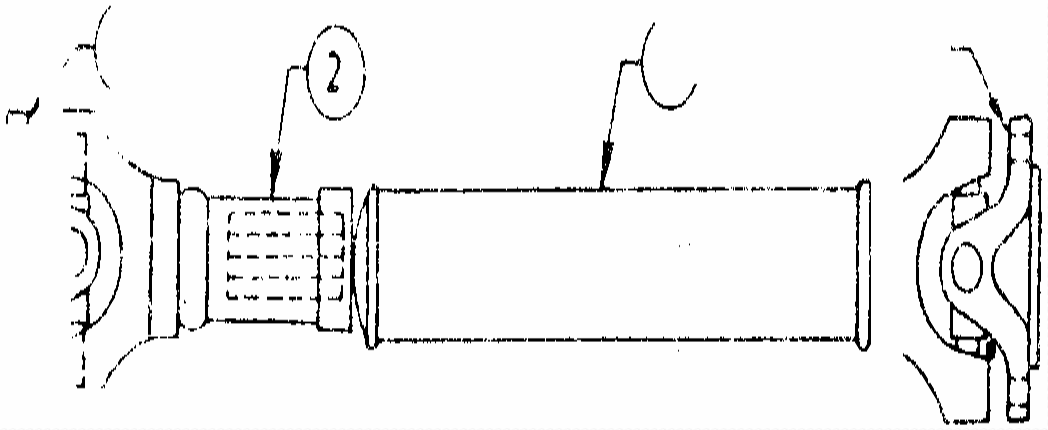
UNIT - IV

Propeller shaft

- This is the shaft which transmits the drive from the gear box to the bevel pinion or worm of final drive in front engine rear drive vehicle.
- Also called drive shaft
- It consists of three parts.

1) Shaft: As this has to withstand mainly torsional loads, it is usually made of tubular cross section
2) One or two universal joints, depending upon the type of the rear axle drive used. The universal joints act for the up and down movements of rear axle when the vehicle is running.
3) Slip joint -Depending upon the type of drive one slip joint may be there in the shaft. This serves to adjust the length of the propeller shaft when demanded by the rear axle movement.

- Fig shows a propeller shaft with two universal joints at end and a slip or sliding joint,
- Slip joint is formed by the internal splines on the sleeve attached to the left universal joint and external splines on the propeller as shown.



- In vehicles with large wheel base , the long propeller shaft would tend to sag and whirl.
- Whirl is like the action of a rope that is in an arc while held at both ends.
- At certain speed the whirling becomes critical and the shaft vibrates violently. This also sets up sympathetic resonant vibrations in the vehicle body.

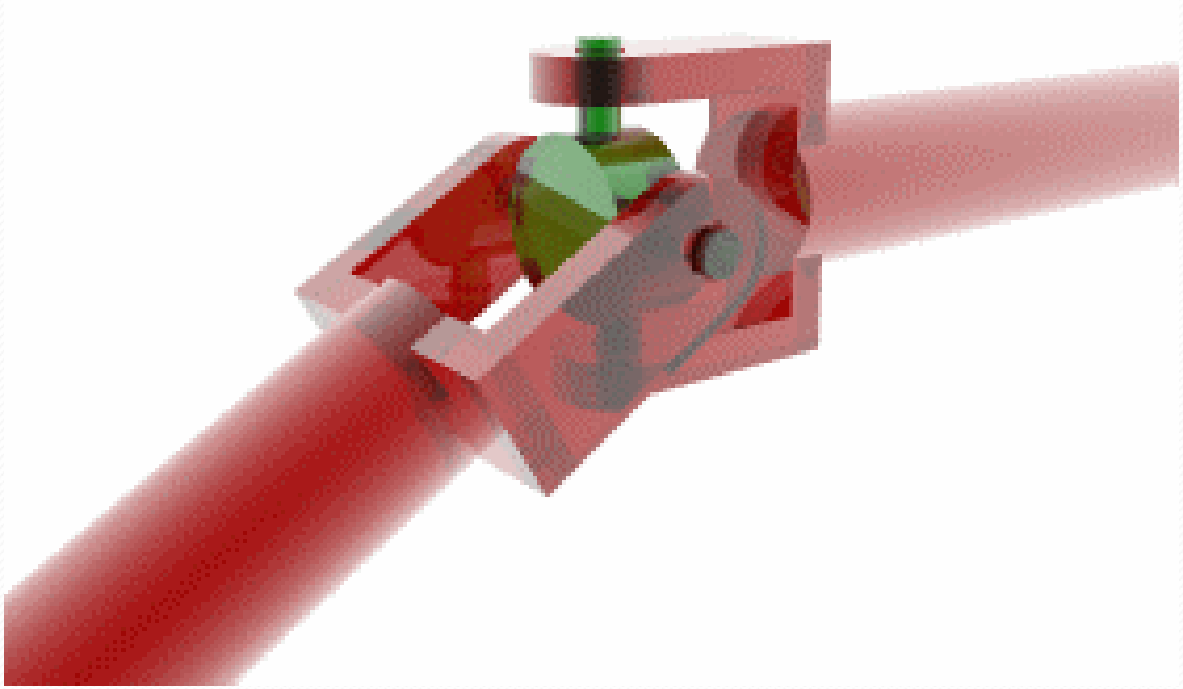
UNIVERSAL JOINT

- A universal joint is a particular type of connection between two shafts , Whose axes are inclined to each other.
- The most simple type of universal joint is Hookes's joint

- An universal joint is used where two shafts are connected at to transmit torque

Hooke’s joint

- **Hooke's joint** is a joint in a rigid rod that allows the rod to 'bend' in any direction, and is commonly used in shafts that transmit rotary motion. It consists of a pair of hinges located close together, oriented at 90° to each other, connected by a cross shaft.
- Hooke's joint is most widely used because of the fact that it is simple and compact in construction.
- Reasonably efficient at small angles of propeller shaft movement up and down (say up to 18 degree)



