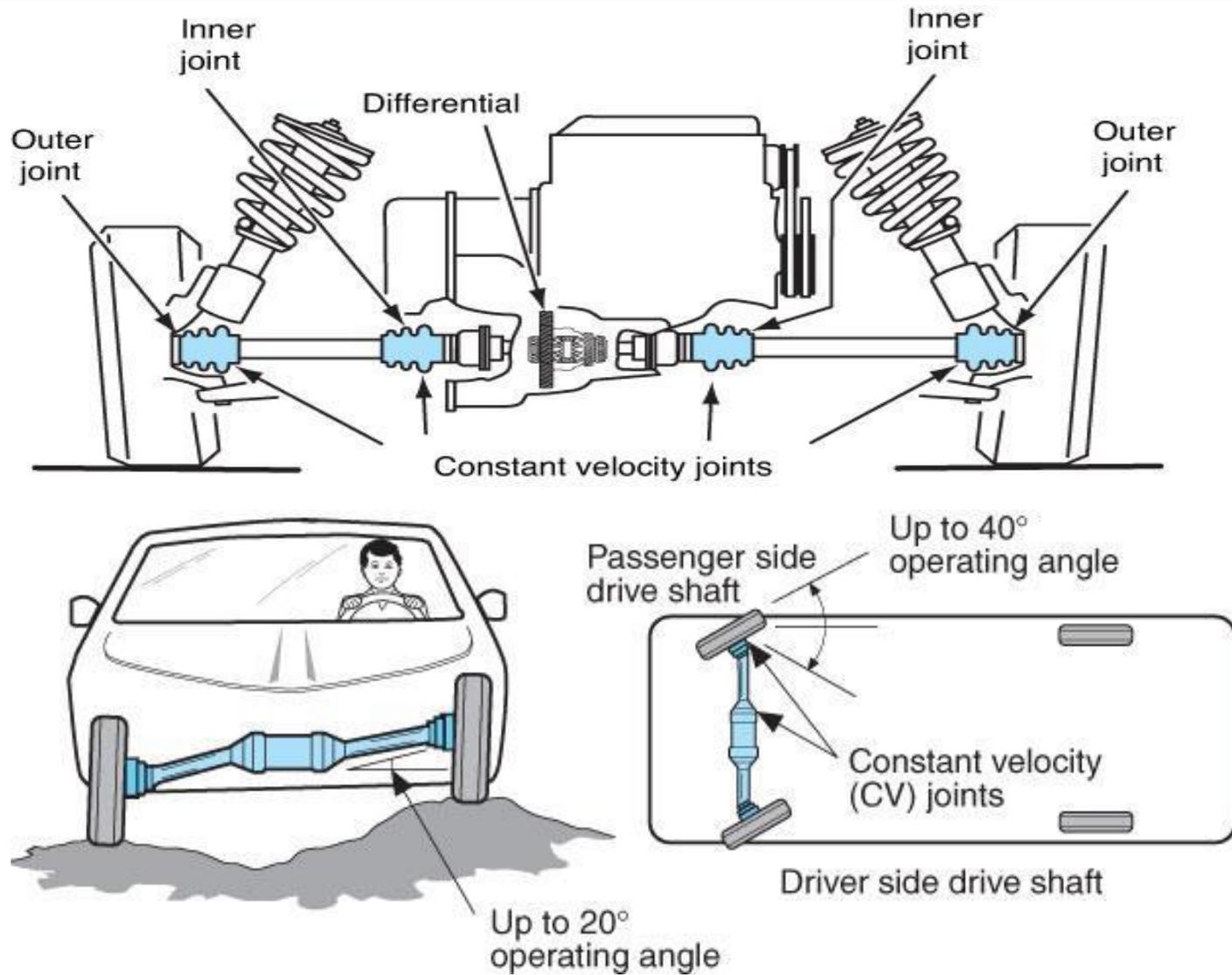




## ❖ Live Axle

- Live axles are used to transmit power from gear box to front wheels.
- Live front axles although, resemble rear axles but they are different at the ends where wheels are mounted. Maruti-800 has line front axle.





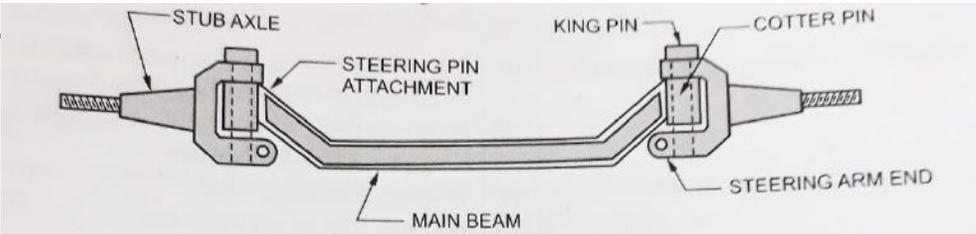


Fig. 33.40. A typical front axle.

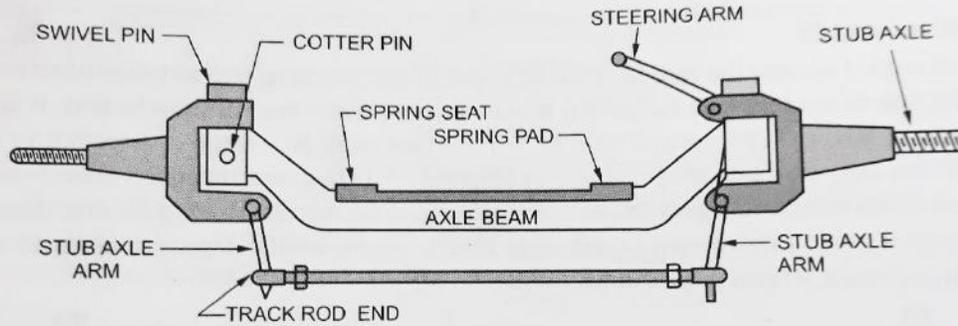


Fig. 33.41. Front axle assembly.

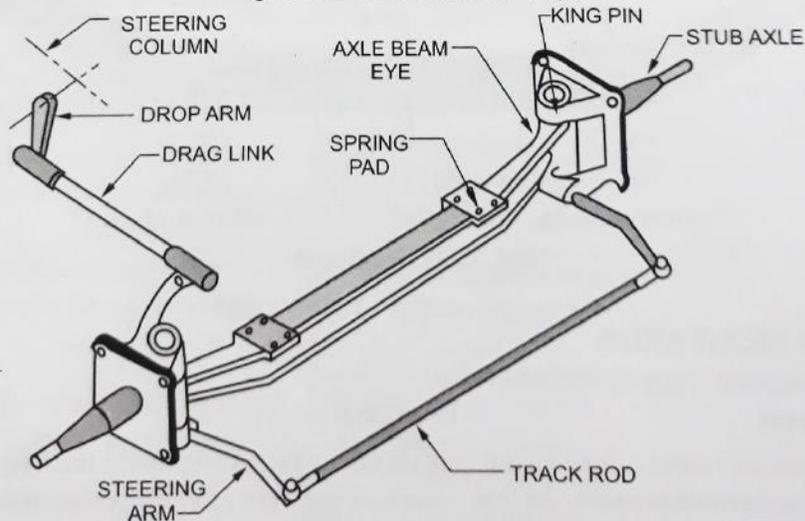


Fig. 33.42. Front axle components with steering linkage.

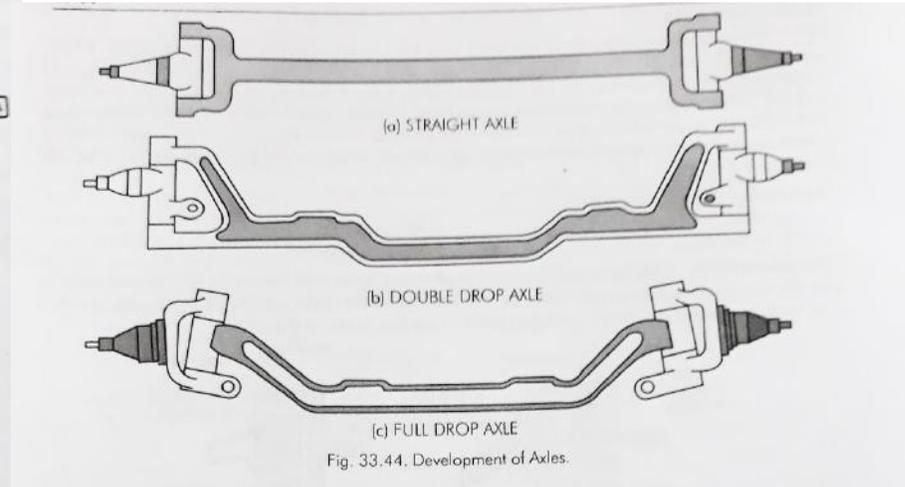
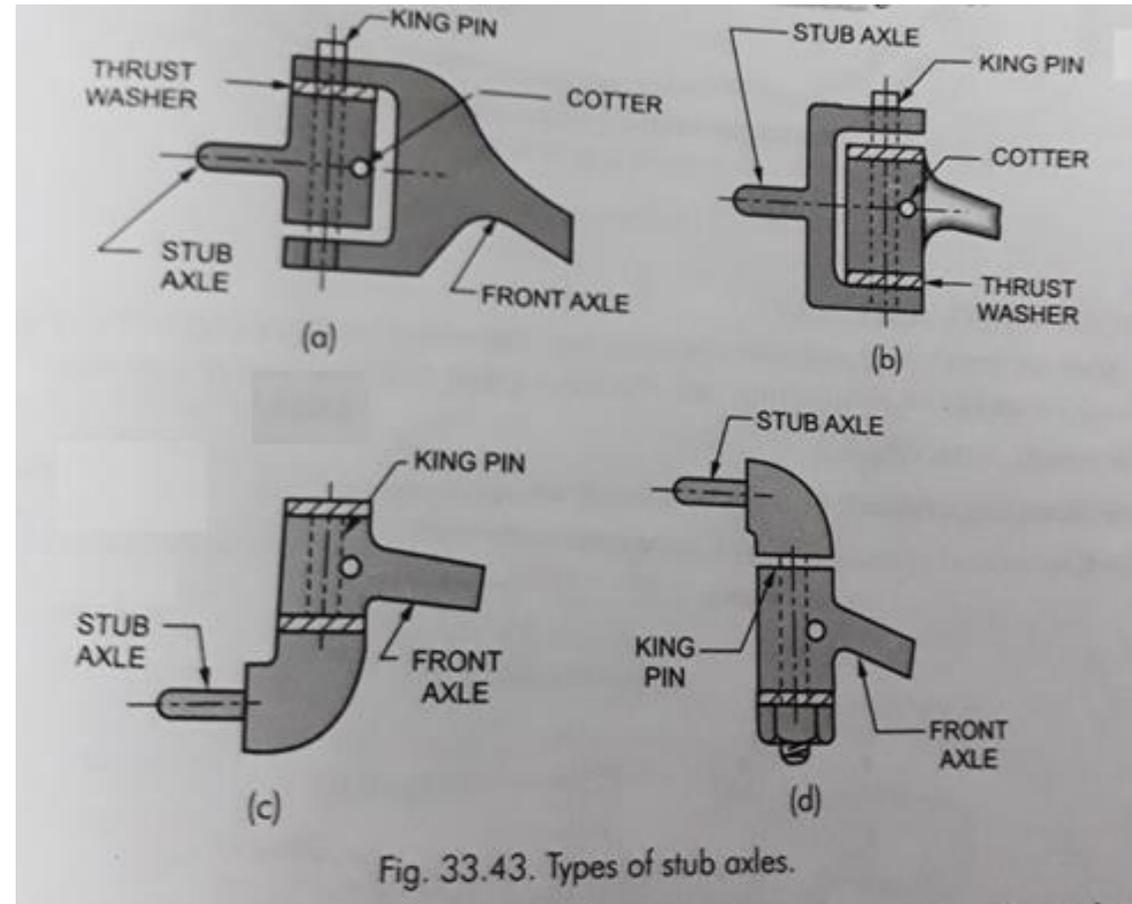


Fig. 33.44. Development of Axles.