Construction and working

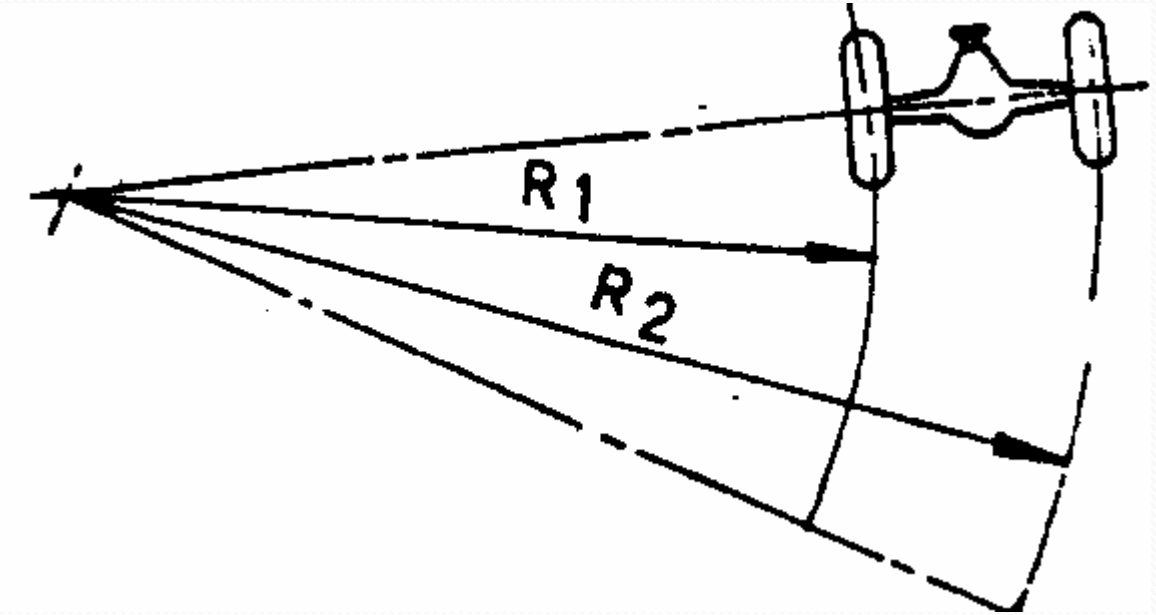
- The axes of shafts (say A and B) Intersects with each other. Each of these shafts contain a yoke.
- The cross C has four arms. The two opposite arms of the cross are supported in bushes in the yoke of shaft A , while the other two arms of the cross are supported in yoke of shaft B. thus shaft A will have angular rotation about axis XX and shaft B about axis YY.
- Thus it is possible for shafts A and B to have positive drive while allowing angular movement between them.

Defect

- The universal joints have one defect in common.
- In all these joints the speed of driven shaft does not remain uniform. Depending upon the angle of inclination of shafts , the driven shaft speed undergoes cyclic variation.
- This variation is zero from zero angle of inclination , but its magnitude becomes considerable when angle is large.

Differential

- If a vehicle travels in a straight line, the two rear wheels turn on the road exactly at same speed. There is no relative movement between the two rear wheels. But when the vehicle takes a turn, the outer wheel travels on a longer radius than the inner wheel.
- The outer wheel turns faster than the inner wheel, that is, there is a relative movement between the two rear wheels. If the two rear wheels are rigidly fixed to a rear axle the inner wheel will slip which will cause rapid tyre wear, steering difficulties and poor road holding.
- Therefore there must be some devices to provide relative movement to the two rear wheels when the vehicle is taking a turn. The differential serve this purpose