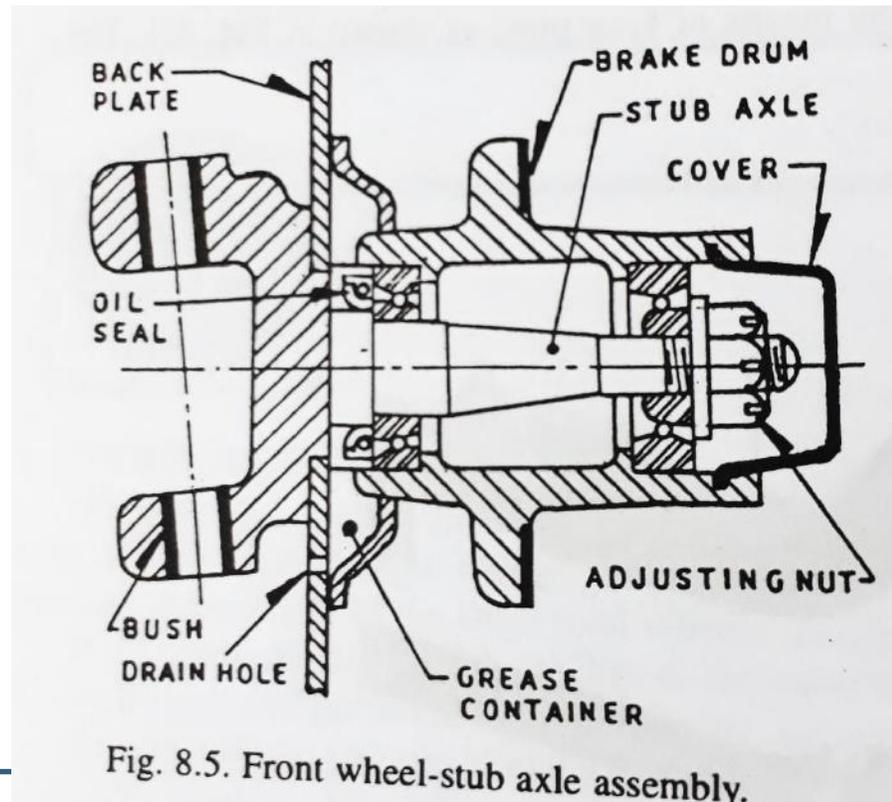
## ❖ **Stub Axle:**

- Stub axles are connected to the front axle by king pins. Front wheels are mounted on stub axles arrangement for steering. Stub axle turns on king pins. King pins is fitted in the front axle beam eye and is located and locked there by a taper cotter pin. Stub axles are of four types:
  - Elliot
  - Reversed Elliot
  - Lamoine
  - Reversed Lamoine
- Material- 3% Nickel steel and alloy steel containing chromium and molybdenum, made by forging.



## Front Wheel Assembly:

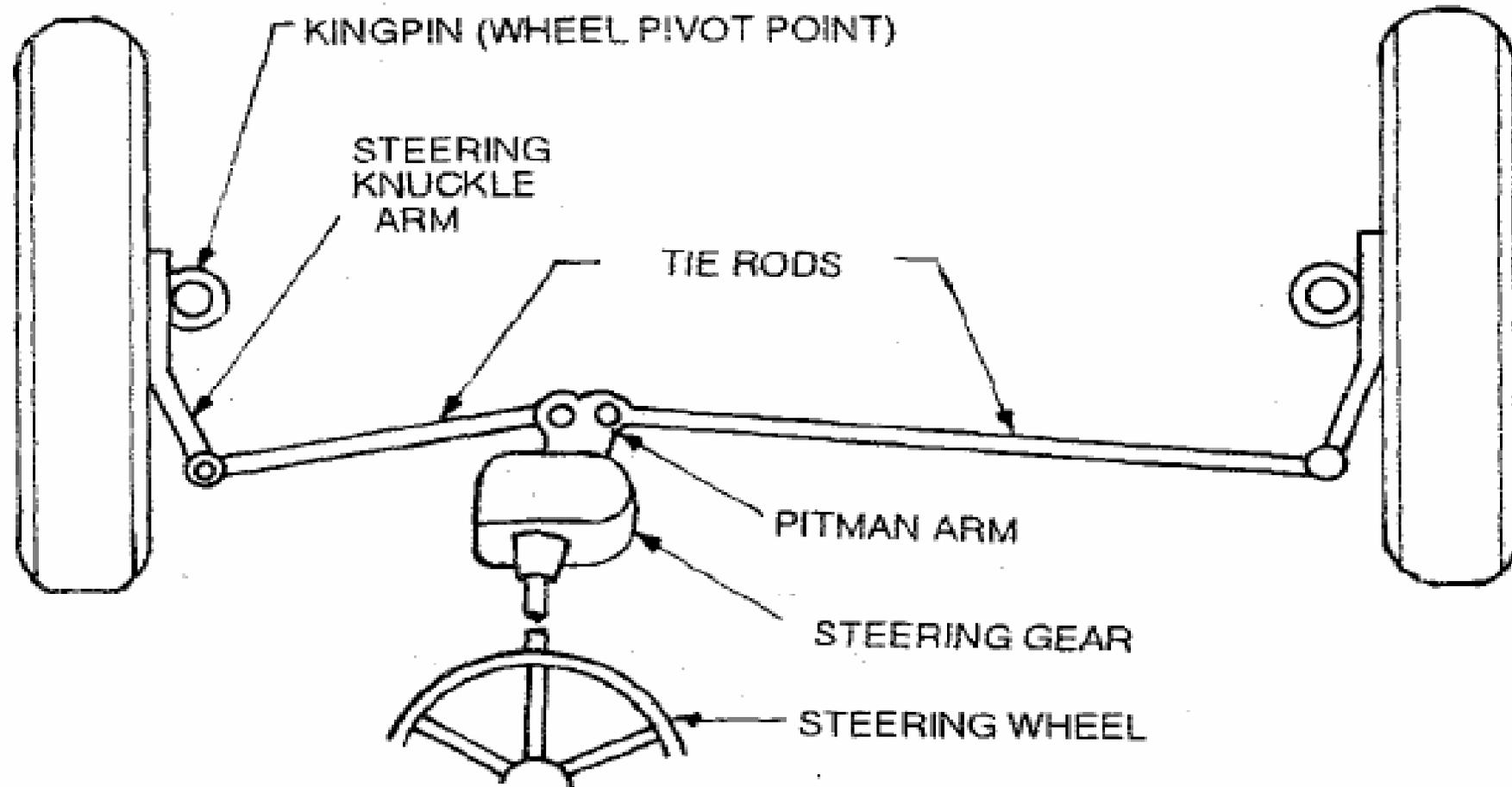
1. The weight of vehicle
2. Side thrust and tendency of the wheel to tilt when cornering
3. Shock Loads duet to uneven road surfaces





## ❖ **Steering System:**

- **Steering** is the term applied to the collection of components, linkages, etc. which will allow a vehicle to follow the desired course.
- The front wheels are supported on front axle so that they can swing to left or right for steering. This movement is produced by gearing and linkage between the steering wheel in front of the driver and the steering knuckle or wheel.
- The complete arrangement is called “Steering System”.
- The function of steering system is to convert the rotary movement of the steering wheel into angular turn of the front wheels.
- The steering system also absorb a large part of the road shocks, thus preventing them from being transmitted to the driver.





## ❖ Requirements:

- It should multiply the turning effort applied on the steering wheel by the driver.
- It should not transmit the shocks of the road surface encountered by wheels to the driver hands.
- The mechanism should have self-returning property so that when the driver releases the steering wheel after negotiating the turn, the wheel should try to achieve straight ahead position.

## ❖ **Functions:**

- It helps in swinging or turning the wheels to the left or right (at the will of driver).
- It converts the rotary movement of the steering wheel into an angular turn of the front wheels.
- It multiplies the effort of the driver by leverage in order to make it fairly easy to turn the wheels.
- It absorbs a major part of the road shocks thereby preventing them to get transmitted to the hands of the driver
- It provides directional stability.
- It helps in achieving the self-returning effect.



## ❖ Front wheel steering Geometry:

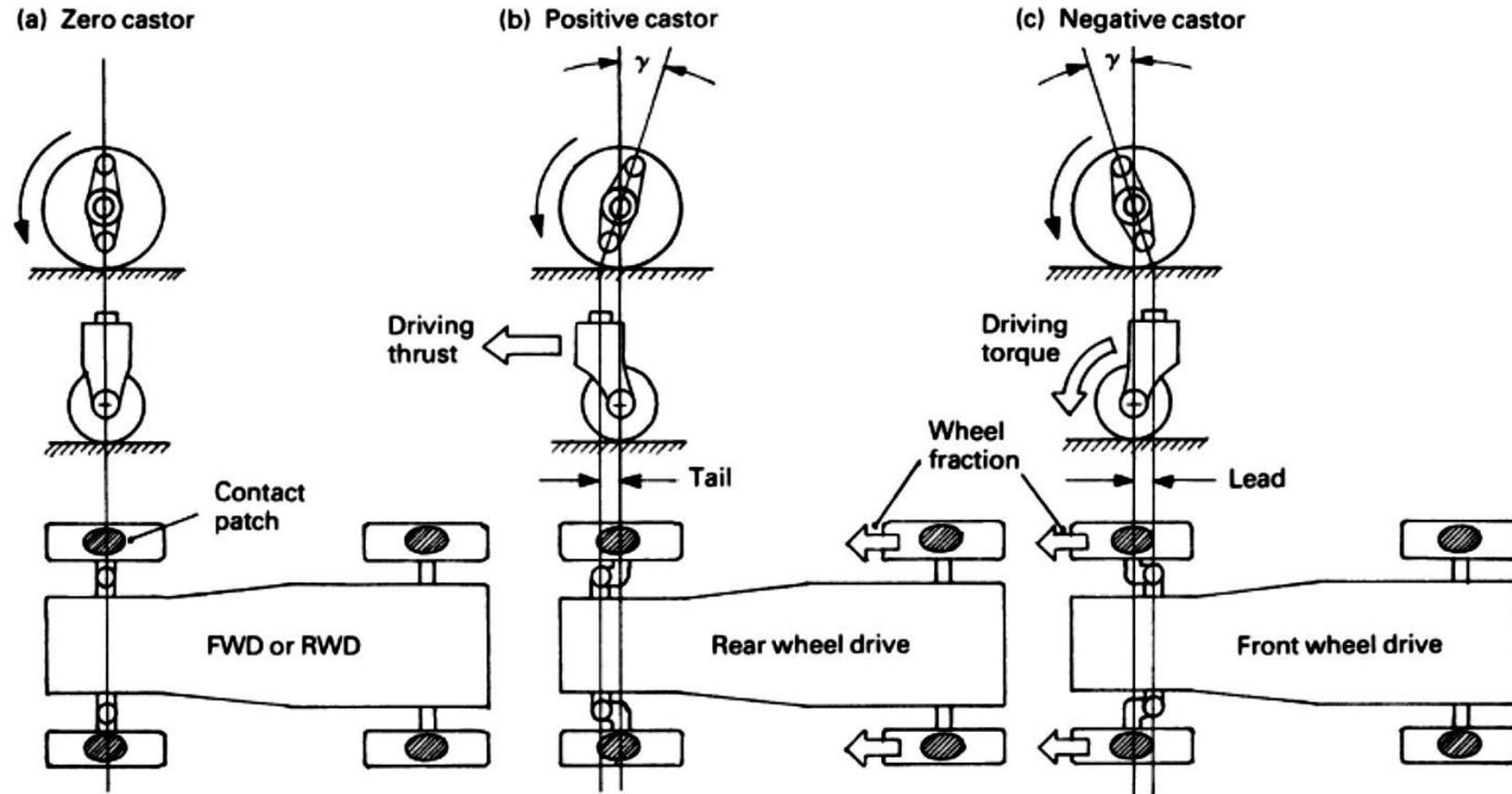
The term "*steering geometry*" (also known as "front-end geometry") refers to the angular Relationship between suspension and steering parts, front wheels, and the road surface. Because alignment deals with angles and affects steering, the method of describing alignment measurements is called steering geometry.