R1
R2

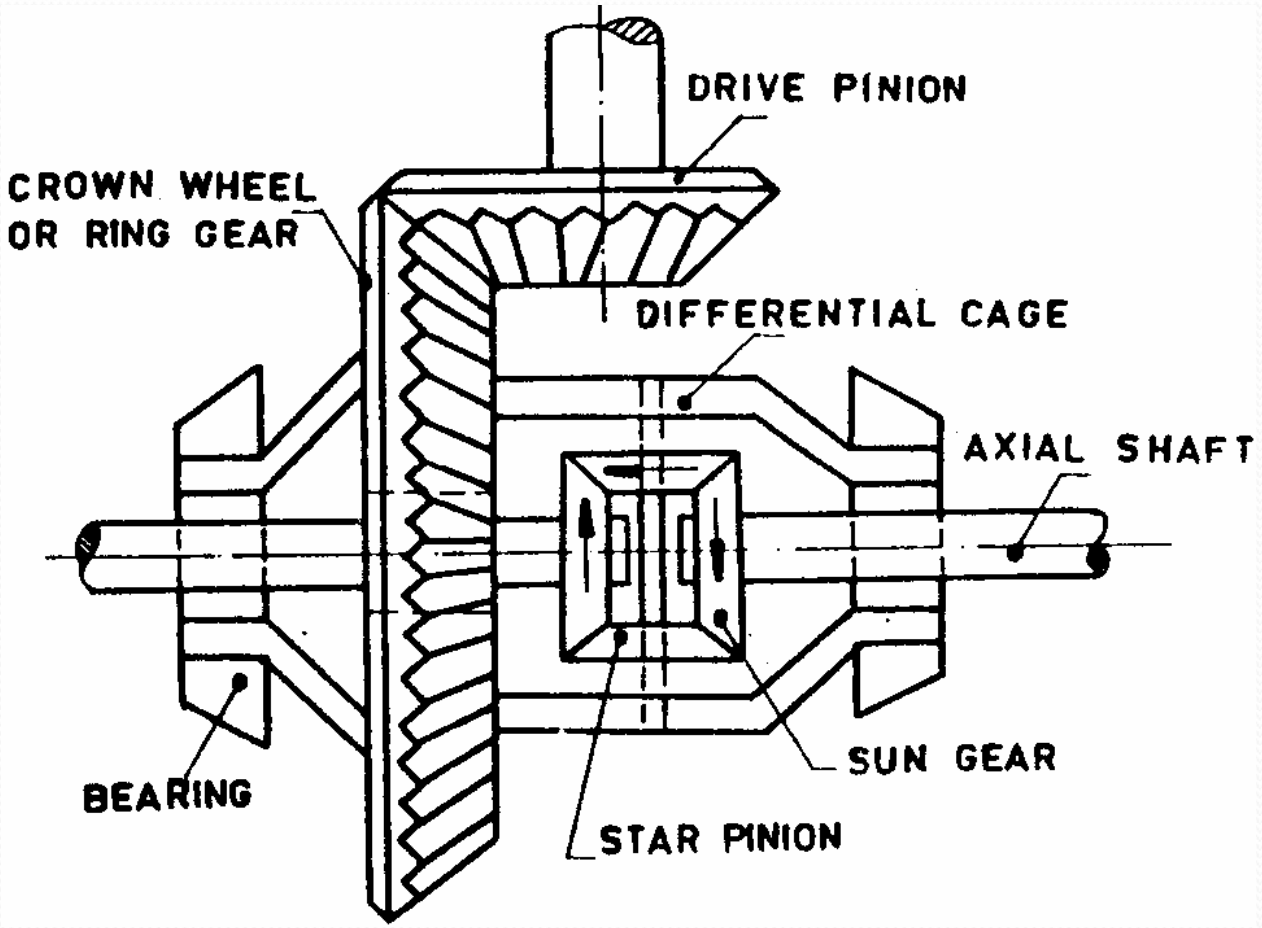
Differential

- When the car is taking a turn , the outer wheels will have to travel greater distance as compared to inner wheels at same time.
- If therefore , the car has a solid rear axle only and no other device , there will be tendency for vehicles to skid.
- Hence , if the wheel skidding is to be avoided , some mechanism must be incorporated in the rear axle , which should reduce the speed of the inner wheels and increase the speed of outer wheels when taking turns.
- It should at the same time keep the speeds of all the wheels same when going straight ahead , Such a device which serves the above function is called **Differential**

- The function of the differential is to allow each rear wheel to rotate at different speeds during running but at the same time transmit equal torque to each wheel when both wheels have equal traction.

- TYPES OF DIFFERENTIAL
- (i)Conventional
- (ii)Power lock or Non-slip
- (iii) Double reduction type.

CONVENTIONAL TYPE (CONSTRUCTION)



- It consists of a cage which contains differential gears. The differential gear consists of two sun gears and four star pinions all the bevel type.
- The star pinions are fitted on a pin if there are two in number and a spider, if four are in number. The pinions are free to move around their axes. The pin or spider is held in between the two parts of the cage which encloses the differential gears. The sun gear and star pinions are always In mesh with each other.
- The differential assembly is supported on taper roller bearing provided on both sides of the cage.

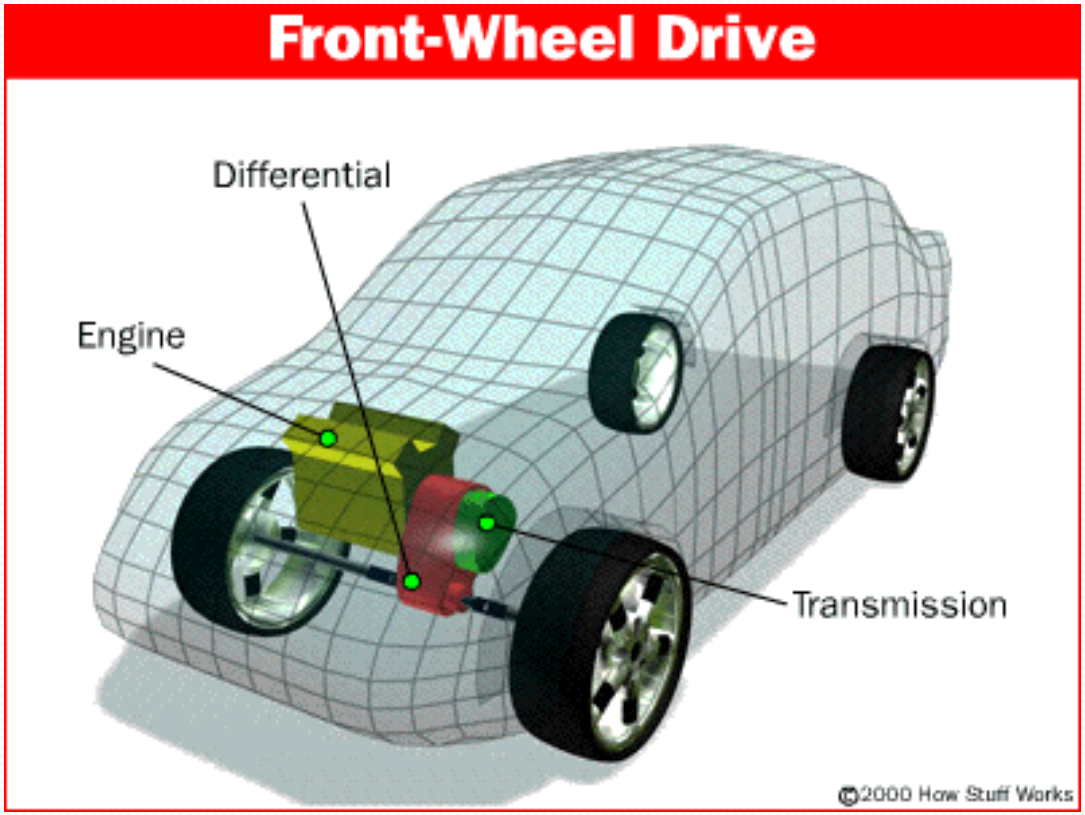
- The ring gears or crown wheel is attached to the differential cage which forms part of the final drive. Drive is given to the ring gear by means of drive pinion to which propeller shaft is attached.
- Such gears are located parallel to ring gear inside the differential cage and face towards each other. Shaft of each wheel is splined into the sun gear of that side.