1. Castor
2. Camber
3. King Pin Inclination (Steering axis Inclination)
4. Scrub Radius
5. Toe-in or Toe- Out

## ❖ Castor Angle:-

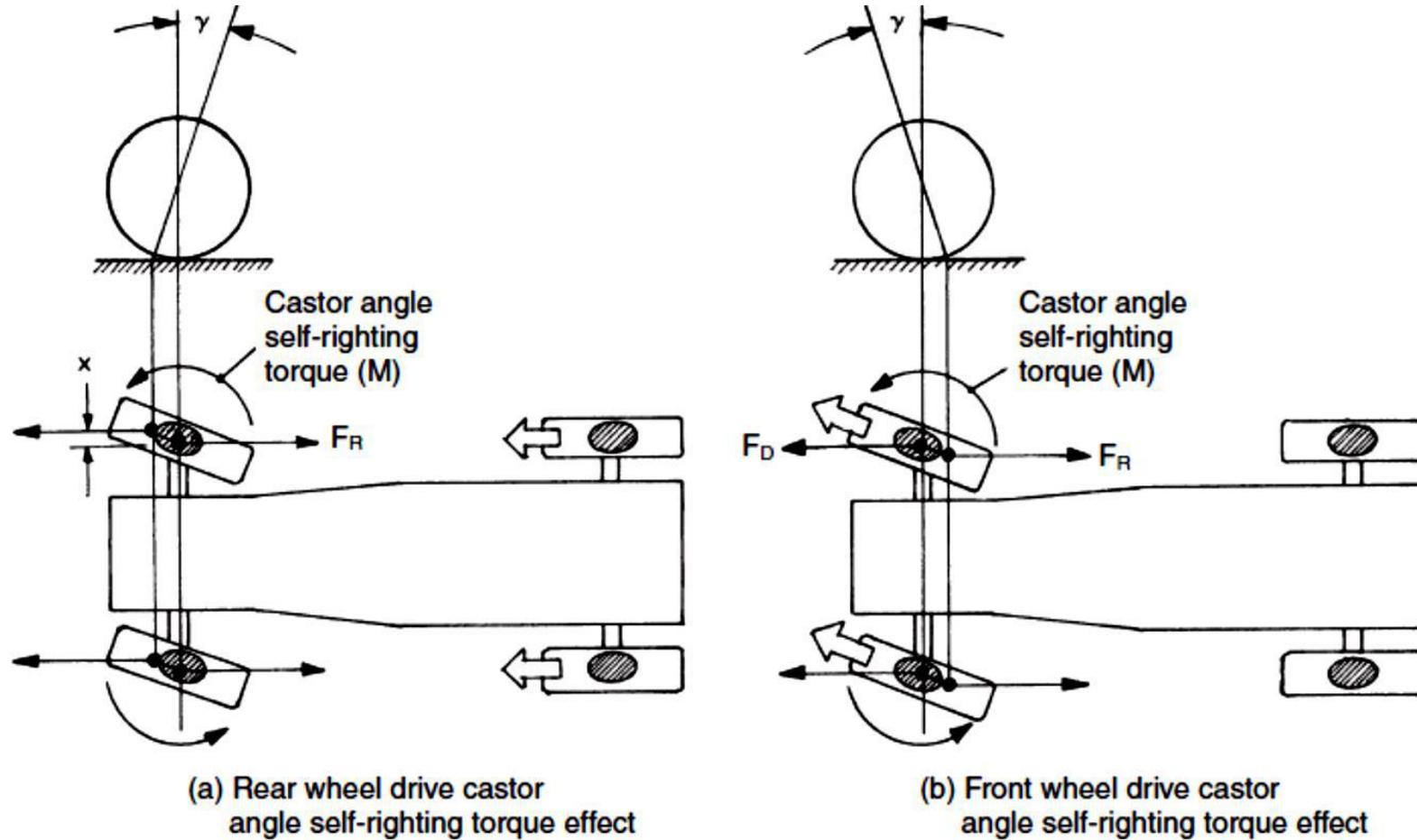
- The inclination of king pin axis in front or rear direction so that the tire contact center is either behind or in front of the imaginary pivot center produced to the ground is known as Castor Angle.
- The angle between the king pin axis and the vertical, in the plane of the wheel is called as castor angle.
- 2 to 8 Degrees.





**Fig. 10.8** Castor angle steering geometry

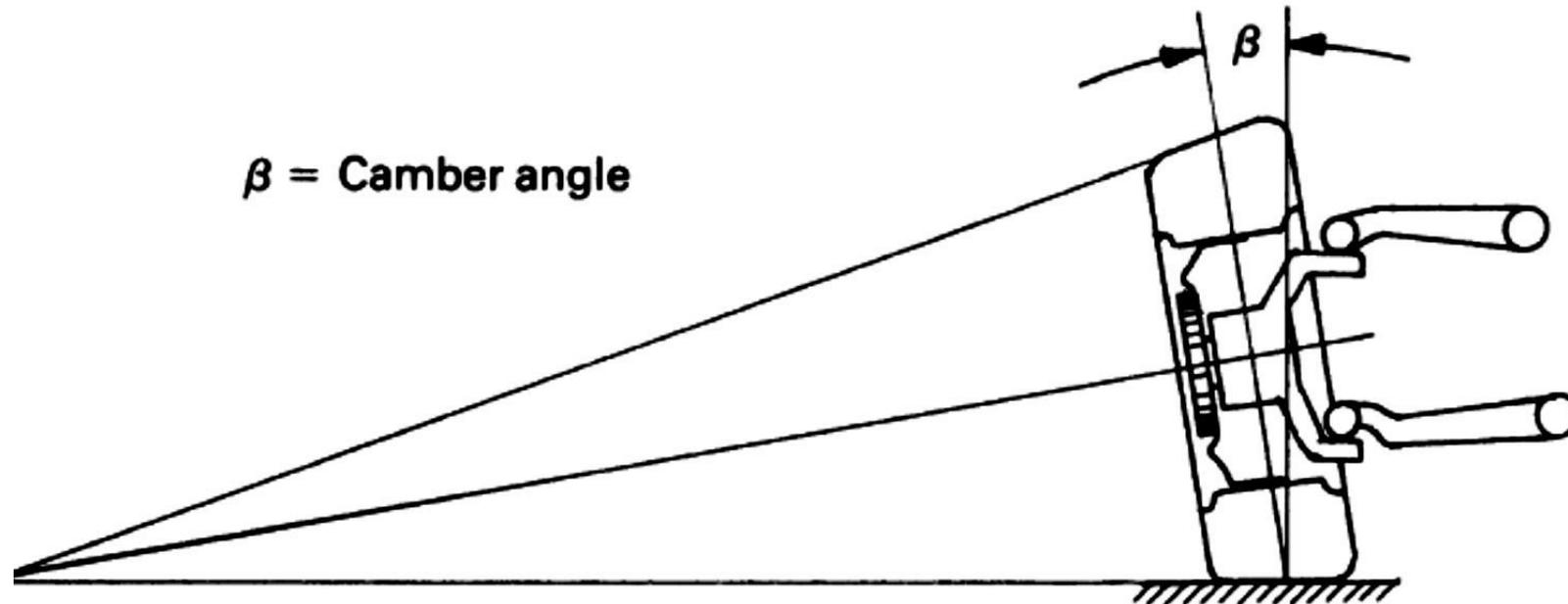
## Effect of Castor Angle:



**Fig. 10.9(a and b)** Illustration of steered wheel castor self-straightening tendency

## ❖ Camber Angle:

- The angle between center line of tire and the vertical line when viewed from front of the vehicle is known as Camber Angle.

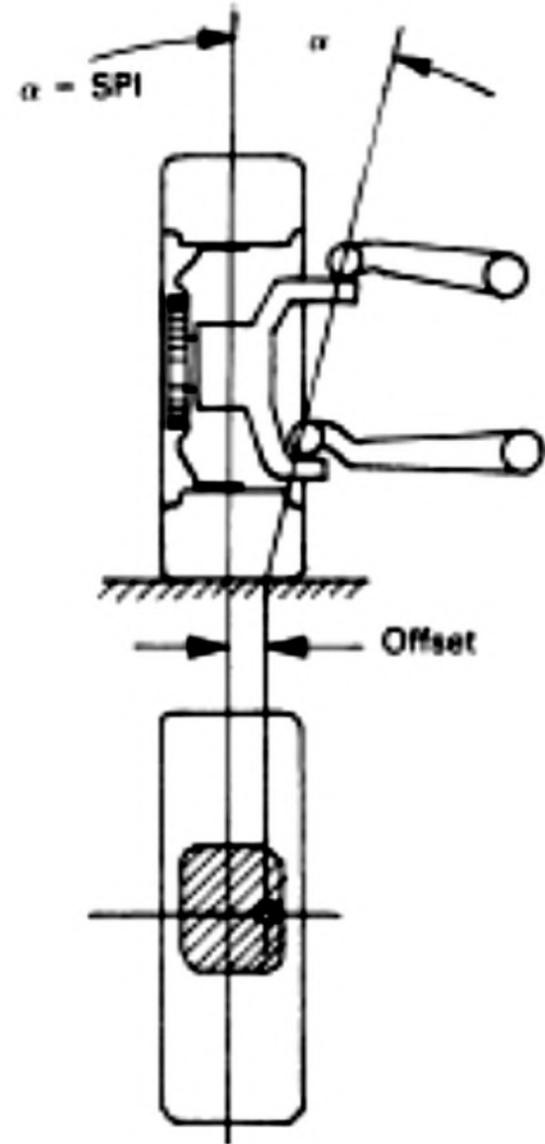
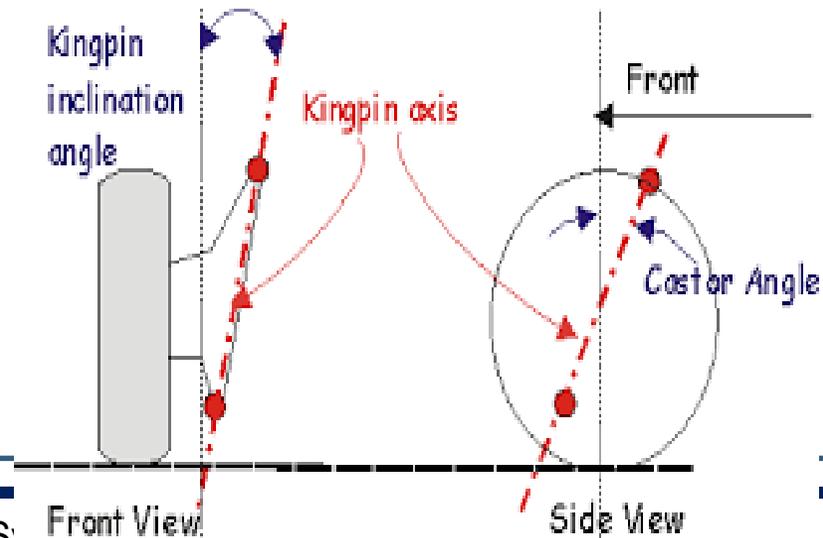




- If the top of the wheel (when viewed from front) is leans outward than bottom it is positive camber conversely if bottom of the wheel is outward than the top it is negative camber.
- Generally, it should not exceed 2 Degrees.
- Positive camber is used on most of vehicles.
- Positive camber increases steering effort.
- Negative camber is used on racing cars to provide directional stability and reduce steering effort.