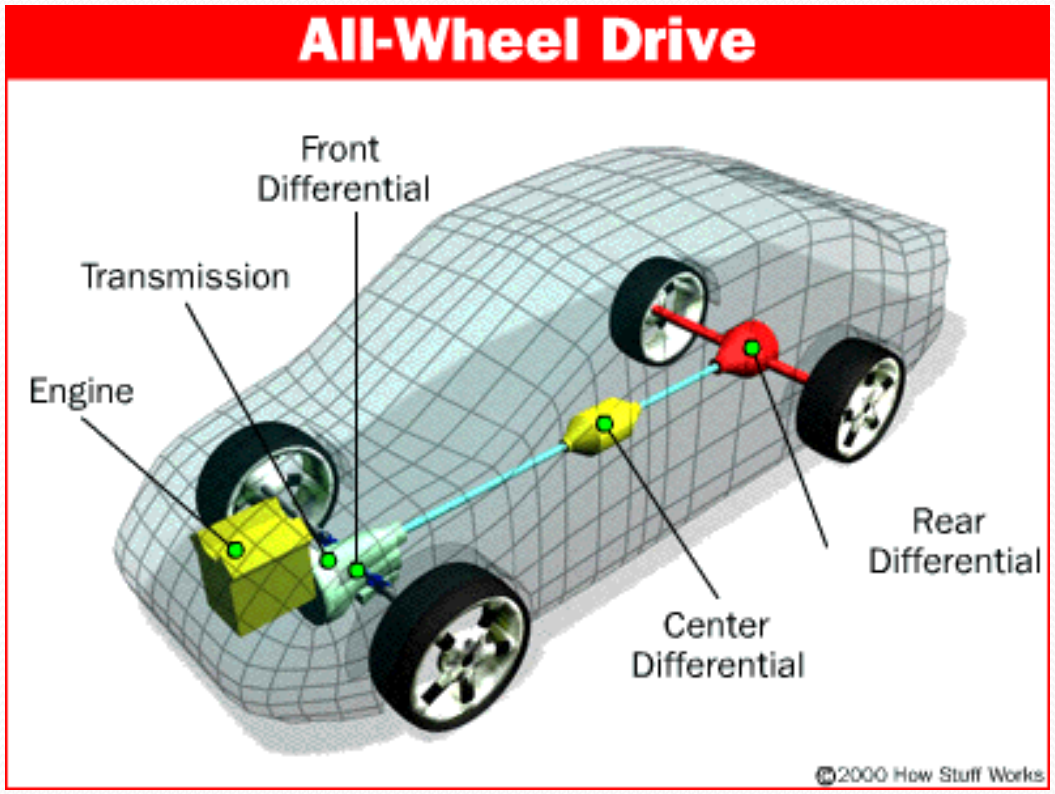
WORKING OF DIFFERENTIAL

- When the vehicle is moving on straight level road and the resistance effecting both the driving wheels is the same, there is no relative movement among the differential gears. The whole arrangement meshed together moves as one unit and both the half shafts in the driving wheel rotate at the same speed.
- When the front wheels are turned to any directions to take a turn, a binding force acts on the inner wheel being nearer to the point around which wheels move in a circle. The sun gear of the side is held slow in relation to the movement of the complete cage or crown wheel.

- While taking a turn when the bonding acts on the inner side sun gear and its speed is slowed down, the star pinion rotate the other side sun gear at a speed as a result of loss on the inner side and gain on the outer side plus the speed at which the complete differential assembly is rotating.
- This results in a faster movement of the outer wheel than the inner one.

Front-Wheel Drive




All-Wheel Drive
Front Differential
Transmission
Engine
Rear Differential
Center Differential
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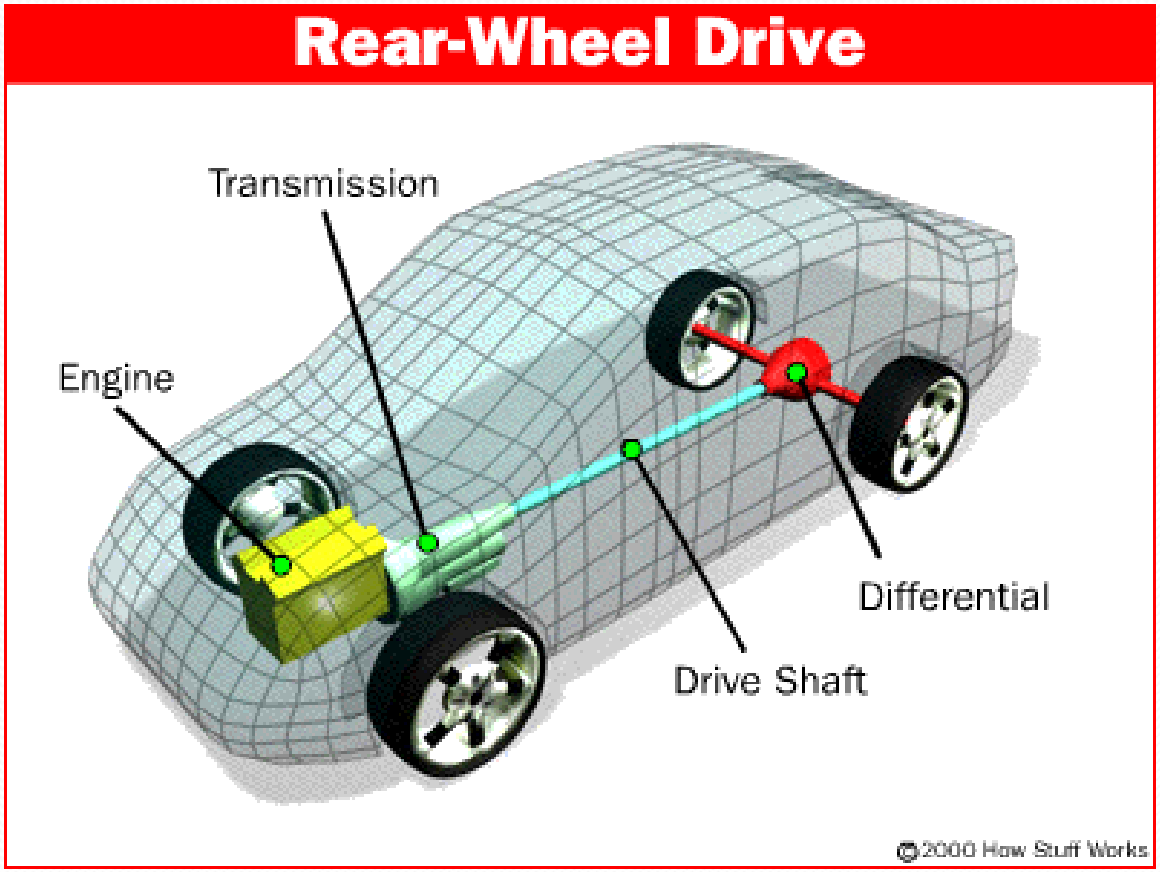
Rear-Wheel Drive



Rear Axles

- The forces experienced by the rear axle are given as under

i)Weight of the body

ii) Torque reaction

iii)Driving thrust

v) Side thrust

- **Weight of the body:**

  The rear axle may be considered a beam supported at the ends and loaded at two points. The rear weight of the body is transmitted to the rear axle through springs.