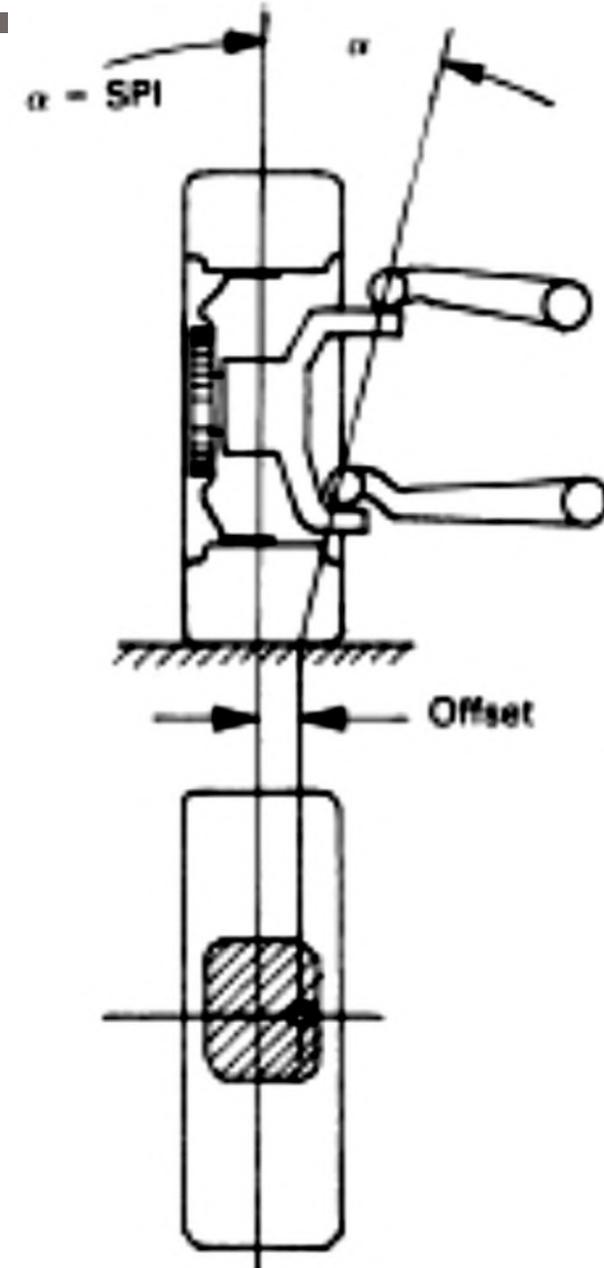
## ❖ King Pin Inclination or Steering Axle Inclination:

- The angle between the vertical line and the center of the king pin or steering axle when viewed from front off the vehicle is known as KPI or SAI.
- The KPI in combination with Castor angle is used to provide the directional stability in modern cars by tending to return the wheels to straight ahead position after any turn.
- This inclination varies from 4 to 8 degree in modern cars.

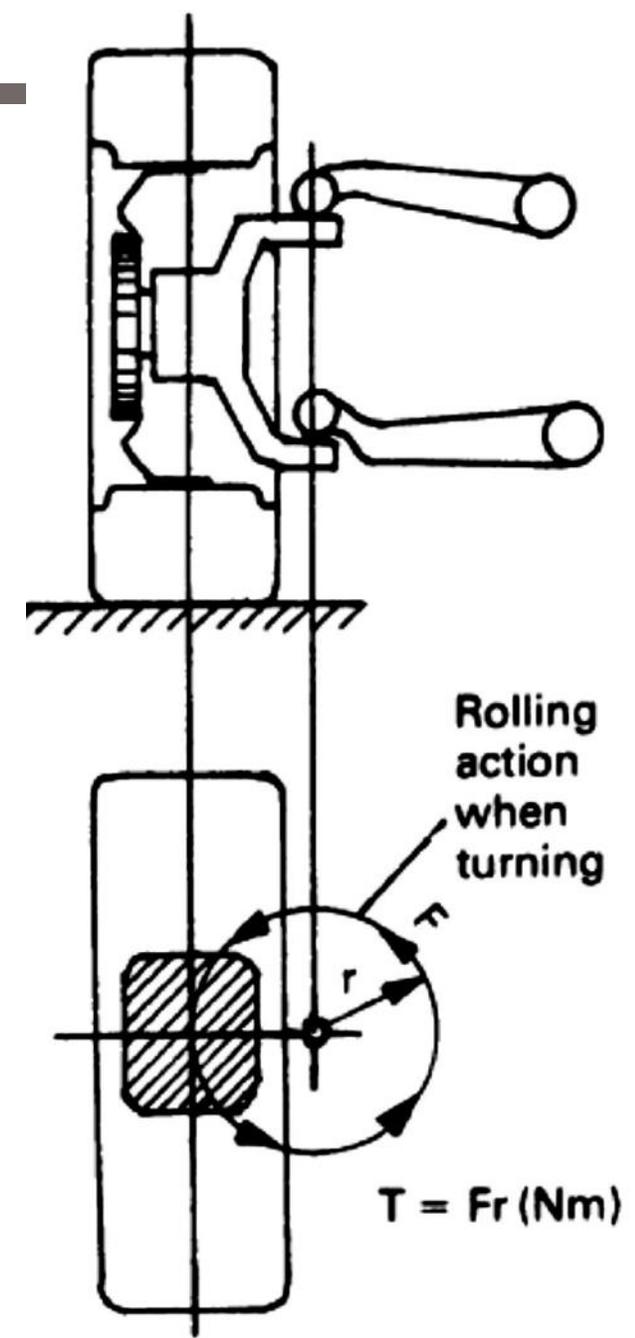


## ❖ Scrub Radius:

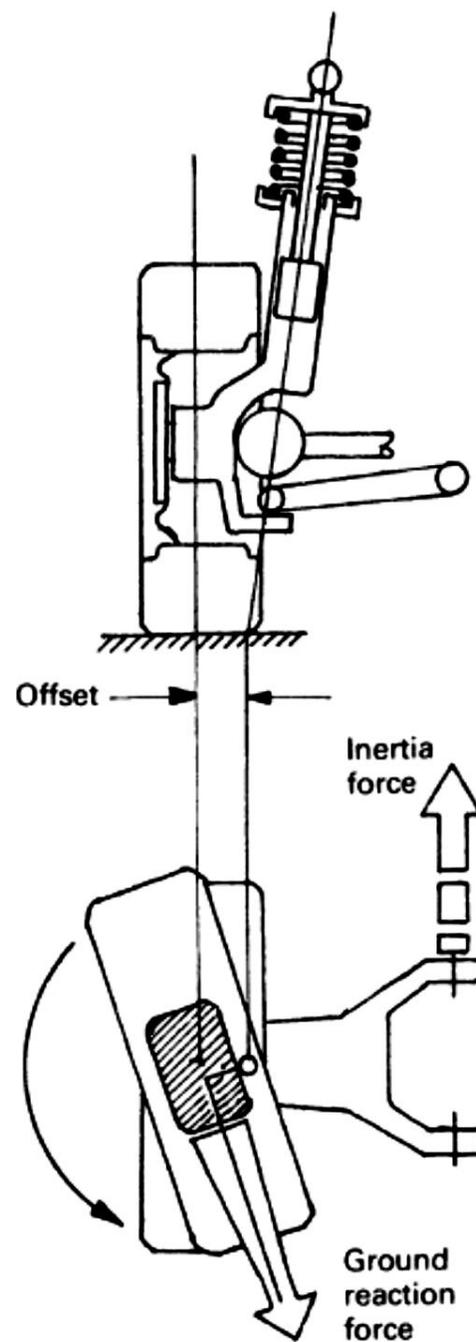
- The offset between the pivot center of king pin and contact center is known as the scrub radius.
- When turning the steering the offset scrub produces a Torque  $T$  by to product of radius  $r$  and opposing ground reaction force  $F$ . (i.e.  $T = Fr$ )
- A large offset requires a big input torque to overcome the opposing ground reaction force therefore the steering will tend to be heavy.
- Zero offset prevents a tread rolling and instead causes to scrub as the wheel is steered so that at low speed the steering also has heavy response.



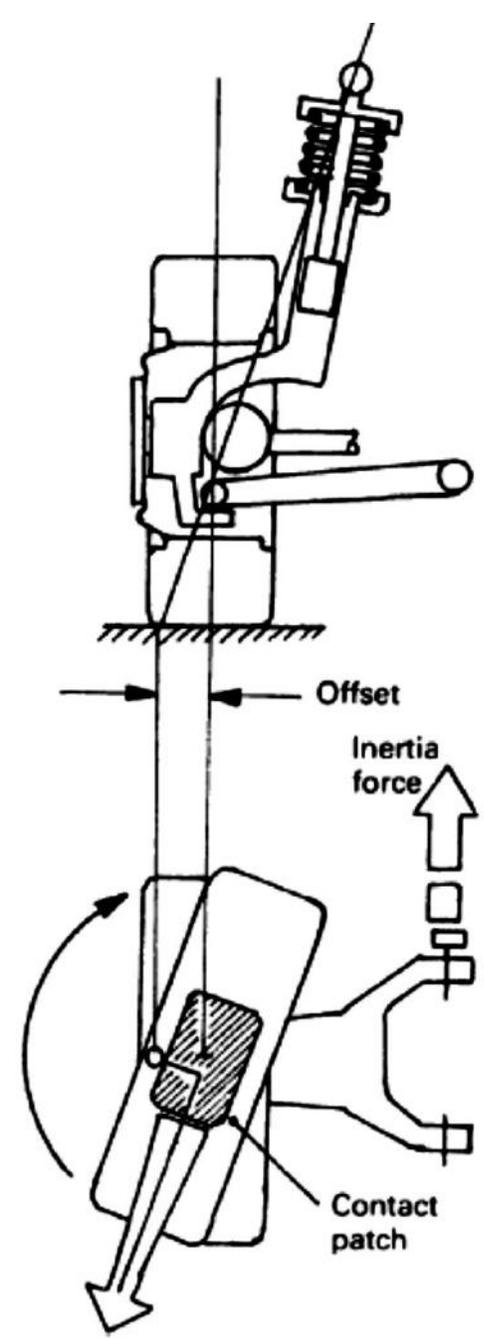
- A compromise is usually made by offsetting the pivot and the contact center to roughly 10 to 25 % of the tread width of standard sized tyres.
- This small offset permits the pivot axis to remain within the contact patch, thereby enabling a rolling movement to still take place when the wheels are pivoted so that the tyre scruff and creep (Slippage) are minimized.
- Another effect of the large offset, when the wheels hit bump or a pothole a large opposing twisting force would be created quickly which would be relayed back to driver steering wheel in a twitching fashion.



- If the offset of the king pin inclination is on the inside of the tyre contact patch center then it is called as positive scrub radius or positive offset.
- If the offset of the king pin inclination is on the outside of the tyre contact patch center then it is known as the negative scrub radius or negative offset.



Swivel pin inclination positive offset



Swivel pin inclination negative offset

## ❖ Toe- In & Toe- Out

- In automotive engineering, toe also known as tracking.
- Positive toe, or **toe in**, is the front of the wheel pointing in towards the centerline of the vehicle
- Negative toe, or **toe out**, is the front of the wheel pointing away from the centerline of the vehicle.