- **Torque reaction:**

  If the road wheels are prevented from rotation with the propeller shaft rotating , it is seen that bevel pinion will tend to roll round the crown wheel. This tendency is also present when the vehicle is running , so that bevel pinion always tend to climb round the crown wheel. Thus there is a force on the axle casing to rotate .This is called torque reaction.

Driving Thrust:

Driving torque is produced in the engine causes the thrust to be produced in the road wheels , which has to be transmitted from the axle casing to the chassis frame and the body of the vehicle. This is most conveniently done by some form of members connecting the axle casing and the chassis frame in the longitudinal direction. Such members are called thrust members or radius rods.

Side Thrust:

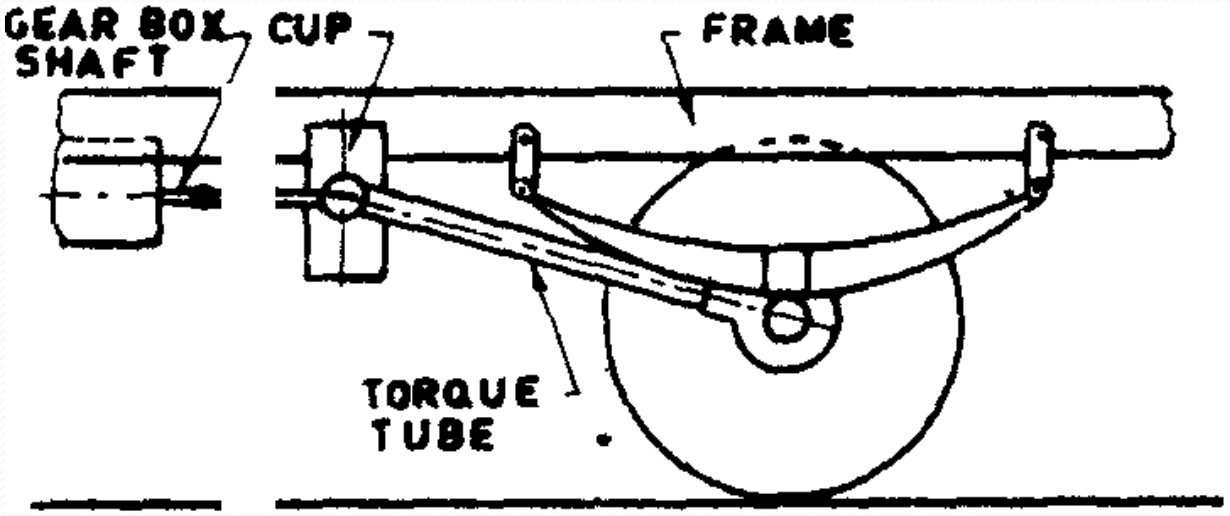
The rear axle experiences side thrust or pull due to any side load on the wheel

REAR AXLE DRIVES

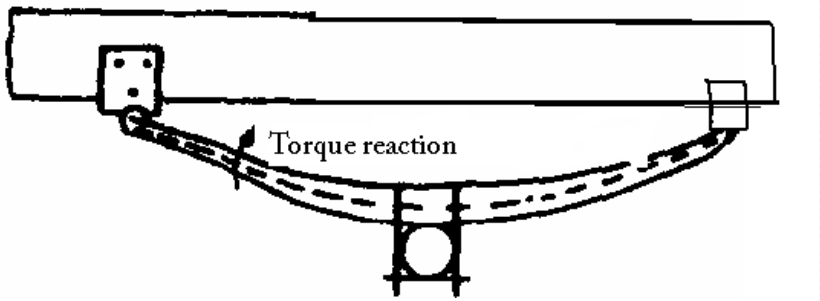
- To transmit the torque from the gear box to the rear axle, the common drives are use are:
- Hotchkiss Drive
- Torque Tube Drive
- Radius Arm Drive

HOTCHKISS DRIVE

- Simplest and most widely used rear axle drive
- The arrangement of the parts is shown in fig:



- In this case the springs beside taking weight of the body, also take the torque reaction, driving thrust and the Side thrust
- The propeller shaft is provided with two universal joints and one sliding joint. The spring is fixed rigidly in the middle , to the rear axle. Front end of the spring is fixed rigidly on the frame while the rear end is supported in a shackle
- Due to torque reaction the front half spring deflects as shown in figure means that the driving thrust is transmitted to the frame by this portion of the spring.



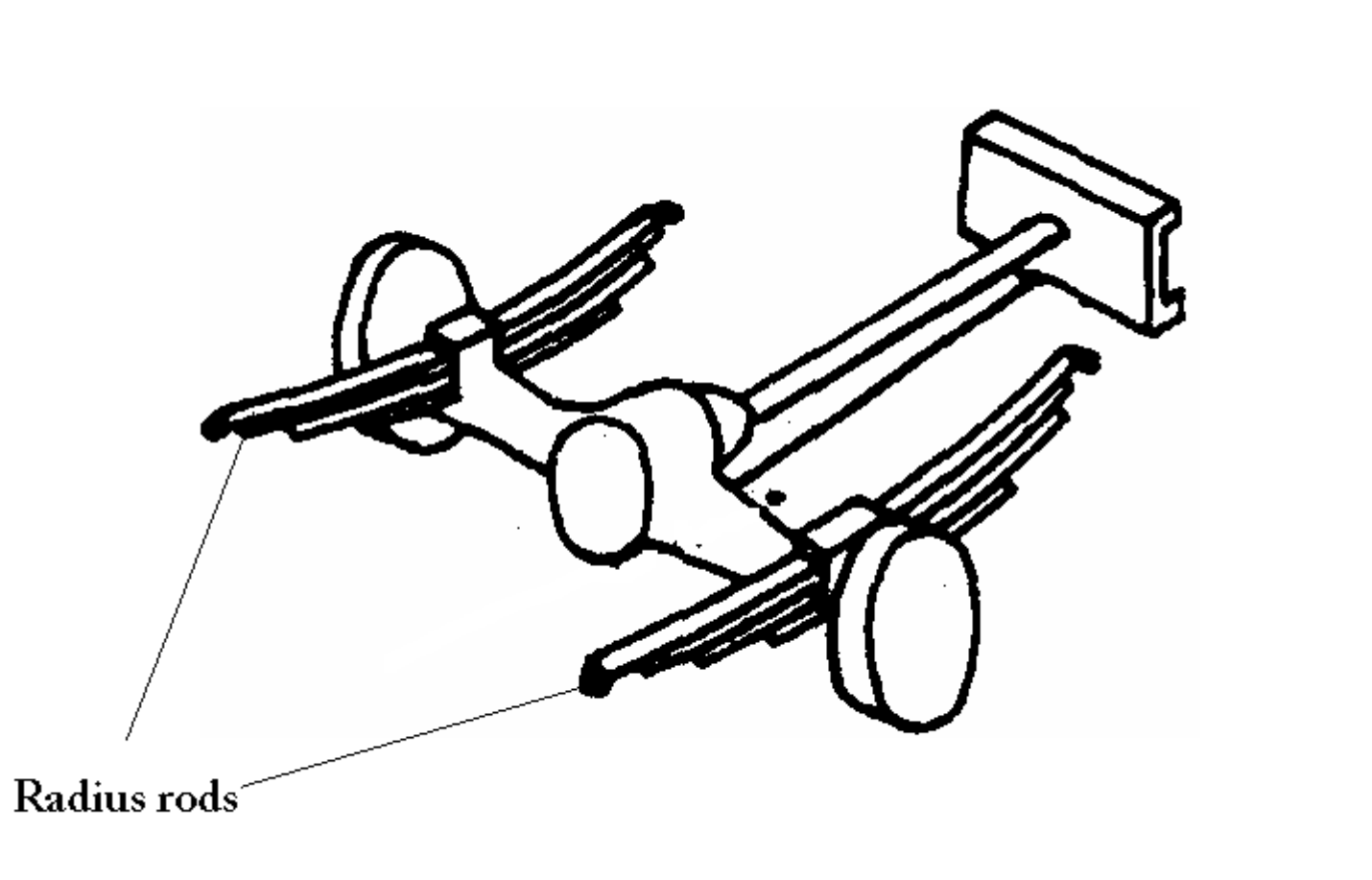
- When the spring deflects in the manner bevel pinion shaft will change its position.
- Therefore , If there is one universal joint near the gear box then under the torque reaction the propeller shaft will bend. Therefore, to avoid the bending of the propeller shaft another universal joint is used at is rear end
- Again when axle moves up and down relatively to the frame it has to move in a circle whose centre lies at the front end of the spring. Then propeller shaft also has to move in circle keeping its centre at the front universal joint. As these two centers do not coincide, therefore, the length of propeller shaft always has to vary this condition which is accommodated by the sliding joint in the propeller shaft

TORQUE TUBE DRIVE

- In this type of drive, the spring take only the side thrust besides supporting the body weight.
- The torque reaction , braking torque and the driving thrust are taken by another member which is called the torque tube.
- One end of the torque tube is attached to the axle casing, while the other end which is spherical in shape fits in the cup fixed to the frame.

- Since in this case the torque reaction and the driving thrust are taken by the torque tube., the bevel pinion shaft axis will always pass through the universal joint at the front end of the propeller shaft if this joint is situated exactly at the centre of the spherical end of the torque tube.
- Due to this reason no universal joint is at the rear end. Since both pinion shaft and propeller shaft will work about the same centre that of the spherical cup while moving up and down the axle then no sliding joint will be necessary.
- In this case **no universal joint is provided** at the rear end of the propeller shaft. Also **no sliding joint is provided** because both the pinion shaft and the propeller shaft in this case will move about the same centre i.e. about the centre of the spherical cup

RADIUS ARM DRIVE:



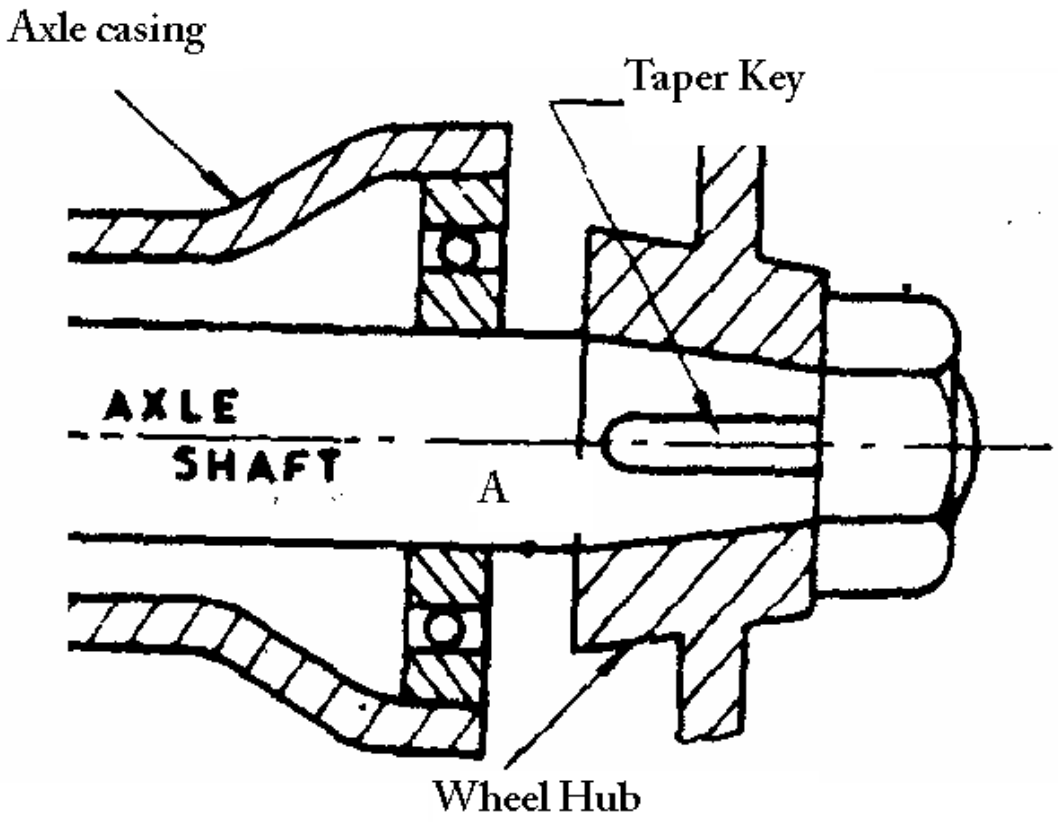
- The radius arm drive method uses two torque rods or radius arm to transmit the driving thrust to the frame.
- The torque reactions is resisted by the springs , the springs must therefore be stiff enough
- The radius arm are connected between the rear axle and the frame by connections that allow relative motion between the two

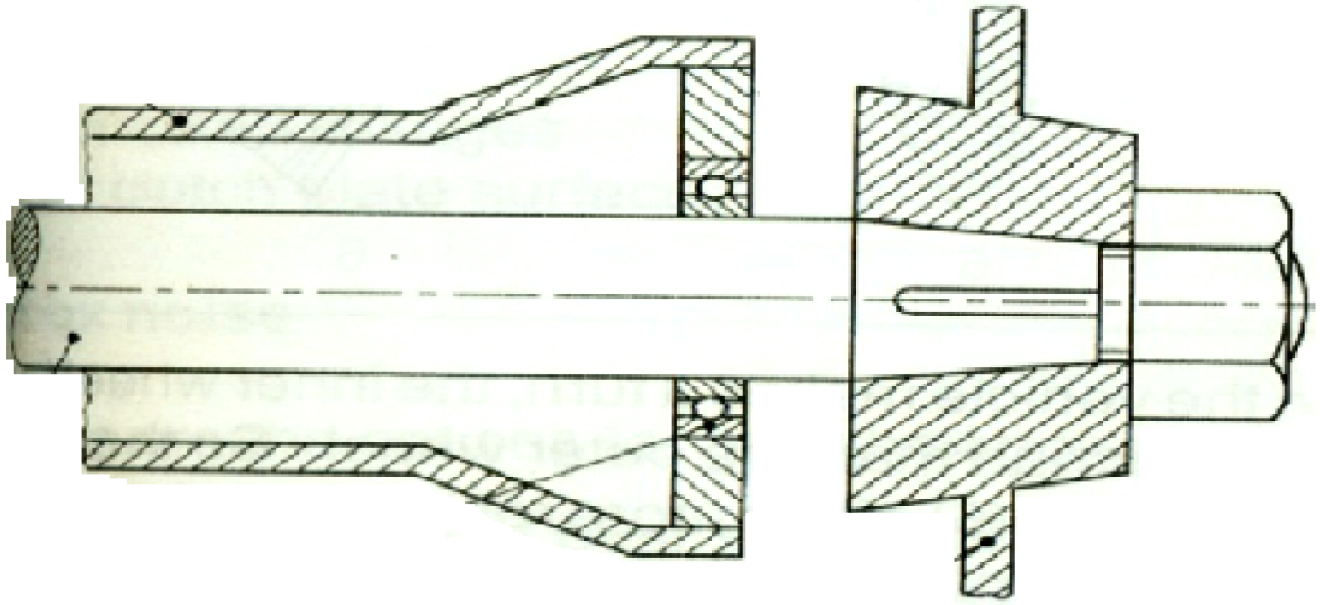
TYPES OF REAR AXLES

- Depending upon the method of supporting the rear axles and mounting the rear wheels, the rear axles are of three types:

1) Semi floating axle
2) Full floating axle
3) Three quarter floating axle.

SEMI FLOATING AXLE

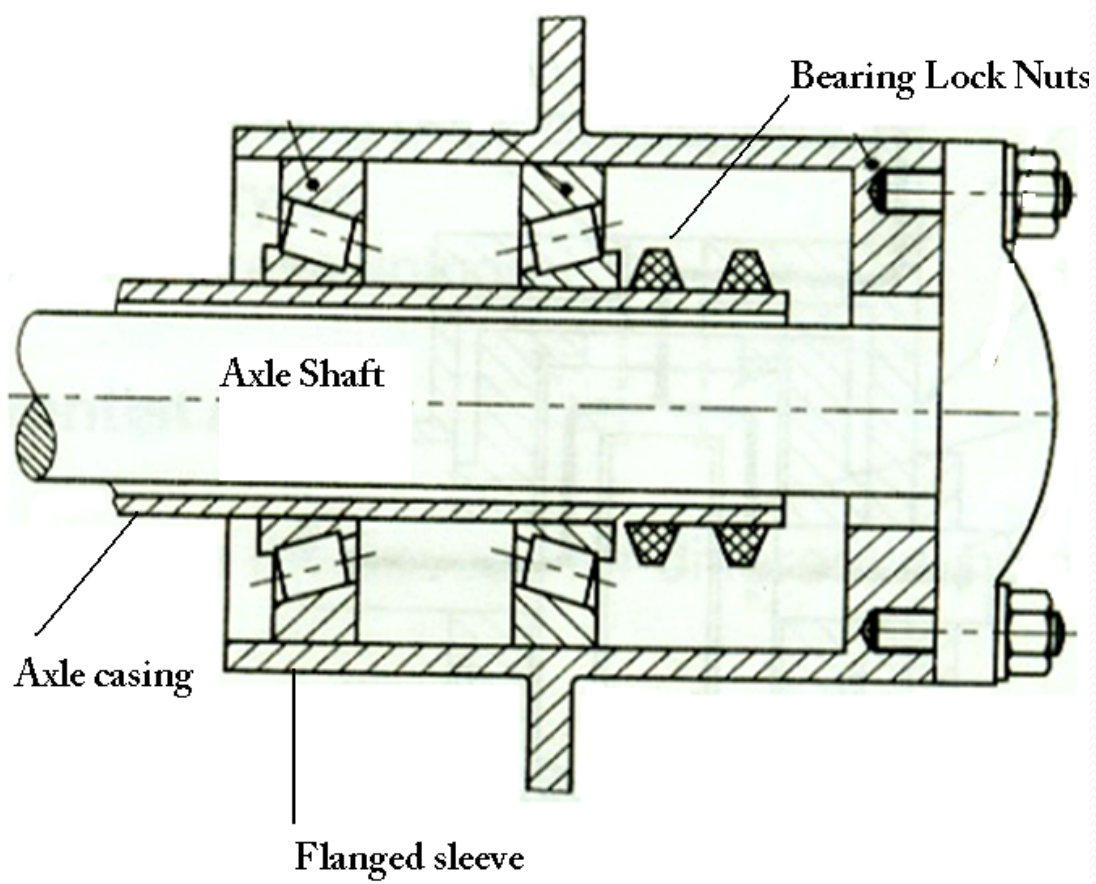




- The wheel hub is directly connected to the axle shaft or is an extension of the same.
- The inner end of axle shaft is splined and is supported by final drive unit, whereas the outer end is supported by single bearing inside the axle casing.
- All the loads are taken by axle shaft. The vehicle load is transmitted to each of half shafts through the casing and the bearing. This causes a bending load and tendency to shear at point marked ‘A’.

- Semi floating axle is simplest and cheapest of all types therefore it is widely use on cars.
- However , since the axle shafts have to support all loads , they have to be of large diameter for the same torque transmitted compared to the other type of axle supporting

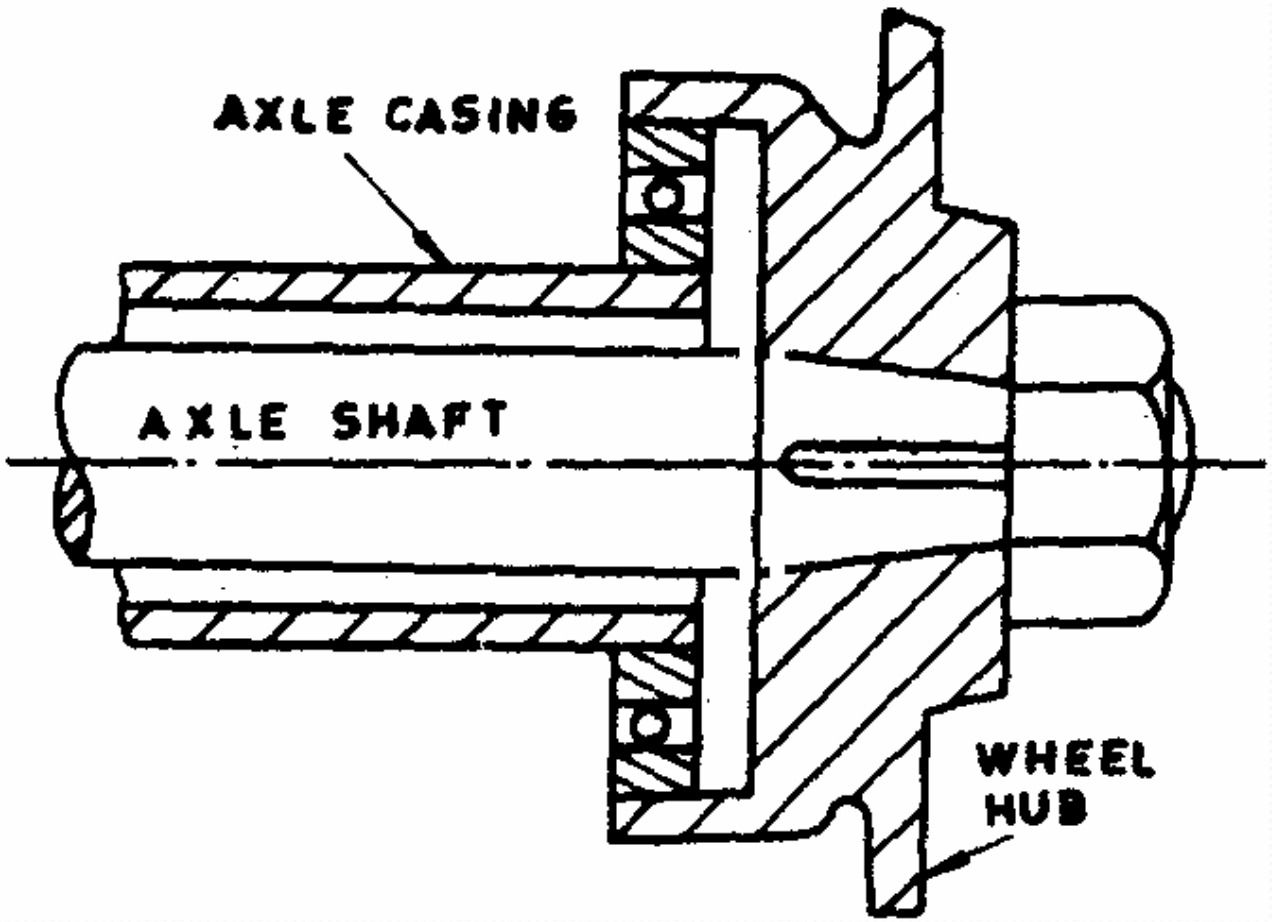
Full Floating axle



- This type is very robust one and is used for heavy vehicles.
- In this the **axle shaft carry only the driving torque**
- A full floating axle has two deep-groove ball or taper roller bearings, located between the axle casing wheel hub.
- The outer of the axle is made flanged to which the wheel hub is bolted. The axle is not supported by bearings at either end, and its position is maintained by the way that it is supported at both ends

- The weight of the vehicle and end thrust are not carried by them , the weight being completely supported by the wheels and the axle casing
- As the axle shaft carry only driving torque , their failure or removal does not affect the wheels.
- The axle may be removed from the housing without disturbing the wheel by removing the nuts An additional advantage of the design is the ability to withstand the vehicle even if it has a broken axle.
- This type of axle is more expansive and heavier than the other axles.

THREE QUARTER FLOATING AXLE:



- In the three quarter floating axle the single bearing located between the hub and the axle casing.
- Thus, the weight of the vehicle is transferred to the axle casing , and only the side thrust and driving' torque are taken by the axle.
- The inner end of this axle has the same construction as that of the semi-floating axle
- The axle shaft do not take any shearing or bending loads due to the weight of the vehicle. However it has to take the end loads and driving torque.

- Although the three quarter floating axle is more reliable but it is not as simple as the semi floating axle